Market Imperfections and Price Rigidities: A Case Study of the Greek Manufacturing Industry

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ABSTRACT

This study investigates the market conditions under which the Greek manufacturing sectors operate, and provides a formal measurement and determination of the observed degree of rigidity in nominal prices using panel modelling techniques. Two parameters in particular are found to capture the essence of market imperfections and price rigidity arising from various sources: the first parameter is conjectural variation elasticity which defines the degree of market divergence from perfect competition; and the last parameter refers to the speed of price adjustment towards the equilibrium level, which is estimated along with a set of important factors that affect this parameter.

The data sample of this research consists of 56 3-digit manufacturing sectors, as defined by Eurostat (*NACErev2*) over the period 1980-2012, while the econometrical approach mainly incorporates the *Fixed and Random Effects Model* for panel data. The estimation process is divided into four steps: in the first step, the degree of market power and the speed of price adjustment are estimated for the whole manufacturing industry; in the second step, the same process is reiterated for the 3-digit sectors individually; in the third step the estimations are conducted for each year over 1980-2012; in the last step, the effects of a set of variables on the speed of price adjustment are estimated in order to provide an adequate interpretation of how market imperfections and price rigidities can be formed and how they relate to each other. By using the Greek economy as a case study, the empirical results provide significant evidence of a degree of market power similar to the one of a duopoly accompanied by relatively slow price adjustment in the 56 manufacturing sectors and the 33 years over 1980-2012.

Key Words: Industrial Organization, Imperfect Competition, Price Rigidity, Conjectural Variation, Speed of Adjustment, Greece, Manufacturing Industry, Panel Data.

DECLARATION OF AUTHORSHIP

I, Chrysovalantis Amountzias, declare that this dissertation entitled *“Market imperfections and price rigidities: A case study of the Greek manufacturing industry”* and the work presented in it are my own.

I confirm that:

This work was done while being a candidate for Ph.D. at the University of Hertfordshire and submitted in partial fulfilment of the requirements of the degree of Ph.D.;

Where I have consulted the published work of others, this is always clearly attributed;

Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this dissertation is entirely my own work;

I have acknowledged all main sources of help.

Chrysovalantis Amountzias **31st May 2016**

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1. Introduction

1.1.The Greek Manufacturing Industry as a Case Study

Economists and market analysts pay close attention to the logic and mechanisms of industrial organization and the interactions of economic agents in the marketplace. An area of particular interest is the identification and measurement of potential market imperfections such as monopolistic power and anti-competitive behaviour that warrant public policy intervention. Earlier indicators of the degree of competition amongst various sectors and/or firms within a market include the size of a sector/firm or the market share that each sector/firm holds. More recent attempts to critically examine market imperfections tend to focus on firms' pricing decisions and the frequency they tend to change in response to both endogenous and exogenous market forces (Olive, 2008; Rezitis and Kalantzi, 2011a; Kano, 2013; Polemis, 2014). On the one hand, any variable that individual firms are able to manipulate can be considered as endogenous, such as production and pricing decisions due to competitive or oligopolistic interactions. On the other hand, any changes that are beyond the firms' ability to manipulate can be treated as exogenous, such as fluctuations in input prices or taxation policy.

The main interest of this research is to investigate the existence of market power and whether or not nominal price rigidity arises from strategic industrial behaviour. Such behaviour is determined by the levels of production and operating costs within the firms, in addition to competitive interactions observed between the participating firms or sectors in the market. The theoretical framework that examines the interrelations of market power and nominal price rigidity has been developed by the *New Keynesian School of Thought* and particularly, by Julio Rotemberg (see chapter 2). The main argument of this theory is that firms with market power will exercise their power in their pricing decisions. This indicates that the greater the power, the greater their ability to manipulate nominal prices and thus, nominal rigidity emerges whenever it is beneficial and profitable. As a result, this line of reasoning may associate nominal price rigidity with sub-optimal equilibrium by deviating from the point of perfect competition (Tirole, 1988). This means that it is of great importance to test whether a relationship between market power and nominal price rigidity exists and how they tend to interact.

The present study focuses on the estimation of two essential measures that define the very meaning of competition and pricing decisions according to the *New Empirical Industrial*

Organization methodology: the first one corresponds to conjectural variation elasticity (Bresnahan, 1982; Lau, 1982) that measures the effect of a sector's individual production upon the aggregate (industrial) level of production; and the second concept sheds light on the speed of price adjustment to changes in particular endogenous and exogenous factors as initially presented by Means (1935) where the mechanism with which the market structure affects pricing behaviour is developed.

The measure of conjectural variation reflects the indicator of market power in terms of production decisions that is going to be considered in this study. In particular, it is more accurate to interpret market power by considering the aforementioned decisions in order to identify whether that power is exercised by the firms or sectors of the market. Production decisions may result in market power acquisition but causation may also depend on pricing decisions. Consequently, in addition to this indicator, the speed of price adjustment is taken into account for the identification of the degree of nominal price rigidity to changes in production factors.

The main purpose of this study is to identify the degree of market power and price rigidity and subsequently, test whether the latter measure is caused by the former. As Rotemberg (1982a, 1982b) highlighted, pricing decisions are highly affected by market factors and as a result, they may lead to rigid nominal price levels over a time period. For this reason, the theoretical interest lies on the identification of market power and nominal price rigidity and whether the latter issue is affected by the former. As a case study for this research, the Greek manufacturing industry is selected due to its highly significant role in the Greek economy. An important element of such investigation refers to the aggregate demand externality of nominal price rigidity. This means that nominal price rigidity in the disaggregated manufacturing levels (i.e. 4-digit level) could give rise to substantial fluctuations in output and employment at the aggregate level. In addition, by empirically identifying and estimating the significance of the main factors and mechanisms underlying price rigidity, this study can also enrich the empirical literature concerning sectorial pricing behaviour.

There are a number of studies that identify the degree of market power in the Greek manufacturing industry and sectors (Rezitis and Kalantzi, 2011a, 2011b, 2012, 2013) by using the conjectural variation and the price-cost margin approaches. However, the analysis is restricted to the manufacture of foods and beverages sectors or in the manufacturing industry at a 2-digit level. As a result, this study will take into account 56 dissagragated sectors by expanding the aforementioned studies in the market structure investigation of the Greek manufacturing industry. In addition, the only study that identifies the degree of price rigidity in the Greek manufacturing industry is the one of Bedrossian and Moschos (1988) but the time sample ends at 1977. Therefore, the present analysis provides an update on this issue over the period 1980-2012. Consequently, the present study extends the literature of market power and price rigidity in the Greek manufacturing by employing dissagrated sectorial data which can accurately reflect the industy's market conditions and pricing behaviour.

To begin with, the selection of that particular industry and the selection of the Greek economy in general is based on the economic environment in Greece in the post 1970s era. It is conjectured that market power and pricing decisions had a significant impact on the economic fortunes of the Greek manufacturing industry and hence, of the whole Greek economy (see below).

In the early 1980s, the macroeconomic performance of the Greek economy was relatively poor compared to the rest of European countries due to expansionary fiscal policies that resulted in a rapid increase in the debt-to-GDP ratio. In conjunction with the second oil shock that took place at the start of 1980s, inflation rose significantly. The average rate of inflation over that particular decade was fluctuating around 19 percent, which was almost three times higher than the European Union average. Consequently, the Greek government had to adopt a policy mix that would bring inflation to its long-run sustainable path and therefore, the revaluation of the national currency would lead to a fall in nominal debt (Oltheten, Pinteris and Sougiannis, 2004).

Such policy programmes were implemented in the late 1980's by cutting down public expenditures and reducing the inflation rate to 16 percent in 1987. Despite the fall in inflation, the debt-to-GDP ratio remained at relatively high level, so there was a sense of urgency to curb the debt level especially since the European Union imposed an adjustment programme on the Greek markets known as the Single European Market (European Commission, 2012). The main goal of this policy framework was to introduce a number of developmental programmes and laws in order to enhance the incentives of competition in the European markets and to minimize exploitation acts of consumer surplus. This action also contributed to the overall reduction of the inflation rate in the Greek economy as the degree of imperfect competition lessened and therefore, the wholesale price-cost margin was reduced (Rezitis and Kalantzi, 2011a, 2011b).

The implementation of the SEM in the Greek markets enhanced competition, especially in the manufacturing industry but nonetheless, the inflation rate remained at very high levels. For instance, when the Maastricht Treaty was signed in 1992, the fiscal deficit and debt-to-GDP ratios were far above the convergence criteria set by the European Union. The Greek deficit-to-GDP ratio was 11.5 percent in comparison to the European Union average which was 3.65 percent [1]. Nevertheless, the implementation of the SEM in conjunction with the efforts of the Greek government resulted in the improvement of the macroeconomic indicators by converging to the required levels under the Maastricht Treaty by 1999. Therefore, by meeting those criteria, the Greek economy was ready to enter the monetary European project known as the Eurozone under which it would be able to adopt the single European currency.

As a result, in 2000, Greece became part of a monetary union with a strong and credible currency compared to the old national currency of drachma. Over the early 2000's, the Greek economy appeared to exhibit very strong growth rates compared to the average growth rate of 4 percent for European countries as a whole. This outcome led to the third exogenous shock for the Greek economy which corresponds to the hosting of the Olympic Games. Given the remarkably annual growth rate, Greece was chosen to host the sporting event in 2004 as expectations about macroeconomic performance were very optimistic. In terms of fiscal policy, the Greek government invested vast amounts of money in infrastructure by expecting higher returns over the Olympic era (i.e. 2003-2005). In terms of domestic markets, the Greek firms and especially the manufacturing sectors experienced an exogenous boost in their demand which gave rise to overpricing behaviour as the international components of demand dramatically increased. The outcome of that shock resulted in a temporary, if not permanent, increase in the sectorial market power in the manufacturing industry (Rezitis and Kalantzi, 2012, 2013; Kasimati, 2003).

The post-Olympic Games era did not generate any unexpected effects in the aggregate economy. However, the fourth exogenous shock which is considered to be the beginning of the Greek economy's downfall corresponds to the global financial crisis erupted in 2008. In particular, through the mechanism of contagion and the interrelations of internalization, the

[1] See Eurostat database.

collapse of the US financial system eventually spread to the European system. A contagion of that magnitude could not have left the European continent unaffected and thus, the governments of the European Union would have to react to such shocks by strengthening the fundamentals of their economies (Rose and Spiegel, 2010). Many governments, including the countries of continental Europe, as well as Ireland, reacted by imposing austerity policies on their economies immediately following the eruption of the financial crisis in order to prevent a chain of reaction process that would have led to a depressing impact on the real economy.

Nevertheless, the financial crisis exposed the "Achilles's heel" of the Greek economy, corresponding to the fiscal derailment in terms of deficit and debt-to-GDP ratios. In particular, following the election of a new government in 2009, updated data concerning the fiscal condition of the Greek economy came to surface, indicating a fiscal deficit-to-GDP ratio of approximately 12 percent, (which was re-estimated a few years later to 15.5 percent) and a debt-to-GDP ratio of 120 percent. Such evidence resulted in the inability of the Greek state to both finance its deficit and also to repay a part of its loans that was about to expire in late May of 2010. This fact led the Greek government to come to a mutual agreement with the European Union, the European Central Bank and the International Monetary Fund under which a loan equivalent to one hundred ten billion euros would be provided in return for fiscal consolidation and contraction (Tsakalotos, 2011). This meant that Greece had a limited time horizon to achieve fiscal adjustment to a deficit target below 3 percent of GDP, as well as to a debt-to-GDP ratio below 60 percent, imposed by the Maastricht Treaty.

This was the fifth and last shock to the Greek economy in the form of the imposition of the austerity programme which is considered to be an endogenous shock. In this case, the main aim of such policies corresponds to the consolidation of the aforementioned fiscal sustainability indicators, the reform of the structure of the economy[2] and the sustainability of the financial system. By fullfilling these outcomes, the Greek economy would be able to reinforce its fundamentals against the current recession and improve future economic performance (Europe, 2012). Nevertheless, macroeconomic policies always depend on the micro interactions in markets. If policy makers wish to form policy proposals, they have to take into account the forces of competition in domestic industries that affect both producers and consumers. For this reason, the focus of this study is placed on the Greek manufacturing

[2] These policies are also focused on the modernization of the Greek public services.

industry and in particular, the manufacturing sectors, due to their significance and influence in aggregate consumption and thus, aggregate production (IOBE, 2014).

According to the Foundation for Economic and Industrial Research (*IOBE*), the Greek manufacturing industry has a significant contribution to the overall Greek economy in terms of employment, sales and value added. Nevertheless, within the broad sector itself different subsectors experienced significantly different economic fortunes. For instance, over 2000-2010 the sector of chemical products along with the sector of structural metal products accomplished the highest average annual increase in total value added (i.e. 1.5 and 1.2 percent respectively), when the manufacturing industry as a whole was facing a modest 0.1 percent expansion over the ten year period's value added. In addition, over the period 2008-2010, when the global financial crisis erupted, the manufacturing industry shrank by 1.7 percent, which led to a loss in its share of GDP by 3 percentage units, leading to an 8.7 percent overall contribution to Greek output (IOBE, 2013).

The Greek manufacturing industry contributes to annual nominal GDP by 16 percent, whilst the contribution by the service sector amounts to 80.6 percent. According to the Eurostat database, out of all the member states of the European Union, Greece achieved the highest manufacturing growth rate of 6 percent from 2005 to 2010. This growth rate is considered to be particularly remarkable if the exogenous shocks of the financial crisis of 2008 and the fiscal crisis of 2010 are taken into account. These shocks reduced manufacturing production by 13.4 percent over 2005-2010 but still, the actual growth rate was the highest in the European Union. Another significant indicator of the underlying robustness of the Greek manufacturing industry is the retail trade of manufacturing products as the average rate of growth was equal to 4.4 percent over the period 1999-2009. As a result of the resilience of the industry, the Greek manufacturing industry is considered to be the main power of the Greek economy's exports with a percentage contribution of around 60 percent despite its low percentage share in total GDP.

In terms of labour productivity, the annual growth rate is very close to the average of the European Union; however, according to IOBE (2014), productivity of output per hour of work was reduced over the period 2010-2012 as a result of the implementation of austerity policies. Therefore, labour productivity in the manufacturing industry was reduced to 74 percent of the European Union average productivity. An important aspect which is neglected from relevant studies concerns the means through which such productivity is achieved. For instance, Giokas, Eriotis and Dokas (2015) estimate that increased productivity in the manufacturing firms of their sample was achieved due to technology improvement rather than labour efficiency. This means that additional investment does not always produce comparable complementary improvement in labour efficiency.

At the sub-sectoral level, the most influential sector of the Greek manufacturing industry refers to the sector of food, beverages and tobacco which has retained the highest share of manufacturing output for many years equal to 19.8 percent in 2012. According to IOBE's report (2013) for the Greek manufacturing industry, the Greek food, beverages and tobacco sector creates about 150,000 jobs annually which account for about 25 percent of total employees in manufacture and holds about 25 percent of total sales of the whole industry. Also, the food and beverages manufacturing sector holds the highest share of total value added which is equal to 30 percent of the industry's total value added.

The importance of the manufacturing industry in the Greek economy can also be verified in comparison with the role of the industry in the European Union. Germany, followed by France, Italy, the United Kingdom and Spain enjoy a share in employment manufacturing to aggregate activities around 65 to70 percent. In the European Union the share of employment that is captured by the food and beverages sector is 16 percent of total employment in manufacturing industry and the share of sales is 16 percent. In addition, its gross value added exhibits a share of 14 percent, by rendering the food and beverages sector as the one with the highest share in value added in the whole industry.

In conjunction with the aforementioned facts, the Hellenic Statistical Authority (EL.STAT.) provides evidence that despite falling GDP over the period 2010-2012, Consumer and Producer Price Index followed an upward trend. Clearly the short-term wholesale price levels did not follow the long-run trend of GDP. In other words, the Greek economy showed signs of stagflation during this period and the underlying reasons and mechanisms warrant critical scrutiny. A number of reasons might be behind the apparent divergence in the paths of the aggregate price and GDP. One reason may be due to a short-term lag of realization of the condition of the aggregate economy and therefore, in the long-run the aforementioned price indices will adjust to the path of GDP. This is proof of sluggish price adjustment to equilibrium according to changes in production factors. Bedrossian and Moschos (1988) provided evidence of nominal price rigidity in the Greek manufacturing industry over the period 1963-1977 under which fluctuations in particular factors are not fully reflected by the wholesale price level. However, there is no additional contribution of price rigidity in this particular industry in subsequent periods.

In addition, the studies of OECD (2012, 2014) denote that the whole industry is under-performing as a result of inefficient regulations. Given the significance of the industry in the aggregate economy, the acquisition and exercise of market power on pricing and production decisions restrains the industry from operating efficiently. Due to the presence of heavy regulations, there exist barriers to entry that prevent entrepreneurial innovations, thus providing market power to the incumbent firms without the need of innovation. This has resulted in the stagnation of the whole industry over the years, thus forming an imperfect form of competition where only the strongest firms can survive. Consequently, the present study validates such claims by identifying the degree of market power and the speed at which prices adjust to changes in market clearing factors. This means that competition must be restored in the manufacturing industry by abolishing inefficient regulations and reformulating them in that manner under which imperfect competitive actions will be minimized.

Based on such indications, the Greek manufacturing industry will be a perfect case for the investigation of the degree of market power and the level of nominal price rigidity between and within the participating manufacturing sectors (Table A). Various econometrics approaches will be employed by emphasising in panel data analysis and subsequently utilizing time series and cross section analysis in order to identify the market conditions in the manufacturing sectors and thus, the manufacturing industry. The crucial variable of identifying market imperfections refers to the conjectural variation methodology (Bresnahan, 1982; Lau, 1982). This measure focuses on production decisions and whether they correspond to the production level under perfect competition.

On the other hand, the measure of price rigidity is the speed at which prices adjust to changes in endogenous and exogenous market factors (Means, 1935a; Dixon, 1983). Such factors may refer to input costs (i.e. labour and capital) and decision variables influencing the pricing strategies of the Greek sectors, such as the European Single market pricing decisions and the value added tax (i.e. VAT). Therefore, the main scope of this research is to test the effects and interactions of market factors and pricing behaviour by employing robust estimation procedures which reflect their relation.

1.2.Research Aims and Objectives

The primary purpose of this study is to empirically measure the extent of price rigidity and determine the mechanisms whereby such rigidity arises in the Greek manufacturing industry. Conceptually, nominal price rigidity can only be meaningfully defined with reference to a perfectly competitive market structure with the Walrasian auctioneering mechanism. Under such a market structure, all that matters for the optimal production and consumption decisions is a set of equilibrium relative prices; the aggregate price level is simply a multiple of a monetary numeraire; and all the nominal values are homogeneous of degree zero in nominal prices. Given the usual absence of such a paradigm in reality, the task of empirically capturing and measuring the extent of price rigidity is not straightforward and calls for indirect approaches. In the literature, price rigidity can arise from a number of mechanisms, including non-competitive market structures according to production and pricing decisions, market power of individual firms, existence of menu costs and structural sluggish price adjustment mechanisms (e.g. arising from staggered wage contracts or sluggish inflation expectations formation).

Moreover, there are intricate interactions between such mechanisms, further complicating the observed pattern of nominal prices at the aggregate and sectorial levels. Following relevant theoretical and empirical literature, this study adopts a number of indirect approaches that are proposed to examine market power and price rigidity arising from such different mechanisms.

In particular, the main aim is to conduct a thorough empirical investigation in order to provide answers about the market structure and the degree of price rigidity in the Greek manufacturing sectors. The first part is centered on the nature of competition that emerges between and within the sectors of the Greek manufacturing industry. By estimating the production effect of the 3-digit manufacturing sectors to the production of the whole industry, the market structure of each sector can be identified by utilizing the conjectural variation methodology. The greater that effect, the closer the sector will be considered to be to monopoly because production will be low relatively to a perfectly competitive firm. For instance, if price demand elasticity of a sector is quite inelastic, then the firms of that sector will have the opportunity to charge a higher price than they could charge under perfect competition. This happens because the level of production is lower than it should be under perfect competition.

The second part concerns the estimation of the degree of nominal price rigidity in the manufacturing sectors of the Greek economy. If such rigidity is significant, then it is important to identify whether it depends on exogenous and/or endogenous market factors. Exogenous factors refer to those that are normally beyond the managerial control in the firm's pricing decisions, like taxes imposed by governments, costly price adjustment, revaluation in input prices, high entry costs for new firms, restricted funding by institutions etc.

On the other hand, endogenous effects comprise of every factor that firms and sectors are able to manipulate, such as their behavior towards expected future demand, formation of cartels or trusts, pricing below their marginal cost for a limited time, in order to force their competitors to exit their sector etc. Based on the theoretical and the empirical literature of imperfect competition and price rigidity that will be presented in chapter 2, the main focus will be directed on factors such as input costs, competitive foreign prices and additional taxation. Such elements may be appropriate to describe pricing behaviour due to uncertainty about the future. This behaviour can motivate entrepreneurs to maximize their present expected value in return for any future gains and thus, retrieve part of their losses which occurred due to unexpected circumstances (i.e. recession) or even secure their survival.

Additionally, market power and/or rigid price levels may be a result of greater concentration or of greater size in terms of sales. This means that the greater the level of production and the volume of sales of a single firm or sector, the greater the market power of that particular sector will be (with respect to the level of production of the manufacturing industry). A potential reason of this outcome may address the fact that a greater share of production of a single firm or sector may indicate a greater expected or actual level of demand, which will result in greater concentration. On the other hand, the size of each sector is determined by the value of its sales. The greater the volume of sales, the greater the size and thus, the greater the market power may be since an increase in revenues signals either an increase in demand of such products or an increase in the price level (or both). Therefore, competitive behaviour depends on the capability of firms and sectors to change their production and/or pricing decisions without experiencing a fall in their returns.

The contribution of this study is to examine the relationship between price rigidity and imperfect competition and whether sluggish price levels emerge as a result of imperfect competitive conduct. For this reason, the profitability and leadership effects (Bedrossian and

Moschos, 1988) will be tested in the Greek manufacturing sectors over 1980-2012 by estimating and employing the measures of conjectural variation and speed of price adjustment (see chapter 4). This is an original contribution to the literature of price rigidity in the Greek manufacturing industry as the last attempt by the aforementioned authors was carried out for the time period over 1963-1977, thus there is no recent analysis. As a result, the aim of this study is to introduce new evidence and results about the competitive conditions and the pricing decisions in the Greek manufacturing industry under the scope of the *NEIO* approach. For this reason, the measures of conjectural variation and speed of price adjustment have been selected as the mainstream tools of carrying out an analysis of this kind.

In addition, a theoretical model of collusive decisions is presented which is an extention of the original model of Green and Porter (1984). This model provides the foundations of how rigid price levels may persist in a particular market through informal price agreements. This model helps with the understanding of how market power and rigid pricing decisions may be related as firms with oligopolistic power may be able to influence the price level in order to obtain more profits. Consequently, the model describes a condition of collusive agreements which is in accordance with the empirical results of the profitability effect.

The structure of the remainder of the dissertation is as follows: chapter 2 includes the evolution of ideas of the literature of imperfect competition and price rigidity; chapter 3 develops an extension of the theoretical model of collusion by Green and Porter (1984) which captures the rationale of imperfect competition; chapter 4 presents the theoretical background for the identification of non-competitive market conditions; chapter 5 analyses the specification process and data variables along with the approach of price adjustment; chapter 6 presents the econometric approaches and tools for the empirical investigation; chapter 7 provides the analysis of the empirical results; chapter 8 gives the summary of the main conclusions and policy implications that can significantly reduce market imperfections in the manufacturing industry.

2. Literature Review

2.1. Introduction

"Industrial organization is as old as economics". This sentence was used by Peltzman (1991: p.201) as an opening in his literature review in The Handbook of Industrial Organization. This phrase can be extended a little bit further by stating that industrial organization is as old as civilization. Many economists and philosophers support the fact that economies cannot exist without markets and markets cannot exist without individual agents. From Aristotle's ancient Greece till Francois Quesnay's physiocrates and from Classical economists like Adam Smith, David Ricardo, Thomas Malthus and Karl Marx till the revolution of Keynesianism and Neoliberalism, markets have played the most crucial role in providing all the necessary conditions under which transactions between two or more parties can materialize. This procedure is the very essence of every market-based activity that is performed within any economy and defines the future evolution of the whole society. The evolution within this domain has taken various meanings through time depending on its structure and efficiency outcomes.

Based on Léon Walras' model (1874) of a pure market exchange economy, an auctioneer is able to extract all the available information about demand and supply for certain goods from the participant agents and come up with a unique relative price equilibrium which equates total demand with total supply. The most prominent features of this model, which can be characterized as a "benchmark" for the theory of price rigidities, laid the very foundation of the theory of free markets and how individuals interact according to market signals. Specifically, a multiple agent equilibrium is formed, after the auctioneer has extracted the clearing price of every commodity that equates supply with demand of the public. The simplicity of this assumption lies with the fact that any interactions between participants are absent, so is any externalities that could affect the decisions of another agent.

When this process is completed, a set of equilibrium relative prices is determined that eliminates any imbalances between demand and supply. If a change in either variable for a certain commodity is observed, then the price level of that commodity will change as well, by indicating completely flexible prices upon output decisions. Such effect occurs for any commodity produced by resulting to the fact that if every market is under the concept of

Walras' equilibrium, then the whole economy will be under General Equilibrium. This fact shows the interrelation between the set of markets that constitute the economy, as well as the flexibility describing all decision variables, including relative prices. Such variables depend only on the forces of demand and supply by ignoring any other effect that can originate from both within and outside the sphere of the market economy.

Even before Léon Walras, Adam Smith provided a theory in The Wealth of Nations (1776) where in every market, the principals of perfect competition and the maximizing profit behaviour of entrepreneurs will be able to extract the equilibrium price for goods based on the implication of the invisible hand, which is the forefather of the auctioneer concept. The hidden axiom of these theories and especially of the neoclassical theory lies on the absolute trust in the forces of markets between interacting private participants. Given that individual agents are rational, they have no need for intervention, unless there is any exogenous or endogenous shock that may cause equilibrium divergence.

This factor is the most crucial for arguments in favor of any notion of equilibrium, either partial or general. The effects of monopoly or collusion between any number of firms can easily destabilize a perfectly competitive economy due to price deviation from the optimal level. The first significant contribution in this field of market theory was made by Antoine Augustine Cournot (1838) in the 19th century. By observing the competitive behaviour in a spring water duopoly, he developed a model which has inspired most of the contemporary analytical frameworks in imperfect competition and oligopoly theory. This model provided the motivation to Walras to present a clear notion of General Equilibrium, rather than the definition of the Partial Equilibrium that was presented by Cournot.

The main point of this review is focused exactly on the very outcome that Cournot provided through his model; even if competition takes place between firms, the equilibrium state the theory of perfect competition suggests may not be the one that the interacting firms will choose to compete under. Specifically, they will choose an equilibrium point where the output produced (since it is the only decision variable) is less than the one suggested by perfect competition by leading to positive profit rates along with a relative price level that remains rigid according to the behaviour and strategic interactions between competitors. Unless there is a change in decision variables, the nominal price level of each firm will remain the same for some time. This feature leads to the following review by examining the ways and mechanisms through which such rigidities in the nominal price level arise.

Despite the great significance of such market structure, the initial contribution in this part of theory had not taken place until the 1930's. The two great figures behind this revolution were Edward Chamberlin and Joan Robinson. In particular, they provided a theory of monopolistic and imperfect competition respectively, by rejecting the "utopian" state described by the theory of perfect competition. Their books "The Theory of Monopolistic Competition" (1933) and "The Economics of Imperfect Competition" (1933) are considered to be the major benchmarks in the field of imperfect competition due to the fact that many contemporary mainstream models have been constructed on the basis of the underlying reasoning. For instance, the "Structure-Conduct-Performance" paradigm provided by this theory has been used by many industrial economists in their empirical models in order to test specific theory implications upon markets and interacting firms, like the degree of industrial concentration or the degree of price markups.

Following the resulting theory of imperfect competition, many economists like Means (1935a) and Stigler (1964) have presented new assumptions and implications within this area of study[3]. They provided the necessary tools with which economists can test both the behaviour of real markets and the degree of consistency between their theoretical and empirical results. Such papers have focused their interest on the two significant issues that describe the very core of this review; oligopolistic behaviour and its resulting effect upon the flexibility of firms' relative prices. This means that according to the degree of such behaviour and the deviation from the competitive price level, pricing decisions may attain characteristics similar to the ones of a monopolistic pricing firm, by resulting in a higher and more rigid price setting.

These concepts have a significant impact on the literature of oligopoly theory especially after the 1970's where the most important contributions had taken place mostly by the New Keynesian School of Thought (Rotemberg, 1987). Dixit and Stiglitz (1977) have extended Chamberlin's theory of monopolistic competition by focusing their interest on the scales of economy and product diversity, while Barro (1972) has presented a monopolistic model by giving emphasis to price variations. Following these papers, the initial New Keynesian contribution was made by Rotemberg (1982a, 1982b) who developed the notion of menu costs within oligopolistic markets which was found to be consistent in real world economies, especially in the United States. Subsequently, there were many extensions of this

[3] Also see Stigler and Khindhal (1971).

theoretical stream and especially of the rigid price adjustment theory that was used in order to provide estimable and consistent results about the price level across industries.

According to such theories, many industrial organization and econometrical methods were developed, like the *NEIO* (New Empirical Industrial Organization) methodology that includes the conjectural variation approach developed by Iwata (1974), as well as the conduct parameter and the weighted profits approach presented by Bresnahan (1982, 1989, 1991)[4]. This methodology is focused on the estimable results along with their derivation from demand and cost functions by obtaining micro level and using 3 or even 4 digit SIC data. In addition, many algorithms have been developed as well, like the one described in Ericson and Pakes (1995), where they construct a Markov-Perfect industry dynamic model by using a number of specific assumptions. In addition, an extension of this paper provided by Bajari, Benkard and Levin (2007) uses a more developed algorithm that estimates dynamic models of imperfect competition under which oligopolistic pricing decisions emerge as a result of market power acquisition.

So far, all the theoretical and empirical methods in the literature of imperfect competition have acquired a high level of attention from many schools of economic thought, despite opposing arguments about the validity of assumptions. The most important outcome is based on the fact that such theories, from the initial contribution of Chamberlin-Robinson till the New Keynesian rigid price adjustment concept, have contributed to the set of knowledge surrounding this theoretical field by analyzing the facts that occur within real world markets. Such theories can definitely motivate the economists of the new generation to imply or to extend their content to industries and individual firms in order to identify the malfunctions and any failure that occur under the veil of markets.

[4] See Kadiyali et al. (2001).

2.2. The early contribution in the theory of imperfect competition

2.2.1. Edward Chamberlin and Joan Robinson's theory

As described above, the Chamberlin-Robinson contribution was the turning point in the market theory that had been dominated by the perfect competition ideology. A great amount of doubtful thoughts were brought to surface regarding the theoretical implications on markets, especially during the Great Depression after 1929. They both intuitively predicted the flaws of the structure of perfect competition and tried to provide a realistic interpretation of real world phenomena in markets around the globe under the impact of a financially and socially destructive recession.

Edward Chamberlin published his book "The Theory of Monopolistic Competition" in 1933 by structuring his model on the neoclassical assumptions of perfect competition and monopoly theory. In particular, he changes the assumption under which every market is characterized by either perfectly competitive or monopolistic behaviour. He assumes an overall market which consists of a small number of markets and identified by an imperfect competitive structure. By also assuming that each market is characterized by a seller's monopoly which is imperfectly isolated from the others, he studies the whole interaction between these institutions under the scope of a *genus* market (which has the leading role in this model) and the assumption of two demand curves (one in the genus market and one in the remaining which is called *species* demand curve). The latter demand curve varies according to price changes in the species of these markets, while the genus demand curve represents any fluctuations in the purchase of a single product when the price of the rest in that market may vary with the price of the leading species. The nature of the two demand functions is the crucial assumption that differentiates his theory from the perfect competition or the absolute monopoly theory; perfect competition is a limiting case where the species demand curve is horizontal and absolute monopoly is the other extreme where the two curves coincide by leading to a single level of quantity.

By following this structure, Chamberlin argued that firms will reach a cooperative solution, the "joint maximization" solution, where total profits are maximized and consistency with the Pareto optimal solution exists. Despite the fact that this solution is not Nash equilibrium due to high incentives of deviation (cheating) from this collusion, Chamberlin supports that such actions will not occur because they are "foreseen to be ultimately self-defeating". The main flaw of this outcome, as it has been argued by many game theorists like Fisher (1989), was that Chamberlin thought of the market structure as a Stag hunt game, where firms try to reach the joint maximizing solution. Instead, the game is a prisoner's dilemma game where firms have to find a coordinative solution which is not the one suggested by this model.

Regardless the outcome of this theory, one thing is for certain; Chamberlin formed a new stream of ideas that future economists would be called to expand and imply on real world economies. His intuitive assumptions and theory implications were very important for economic theory in general because he conducted the first market experiment and the first economic experiment of any kind by showing how prices cannot necessarily reach the equilibrium level of perfect competition.

The intersection that Chamberlin used between the theory of perfect competition and his own theory can initially be understood by showing that the equilibrium price is no longer a Walrasian-Smithsonian concept. It may be spontaneously defined by the forces of demand and supply alone, but it is also dependent on the outcome of a set of production decisions along with strategic interactions. In addition, the extent of nominal price rigidity lies on the monopolist's expectations about the reaction of his pricing decision by other monopolistic competitors. Nevertheless, it should be mentioned that the author focused his interest on identifying why a cooperative solution will occur as an optimal decision between firms, opposing any action that may result in a defection from this solution as the conception of Nash Equilibrium suggests.

An interesting, but rather insufficient explanation could be based on the term of product differentiation that can be used as a strategic variable by firms in order to render their products more competitive, even under perfect competition. This means that the differentiation of a product can be interpreted as a strategic decision for acquiring greater market share, which can also result in a rigid relative price level as long as the quality of that product satisfies the needs of consumers. Nevertheless, this fact cannot capture any interactions that emerge among firms regarding their pricing behaviour and the externalities they are called to face from such decisions. A potential explanation could be that such externalities result in non-cooperative interactions which may trigger an all-out "price war", but such analysis is neglected by this particular model.

The second great contributor to this theoretical field of economics is Joan Robinson. Her book "The Economics of Imperfect Competition" was published in 1933 as well by providing an alternative pattern of competition; the imperfect competition. This book was heavily criticized during its publication by many economists due to the definition of the word imperfect.

In particular, Chamberlin himself stated that "Imperfect Competition followed the tradition of competitive theory, not only in identifying a 'commodity' (albeit elastically defined) with an 'industry', but in expressly assuming such a 'commodity' to be homogeneous. Such a theory involves no break whatsoever with competitive tradition. The very terminology of 'imperfect competition' is heavy with implications that the objective is to move towards perfection" (1950: p.87). The opposition essence behind this argument is that Joan Robinson (as John Maynard Keynes) provided an extension of the Marshallian tradition, so there was no intension in providing a breakthrough in the theory of competitive value as many economists expected.

One of the most important aspects of this book is the utilization of the relationship between average and marginal curves. By adopting Cournot's notion of marginal revenue, Robinson incorporated the whole reasoning behind the equilibrium of a group, as it was presented in Sraffa's essay (1926). By co-working with Richard Khan, she used more complicated assumptions, like the variability in the number of firms, in contrast with Sraffa's fixed number. So, the main problem in this analysis was the very nature of the demand curve. By using Marshall's notion of monopoly, where a single firm controls the whole industry, Robinson tried to face the problems posed by the interdependency between firms and provide a reasonable analysis of this market structure.

In particular, she wished to create a structure under which a "logically coherent marginalist theory of the firm" will be reached, by rejecting the neoclassical view, where the forces of free markets lead to an outcome in which unsatisfied customers' needs can coexist along with firms' excess capacity. This argument is based on the nature of the cost curves that every firm has to face; the average, marginal and total cost curves. For instance, under perfect competition, a single firm can sell all the desirable amount of products without influencing the aggregate price level because an increase in production will be followed by an increase in its total cost function.

Nevertheless, if demand for a single product is falling (shift of demand curve to the left), then marginal revenue will fall as well. This indicates a spontaneous initial move on the relative curve and a backward move of that curve afterwards, as demand falls, which means that beyond a certain threshold, sales will result in negative marginal revenues (diminishing marginal revenue curve). Therefore, under perfect competition firms will have no incentives in increasing their supply beyond a certain level of production due to a decrease in the level of their profits and thus, sustaining a rigid nominal price level for the desirable volume of production.

Given this state of market, the next question imposed refers to the existence of positive profits in equilibrium due to a small number of entrepreneurs. Robinson argued that competitive equilibrium profits are related with the "marginal productivity of the entrepreneurial ability for the industry". This argument holds because the rate of remuneration of a factor is proportional to its marginal productivity, which in turn cannot be satisfied by the entrepreneurial ability when marginal productivity refers to the firm level. This means that if this factor is supposed to be a variable input, then profits can never be equal to the marginal contribution of entrepreneurial ability.

The only way to fix this inequality is to assume the two following conditions; to treat the latter meaning as a fixed productive factor and to shift the analysis attention from the firm to the industrial/sectorial level. In this case, aggregate output will be related to the number of firms within the industry. This means that for a given level of inputs, the marginal productivity of a firm will be defined by the output increase and thus, marginal gains will be equal to the marginal productivity of the industry which it belongs to.

It is clear that Joan Robinson by preserving the main neoclassical assumptions of the market structure and by forming extra assumptions about certain measures that coexist with this theoretical domain, presented a different outcome than the one described by neoclassical theory. Also, by extending the scheme of perfect competition to other states, she proved that distortions in the aggregate industry can result in deviation from the optimal solution and thus, to a sub-optimal social welfare outcome.

Both Edward Chamberlin and Joan Robinson at that time provided a different approach of the existing literature of competition based on the assumptions of neoclassical theory and formed their results about different market structures. Despite Chamberlin's continuation of using the neoclassical pattern as his main tool, Joan Robinson made a shift to the Post-Keynesian school of thought. Specifically, in 1953, Robinson published a paper called "Imperfect Competition Revisited", where she provided a Post-Keynesian critique of her earlier book. She stated that "The assumptions which were adequate (or which I hoped were adequate) for dealing with such questions are by no means a suitable basis for an analysis of the problems of prices, production and distribution which present themselves in reality" (1953: p. 579).

On the other hand, Chamberlin accomplished to provide an early stage of collusion between firms by indicating a form of nominal price rigidity that could also lead to price rigidity for the whole industry. This argument is based on the fact that firms will always prefer to sustain an agreement where they maximize their profits. By adopting such behaviour, any inefficient levels of competition that result in a lower level of profits in the long-run are not taken into consideration. Either way and regardless the theoretical background that the authors used, these books have been and will be the major landmarks in the field of imperfect competition by providing the basic foundation for the evolution of future work with application to both theory and real world economies.

2.2.2. The Administered Price Thesis and the Development of Oligopoly Theory

Two years later in 1935, a controversial theory that could be considered as a complement to the revolution of 1933 is presented by Gardiner Means. This theory comes by the name of "Administered Price Thesis" and argues in favor of a positive relationship between the infrequency of price changes, according to changes in the market clearing price, and industrial concentration. Means (1935a, 1935b, 1939) challenged the perfect competition assumption about price flexibility and proved that market power allows firms to circumvent the normal workings of markets and control the variation of prices which tend to change less in administered markets.

Means tested 747 Bureau of Labour Statistics wholesale price series from 1926 to 1933 and found that approximately 50 percent of his sample changed price at the rate of less than once every four months, 25 percent changed less than once every ten months and 13 percent changed less than once every eight years. Such findings proved to be a very important challenge to mainstream economics and especially to the economics of perfect competition due to his evidence that firms with market power are more "upward aggressive" than competitive firms. This fact resulted in the validity of the price rigidity assumption in markets with oligopolistic or monopolistic power.

Means also believed that the frequency of price changes was positively correlated with their amplitude due to evidence that over 1929-1932, there was a greater decrease in the average value of more frequently changing prices but only a smaller decrease (or no decrease at all) in the average value of less frequently changing prices. Therefore, given these facts, he concluded that the administered price concept resulted from the relative small number of concerns that dominate particular markets.

Following the 1950's, Means (1959, 1975, 1983) observed an additional interesting fact about price behaviour; administered prices had risen sluggishly during booms but they continued to rise even in recessions. The rate of inflation caused from such behaviour drew the attention of policy makers during the 1970's and his theory was revised as the "Administered-Inflation Thesis". But even Means himself did not provide any theoretical interpretation about how some firms with market power are able to ignore market conditions in order to administer their prices. In addition, there was also inadequate evidence of an empirical explanation of how the prices administered by such firms are related to inflation.

Following the publication of the previous literature in the theory of oligopoly, the third important aspect that complements this chain of evolution is considered to be Stigler's paper "A Theory of Oligopoly" (1964). In this paper, a different approach compared to the classical ones of Cournot or Stackelberg is presented under which oligopolists have to form collusion in order to avoid any unnecessary conflicts that will have a negative impact on their profits. This reasoning is based on Chamberlin's theory of equilibrium solution were firms have to cooperate in order to maximize their total profits. But the main attribute of Stigler's model is the fact that he takes into account the case that Chamberlin rejected; collusion cannot be sustained for too long because it is not a stable Nash equilibrium and thus, there will be incentives for defection under certain circumstances. Therefore, in order for such actions to be avoided there must be an endogenously determined "self-policing" way that will maintain the agreement signed by the participating firms of the collusion.

The main market characteristics assumed in this model are product homogeneity, in order for the substitution axiom between goods to be valid, and heterogeneity among buyers while the industry structure is immune to entry. Given these assumptions, Stigler focused his interest on what he identified as "secret price cutting" instead of testing the degree of industrial concentration, as the administered price theory suggested. The action of secret price cutting is motivated by specific fluctuations in markets, such as an unexpected increase in demanded quantity. It gives the incentives to firms to break the collusive contract and charge a lower price level in order to attract a higher portion of consumers and thus, attain more profits. In order for such behaviour to be avoided, Stigler considered the collusion as a "Leviathan" (following the notion given by Thomas Hobbes) whose work is to protect the interacting members from exogenous shocks and impose penalties to anyone who would try to deviate from their contract.

To this end, this is a more realistic application of Chamberlin's theory where strategic pricing decisions are dependent on detailed market conditions specification, like the fact that the number of sellers is very small while the number of heterogeneous buyers is quite large. Also, unsustainable equilibrium can be attained under some restrictions imposed by the collusion by avoiding infinite reversionary episodes, like a Cournot competition, which will result in less discounted profits compared to the ones that can be attained under the collusion. The fact that sets such conditions credible (that can be characterized as "threats") regards the market power that every firm possess; the higher that power is, the more endurable a firm will be by entering a state of competition as a form of punishment for the ones who have defected from collusion. These restrictions can transform this solution into a sustainable equilibrium by changing the payoffs of every player and provide them an efficient outcome compared to the one acquired by the non-cooperative solution.

The empirical results of the manufacturing industries of the United States and Canada show that the higher the degree of industrial concentration, the higher the frequency of price reductions (Stigler, 1964). This means that either there is no sufficient motivation for collusion in real world markets or participants are not willing to maintain their agreement under positive demand fluctuations. The implication behind that intuition is that nominal price rigidity can be manipulated by the market structure along with any strategic interaction formed by competitors, as well as by any external shocks that can affect the demand curve for the industrial products. In addition, the form of such collusions can sustain the price level to a certain path for a long time, depending on the behaviour of firms. Such action enhances the price rigidity assumption in the interacting industry under any form of competition. Even in Adam Smith's markets, if firms have the incentives to strike an agreement and form collusion, then the invisible hand will fail to do its work and aggregate surplus (especially consumer's surplus) will be reduced by causing inefficiency to the whole society.

Given Stigler's reasoning about collusion and how prices can be rigid through informal agreements, such behaviour can be strengthened under specific circumstances, when a small number of firms get a large portion out of a product's demand. For instance, during recessions many firms find themselves difficult to operate and thus exit their market, by allowing the remaining firms to serve their portion of consumers. As a result, aggregate demand will decline (due to a decrease in aggregate income) and the remaining firms will get a greater market share depending on the elasticity of their products (Keynes, 1936).

In addition, Cagan (1974) studied the recession behaviour of wholesale prices since World War II and compared them to the 1920s as the most recent period of earlier recession. He found that prices failed to fall according to aggregate income over the recessions of 1954, 1958 and 1961. This fact occurred due to the presence of downward nominal price rigidity along with the tendency of producers to administer their prices with less regard in short-term changes of demand. An explanation provided by Cagan was that the growth rate of firms' market power after World War II allowed them to set rigid prices in conjunction with labour unions that dictated wages. Another explanation is based on future expectations about price setting. Specifically, he argued that "The Employment Act" of 1946 which enforced governments to pursue full employment policies was followed by high inflation periods and thus, an upward pricing trend by presuming that any deflationary pressure would be very brief. A significant factor of this trend was the "sporadic bursts" of demand-pull inflation which caused the failure of prices to undergo any fall during the recession.

In 1970, the aggregate price level kept on increasing due to expectations about future inflation. This happened because a highly anticipated rate makes the actual one to rise and if quantity demanded declines by a slow and steady rate, prices will continue to rise. For this reason, prices that respond to recessions have to be measured by the rates of change relative to the anticipated rates. This shows that expectations formulate a very important element in such theory due to the power of psychology and behaviour about fluctuations. If people expect that the price level will rise in the future, then it will definitely rise, since their actions will lead to a similar outcome (self-fulfilling prophesy). The essence of this mechanism is based on the economic agents' rational concern of the decision variables that must be protected through the inflation-indexation process of the corresponding nominal variables.

According to these theoretical implications, Cagan's empirical evidence support that changes in the composition of aggregate indexes, such as production and price indexes, have indeed affected their cyclical behaviour. This happened due to a decline of the average rate of inflation over recession periods since the 1920s. Their distributions provide a high rate of variability, compared to the ones of the 1920s, with little change during the last four recessions. Therefore, the slowdown of the price change rate had taken place due to the reduction of the frequency of price response to excess capacity along with the increase in the expected speed of price adjustment. The rate of inflation at the end of 1969 remained persistent for the two following years and the expected adjustment of anticipated prices was faster as a result of the high post-war inflation level. The main result from such evidence is that changes in pricing behaviour appear to take some time and remain rigid for a few years, while elasticity of price to aggregate shocks appears to have moderate accumulations across industries.

Carlton (1978) following the reasoning of price rigidities based on the entrepreneurial behaviour indicated by Stigler, studied price inflexibility, timing consideration and demand uncertainty as a result of market interactions between firms. He argued that prices cannot instantly adjust after a change in demand preferences or expectations about future consumption. This happens because they are endogenously determined by market forces and their magnitude, followed by time of realization of these changes that will shape the time adjustment of the price level. Uncertainty about demand lies on the assumption that entrepreneurs cannot observe the demand function after they have set their prices. This means that they have to rely on expectations by taking into account past information, current and future conditions that can shape the economy (i.e. fluctuations of consumer income). Lastly, time consideration includes all the necessary equipment and resources needed in order for production to occur in every time period.

Given these considerations, Carlton constructed a model in which the capacity of firms producing a single good is presented, along with the inability of some consumers to purchase that good. As a result, there will be excess capacity by a number of those firms that failed to sell their whole stock (due to fluctuations in demand). Each good is characterized by its price and probability of purchase. Under these assumptions, if social welfare is measured by expected surplus, then competitive equilibrium will be the optimal one, by excluding any implications under demand uncertainty.

One year later, Carlton (1979) published an extension of this paper by adding the feature of contracts and transaction costs between interacting firms or agents. He argued that uncertainty and transaction costs motivate firms to use both long-term and short-term fixed price contracts due to the difference in their move and their magnitude. Contracts can secure and provide information about future demand by eliminating uncertainty and search costs of future production. By using a simple equilibrium model, he shows that firms may use delivery lags as a reallocation mechanism for goods in order to ensure their efficient allocation that would result if signing new contracts was not too costly. The results demonstrate that in response to supply shocks, both short-term and long-term contract prices will move in the same direction by a different magnitude, while in response to demand shocks, both of them will move in a different direction.

The final part of this theory was completed in his paper “The rigidity of prices” (Carlton, 1986) where he found consistent evidence with the administered price thesis. Aggregate price indices may be an inaccurate measure to test for price rigidity in concentrated industries due to the lack of information about individual actions that reflect transaction prices. By using the Stigler-Kindahl data (price data on actual transactions) he found that the degree of price rigidity is significant in many concentrated industries. This indicates that a fixed number of permanent consumers exist, by identifying no need for endogenous price fluctuations.

His third finding concerns the existence of negative correlation between price rigidity and the length of buyer-seller association. If there is not any distrust or incomplete information between each other, the longer the association, the lower the cost of changing prices will be. If the transaction process would take place for a long time, then both parties would be interested in the average price. This happens due to the fact that prices would change less frequently but with higher intensity in rigid than in less rigid contracts. This procedure indicates a positive relationship between price rigidity and average absolute price change because higher rates of rigidity will result in more intense price changes.

The evidence shows that there is not necessarily an asymmetry in price rigidity by indicating that prices are not necessarily rigid downwards as it has been implemented by many other papers (see sections 2.3, 2.4). There are also small fixed costs to some buyers of the sample to change their prices and very weak evidence that the same buyers have systematic preferences across products for unchanging prices.

As a summary of the discussion so far, the main empirical finding concerns the strong correlation between the degree of industrial concentration and rigid prices. The higher the market share within an industry, the longer prices will remain rigid. Carlton (1986) argued that this outcome does not necessarily imply inefficiency because it can result from an unchanged demand and supply curve for a long time period. Depending on the conditions that describe the sampling industries that have been taken into account, the outcome supports that price rigidity depends on the behaviour between buyers and sellers based on how they have formed their transactions (for example through short-term or long-term contracts). Such theories address the concept of price rigidity of individual products in confined markets but it is quite unclear how actual and potential entry and exit decisions can modify such results.

2.3. The Concepts of Imperfect Competition, Pricing Behaviour and the Menu Cost Approach under the Scope of Macroeconomics.

2.3.1. The Monopolistic/Oligopolistic Competition and Price Adjustment theory after the 1970's.

Following the major contributions in price rigidity theory, there have been many approaches that tried to capture the very nature of such behaviour in many markets. The initial contribution was made by Barro (1972) who presented a theory of price adjustment under monopolistic market conditions in order to observe the impact of consumers' actions upon this procedure. He constructed a model where there is one monopolistic seller (price setter) and many perfectly competitive buyers (price takers). Its main feature incorporates the variations in prices due to administrative and implicit costs that are generated only by markets and not by individuals' actions. This means that optimal price adjustment depends on specific institutional characteristics under which trading occurs, such as the nature of contracts. An additional factor concerns the determination with which market participants declare the desirable prices in the absence of any marketeer which is similar to the Walrasian auctioneer.

Given these assumptions, the market price level adjusts to a disequilibrium level due to the monopolist's pricing behaviour where he equates marginal revenue to marginal cost in order to maximize his profits. An inelastic demand curve emerges if the firm is ever to change its price which is quite a reasonable outcome. It occurs because monopolistic firms may lose their customers either due to new entry of competitors in the operating sector or due to a decline in the demand curve of their goods.

According to this specific market structure, Barro provides the effects and interactions between price changes and demand behaviour that result from the actions of the monopolist. If price fluctuations occur within the market, then the optimal solution between average price change and excess demand (that will maximize the profits of monopoly under the assumption of costly price adjustment) can play a crucial role in such decision making. This happens due to the magnitude of excess demand which can result in a slightly price increase (or no price increase at all) that will both satisfy the maximization conditions of the firm and consumer preferences about the desired demanded quantity.

The next step of a monopolistic competitive market state is developed by Dixit and Stiglitz (1977) by investigating the mechanisms through which scales of economy can affect social output. The central procedure refers to the level of production of any commodity that takes place only if operating costs can be covered by the sum of revenues along with an efficiently defined measure of consumer surplus. If this assumption holds, then the optimal solution of the scales of economy's effect on production is determined whenever demand price is equivalent to marginal cost (this effect is realized only under perfect pricing discrimination). However, this condition cannot be sustained either by a competitive market, given that the marginal condition would result in negative overall profits, or by a monopolistic firm due to the maximization mechanism. Therefore, the only way to find a credible solution is to address the issue as one of quantity versus diversity, by differentiating between a good substitutability among commodities and a bad one within a particular industry.

Under this line of reasoning, another interesting implication of the monopolistic competition theory would concern its relationship and impact on aggregate demand upon economic activity (Blanchard and Kiyotaki, 1987). Based on a general equilibrium model where monopolistic competition prevails in both good and labour markets, inefficiency in such market structure is associated with aggregate demand externalities. This means that monopolistic competition generates effects of aggregate demand that cannot be captured by perfect competition. The emergence of such costs that firms face may be an important factor based on consumer preferences about the price level of products (an accurate description of these costs is provided in the following section).

The last finding of this research shows that a more accurate account of the response of the economy to aggregate demand shocks can be taken into consideration if prices and wages are unaffected by changes in nominal money. In addition, monopolistic competition is assumed to allow for fixed costs in output, productivity and entries by new firms which are included in the firm's objective function. The equilibrium level provided by this structure is characterized by "a relationship between real money balances and aggregate demand, a pair of demand functions for goods and labour and by a pair of price and wage rules" (Blanchard and Kiyotaki, 1987: p. 650). An interesting observation that can be made is that Dixit and Stiglitz (1977) turned their interest on the effects of scales of economy; while Blanchard and Kiyotaki (1987) focused on real economy effects, by choosing to standardize the effect of new entry in markets or consider it as an exogenous variable.

In contrast, Encaoua and Jaquemin (1980) took into account the possibility of entry as an endogenous variable in oligopolies by studying both a static and a dynamic model under the threat of entry and cooperation between firms. They emphasized on the extent to which the main measures of industrial concentration can be related to the ones of the aggregate degree of monopoly. As a result, they made a distinction between a list of properties that a measure of concentration must satisfy based on the number of firms (Encaoua and Jaquemin, 1980: p. 89).

On the other hand, as Hannan and Kay (1977) proposed, if many small firms enter the industry but acquire a very low market share, then industrial concentration will not be affected; however, the degree of inequality in the size of the firms will greatly increase. Given this observation, the second set of properties, based on a variable number of firms declares that the measure of concentration must not decrease if a merge between two or more firms is to take place. Also, if the size of the two industries is equal, then this measure must remain the same even if the number of firms is increased.

According to these arguments, concentration indices are not able to provide a sufficient interpretation of monopolistic power by themselves but instead, many other characteristics have to be taken into consideration. They refer to the threat of entry, the reasons related to the adjustment speed of prices, entrepreneurial behaviour and future uncertainty that can formulate a better approach in defining the degree of monopolistic power. Additionally, product differentiation and market segmentation can also be considered as influential factors determining the degree of market power.

As an empirical validation of the aforementioned models, Dixon (1983) focused his interest on identifying the relationship between the speed of price adjustment and industrial concentration. An econometric model was estimated where the effect of the lag coefficient of production and other variables, such as industrial concentration, is tested on the speed of price adjustment. Dixon found evidence that support the interrelation between the length of production lag and the lag between changes in unit costs with the dependent variable of price adjustment. Secondly, he contradicted Stigler's hypothesis about the relationship between secret price cutting and the number of operating firms within an industry. Such actions can affect the rate of inflation only if they occur in an aggregate level. Therefore, attention has to be given to the characteristics of the production process along with the industrial structure. He also argued that there is a potential destabilization of macroeconomic policies that try to maintain the level of inflation to a certain low level.

Instead of focusing on the characteristics that define monopolistic power as mentioned above, Green and Porter (1984) developed a direct expansion of Stigler's original paper by reintroducing the assumption of imperfect information. They presented a model where price cutting is a rational choice for firms under specific circumstances without defecting from their contracting agreement. In particular, they argued that under demand uncertainty, optimal incentive equilibrium may involve "episodic recourse" to a short-term unprofitable solution, like a "price war". However, in such state, it cannot be clearly defined if the explanatory outcome is the same with the one under perfect information.

In spite of demand uncertainty, they made four fundamental assumptions in their model; industry stability holds in order for the rational expectations axiom to be valid, the only endogenous variable that firms can determine is the quantity of output so that there is no asymmetric incentives under collusion, information about the industry and environment is publicly known and lastly, the monitoring information that firms use in order to see the collusion's behaviour is imperfectly correlated with firms' conduct.

Under these assumptions, Green and Porter showed that collusive conduct might be characterized by repeated episodes that may result in price and profit decreases. This result leaves no place for the view of an industry in which firms are acting on abortive attempts to form collusion. Therefore, if any collusion is formed under demand uncertainty, then no firm will ever defect due to the lack of information that will allow a cost-benefit analysis of expected future returns.

Nevertheless, when low prices are observed, this signals an increase in quantity demanded for a particular product by rendering the participation in reversionary episodes for every firm a rational choice. The final observations from these results indicate that price instability will be intense between normal and reversionary periods due to the stable pattern of prices when firms have decided to collude.

The next step of this analysis is provided by Maskin and Tirole (1988a), where they overlook the micro-level of the collusion analysis and concentrate on the contestability, the nature of kinked demand curve and any short-run commitment that affect firm behaviour. They use a class of infinite horizon sequential duopoly games in which firms maximize their discounted sum of single period profits. At first, a type of exogenous commitment is assumed where firms can make their move once every three periods because of short-term contracts. Firms compete only in quantities; however, fixed costs are very high to enable any single firm from making profits.

Under these assumptions, a unique symmetric Markov Perfect Equilibrium exists where only one firm produces and operates according to the monopolistic level in order to prevent any entry (this is a specific type of monopoly; natural monopoly). As the discount factor tends to unity, future profits become increasingly important and natural monopoly output tends to be equal to competitive output (Baumol, Pazar and Willig (1982)). Maskin and Tirole (1988b) in their companion paper provided findings arguing that when price competition is taking place under undifferentiated commodities, then equilibrium under a kinked demand curve along with the Edgeworth cycle determine the natural equilibrium of this model.

2.3.2 The New Keynesian Contribution in Oligopoly Theory and the Menu Cost Approach

Rotemberg (1982a) developed his model according to Barro's work (1972) of monopolistic price adjustment and its effects on aggregate output. He argued that nominal shocks have persistent effects on output fluctuations, such as an expansionary monetary policy through liquidity increase. The producers of this model produce differentiated goods and have full information about present prices charged by their suppliers. In addition, they are aware of the aggregate price level and nominal monetary imbalances under which they are called to set nominal prices after their demand and cost functions are observed.

The final assumption regards the cost of resources in order for price changes to occur due to fluctuations in consumers' preferences. If a monopolist raises the price of his product, then his consumers might reduce their purchases or even stop consuming this product i.e. due to an unsustainable loss of consumer surplus or other psychological factors that may affect their behaviour. This effect is known as the *menu cost* approach which forms a type of rigidity that represents a crucial factor for correlated responses in output to uncorrelated nominal shocks.

The key point of this approach concerns the costs that firms face when they are called to change their prices due to the reaction of their customers, as was mentioned in section 2.1. If a price change is unpleasant for a portion of customers (i.e. price increase), then they will search for the desired product sold by another firm in the desirable price level. This means that whether or not a firm decides to change its price depends on the weighing up of costs that it will face in its purchased quantity along with the benefits of this price change. As a result, it will enjoy a lower portion of sales for a higher price. If the latter outcome is preferable to the former, then the firm will have the incentives to change the relative price. Otherwise, a menu cost will emerge that will provide the incentives to the firm to cut the price level in order to avoid any unpleasant loss of customers.

Given these assumptions, monopolists set their prices optimally by taking into consideration the imposed costs in changing them. The model developed results in a rational expectation equilibrium which is a stochastic process for both price and output level, while it is affected by shocks to the level of monetary balances. When money supply follows a random walk path, then output will be serially correlated due to a constant expected rate of monetary expansion. According to these implications, the author argued that in times where prices are relatively high, workers may misperceive their current return to working to be higher than usual. This means that by working more hours for lower long run real wages, an increase in output will occur. As a result, the intensity of this behaviour can explain actual business cycles according to output fluctuations.

To support the theory of costly price adjustment, Rotemberg (1982b) implied the previous model (with slightly changes) to the United States manufacturing industry by using a data set over 1948-1979. In this case, firms with market power face quadratic price adjustment costs, while a separation between the farming and non-farming sectors is made regarding the assumption of price setting. The estimates obtained by the empirical model are consistent with the menu cost concept for the United States because prices appear to be quite sticky. In order to ensure the robustness of these results, Rotemberg compared the estimated equations with less restricted ones to ascertain whether the US data reject the model, even under general specifications. He found that the equations reflecting money and price balances are not rejected, in contrast to the output equation which neglects the effect of relative prices on aggregate output.

These papers are considered to be of great significance to the literature of price rigidity and are considered as a benchmark for future work. The next step in the menu cost approach regards the argument that sticky prices can be, on the one hand, privately efficient but on the other hand, socially inefficient. Mankiw (1985) argued that business cycles result from this effect in response to demand shocks. Small menu costs can cause large welfare losses because "the claim that price adjustment costs are small does not rebut the claim that they are central to understanding economic fluctuations" (1985:p. 529).

To support this argument, he constructed a simple static monopolistic model of partial equilibrium. In this model, the monopolist initially sets the price level and changes it afterwards, following the occurrence of a small menu cost effect which does not result in a socially optimal solution. This means that the firm has to incur this cost if it changes the declared nominal price due to fluctuations in aggregate demand. The results provide evidence of asymmetry between demand contractions and expansions, which means that upward price changes are more flexible than downward price changes.

This effect can be explained on the basis of private incentives due to the maximizing profit nature of monopolists; they will increase their price when they get the chance but they won't respond immediately to a shock that necessitates a price reduction. Another implication of this model is that aggregate demand contractions are highly associated with inefficient underproduction, while aggregate demand expansions are not necessarily associated with inefficient overproduction. To this end, the main outcome of this model validates the power of entrepreneurs to affect prices by restricting output (below social optimum equilibrium) whenever they expect a higher portion of their profits.

In Rotemberg (1982a) and Mankiw's (1985) models the market structure is considered to be of monopolistic nature in order to provide a theory of how menu costs can result in a socially suboptimal solution. Nevertheless, Rotemberg and Saloner (1986) replaced this structure with one of oligopolistic nature and focused on its behaviour upon demand fluctuations. They argued that colluding oligopolies behave more competitive during periods of high demand in order to attract the maximum portion available of that demand increase. For this reason, collusions tend to reduce the mark ups of their prices during such periods in order to avoid any defection that could break down their agreement. Such behaviour is proved to have macroeconomic effects because an increase in demand for the products of oligopolies will lead to an increase in competition by causing an efficient raise of output in all sectors.

They constructed a two-sector general equilibrium model; one of oligopolistic and one of competitive behaviour, in which prices are strategic variables and the marginal cost of firms is constant. The findings show that the ensuing reduction in the price of oligopoly can lead the second sector, described by competitive characteristics, to increase its output as well due to the use of oligopoly’s output as input. Also, positive shocks in demand beyond a certain threshold will lower prices monotonically. If firms are capacity constrained during positive demand fluctuations, then they will be unable to deviate so that the oligopoly won’t have to cut prices. The main argument of this paper comes in contrast with the industrial organization folklore (Scherer, 1980). It provides evidence of the cement industry price behaviour (studied by Scherer) that price wars can occur more in times of high demand than in times of recession due to the relationship between business cycles and slow price adjustment. There is also evidence that the cyclical properties of the price-cost margin are consistent with this theory because the ratio of prices to marginal cost tends to be countercyclical in more concentrated industries.

As the authors have argued, the significance of the demand multiplier indicates that an increase in demand will raise aggregate output, which in turn will lead to a further increase of aggregate demand. This mechanism justifies the reason for which the competitive sector will raise its output following an increase of oligopoly’s output. Therefore, an increase in quantity demanded will lower the oligopoly’s price level by leading to an increase in aggregate output and thus, national income. The latter increase will lead to increased demand for other products that will cause a fall in the oligopoly price level and an increase in their production which will further raise aggregate output.

Following the implications of oligopolistic pricing, Rotemberg and Saloner (1987) focused on the oligopolistic part of the aforementioned model. They argued that duopolies change prices more often than monopolies because by treating prices as strategic variables, fluctuations in demand will have a higher impact on duopolists that antagonize each other. This effect will result in a Cournot-based game where firms try to attract the maximum portion of additional demand, as was presented above. By assuming homogenous goods and constant marginal costs, they study a two period model described by an unexpected increase in firms' constant marginal costs of production.

Subject to fluctuations in their costs, it is more costly for each member of a tight oligopoly to maintain its price constant compared to monopoly. However, if fluctuations in demand occur, this argument is reversed due to positive shocks that will motivate the monopolist to raise the price level. When inflationary or deflationary shocks affect both cost and demand functions, the cost effect will be dominant due to a higher impact than the one caused by demand fluctuations, directly imposed on firms' profits. It is also supported that circumstances that would cause a monopolist to change his price will always lead to price changes in oligopolies.

Nevertheless, this outcome has been criticized by Fischer and Konieczny (1995), as it will be discussed in the next section, due to its inconsistency with real world markets. Rotemberg and Saloner have argued that their model is strictly based on a duopolistic market that interacts only for two periods. However, it could also be applied in the case of more firms by generating the same results. This effect holds because perceived demand curves from oligopolists become flatters as the number of competitors is increased by rendering price changes more attractive due to the derived benefits at their expense. Also, "the incentives to change price that firms face in response to exogenous changes in costs and demand, are related to the incentives that firms have to endogenously change costs and demand through innovation" (Rotemberg and Saloner, 1987: p. 925). This means that any change in the firms' demand and/or cost functions will give them the incentives to innovate, in order to fill in the gap between present and expected profits by providing the probability to theoretically sustain the same price level as before.

A different type of price behaviour in a duopoly was introduced by Rotemberg and Saloner (1990) where the two firms have colluded. Information about demand fluctuations is owned only by one firm (leader), while the other one adjusts its price according to the leader's price level (follower). The model assumes differentiated products and asymmetric information in order to provide a price leadership pattern in which such actions emerge. Under this pattern, no overt collusion is required and both firms benefit from responsiveness in demand conditions because prices embody the leader's set of information. This argument holds because even if the leading firm enjoys a higher amount of profits than the following firm, the latter one will be benefited by price rigidity given the fact that the current price set by the leader reflects all the necessary information about consumer demand. This means that the follower has no cost about realizing private information and its only concern lies within the degree of uncertainty about the actual set of information owned by the leader.

This study is developed under a price leadership scheme that can be sustained as a collusive equilibrium in a repeated game with a threat of deviation in presence if any firm decides to cheat. The follower can observe past price and demand levels but can only form expectations about the current ones, while it trades-off the one period benefits of deviating against the future costs of a breakdown in collusion. Under these characteristics, the equilibrium solution suggests that the preference on the price level will differ due to the fact that it is set according to the first firm's cost function, while the second firm will have to adjust to this choice, when a common price is charged. Also, the disparity in profits between the two firms can be reduced if the price level remains rigid for some time, which will give the chance to the latter firm to perform this adjustment more efficiently. A rigid price level will raise the leader's current profits if it exploits the follower to present relative demand fluctuations. However, such action will lower future profits if relative demand conditions are expected to return to normalcy.

The last part of this line of inquiry addresses the effect of aggregate demand shocks on economic activity caused by a change in government purchases and acts as a consequence of imperfect competition. Rotemberg and Woodford (1992) developed and estimated a dynamic general equilibrium model by using data of the United States military purchases due to the consideration of being the most exogenous government purchases. Demand for such products is endogenously determined, as well as the cost of production, and follows a stochastic process, as random shocks occur frequently. In addition, there is close substitutability between military products that result in strategic interactions emergence between firms by competing in quantities, while they are regarded as monopolistic competitors.

By competing over time, in order to reach a stationary equilibrium point, Rotemberg and Woodford argued that collusion is enforced on those firms in order to both avoid any inefficiency caused by Cournot competition and maximize their total profits. Nevertheless, in order for such collusion to be the optimal choice for the interacting firms, a penalty is imposed for any deviation which will lead to zero present discounted value. In order for such behaviour to be prevented, the future gains from collusion must be greater than the present gains of every firm in order to prevent a collusion breakdown. This means that if an increase in future demand is expected, the gains of present deviation will be higher. The tool for avoiding such actions is a smaller price markup (as suggested by Rotemberg and Saloner, 1986) in order for the incentive compatibility constraint to hold by eliminating any behaviour for defection. If such actions take place, then the markup can be considered as countercyclical and prevent any price wars that are about to occur among firms of the same collusion.

Therefore, by concluding the literature of the New Keynesian contribution in imperfect competition, suggestions in favor of a stable equilibrium have been presented, by trying to avoid extreme competitive interactions. Such interactions will result in lower profits and thus, producer surplus reduction, due to the negative effects of defection. Collusion formation is the main tool in obtaining such outcome, while expectations about future demand fluctuations have to be realized as soon as possible. The main reason lies on the fact that the interacting firms must agree to a commonly accepted price level that will be charged for a certain time period; otherwise, if there is no sufficient time to come to such agreement, the possibility of a breakdown will be very high. Consequently, efficiency in private pricing decisions could be associated with sub-optimality in social welfare and aggregate fluctuations in real economic activities because collusive pricing decisions may result in consumer surplus exploitation.

2.4. The Theoretical and Empirical Analysis following the dominant theories

2.4.1. The administered price thesis; consistent evidence and contradictions

A vast literature of both theoretical and empirical papers has been constructed on the basis of the aforementioned theories in order to provide evidence about their validity or rejection in real world markets. The prediction of such theories is not always very clear and may vary across different industries due to the absence of the axioms of homogeneity or ergodicity in reality, as John Maynard Keynes (1936) highlighted. The analysis of the evolution of ideas will start with the administered price thesis and the early contribution of imperfect competition, according to the aspects of Chamberlin-Robinson and the New Keynesian concepts of price rigidity.

The administered price thesis as presented by Gardiner Means (1935) reflects a positive relationship between aggressive pricing behaviour and industrial concentration. Many papers have provided empirical support for this theory (Bain, 1951; Ross Watcher, 1975; Winters, 1981; Bedrossian Moschos, 1988; Ross, 1988; Shaanan Feinberg, 1995), while others have rejected its implications in various industries (Domberger 1979, 1980, 1982, 1983; Aaronovitch and Sawyer 1981; Weiss 1993; Kraft 1995).

To begin with, Bain (1951) estimated a model using data for the United States manufacturing industry over 1936-1940 in order to study the association between the intensity of competition and industrial structure. The main assumptions take into account seller and buyer concentration, as well as the degree of product differentiation to profits and selling costs. He found that the size of profit rates is related with the number of seller concentration in every industry. The higher the degree of concentration, the higher the rate of profits will be. Ross and Watcher (1975) concentrated their work on the argument that firms are characterized by high incentives in maintaining fixed pricing strategies for some time. By focusing on the relationship between market structure and the pricing time problem, the authors identified the presence of fixed planning periods for oligopolistic firms, under the assumption of a pending collusion that has been denied in the beginning. As a consequence of this action, imperfect information will lead to uncertainty that will cause firms to move at discrete times. Therefore, whether there are competitive interactions or any form of collusion within an industry, pricing behaviour will follow the path indicated by the administered price thesis.

On the basis of this paper and the introduction of a price-cost margin relationship, Ross (1988) argued that these margins form the main cause of price rigidities in concentrated industries due to limited intensity of price changes. Specifically, he re-examined the studies of Thorp and Crowder (1941) and Neal (1942) and replaced part of their assumptions and data with consistent hypotheses. Thorp and Crowder collected data on a large sample of narrowly defined census products during the Great Depression. Despite their findings about an insignificant relationship between concentration and price changes, Ross argued that biased estimations are observed in this data set and thus, a larger database is needed in order to get robust results. Neal was the first to employ a cost-adjusted approach in a cross section sample by finding that price changes were closely related to changes in average costs.

Nevertheless, industrial concentration fails to provide an adequate interpretation, when it is statistically significant, by leading to extreme biased estimates in regressing prices on costs. The main result extracted from these models is that prices tend to be cyclical rigid due to short-run strategies adopted by oligopolists in order to resist temporary fluctuations in real demand.

On the other hand, Aaronovitch and Sawyer (1981) by using data for the United Kingdom over 1963-1975, concluded that overall, there is no evidence that industrial concentration affects price flexibility. However, there is limited support for the administered price thesis in two out of five sub-periods of the sample, because price fluctuations were related to the industrial structure. The results of this study indicate that the relationship between price flexibility and concentration is quadratic rather than linear. It reflects a stronger effect along with a turning point in both periods where the relationship is statistically significant and equal to 0.25 (Herfindahl Index). Changes in costs have a limited role because their coefficient is lower than unity but marginally significant, while output changes have no impact on price changes.

These results support that even if the administered price thesis holds for two periods, its effects are barely significant and do not provide a strong relationship between concentration and price fluctuations. Domberger (1979) as well, estimated a dataset of twenty one sectors in the United Kingdom over 1963-1974 and found evidence of positive relationship between industrial concentration and the speed of price adjustment. The main concluding argument of such evidence was that if concentration speeds up price adjustment, then it could contribute to the inflationary problem in the United Kingdom.

Nevertheless, Winters (1981) argued against Domberger due to the consideration of every industry under the assumption of homogeneity, instead of having a division between engineering and non-engineering sectors. Specifically, he contradicted the argument in favour of inflation by supporting that this effect will have an impact only on the distribution of an inflationary shock over time rather than its ultimate effect. Therefore, unless more rapid pass-through generates additional inflationary pressures, Domberger's model cannot provide a sufficient interpretation of long-run inflation. The same linear equation as Domberger was used in that model by adopting the distinction between engineering and non-engineering sectors. Winters found that the mean square error of the latter group is about four times that of the former. This means that the assumption under which higher concentration permits more rapid price adjustment does not hold for the engineering sectors.

In addition, Bedrossian and Moschos (1988) provided evidence of how the "industrial profitability and leadership effect" affect the relationship between the speed of price adjustment and market structure in twenty Greek manufacturing sectors. They focused on the role of distinguishing profits between firm and sectorial level and analyzed the paths through which concentration exerts any influence on the speed of price adjustment. By assuming that the latter concept is related to both industrial concentration and the length of production, they found that both concepts are negatively related due to short-run price rigidities in high concentrated sectors. Such evidence is consistent with the administered price thesis, even when relative firm profitability within a sector and relative profitability among sectors work in different directions.

Subsequently, a dynamic model of competition and price adjustment was developed by Shaanan and Feinberg (1995) by using data from the United States manufacturing sectors over the period 1972-1982. The main goal was to estimate the price effects of entry due to changes in optimal prices or in their speed of adjustment. By formulating an equation where price changes are considered to be the dependent variable, they found that cost and demand fluctuations have a positive effect on such changes but only the first value is significant and its elasticity is 0.74. The expansion of capacity by new firms to the manufacturing industry results in a negative impact on optimal price changes. It was also argued that entry decisions through a change in production leads to more intense price fluctuations due to a positive effect of variable costs on wholesale prices.

Lastly, the results show that industrial concentration has a negative effect on the speed of price adjustment, while domestic entry has no significant effect. Nevertheless, the latter result may not hold for every country because changes in imports differ from OECD to non-OECD countries regarding the amount and the influence on price levels. For instance, Encaoua and Geroski (1986) presented evidence for five OECD countries that price inflexibility is not universal across industries due to the rate of variation of particular measures that influence industrial decisions. Cost and demand mechanisms have a significant effect on price flexibility and through them the market structure and price variations can be identified in an intertemporal framework.

On the other hand, as Aaronovitch and Sawyer (1981) along with Domberger (1979) provided inconsistent results with the administered price thesis, two more papers complement their findings. Weiss (1993) argued that cost changes are less fully transmitted to prices in highly concentrated industries due to large economies of scale that result in low variable costs. In particular, he estimated a price equation for seventeen Austrian industries over 1974-1988 to test the sensitivity of prices to cost and demand changes, the speed of price adjustment and the asymmetry of price behaviour. A weak relationship between industrial concentration and the asymmetry of prices is also observed, following either cost or demand changes. This means that the administered price thesis, as well as the implications of Rotemberg and Saloner (1986) about price wars during high demand peaks, cannot be supported in the constituent Austrian industries.

Kraft (1995) developed a consistent model with this literature by taking into consideration a dataset of seventeen German industries over 1970-1987 in order to provide the effects of business cycles and capital intensity on price adjustment. In this case, concentrated industries had faster price adjustments, a result which comes in contradiction with the administered price thesis. The findings also support that capital intensity had a negative effect on price adjustment because prices were more flexible during demand peaks than slumps, thus showing an asymmetry in dependence to demand and cost conditions.

It has been presented that the administered price thesis has resulted in contradicting results, depending on the undertaken industry. For instance, evidence from the industries of the UK, Austria and Germany suggests a positive relationship between industrial concentration and the speed of price adjustment, thus rejecting this thesis. Consequently, no matter the theoretical framework, real markets can adopt a different behaviour due to factors that are either not taken into consideration or neglected on purpose based on the author’s interest in other parameters.

2.4.2 The Behaviour and Effects of Imperfect Competitive actions

The second part of the literature evolution of the theory of imperfect competition springs from the contribution of Edward Chamberlin and Joan Robinson, as well as by early papers (like Stigler’s theory of collusion). It provides a rational comprehension of the theoretical concept of industrial decisions, along with empirical implications observed in real world economies. The analysis of this part consists of a complementary approach to the administered price thesis, by indicating how market structure can affect pricing behaviour.

Stiglitz (1984) presented a theoretical interpretation of how prices and wages can be shaped under non-market clearing conditions, where real product wages may be decreasing if the economy is under depression. In particular, the author argued that if prices convey private information, then firms may be reluctant to reduce their price level only when consumers expect a fall in product quality. This means that there will be consumers who prefer a higher level of quality and as a result, the firms will reduce their market prices to offset that loss in quality. In this case, markups over marginal costs will rise by reducing consumer surplus and formulate incentives for collusion. Secondly, if the searching cost of consumers is relatively high, then demand curves may be kinked due to different assessment and preferences for this cost, which may lead consumers not to choose the optimal solution (lowest price).

Lastly, as long as there is low threat of entry in oligopolistic markets, firms will have the incentives for charging a higher markup. This will result in higher price levels and possibly price rigidities, if collusive arrangements are sustained by a non-cooperative equilibrium. To this end, evidence validates the argument that even under recession, firms can charge a higher price level than the one proposed by traditional theories. They can maintain a form of rigidity due to the acquisition of market power, possibly after the exit of firms.

An additional paper about price rigidity in a similar light was produced by Rotemberg and Summers (1990), where they introduced the effects of inflexible prices to procyclical productivity. They argued that rigid prices within periods of weak or strong demand can lead along with labour hoarding to the procyclical behaviour of total factor productivity. This happens because firms that set prices before demand is realized cannot afford to charge a low price in order for output value reduction to be equal to cost reduction.

The results obtained from this model indicate that procyclical productivity along with positive markups occur whenever demand is low under free entry and constant returns to scale. Also the two measures of labour hoarding estimated are significantly related to the procyclical behaviour of productivity but the measure of market power has the opposite sign than anticipated. Therefore, these results confirm earlier studies, like Prescott (1975), suggesting that productivity rises to a certain point and then falls, by following demand impulses as it would be expected if labour was hoarded.

Rotemberg and Woodford (1993) discussed the consequences of imperfect competition on the effects upon product market growth and the new characteristics of this structure that differ from the ones under perfect competition. Such characteristics include increasing returns to technologies which reflect the significance of innovation in the production process; shocks to the level of government purchases; as well as changes in individual producer's degree of market power. Under these specifications, the model refers to a dynamic general equilibrium model by showing that an increase in markups between price and marginal cost will result in a reduction in the level of labour input. This fact indicates that fluctuations in the level of markups can generate great employment variations.

A different paper that is connected with the literature of oligopolistic and monopolistic pricing is the one of Fischer and Konieczny (1995). It provides evidence based on Canadian daily newspaper data over 1965-1990 which contradict the outcome of Rotemberg and Saloner (1987). In particular, they reject the argument that oligopolies change prices more often than monopolies by showing that price behaviour depends on market characteristics. Even if oligopolies change prices more frequently than monopolies, these changes will be larger due to the intensity of competition under fluctuations in demand by leading to lower future price levels.

A higher expected inflation rate will reduce the gap between real price adjustments of the two types of firms, while prices charged by oligopolies will be more eroded between adjustments. This means that under such conditions, the lower bound of monopolies will be reduced but the one of oligopolies will increase due to the interaction of competitive forces. In monopoly, since there is no competition, a higher expected inflation will be able to reduce the lower bound of pricing in order for the monopolist to be able to extract the maximum amount of consumer surplus as before.

2.4.3. When Theory Meets Reality; Market Operation and Industrial Interpretation

Following the aforementioned literature, price discrimination can be considered as another form of price adjustment determined by firms endogenously. Ghoshal (2000), based on Rotemberg and Woodford's model (1996), formed a sample of 253 4-digit SIC manufacturing firms over 1958-2001 in order to test the role of imperfect competition in the response of markups to energy and monetary fluctuatuions. A crucial part of this study regards the distinction between the source of cost and demand shocks in order to retrieve a more realistic approach of business cycles fluctuations. If markups increase in response to demand variations due to cost revaluation, then there may be little or no information conveyed by using an overall business cycle indicator. The main findings of this paper support that in highly concentrated industries markups increase with monetary expansions and fall when energy prices rise in order to keep the real price level in a relatively stable state.

On the other hand, in less concentrated industries markups are not affected either by monetary expansions or energy price changes due to the occurrence of competition and reflect a stable low price level. Despite that outcome, procyclical markups in highly concentrated industries are not being driven by differences in the degree of labour hoarding among markets of different type. This result is consistent with Rotemberg and Saloner (1986) about the criticism that markups are independent of labour hoarding due to intensive price wars when demand is relatively high.

A similar study was developed by Olive (2004) in order to estimate the degree of markups and returns to scale for eight Australian manufacturing sectors along with their effects on business cycles. He based his model on a Hall type markup model (Hall et al, 1986; Hall, 1988, 1990) in order to estimate the industrial markup by avoiding the direct calculation of marginal cost. He took into account fixed cross sectional data with time effects to investigate the contribution of technological change to industrial growth. The results indicated that in six out of eight industries, markups are higher than unity, which validates the emergence of market power within these sectors. Constant returns to scales are not rejected; however, in some cases, diminishing average cost is very intense according to technological growth.

Bloch and Olive (2003) extended this theory in the segmented manufacturing markets of Germany, Japan, the United Kingdom and the United States by using an industry pricing equation that embodies price-cost margin and profit maximizing behaviour. The estimations show that the markup model does not hold for most industries due to intense competition. Nevertheless, a fixed low markup is observed in many of them, by suggesting that firms were competing in a Cournot game where cooperative behaviour is neglected. Countries facing high industrial concentration may have their markups influenced by competing foreign prices, resulting in pro-cyclical behaviour.

2.5. Recent Contribution in the Theory of Imperfect Markets

From the most significant papers that have been considered as a benchmark in this field of industrial organization and macroeconomics to the most recent contributions, there have been quite a few controversial results that vary across industries, based on entrepreneurial behaviour. The most recent papers that present a narrow and targeted analysis can summarize the aforementioned theoretical outcomes by focusing on strategic interactions within sectors. They define the state of competition, the nature of the demand and cost functions. The crucial factors that determine and affect such behaviour comprise of the speed of price and cost adjustment, the amount of investment that will maintain a stable production process and the type of tools that firms will choose to compete with. According to these mechanisms, an efficient interpretation can be provided in order to acquire the necessary information about the market structure of any industry.

Asche, Kumbhakar and Tveteras (2008) studied a dynamic profit function with adjustment costs to inputs and outputs under the optimization problem. The main interest is based on the nature of cost adjustment, whether it is quasi or fully fixed. The estimates showed that any disequilibrium in such factors, connected with adjustment costs, influence the demand of inputs and the final output level. This happens due to the effect of marginal productivity of capital, where the use of an additional capital unit will affect the production process.

Additionally, the empirical results for the United States agricultural industry provided evidence that adjustment costs are associated with the production of one output and the use of all inputs, while there is no evidence that relates them with any other output. However, the estimated profit function includes two outputs (livestock and crop) and three inputs (capital, labour and intermediate inputs). This shows that adjustment costs do not always affect the whole production process and according to the characteristics of any output or input, their relationship may significantly vary.

A similar study regarding the costs of price adjustment was presented by Olive (2008) for the Australian manufacturing sectors over 1994-2002 in order to calculate the speed of price adjustment as a function of market power. By estimating a profit function under quadratic price adjustment costs, he concluded that large firms have less reason to slow the speed of prices, while firms with market power are better able to offset it. The model derived focuses on the positive relationship between economies of scale in regard to quadratic price adjustment costs and the speed of price adjustment. By averaging across sectors, the model is converted into an error correction model by limiting the restrictions on the short run dynamics of the estimating equation. The empirical results suggest that the speed of price adjustment at the sectorial level is positively related to the average size of scales for large firms and negatively related to industrial concentration. These effects occur because firms try to minimize their losses by maintaining a fixed output level through smaller price changes, which represents the fact that implicit costs can arise from adjustments in both product and input markets.

The last part of this chapter concerns the estimations of market power and strategic interactions within particular industries that provide consistent results with the theory of imperfect competition. In the first paper, the market power in the Greek food and beverages manufacturing industry was estimated by Rezitis and Kalantzi (2012) by using the conjectural variation methodology (Bresnahan, 1982, 1989) over 1983-2007. The estimates are based on three approaches; the first one assesses the extent of market power of the whole industry over the testing period, the second one tests the degree of market power in each one of the nine sectors of the industry and the last one estimates the extent of market power for the whole Greek food and beverages manufacturing industry over specific sub-periods. Their interest also lies on the net loss of welfare along with the reduction of consumer surplus due to income transfer towards firms with oligopolistic or monopolistic power.

The empirical results of the first and the second approach indicate that a non-competitive market structure in all nine sectors is present, while the third one suggests that in each sub-period, imperfect competition appears to emerge due to some degree of market power in the whole industry. As a result, welfare losses are observed, by affecting consumer surplus the most. The results also prove that economies of scale are persistent, especially over 1983-1985 where the degree of market power had reached its climax.

The second paper involved a similar study for the product (graham crackers) of four producing firms that supply a large supermarket chain in Chicago (Kano, 2013). A state dependent pricing model was introduced in the presence of menu costs and duopoly strategic interactions in which the brands of retail products compete in a pricing dynamic game. The estimates of such model are considered to be unbiased compared with the ones resulting from a monopolistic competition model due to the fact that a duopoly can take into account the strategic interactions between firms. Since price changes can be based on such behaviour partially justified by the menu cost approach, the estimates are found to give a more profound and unbiased outcome for this study.

The structure of this model assumes that competition takes place between brands, while the shelf price level is set by each store separately. This means that pricing decisions at the brand level are dominant for the price of graham crackers, but retail stores appear to have a degree of discretional power. Based on these features, the estimates support that price rigidity in duopoly is more intense than monopolistic competition, while the size of own-price and cross-price elasticities is crucial in determining how price rigidity is related to the level of own and rival price in the state space. As the strategic complementarity grows stronger, prices will tend to be more rigid as lagged price levels of both brands are higher. Therefore, strategic interactions under intensive price rigidity can be interpreted as a collusion outcome in a duopolistic and oligopolistic environment.

2.6. Applying the literature of imperfect competition in the case of Greek markets

Most of the aforementioned papers reflect the implication of theories of firm behaviour within industries that define the structure of competition and the market price level that can shape consumer demand. The most important elements that can lead to distortions in competitive market behaviour concern the formation of collusion among firms in order to attain higher market share. Therefore, they will acquire a degree of oligopolistic power under the motive of total profit maximization which will result in a higher portion of individual profits than before.

Another interesting factor concerns the preferences of consumers and their elasticity in price changes which can motivate firms to sustain a fixed price level for some time. This way, they prevent any fluctuations in order to minimize the loss in the number of consumers and thus, minimize any profit losses. This means that when firms face the dilemma of whether to raise their prices or not, they have to consider an expected benefit-cost analysis in order to see whether the extra revenues from a price increase will overcome the losses by the dissatisfied consumers. Instead of treating the reaction of consumers as the main decision variable, many firms take into account their cost functions as well which consist of input costs, investment decisions and labour contracts. This effect will have an impact on the speed of price adjustment by identifying the degree of price flexibility and market power that has been acquired by various industries.

Furthermore, it is argued that sectors within the manufacturing industry have acquired a degree of market power due to the fact that many firms were forced to adopt exit decisions as a result of depression. In particular, there is a number of papers that investigate competitive conditions by Bourlakis (1992b, 1992c, 1997), Rezitis and Kalantzi (2011a, 2011b, 2012, 2013) and Polemis (2014). Bourlakis (1992b) examined the relationship and effects between profits and market power over time by investigating the degree of correlation between concentration and profits. By empoloying industry-level data, the results do not support evidence of a systematic relation between those two measures but they indicate that more concentrated industries face a higher level of profits. On the other hand, by using firm-level data, the estimations indicate a positive relation of concentration and profits. The empirical estimations imply that, at a large extent, monopolistic or oligopolistic market structures reduce consumer surplus. Therefore, the main findings indicate that there is a fluctuant level of market power in the Greek manufacturing industry over the period 1958-1988.

Additionally, Bourlakis (1997) investigated the competitive conditions in the Greek manufacturing industry and specifically, in the Greek food and beverages sector. He identified a co-moving pattern emerging between past and present price-cost margins, by verifying the presence of market power. A low degree of concentration and barriers to entry was also identified, where there is a tendency of general suppression and mobility in price-cost margin ranks, indicating that disciplinary competitive forces are also at work within the manufacturing sectors.

Another study which is of great importance to this analysis was made by Rezitis and Kalantzi (2012, 2013) for the Greek food and beverages industry, by providing evidence of market power over the period 1983–2007. In particular, by using Bresnahan's (1989) conjectural variation model, they developed a three step approach: In the first step they assessed the extent of market power of the whole industry over the period 1983–2007; in the second step they tested the degree of market power in each one of the nine sectors of the industry over the whole period; and in the third one they estimated the extent of market power for the whole Greek food and beverages manufacturing industry over specific sub-periods.

Rezitis and Kalantzi (2011a, 2011b) also investigated the market structure of the Greek food and beverages industry and the manufacturing industry in general, based on the Hall-Roeger (1995) approach in order to estimate the price-cost margin. Once more, by following a three step procedure as above, they provided evidence that the whole industry, as well as each constituent sector, operates under non-competitive conditions over the period 1984–2007. These papers also identified factors significantly affecting the markup level, such as the size of the sector, the number of establishments and labour/capital intensity. In addition, Polemis (2014) took into consideration the Hall-Roeger (1995) methodology as well in order to investigate the level of market power in the Greek manufacturing industry and services over the period 1970-2007. He also supported that the aforementioned industries operate under non-competitive conditions, where the services industry is found to be more competitive than the manufacturing industry.

To conclude with, regardless the conditions that can give rise to imperfect competitive behaviour, the outcome in every case is the same. On the one hand, prices tend to be rigid in a relatively high level compared to the one they should have been, had the prices been flexible. On the other hand, industrial activities become very limited and entrepreneurial decisions are based initially on the survival of the firm and afterwards, on a set of actions that will attract more consumers. Therefore, based on the previous literature evolution, the best application for the current situation in the Greek markets would be to consider all the proposed assumptions and remedies under the scope of imperfect competition.

Table 1. *Summary of the literature of Imperfect Competition and Price Rigidities*

Paper	Form of Rigidity	Type of Paper	Characteristics	Mechanism of Rigidity
Cournot Model (Cournot, 1838)	Nominal Price Rigidity	Theoretical	Two firms competing in quantities, Homogenous products	Strategic interactions resulting in a price level that allows positive profits ($p^c>p^{pc}$)
General Equilibrium Model (Walras, 1877)	Nominal Flexibility	Theoretical	Multiple market/agent equilibrium, Perfect information about supply price	Flexible price level that always equates demand and supply by clearing markets
The Theory of Monopolistic Competition (Chamberlin, 1933)	Nominal Price Rigidity	Theoretical	Small number of markets with imperfect competitive behaviour, Product differentiation, Each market is characterized by a seller's monopoly imperfectly isolated from the others, Two demand curves	Monopolistic competition through product differentiation (allows positive profits), Collusion through Joint Profit Maximization
The Theory of Imperfect Competition (Robinson, 1933)	Nominal Price Rigidity	Theoretical	Unsatisfied customers' needs can coexist along with firms' excess capacity, Introduction of average and marginal cost curves, Existence of positive profits in equilibrium due to a small number of entrepreneurs	Competitive equilibrium profits relate with the marginal productivity of the entrepreneurial ability for the industry, Nominal price level varies according to entrepreneurial decisions
Administered Price Thesis (Means, 1935a)	Nominal/Real Price Rigidity	Empirical		Industrial concentration leads to upward aggressive pricing (price manipulation), Sluggish rise of prices during booms and even recessions
A Theory of Oligopoly (Stigler, 1964)	Nominal Price Rigidity	Theoretical	Homogeneous goods, Small number of sellers, Great number of heterogeneous buyers, No entry allowed, Heterogeneity of purchases, Collusion formation	Monopolistic pricing, punishment of any defection due to secret price cutting, Strategic interactions due to externalities
Changes in the Recession Behavior of Wholesale Prices: The l920s and Post-World War II (Cagan, 1974)	Nominal/Real Price Rigidity	Empirical		The growth of firms' market power and the contracts with labour unions for sticky wages and growing aggregate demand, Policies of full employment that led to high inflation levels

(Table 1 continue)

Market Behaviour with Demand Uncertainty and Price Inflexibility (Carlton, 1978)	Nominal Price Rigidity	Theoretical	Production of a single good, Inability of some consumers to purchase that good, Excess capacity of a portion of those firms that have failed to sell their whole stock	Strategic Interactions, Entrepreneurial cost decisions, Demand uncertainty
Contracts, Price Rigidity and Market equilibrium (Carlton, 1979)	Nominal Price Rigidity	Theoretical	Production of a single good, Inability of some consumers to purchase that good, Excess capacity of a portion of those firms that have failed to sell their whole stock	Contracts and transaction costs between interacting firms or agents
The Rigidity of Prices (Carlton, 1986)	Nominal/Real Price Rigidity	Empirical	Lack of information about individual actions that reflect transaction prices	Administered Price Thesis > Fixed number of costumers
A Theory of Monopolistic Price Adjustment (Barro, 1972)	Nominal Price Rigidity	Theoretical	One monopolistic seller (price setter), Many perfectly competitive buyers	Monopolistic Pricing, Administrative and implicit costs that are generated by markets' and not by individual actions, Institutional characteristics under which trading occurs
Monopolistic Competition and Optimum Product Diversity (Dixit and Stiglitz, 1977)	Nominal/Real Price Rigidity	Theoretical	The production of any commodity takes place if the costs can be covered by the sum of revenues along with an efficient defined measure of consumer's surplus	Monopolistic Power by distorting resources
Monopolistic Competition and the Effects of Aggregate Demand (Blanchard and Kiyotaki, 1987)	Nominal/Real Price Rigidity	Theoretical	General Equilibrium model where monopolistic competition prevails in both goods and labour market	Monopolistic Competition, Costly price changes, Low output due to demand externalities
Degree of Monopoly, Indices of Concentration and Threat of Entry (Encaoua and Jacquemin, 1980)	Nominal Price Rigidity	Theoretical	Static and Dynamic model of endogenous entry and firm cooperation	Industry Concentration, Aggregate degree of monopoly
Industry Structure and the Speed of Price Adjustment (Dixon, 1983)	Nominal Price Rigidity	Empirical		Administered Price Thesis, Relationship between the length of production lag and the lag between changes in unit costs and prices, Resilience of oligopolies to both fiscal and monetary shocks

(Table 1 continue)

Non Cooperative Collusion (Green and Porter, 1984)	Nominal Price Rigidity	Theoretical	Collusion formation, Cournot Competition, Industry Stability, Information about the industry and environment is publicly known	Collusion,-Monopolistic Behaviour Monopolistic Pricing
A Theory of Dynamic Oligopoly (Maskin and Tirole, 1988)	Nominal Price Rigidity	Theoretical	Infinite horizon duopoly games, Exogenous reasons for commitment, Large fixed costs allow only one firm to make profits	Large fixed and sunk costs, Monopolistic pricing, Short- commitment
Monopolistic Price Adjustment and Aggregate Output (Rotemberg, 1982a)	Nominal Price Rigidity	Theoretical	Costly price changes, Monopolists observe their demand along with money supply and take any other price as given, Product differentiation	Menu costs, Monetary shocks
Sticky Prices in the United States (Rotemberg, 1982b)	Nominal Price Rigidity	Empirical		Menu costs, Market Power
Small Menu Costs (Mankiw, 1985)	Nominal Price Rigidity	Theoretical	Simple static monopoly model of partial equilibrium in which the monopolist sets his price and changes it, after the occurrence of a small menu cost	Small menu cost, Asymmetry in price changes during expansions and contractions, Monopolistic Power
A Supergame of Price Wars during Booms (Rotemberg and Saloner, 1986)	Nominal Price Rigidity	Theoretical	Prices as strategic variables and constant marginal costs, Oligopolistic structure and how it responds to demand fluctuations	Price wars (strategic interactions) occur more during booms than recessions > Lower degree of price rigidity
The Relative Rigidity of Monopolistic Pricing (Rotemberg and Saloner, 1987)	Nominal Price Rigidity	Theoretical	Two period model described by an unexpected increase in marginal cost	Fluctuating costs reduce the degree of price rigidity, Demand fluctuations increase the degree of price rigidity
Collusive Price Leadership (Rotemberg and Saloner, 1990)	Nominal Price Rigidity	Theoretical	Two-firm oligopolistic model; Price changes are announced by the first firm due to private information access about demand fluctuations while the second firm follows	Price leadership due to realization of demand fluctuations, No incentives for overt collusion

(Table 1 continue)

Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity (Rotemberg and Woodford, 1992)	Nominal Price Rigidity	Theoretical	Dynamic General Equilibrium model with endogenous demand and production costs, stochastic industry demand	Strategic Interactions, Sensitivity of demand changes on pricing decisions
Markov Perfect industry Dynamics (Ericson and Pakes, 1995)	Nominal Price Rigidity	Theoretical	Industry dynamics with entry and exit decisions, Firm uncertainty generating variability in the future of the sector	Investment Uncertainty, Strategic Interactions, Prevent from entry
Scale economies with regard to price adjustment costs and the speed of price adjustment in Australian manufacturing (Olive, 2008)	Nominal Price Rigidity	Empirical	Quadratic price adjustment cost function	Slow speed of price adjustment due to market power
Menu Costs and Strategic Interactions (Kano, 2013)	Nominal Price Rigidity	Theoretical/Empirical	Estimation of menu costs in oligopolistic competition model	Menu costs- Costly price adjustment Strategic interactions

Note: In every model the assumptions of rational expectations and maximizing behaviour hold for every agent.

3. A Theoretical Model of Collusive Decisions and Punishment under Demand and Cost Uncertainty

3.1. Introduction

A crucial issue highly significant to both industrial organization and game theory economists concerns the formation of collusive contracts among firms in order to reach a desirable agreement. Such collusions are formed whenever market participants consider this action necessary in order to reach the joint optimal solution, under a set of circumstances and constraints they are called to face. The major interest is focused on the nature and the degree of implicit collusion that can be sustained through strategic interactions and production decisions depending on past and present information about every firm's actions.

In the seminal paper *A Theory of Oligopoly*, Stigler (1964) provided a dynamic interpretation of oligopoly theory were firms have to cooperate in order to maximize their total profits. Nevertheless, the main attribute of this paper is the fact that Stigler took into consideration the long run unsustainability of collusion due to its instability as Nash equilibrium by giving birth to incentives for defection under certain circumstances. Therefore, in order for such actions to be avoided there must be an endogenously determined "self-policing" way that will monitor the signed contracts between the participating firms.

Under product homogeneity and an industry structure immune to entry, Stigler focused his interest in secret price cutting. This action is motivated by specific fluctuations in markets, such as an unexpected increase of demand for a given price. It provides sufficient incentives to participants in breaking the contract with collusion, thus charging a lower price level to attract a greater portion of consumers and attain more profits.

Green and Porter (1984) attempted a direct expansion of Stigler's original paper by reintroducing the assumption of imperfect information. They presented a model where price cutting is a rational choice for firms under specific circumstances without defecting from their contracting agreement. In particular, they argued that under demand uncertainty, optimal incentive equilibrium may involve an episodic recourse to a short-term unprofitable solution (i.e. price war). However, under such regime, it cannot be clearly defined whether the explaining outcome is the same with the one under certainty.

In spite of demand uncertainty, Green and Porter (1984) supported that collusive conduct might be characterized by repeated episodes that may result in a reduction in the price and profit level. This outcome is triggered by a fall in the observed price of the collusion's goods. This result leaves no place for the view of an industry in which firms are acting on abortive attempts to form collusion.

The objective of the present chapter is to provide a general interpretation of how collusions work based on the model presented by Green and Porter (1984). This chapter incorporates the proposition of the original model where firms return to collusion after a temporary demand shock; however, the present model introduces the choice of punishment as a credible strategy whenever such defection occurs. The main intention is to present a point of view, under the fact that threat conditions are regarded as credible based on the market power that every firm possess; the higher that power is, the more endurable a firm will be. It will enter a competitive state as a form of punishment to the ones who have defected from the contracts of collusion.

A major assumption of this model is that the credibility of punishment decisions depend on the economic environment and thus, on the behaviour of consumers in the market. For instance, in times of low demand (i.e. recession) the threat of punishment is highly credible because firms need to coordinate their actions in order to minimize losses. They are more reluctant to losses under recession because they may be forced to exit the market. Therefore, if any defection occurs under a temporary boom in demand, then a form of punishment will be imposed in order to disciple the collusion members and thus, to avoid any future unnecessary losses. These restrictions can transform this solution into a sustainable equilibrium by changing the payoffs of every player and providing them an efficient outcome, compared with the one acquired by the non-cooperative solution.

Consequently, this form of equilibrium that consists of either collusive or punishment decisions reflects the mechanisms through which collusive agreements may result in nominal price rigidity. If firms decide to sustain a collusive agreement over a time period, then the nominal price level in that particular market will remain rigid. On the other hand, if for some reason a form of punishment is bestowed, then the nominal price level will change but still, it will remain rigid for some time. This means that no matter the state of equilibrium according to the decisions of the participants, the price level will remain rigid. This is the theoretical intuition under which market imperfections through collusive agreements result in nominal price rigidity. This is the first step of the theoretical relationship between market power and rigid price levels which will be tested in chapter 6.

The main argument consists of two parts; the first one provides a description of the collusion structure that is about to be studied in terms of industry conduct. The second one shows that even if collusive conduct results in reversionary episodes as a rational choice in which price and profit levels sharply decrease, as was shown by Green and Porter (1984), firms may prefer to bestow a form of punishment upon collusion participants[5]. However, a high degree of future uncertainty may render a number of firms unable to undertake such reversionary actions due to cost factors appreciation, even over the period of competition. This means that their costs might unexpectedly rise by leading to a forced price increase as a result of a marginal cost increase. As a result, this will render the products of such firms unattractive, given that their competitors will continue to charge a competitive price.

Another reason may be the very case that is neglected by the fact that cost functions are publicly observed. If firms are able to observe the cost functions of their rivals, including all the elements such as production costs, investment and debt or liabilities, then they will have the incentives to charge a competitive price by creating a reversionary episode for the collusion when they face the lowest total cost. If expectations about their future net profit position are optimistic, then this action will force the remaining firms to charge competitive price levels as well. Therefore, if expectations are not falsified, the strongest firm(s) will survive in the long-run by forcing the remaining to exit the sector. This fact will provide monopolistic power to the remaining firm(s) by increasing its (their) profits and depreciate the losses imposed by competition in very short time.

3.2.Collusive Decisions under Demand and Cost Uncertainty

The model that will be studied is based on the fact that demand and cost fluctuations are not directly observed by other firms which may lead to unstable industry performance. The main structure reflects a market sector in which demand is deteriorating due to a slump in aggregate consumption. When firms notice that their profits are rapidly decreasing, they will choose to undertake an act of collusion in order to both secure their short-term profits and maximize their long-term expected returns as well, over the time horizon.

[5] This form of punishment is similar with the one proposed by Rotemberg and Wootford (1992).

The model consists of a super game defined by firms' actions according to their incentives and the signals they receive from the market environment. They choose to compete under Bertrand behaviour by identifying a "trigger quantity" which may motivate firms to enter a reversionary episode. The time horizon includes $k=0,1,2,\ldots K$ time periods and $t=0,1,2,\ldots T$ time sub-periods. Sub time periods denote whether collusion is in a normal or a reversionary state, while time periods denote the decisions of collusion. Such decisions may refer to an outcome similar to Green and Porter's or an outcome of punishment based on future uncertainty. Specifically, Green and Porter argued that it is optimal for all firms to enter a reversionary episode which is triggered by an observed price reduction (Cournot behaviour) as long as "the marginal return to a firm from increasing its production in normal periods is offset exactly by the marginal increase in risk of suffering a loss in returns by triggering a reversionary episode" (1984: p.93). In addition, since product homogeneity along with an accurate realization of competitors' cost functions hold, then there will be no need for punishment.

The main intention of this chapter is to overcome the assumption of fully observing competitors' cost functions and by adding the element of uncertainty and speculation, to render the option of punishment credible. The industry that this model might appropriately describe is characterized by four features.

- First, the industry is assumed to be stable over time by rendering any expectation made to be rational based on the available information that firms are called to use. This assumption is necessary in order for this model to result in temporary stability.
- Second, the decision variable is the relative price set by firms which leads to Bertrand competition[6].
- Third, there is private information about cost decisions which sets uncertainty as a crucial factor of forming or deviating from collusion[7]. Therefore, an accurate idea can be formed regarding only the production costs of their competitors.
- Fourth, the set of information that firms use to monitor whether the collusion is in a collusive (normal) or reversionary state has to be imperfectly correlated with their

[6] It is assumed that quality improvement during this game remains the same due to restrictions in investment, but differentiation in products exists, because of the set of actions undertaken over the periods prior to the slump in demand.

[7] Despite the fact that the Nash equilibrium assumption presupposes that firms have an accurate idea of their competitors' cost functions, private knowledge renders very difficult for variables such as quality investment or liabilities to be observed.

conduct. This means that no direct compliance is allowed because reversion would never occur.

3.3.The Model

As mentioned above, a game of K periods and T sub-periods is assumed that incorporates the decisions and strategic interactions of the participating firms. The game starts at $k=0$, $t=0$ when it is assumed that the participants form collusion and charge a price level which maximizes their joint profits. Consider an oligopoly of N firms which produce a differentiated product in a stationary and time separable environment, like the one described by Friedman (1971). It is assumed that if $i=1,2,\ldots,N$ indicates the number of firms, then $\pi_i: R^2_+ \rightarrow R$ is the return function of firm i and $\pi_i=\pi_i(p_i,q_i)$, where p_i is the set of price decisions and q_i is the output produced corresponding to quantity demanded for a certain price level (expressed in logarithms). If β is the discount factor and firms are assumed to be risk neutral, then they are called to maximize their long-run value function $\mathrm{E}[\sum_{k=0}^{\infty}\beta^k \sum_{t=0}^{\infty}\beta^t \pi_i(p_i,q_i)]$.

The observed demand function is given by

$$Q_{it}{}^{d} = A_i \left(\frac{P_{it}}{P_t}\right)^{-b_i} \left(\frac{M_t}{I_{it}{}^{\lambda} P_t}\right)^{\mu_i} \left(\frac{Z_{it}}{P_t}\right)^{\zeta_i^1} \qquad (1)$$

where

- A_i, is a constant that captures any shock in demand
- P_{it}: $R_+ \rightarrow R_+$, is the relative price charged by firms
- P_t: $R_+ \rightarrow R_+$ is the industry's aggregate price level
- $\left(\frac{M_t}{I_{it}{}^{\lambda} P_t}\right)$ is the wealth effect or the realization of liquidity from the public
- $\left(\frac{Z_{it}}{P_t}\right)$ is the expected/undertaken investment in product quality

In this point, as denoted by Green and Porter (1984), it is assumed that firms choose their strategies from an infinite sequence $s_i=(s_{i0}, s_{i1}, s_{i2},\ldots.)$ where s_{i0} is a determinate initial price level p_{i0}, and s_{it+1}: $R_+^{t+1} \rightarrow R_+$ determines i's price level at time $t+1$ as a function of past output produced by $s_{it+1}(q_0,\ldots,q_t)=p_{it+1}$. Also, it is assumed that a price decision taken at time t is dependent on past pricing decisions formed by both j competitors and firm i, thus confirming the assumption of rational choices, where $p_{it}=p_{it}(p_{i0},p_{i1},....,p_{it-1},p_{j0}, p_{j1},...., p_{jt-1})$ and p_{jt} indicates the pricing decisions of competitors.

A strategy profile $(s_1,..., s_n)$ determines recursively a stochastic process of output, which in turn induces a probability distribution on the space of infinite sequences of such variable. Expectations with respect to this distribution will be denoted by $E_{s_1,...,s_n}$. This means that a Nash Equilibrium is a strategy profile $(s_1^*,..., s_n^*)$ that satisfies

$$E_{s_1,\dots,s_n}[\sum_{t=0}^{\infty}\beta^t\pi_i(s_{it}(q_0,\dots,q_{t-1}),q_t)] \le E_{s_1^*,\dots,s_n^*}[\sum_{t=0}^{\infty}\beta^t\pi_i(s_{it}^*(q_0,\dots,q_{t-1}),q_t)] \Leftrightarrow$$

$$E_{s_1,\dots,s_n}[\sum_{k=0}^{n}\beta^k \sum_{t=0}^{\infty}\beta^t\pi_i{}^k(s_{it}(q_0,\dots,q_{t-1}),q_t) \le$$

$$E_{s_1^*,\dots,s_n^*}[\sum_{k=0}^{\infty}\beta^k \sum_{t=0}^{\infty}\beta^t\pi_i{}^k(s_{it}^*(q_0,\dots,q_{t-1}),q_t)] \quad (2)$$

for all firms i and feasible strategies s_{it}, where π_i^k indicates the profit level at time k.

On this basis, firms start their production at $k=0$, $t=0$ under a commonly accepted price when the slump in demand persists. The reasoning behind this process is based on the degree of influence each firm possesses. The higher that degree is, the higher the amount of output produced by that firm will be. As long as quantity demanded remains under a threshold $\hat{q}^k$ (the value of $\hat{q}$ at time k) which is commonly accepted by all participants as the "*trigger quantity*" that will result in Bertrand competition, collusion is sustained and firms keep on charging a common price level. If for some reason, this threshold is overcome due to improvement in demand conditions, like an expansionary policy that bolsters aggregate income or demand, then at least one firm will reduce its price to the competitive level, by leaving no other option to the rest but to follow such action.

In this model, the element of uncertainty does not provide an outcome based on mutual trust. In fact, three cases emerge after the increase of the observed quantity demanded above the trigger threshold; the first is the one where the trust of collusion is not broken and thus, firms return to charging the initial price level; the second declares a crumble in the relationship of the collusion members that leads to a new collusion under which the price level charged is lower than the initial one; the last reflects a complete lost in trust which leads to an infinite Bertrand competition for $k=1,2,..., K$ where the strongest firm(s) will survive.

3.4.Profit Functions in Normal and Reversionary Period

Initially, assume that $p^k=\{p_1^k,....,p_N^k\}$ is a profile of monopolistic pricing choices for each firm and $p^{Bk}=\{p_1^{Bk},....,p_N^{Bk}\}$ is a Bertrand pricing profile. For simplicity, the case for $k=0$ will be considered. An output level $\hat{q}^m$ is chosen along with a length of time t to be normal if (i) $t=0$ or (ii) $t-1$ was normal and $\hat{q}^k \geq q_{t-1}^{dk}$ or (iii) $t-T$ was normal and $q_{t-T}^{dk} > \hat{q}^k$,where $q_t^{dk}= q_t^{dk}(p_t^k)$ indicates the observed demand function for time k. For any other case, define t to be reversionary. Each firm faces a pricing strategy set

$$p_t = \begin{cases} p_i^m, \text{ if } t \text{ is normal under no punishment in effect} \\ p_i^1, \text{ if } t \text{ is normal under punishment in effect} \\ p_i^B, \text{ if } t \text{ is reversionary} \end{cases}$$

It is optimal for firms to charge a fixed common price $\bar{p}^k$[8] in normal periods and p^{Bk} in reversionary periods. The analysis starts from the first collusion. The joint expected profits that firms have to maximize for $k=0$ are given by

$$\pi_t{}^m = \sum_{i=1}^N \gamma_i = \bar{p}_t{}^m q_t{}^{dm}(\bar{p}_t{}^m, z_t) - \sum_{i=1}^N c_{it}(q_{it}{}^{pm}, l_{it}) \quad (3)$$

where

$$\bar{p}_t{}^m = p_t = \sum_{i=1}^N \frac{\psi_i}{\sum_{i=1}^N \psi_i} p_{it}{}^m \quad (4)^9$$

$$q_{it}{}^{pm} = \frac{\psi_i}{\sum_{i=1}^N \psi_i} q_t{}^m \quad (5)$$

$$q_t{}^m = q_t{}^{dm}(\bar{p}_t{}^m, z_t) = \sum_{i=1}^N q_{it}{}^{pm} \quad (6)$$

The variable q_{it}^p corresponds to the quantity produced by firm i, $q_t^{dm}= q_t^{dm}(\bar{p}_t{}^m, z_t)$ refers to the observed demand function of the collusion at $k=0$, $t=0$, q_t^m is the observed quantity demanded for price $\bar{p}^m$, z_t denotes a vector of determinants of collusion's demand curve, l_{it} refers to a vector of cost determinants for each individual firm i, and ψ_i reflects the influence that firm i possesses in the operating sector. Therefore, for the last factor holds that

[8] The common price charged by collusion at time $k=0$ is denoted by $\overline{p}^m$.

[9] See Rotemberg (1982a).

$$\sum_{i=1}^{N}\frac{\psi_i}{\sum_{i=1}^{N}\psi_i}=1 \tag{7}$$

where $\theta_i=\frac{\psi_i}{\sum_{i=1}^{N}\psi_i}$ is the weighted average of individual production in collusion[10].

The expected profits of individual firm *i* participating in collusion are given by

$$\gamma_{it}(\bar{p}^m)=\bar{p}^m\frac{\psi_i}{\sum_{i=1}^{N}\psi_i}q_t{}^{dm}(\bar{p}^m,z_t)-c_{it}(\frac{\psi_i}{\sum_{i=1}^{N}\psi_i}q_t{}^m,l_{it}) \tag{8}$$

However, if production is increased beyond the threshold point by an individual firm (due to an increase in observed demand), then that firm will start charging a competitive Bertrand price $p_i{}^B$ by forcing the remaining *N-1* firms to follow such strategy as well. Under Bertrand competition, the expected profits for each firm are given by

$$\delta_{it}(p_{it}{}^B)=p_{it}{}^Bq_{it}{}^{Bd}(p_{it}{}^B,z_{it})-c_{it}(q_{it}{}^{Bp},l_{it}) \tag{9}$$

where $q_{it}{}^{Bp}$ corresponds to the quantity produced by firm *i* when charging $p_i{}^B$.

3.5.Definition of Value Functions

Let $V_i^m(\bar{p}^m)$ be the expected discounted present value of firm *i* if $p_i{}^m=\bar{p}^m$ in normal periods. Let also *Pr(.)* denote probability with respect to the distribution of θ_i which follows the same properties as ψ_i, dependent on demand shocks. Also, *Prb(.)* denotes the probability with discrete density that defines the volume of output produced in every sub-period *t*. If it is also assumed that $\gamma_i(p_i{}^m)>\delta_i(p_i{}^B)$, the value function for each firm satisfies the following equation

$$\begin{aligned}V_i(p_i{}^m=\bar{p}^m)&=\gamma_i(\bar{p}^m)+\beta\Pr(q^{dm}\le\hat{q}^m)V_i{}^m(\bar{p}^m)\\&+\Pr(q^{dm}>\hat{q}^m)(Prb(q^p=q^{Bp}))^{T-1}Prb(q^p=\theta_iq^m)[\textstyle\sum_{t=1}^{T-1}\beta^t\delta_i(p_i{}^B)+\beta^TV_i{}^m]\\&+\Pr(q^{dm}>\hat{q}^m)(Prb(q^p=q^{Bp}))^{T-1}Prb(q^p=\theta_i{}^1q^1)[\textstyle\sum_{t=1}^{T-1}\beta^t\delta_i(p_i{}^B)+\beta^TV_i{}^1]\\&+\Pr(q^{dm}>\hat{q}^m)(Prb(q^p=q^{Bp}))^{T-1}Prb(q^p=q^{Bp})[\textstyle\sum_{t=1}^{T}\beta^t\delta_i(p_i{}^B)]\end{aligned} \tag{10}$$

[10] This factor can also be viewed as the degree of market power of firm *i*.

The first term of the right hand side reflects the returns that every firm i expect to receive if the agreement for charging a fixed price level $\bar{p}^m$ persists, as long as the quantity demanded threshold is not overcome. The remaining three terms capture the implications of deviating from the pre-agreed price level due to an increase in observed demand. Specifically, the second term reflects the assumption presented by Green and Porter where Cournot (Bertrand in this case) competition persists for *T-1* sub-periods and in time *T* collusion reverts back in charging the initial monopolistic price level. The third term provides the first form of punishment; after competing in Bertrand terms for *T-1* sub-periods, most of the firms believe that such behaviour will be repeated. In order to punish such actions by minimizing intertemporal expected occurring losses, they agree in forming another collusion under which they charge a price level $\overline{p}^1 < \bar{p}^m$. This action materializes because even if at least one firm starts charging ${p_i}^B$, the participants will not be able to identify that firm because all of them will adopt the same strategy almost instantaneously.

This assumption may not accurately correspond to reality, but it is of great help to this analysis for emerging its dynamic elements. If firms could observe the one who would be deviating every single time, then they could adopt various strategies. They could either bestow penalties on this firm, or if the deviating firm had higher market power than the rest, all of them would be forced to charge competitive prices, where in the long-run only the strongest firm would survive. This effect is captured by the last term of this equation. It indicates a complete breakdown in collusion agreements and gives the signal for an all-out competition among participants, thus rendering any agreement about future collusion impossible.

Another difference from the original paper concerns the probability that determines the volume of output produced. It will be set as $r_{k+1} = (Prb(q^p = {q_i}^{Bk}))^{T-1}$the probability which shows how long Bertrand competition will last. In the original paper, it is assumed that $r_1\Big(Prb(q^p = {q_i}^{pk})\Big) = 1$ and thus, the duration of charging a competitive price is determined only by $\Pr(q^{dm} > \hat{q}^m)$. In the present case, the duration of such competition is determined by $r_1(\Pr(q^{dm} > \hat{q}^m))$ and according to firm decisions of how they will respond in time *T*, their strategy is given by $Prb(q^p = \theta_i q^m)$ if they choose to return to the initial collusion; $Prb(q^p = {\theta_i}^1 q^1)$ if they choose to form another collusion; and $Prb(q^p = {q_i}^{Bp})$ if they choose not to cooperate. For this reason holds that

$$r_1[Prb(q^p = \theta_i q^m) + Prb(q^p = \theta_i{}^1 q^1) + Prb(q^p = q_i{}^{Bp})] = 1 \quad (11)$$

In this point, by taking logarithms of (1) at *k=0, t=0*, it follows that

$$q_{it}{}^d = a_i + \mu_i (m_t - \mathrm{I}_{it}{}^{\lambda} - \overline{p}^m) + \zeta_i^1 (z_{it} - \overline{p}^m) \quad (12)$$

In this equation, it is seen that the real price effect of this sector is not taken into consideration since every firm charges the same nominal price level and acts like a monopolist whose products do not have any substitutes[11]. This means that elasticity b_i will be fixed responding to the agreed price level and won't impose any changes in demand for the output of collusion. Intuitively, this outcome is consistent with the assumptions of this model because (12) indicates that a change in demand will take place only if there is a change in μ_i or ζ_i^1 that can occur due to fluctuations in the liquidity capacity of the public or the quality of investment. Either way, a change in observed demand does not result from a change in the elasticity of demand with respect to nominal price. Since it has been assumed that production always corresponds to the level of observed demand, it holds that

$$q_{it}{}^d = q_{it}{}^p = \theta_i q_t{}^m \Leftrightarrow q_t{}^m = q_t{}^{dm}(\bar{p}^m, z_t) = \frac{a_i + \mu_i(m_t - I_{it}{}^{\lambda} - \bar{p}^m) + \zeta_i{}^1(z_{it} - \bar{p}^m)}{\theta_i} \quad (13)$$

Based on the assumptions made for *Pr(.)*, it holds that

$$Pr(q^{dm} \leq \hat{q}^m) = \Pr\left(\frac{a_i + \mu_i(m_t - I_{it}{}^{\lambda} - \bar{p}^m) + \zeta_i{}^1(z_{it} - \bar{p}^m)}{\hat{q}^m} \leq \theta_i\right) = 1 - F(\frac{q_{it}{}^d}{\hat{q}^m}) \quad (14)$$

The last element of this analysis corresponds to the incentives of punishment. In order for such action to be credible, all firms must abandon a Pareto optimal condition and choose a different one, less preferable than the initial. This means that the expected profits and the expected value from an action of punishment must be less than the initial expected returns from collusion. For this reason, since it has already been assumed that $\gamma_i(p_i{}^m) > \delta_i(p_i{}^B)$, it must also hold that $V_i^m(\overline{p}^m) - V_i^1(\overline{p}^1) \geq 0$. If (10), (11) and (14) are substituted in this inequality it holds that

[11] It holds because $\sum_{i=1}^{N} \theta_i p_{it} = p_t$ (see equation 4).

$$V_i^1(\overline{p}^1) \leq \frac{\gamma_i(\overline{p}^m) - \delta_i(p_i^B)}{1-\beta+(\beta-\beta^{\mathrm{T}})F(\frac{q_i^d}{q^m}) + r_1 F(\frac{q_i^d}{q^m})\beta^{\mathrm{T}} \Pr(q_i^B)} + \frac{\delta_i(p_i^B)}{1-\beta}$$

$$-\left[\frac{r_1 F(\frac{q_i^d}{q^m})\beta^{\mathrm{T}+1} \Pr(q_i^B)}{(1-\beta)\{1-\beta+(\beta-\beta^{\mathrm{T}})F(\frac{q_i^d}{q^m}) + r_1 F(\frac{q_i^d}{q^m})\beta^{\mathrm{T}} \Pr(q_i^B)\}}\right]\delta_i(p_i^B) \qquad (15)$$

The first and the second term of the right hand side is the same as in the model of Green and Porter. They indicate the single-period gain in returns to colluding plus the expected discounted value of firm *i* in Bertrand environment. This was the sum of the value of firm *i* when there was no punishment. In this model, expression (15) reflects the fact that the value function includes an extra element; the expected gain in entering an infinite Bertrand competition for more than one periods or for the rest of the game. If the right hand side is greater than the form of punishment under which firms create a new collusion with lower price (i.e. $V_i^1(\bar{p}^1)$), then firms will have the incentives not to choose this new form of punishment.

Specifically, (15) provides the main outcome of this paper. The act of punishment indicates the risk that firms may be willing to take in order to discipline their collusion. If most of them are determined to sustain such collusion in the long-run to secure and form a strong arsenal against future uncertainty, then they may also be willing to force such punishment upon the colluding firms. This action can minimize any unnecessary losses and keep the firms on operating by both ensuring their survival and effort to recover their losses after the emerged slump in demand. In addition, the act of punishment is a way of exploiting the weakest firms by revealing their cost elements through their inability to keep on operating under a lower price level. This way, the remaining members of the collusion and especially the ones on the margin of operating under the new price level, will be forced to abide by the contracted rules.

Therefore, if firms intend to impose a form of punishment, they will have to maximize the gap between the two forms of collusion at *k=0* and *k=1* and thus, by substituting (2) in (15) it is obtained

$$V_i^m(\overline{p}^m) - V_i^1(\overline{p}^1) \le V_i^m(p_i^m) - V_i^1(p_i^1) \tag{16}$$

The first-order partial derivative for (16) is

$\frac{\vartheta[V_i{}^m(p_i{}^m) - V_i{}^1(p_i{}^1)]}{\vartheta p_i{}^m}$ =0 for every firm *i*.

So, it holds that

$$0= [(1-\beta)+(\beta-\beta^{\mathrm{T}})F(\frac{q_i^d}{q^m})+r_1F(\frac{q_i^d}{q^m})\beta^{\mathrm{T}}\Pr(q_i^B)]\gamma_i{}'(p_i^m)$$

$$-[(\beta-\beta^{\mathrm{T}})\xi+r_1\beta^{\mathrm{T}}\Pr(q_i^B)\xi](\gamma_i(p_i^m)-\delta_i(p_i^B))$$

$$-[(r_1\beta^{\mathrm{T}+1}\Pr(q_i^B)\xi)(1-\beta+(\beta-\beta^{\mathrm{T}})F(\frac{q_i^d}{q^m})+r_1F(\frac{q_i^d}{q^m})\beta^{\mathrm{T}}\Pr(q_i^B)]\frac{\delta_i(p_i^B)}{1-\beta}$$

$$+[(r_1F(\frac{q_i^d}{q^m})\beta^{\mathrm{T}+1}\Pr(q_i^B))((\beta-\beta^{\mathrm{T}})\xi+r_1\beta^{\mathrm{T}}\Pr(q_i^B)\xi)]\frac{\delta_i(p_i^B)}{1-\beta}$$

$$-\frac{\vartheta V_i{}^1(p_i{}^1)}{\vartheta p_i{}^m} \tag{17}$$

where $\xi = \frac{1}{q^m}F'(\frac{q_i^d}{q^m})[\mu_i(\frac{\partial m_t}{\partial p_i^m}-1)+\zeta_i^1(\frac{\partial z_{it}}{\partial p_i^m}-1)]$ and $\gamma_i{}'(p_i{}^m) = \frac{\vartheta\gamma_i}{\vartheta p_i{}^m}$

Equation (17) states that the marginal return to a firm from reducing its price in normal periods $(\gamma_i{}'(p_i{}^m))$ must be equal to the sum of (i) the marginal increase in risk of suffering a loss in returns $(\gamma_i(p_i{}^m) - \delta_i(p_i{}^B))$, (ii) the discounted expected profits from maintaining an infinite Bertrand competition $(\frac{\delta_i(p_i{}^B)}{1-\beta})$ and (iii) the marginal value from entering a new collusion by triggering a reversionary episode[12]. Without (ii) and (iii), this equation reflects the incentives of charging a lower price level when observed demand is increased beyond the trigger quantity and subsequently, return to the initial collusion. In the present model, it reflects the incentives of participants to punish any defection from the initial collusion. The only term that has further to be defined is the expected marginal value of a new collusion under a change in p_i^m. If a similar function like V_i^m is assumed, then the

[12] If this equation holds, then the participants will be indifferent in choosing between the alternative forms of punishment.

decision variable that would affect ${V_i}^1$, would be the price set $\bar{p}^1$ under which firms are called to set a new fixed price $\bar{p}^1 < \bar{p}^m$.

Equation (17) reflects the set of strategies that firms have in their disposal in order to exploit the benefits of collusion and maximize their intertemporal gains. The form of punishment in forming new collusions will not be adopted, only when individual profits from collusion k are equal or slightly less than the ones under Bertrand competition (for *k=0*, the initial monopoly m holds). This means that firms will stop adopting the first form of punishment as long as ${p_i}^k = {p_i}^{Bk}$ and

$${\gamma_i}^k({p_i}^k) \leq {\delta_i}^k({p_i}^{Bk}) \Leftrightarrow {p_i}^k {\theta_i}^k q^k - c_i({q_i}^p) \leq {p_i}^{Bk} {q_i}^{Bk} - c_i({q_i}^{Bp})$$

$$\Leftrightarrow {p_i}^k \leq \frac{c_i({q_i}^{Bp}) - c_i({q_i}^p)}{{q_i}^{Bk} - {\theta_i}^k q^k} \tag{18}$$

The right hand side of (18) indicates the difference between the risk in average cost that firm *i* will undertake under Bertrand competition and the benefit in average cost that firm i faces if the choice of producing $\theta^k q^k$ is maintained without defecting from collusion. As long as the price choice falls below that difference, then it pays no more to use as a method of punishment (or sustain) the formation of a new collusion by charging a lower common price because ${p_i}^k \leq {p_i}^B = mc_i$, thus signaling negative profits.

3.6.Concluding Remarks

According to such results, there are two final observations about the formal model of collusion under demand and cost uncertainty. First, the higher the operating cost of individual firm *i*, the lower the incentives of deviating from collusion will be. However, given the fact that collusion cannot observe the sequence of firms that cause a reversionary episode, then if a form of punishment is chosen, the weakest firms will be the first to face the consequences. On the other hand, if some of the firms with a high ψ_i value are expected to deviate, then Bertrand competition will be chosen. This happens because the degree of distrust among firms overcomes the degree of profit loss due to uncertainty. In equilibrium, the frequency of a reversionary episode to occur is given by $F(\frac{{q_i}^d}{\hat{q}^m})$.

Second, firms know that a higher observed demand level does not reflect simultaneous low pricing strategies by competitors. Consequently, it is rational for them to participate in reversionary episodes as long as there is belief that no punishment will occur[13]. A reversionary episode is just a temporary switch to Nash equilibrium in non-contingent strategies. It would not pay any firm to deviate unilaterally from its Nash strategy in this temporary situation as was presented by the original paper. This behaviour is expressed by equation (17) and as long as it is satisfied, firms will be able to choose a form of punishment as the optimal reaction. This strategy may be adopted even if entering a reversionary episode was the optimal choice, as it would be suggested if the terms of punishment $\frac{\delta_i}{1-\beta}$ and $\frac{\partial V_i{}^1(p_i{}^1)}{\partial p_i{}^m}$ were excluded.

The structure of this model has tested a more general case, as well as provided a general outcome compared to the one of Green and Porter by trying to provide a degree of convergence between theory and reality. Some of the assumptions may still have quite a significant gap from reality, but the main point was to formulate a model of rational strategic choices consistent with Nash equilibrium where punishment is taken into account. In marked contrast, such actions play an essential role in maintaining an ongoing scheme of collusive incentives.

The traditional views would predict the transience of collusion in a market marked by these episodes of price instability, and a breakdown of collusion at the beginning of competition by eliminating such effect. However, this model suggests that industries under certain structural characteristics will exhibit demand and industry fluctuations as a feature of a stable, time-stationary pattern of output if the operating firms are colluding[14].

The theoretical rationale reflected by this model will be incorporated in the empirical research presented over the following chapters in order to capture market factors that affect pricing decisions. The demand function will be used to identify how various measures influence the manufacturing production and the market power indicators. These indicators can either verify or reject the persistence of production decisions below the equilibrium level of competition. This theoretical intuition will be investigated for the 3-digit Greek manufacturing sectors along with the fact of whether the speed of price adjustment to

[13] This outcome corresponds to the one proposed by Green and Porter (1984).
[14] See Appendix B1 for the stochastic process of output which arises in the equilibrium of the model.

equilibrium is affected by relevant measures that may result in long-run nominal price rigidity.

4. Model Formulation and Data Variables of Empirical Investigation

The literature review of market imperfections and price rigidity utilizes a range of empirical tools in order to reach a conclusion that illustrates the relationship between market power acquisition and rigid pricing decisions. The degree of market power has been expressed both in terms of production (Bresnahan, 1982) and pricing decisions (Hall, 1988; Roeger, 1995) along with the degree of price rigidity reflected by the speed of convergence to the state of equilibrium (Dixon, 1983). As a result, the first measure is going to be taken into consideration in the empirical analysis of this study given its formulation and its significance on the theoretical concept presented in chapter 3[15].

In particular, it is useful to identify whether imperfect competition exists in the Greek manufacturing sectors in terms of production decisions. It is expected that if firms exercise their market power then this measure will provide evidence of imperfect competitive conduct. However, if there exist exogenous factors, such as government taxation, that distort the competitive price level, then there may be evidence of sluggish and over-pricing behaviour but the production-based indicator might not suggest the same outcome.

For this reason, the estimation of the speed of price adjustment will provide evidence of whether nominal price rigidity persists in the Greek manufacturing sectors and if so, how market power influences this particular outcome. This means that pricing decisions may not incorporate changes in the costs of production given the degree of market power exercised by a particular sector or firm. In this case, it is expected that a positive relationship will emerge by verifying the fact that nominal price rigidity is associated with market power. Consequently, this chapter will present the formulation and implementation of those measures in the Greek manufacturing sectors in order to test the theoretical intuition that nominal price rigidity is caused by market power acquisition.

In this chapter, the model formulation of the conjectural variation methodology and the speed of price adjustment concept will be presented. The empirical investigation is conducted in a four step analysis by taking into consideration 56 3-digit *NACErev2* level manufacturing sectors over the period 1980-2012 in the Greek economy. Each step will be

[15] The price-cost margin approach of Hall (1988) and Roeger (1995) was not included in this study as the effect of inputs on pricing decisions is reflected by the pricing equation (see section 4.1.2).

discussed separately and a thorough description of the underlying methodology and techniques will be developed.

In particular, the first step consists of an analysis for the whole Greek manufacturing industry by considering the aggregate effect of the constituent manufacturing sectors. This means that aggregated sectorial effects can reflect the behaviour of the whole manufacturing industry and thus, provide an interpretation of the market structure and the degree of price rigidity over the sample period. As a result, the indicators of conjectural variation and speed of adjustment will be estimated for the Greek manufacturing industry overall by incorporating the individual effects originating from the manufacturing sectors.

The second step, disaggregates the analysis to a 3-digit level by estimating the results of market power and price rigidity for each manufacturing sector individually. A range of panel estimation techniques will be employed in order to obtain such estimates that will incorporate pricing and production decisions that may lead to imperfect competitive conduct.

The third step, on the other hand, aggregates once again the effects of the manufacturing sectors in order to observe the overall behaviour of the manufacturing industry. However, the estimation process is conducted for each year individually over the period 1980-2012. This means that the behaviour of the Greek manufacturing industry will be estimated for each year by investigating whether production and pricing decisions resulted in market power acquisition and sluggish adjustment to equilibrium.

The fourth and last step concerns the main implication of this study which refers to the relationship between nominal price rigidity and market power. In particular, one equation is going to be estimated. It takes into consideration how the speed of price adjustment is affected by the degree of market power exercised by the manufacturing sectors along with their production costs. This is the most important objective of this study concerning the relationship between nominal price rigidity and market power by either verifying or rejecting the effects of profitability and leadership (Bedrossian and Moschos, 1988; Olive, 2008). Therefore, those steps are going to be discussed in this chapter in order to identify whether imperfect conduct and sluggish pricing decisions persist both in the manufacturing industry and the individual manufacturing sectors.

4.1. First Step: Assessment of the Greek Manufacturing Industry

4.1.1. The Conjectural Variation Approach

In this section, the methodology on the techniques of investigating the conditions of imperfect competition is introduced, as aforementioned in the literature. To begin with, the first approach used in this study in order to investigate the degree of market power in the Greek manufacturing industry was developed by Bresnahan (1982) and Lau (1982), as expanded by Bresnahan (1989). This approach corresponds to the conjectural variation model of competition, where firms within an industry are assumed to face an inverse demand function $p = p(y, z)$ with $Y = \sum_{i=1}^{N} y_i$, where p is the output price, y_i represents the quantity supplied by firm *i* and *z* is a vector of exogenous factors affecting the demand curve.

By also assuming a profit function of the form

$$\pi_i = p(Y, z)y_i - C_i(y_i, w_i) \tag{19}$$

where C_i is the cost function of firm i and w_i is a vector of input prices for firm i, the first order condition of profit maximization for (19) is given as:

$$\frac{\partial \pi_i}{\partial y_i} = p(Y, z) + \frac{\partial p}{\partial Y}\frac{\partial Y}{\partial y_i} y_i - \frac{\partial C_i}{\partial y_i} = 0 \tag{20}$$

In order to get the expression of conjectural variation elasticity, (20) has to be re-arranged into

$$\frac{p - MC_i}{p} = -\left(\frac{\vartheta p}{\vartheta Y}\frac{Y}{p}\right)\left(\frac{\vartheta Y}{\vartheta y_i}\frac{y_i}{Y}\right) = -\frac{f_i}{h} \tag{21}$$

where MC_i is the marginal cost of firm i, $h \equiv (\frac{\vartheta Y}{\vartheta p}\frac{p}{Y}) < 0$ denotes the elasticity of industrial output demand with respect to price and $f_i = (\frac{\partial Y}{\partial y_i} \cdot \frac{y_i}{Y})$ represents the conjectural variation of firm *i* by indicating the reaction of industry output to a change in individual firms' output decisions as a measure of competition. A value of f_i equal to zero for all firms means that the industry is under conditions of perfect competition, while a value of one indicates a monopolistic market. When f_i ranges over zero and one, it is assumed that conditions of Cournot oligopoly for the industry are implied.

According to Bresnahan (1989), if equation (21) is multiplied by *yi/Ci*, by summing over every firm *i* and rearranging the terms, the supply function for the whole industry is obtained

$$S_y(1+\frac{f}{h}) = MC_d \tag{22}$$

where S_y is the ratio of aggregate revenues to total cost, MC_d is the industry weighted marginal cost, $\frac{p-MC_d}{p} = -\frac{f}{h}$ and *f* indicates the conjectural variation elasticity for the whole manufacturing industry. Also, according to Cowling and Waterson (1976), *f* indicates the average degree of competition, which measures the average deviation of a monopolistic behaviour in the whole industry. If it is properly identified, it reflects the degree of market power exerted by all manufacturing firms, where $f=1$ indicates a monopoly, $f=0$ indicates perfect competition and $0<f<1$ Cournot Oligopoly.

The last part of this approach concerns the specification of price and output indexes. By following the methodology of Dickson and Yu (1989), the industry demand curve is represented by $Y = 1/p^{|h|}$ where $|h|$ denotes the absolute value of demand elasticity with respect to price. Also, the weighted industry marginal cost curve MC_d is presented by $Y=MC_d{}^{\varepsilon}$, where ε refers to the inverse of the weighted industry demand elasticity with respect to marginal cost. In addition, the left hand side of equation (22) denotes the Lerner Index[16] which shows the relative markup or the price-cost margin for every firm *i*, which is defined as the ratio of conjectural variation elasticity over industry elasticity of demand. Based on this index, the oligopoly price p_0 and oligopoly output Y_0 are given as

$$p_0 = (\frac{|h|}{|h|-f})Y_0^{\frac{1}{\varepsilon}} \tag{23}$$

$$Y_0 = 1/p_0^{|h|} = (\frac{|h|-f}{|h|})^{\frac{|h|\varepsilon}{|h|+\varepsilon}} \tag{24}$$

As long as $0<f<1$, p_0 and Y_0 denote the oligopolistic price and output respectively. If *f* takes the value of zero, the level of price and output under perfect competition will be $p_c = Y_c^{\frac{1}{\varepsilon}}$ and $Y_c = 1/p_c^{|h|}$ respectively, while a value of *f* equal to unity reflects the monopolistic price level $p_M = (\frac{|h|}{|h|-1})Y_M^{\frac{1}{\varepsilon}}$ and output $Y_M = 1/p_M^{|h|}$ respectively.

[16] Lerner Index= $(p_i-MC_i)/p_i$ which indicates the relative price-cost margin for firm *i*.

As a result of this formulation, the first set of functions necessary for the estimation of conjectural variation elasticity is extracted and modified from Bresnahan (1989) and Rezitis and Kalantzi (2012, 2013). In particular, a transcendental logarithmic (translog) specification of the total cost function[17] is taken into consideration, along with two inputs (i.e. capital and labour), one output and symmetry and linear homogeneity restrictions with respect to input unit costs imposed. The equation is formulated as:

$$\ln(\frac{C_t}{UKC_t}) = a_0 + a_y \ln Y_t + \frac{1}{2} a_{yy} (\ln Y_t)^2 + g_{ly} \ln Y_t \ln(\frac{ULC_t}{UKC_t}) + a_l \ln(\frac{ULC_t}{UKC_t})$$

$$+ \frac{1}{2} g_{ll} \ln(\frac{ULC_t}{UKC_t})^2 + x_t T + x_{ty} T \ln Y_t + x_{tl} T \ln(\frac{ULC_t}{UKC_t}) + \varphi_{1t} \quad (25)$$

where C_t represents the aggregate cost of the manufacturing industry, Y_t corresponds to the volume of industry output, ULC_t denotes the unit labour cost, UKC_t is the unit capital cost[18], T is the time trend and φ_{1t} is a random error term which indicates the presence of endogeneity.

It is worth noting that the original formulations use wages and capital prices respectively instead of unit cost indicators. That kind of approach takes into consideration the variations in both wage contracts and capital depreciation, but neglects their relationship towards the production process. In order to capture the relationship amongst total salaries, gross capital expenditures and output, the unit cost approach is more sufficient. Rezitis and Kalantzi (2011a, 2011b) based their study on input prices, so it will be beneficial to compare and contrast the results of this study with their results in order to see if there is any significant difference.

Additionally, output is measured in terms of total value added, so there is no need to include the input of raw materials necessary for production, since total value added is equivalent to revenues, less the purchases of materials and services attributable to production. A number of papers (i.e. Bedrossian and Moschos, 1988; Siegel, 1999) regard the purchase of materials as variable cost because such costs depend on the volume of production. However, this means that they measure output in terms of gross output. On the other hand, in this first approach, since Y_t is expressed as the final product reflecting total value added, then this study accounts labour and capital as the only input factors. Also, gross capital expenditures

[17] The translog cost function of this form results from the translog specification, introduced by Christensen et al. (1973) which is a second order Taylor series approximation to any cost function that satisfies the assumption of concavity (Saal and Parker, 2000).

[18] $ULC_t = \frac{Employed's \text{ remuneration}}{Output}$ and $UKC_t = \frac{\text{Gross Capital Expenditures}}{Output}$

are considered to be the sum of capital equipment and capital investment[19] undertaken, necessary for the production process by representing the fixed cost of the translog cost function.

In order to capture the effects of labour and capital upon the cost function of the manufacturing industry, Shephard's Lemma[20] is applied in (25) by providing the cost share equation of labour and capital respectively

$$s_{lt} = a_l + g_{ly} \ln Y_t + g_{ll} \ln(\frac{ULC_t}{UKC_t}) + x_{tl} T \tag{25a}$$

$$s_{kt} = a_k + g_{ky} \ln Y_t + g_{kl} \ln(\frac{ULC_t}{UKC_t}) + x_{tk} T \tag{25b}$$

Since the sum of the dependent variables over the two cost share equations (25a) and (25b) always equals 1, then only one equation is linearly independent. As a result, it is necessary to omit one equation (the equation for capital is considered) in order to avoid singularity of the estimated covariance matrix. In addition, since labour and capital share are the two input components of the cost function, their coefficients, or otherwise their impact on total cost, must always be equal to 1. This means that $a_l+a_k=1$ must hold in all cases, where a_l and a_k denote the elasticity of cost with respect to labour and capital respectively.

The last important element for the estimation of conjectural variation of the manufacturing industry, refers to the industry supply function which is described as

$$s_{Yt}(1+\frac{f_{man}}{h}) = a_y + a_{yy} \ln Y_t + g_{ly} \ln(\frac{ULC_t}{UKC_t}) + x_{ty} T + \varphi_{2t} \tag{25c}$$

where s_{lt} is the ratio of labour cost to total cost, s_{kt} corresponds to the ratio of capital cost to total cost and s_{Yt} represents the ratio of industry's aggregate revenue to total cost. Additionally, h denotes the industry demand elasticity with respect to price and f_{man} is the

[19] As defined by the Hellenic Statistical Authority (*EL.STAT.*). The formulation of this index is based on the methodology provided by Rezitis and Kalantzi (2012).

[20] In the theory of the firm, Shephard's Lemma provides a formulation for each input factor included in the cost function. In this case, the derivative of the cost function with respect to capital and labour unit costs $c(w,y)$ is given by:

$x_i(w,y) = \frac{\partial c_i(w,y)}{\partial w_i}$, and the derivative of the cost function with respect to output (marginal cost) is given by

$mc = \frac{\partial c_i(w,y)}{\partial y_i} = w_{1i}\frac{\partial w_{1i}}{\partial y_i} + w_{2i}\frac{\partial w_{2i}}{\partial y_i}$, where $x_i(w,y)$ represents the conditional factor demand for input i expressed in terms of unit cost prices (w_1=labour unit cost and w_2=capital unit cost) and output y and mc denotes the marginal cost assuming that input prices are determined by output y (Shephard, 1953).

conjectural variation indicator for the whole manufacturing industry. In particular, f_{man} indicates the aggregate effect of manufacturing industry upon the whole economy and thus, provide an index of competition and market power. Therefore, an alternative interpretation would regard the effect of the industry's output decisions to Gross Domestic Product.

This indicator takes values over the range [0,1] where *0* indicates a perfect competitive market, while *1* indicates a monopolistic market. The right hand side variables of (25a), (25b) and (25c) can be estimated from the cost function of the manufacturing industry (25). The remaining two unknown variables are the conjectural variation (f_{man}) and the demand elasticity (h) of the industry. Since the main interest lies on the investigation of f_{man}, the only parameter that needs to be estimated is h.

Its estimation is provided by the following demand function as initially indicated in the studies of Lopez, Azzam and Liron-Espana (2002), Azzam and Pagoulatos (2006), and Rezitis and Kalantzi (2012, 2013):

$$\ln Y_t = a + h\ln(\frac{P_t}{b_t}*100) + h^z \ln(\frac{Z_t}{b_t}*100) + h^H \ln(\frac{Herf_t}{b_t}*100)$$

$$+h^{liq} \ln(\frac{MS_t}{b_t * POP_t}*100) + u_t \qquad (26)$$

where h^z is the elasticity of output with respect to investments Z_t, h^H represents the elasticity of output with respect to sales concentration $Herf_t$[21], h^{liq} corresponds to the elasticity of output with respect to available liquidity, b_t is a variable deflator which is considered to be the consumer price index, POP_t is the population of Greece in time t and u_t is a random error which is correlated with the independent variables, by indicating the problem of endogeneity. The original model includes the first parameter h and the elasticity of output with respect to real Gross National Product. In this regression, the effects of investment, market concentration and liquidity have been added in order to identify factors like the preferences of consumers based on market dominance or reputation. An additional factor regards the

[21] As an index of sales concentration, a similar method like *the Herfindahl-Hirschman Index (HHI)* for market concentration is considered which is defined as $H = \sum_{i=1}^{n} s_i^2$, where s_i is the share of each 3 digit sector (in this study) to industry output and *n* is the number of the 3 digit sectors. The *HHI* ranges from *1/n* (high competition) to one (monopoly). The Horizontal Mergers Guidelines of the U.S. Department of Justice and the Federal Trade Commission (2010) suggest that a *HHI* less than *0.01* indicates high competitive market conditions, while an index above *0.25* indicates a high degree of concentration. Thus, in this study, the sales concentration index is defined as $Herf = \sum_{i=1}^{n} S_i^2$, where S_i is the ratio of individual sales to total sales.

production decisions made by firms based on an index of liquidity[22] available in the Greek economy.

In particular, investments can be considered as an important factor that can shape the allocation of market power within industries and affect or change consumers' preferences. Bustamante (2011, 2015) argued that when production technologies and the level of investments is heterogeneous within an industry, then cross sectional variation in expected returns will be high and that industry will be more concentrated. The manufacturing industry may provide a consistent example of that argument due to its importance to the aggregate economy through its contribution to the satisfaction of the primary needs of consumers.

Sales concentration is another index that may be able to provide evidence about consumers' preferences based on the share of sales that a firm or a sector holds in contrast to their competitors. In a number of studies (Rezitis and Kalantzi 2011a, 2011b) the ratio of sales to total sales is considered to be an important factor that may affect the degree of market power a firm or a sector holds. For this reason, a similar index to the *HHI* is taken into consideration which does not result in multicollinearity in (26) and at the same time provides a relationship between sales concentration and output produced. This indicator is also important especially on a 3-digit level analysis because it might be able to provide an explanation to the fact of whether consumers tend to choose from the most reputable suppliers.

The last indicator refers to a measure of liquidity and its effect upon individuals' decisions about their purchases. In particular, part of the structure of the demand function is based on the theoretical foundations provided by Rotemberg (1982a) where he assumes a demand function subject to real price changes and real money balances. As real money balances he used the ratio M_t/P_tV_t, where M_t is the nominal money supply, P_t is the aggregate price level and V_t is a time varying taste parameter. In this study, the time varying taste parameter is assumed to be the population of Greece while the price deflator refers to the consumer price index, as considered by Rezitis and Kalantzi (2012, 2013).

As nominal money balances, the money supply index (*M2*) for the Greek economy is used in order to estimate whether there is a significant effect on production decisions caused

[22] As an index of liquidity, the money supply (*M2*) available to the Greek economy has been taken into consideration instead of Gross National Product. This was chosen in order to test the impact of a change in accessible money which may expand or reduce liquidity from the Greek economy and thus, the Greek manufacturing sectors by affecting their production decisions.

by a change in the available liquidity in the whole economy. Intuitively, it is expected that when there is a contraction in money supply, consumers will face a reduction in their liquid assets and thus, they will limit their consumption or any other expenditure in order to compensate for the lost amount of liquidity. However, since the manufacturing industry is a crucial industry for people's primary needs, it would be interesting to test the effects of money supply upon production decisions which are highly determined by expectations of future demand.

4.1.2. A Measure of Price Rigidity: The speed of price adjustment

The second approach concerns the estimation of a set of price adjustment equations to both cross sectional and time series analysis in order to obtain the coefficient of the speed of price adjustment in the manufacturing industry as developed by Bedrossian and Moschos (1988). This study takes into account changes in the nominal price level and particularly, in the wholesale price set by the manufacturing sectors. Nominal price rigidity can be identified as the resistance of the nominal price level to changes in the market clearing price over a relevant time period. The indicator of the speed of price adjustment reflects this condition and tests the intensity of the nominal price resilience according to shifts in the cost of inputs, as determinants of supply decisions. This means that the speed of price adjustment indicates the proportional change in the nominal price level according to fluctuations in the cost of inputs faced by firms or sectors.

In particular, assume that the optimal price level under equilibrium is specified in a log-linear form as a markup from inputs, which in the original case correspond to unit labour and unit material costs. However, since the authors argued that they have used unit material cost due to insufficient data of unit capital costs, in this study the indicator of unit capital cost is proposed under the conjectural variation approach. Under oligopolistic conditions, the equilibrium markup is positively related to industrial concentration and negatively related to the elasticity of demand[23]. Also, under the assumption that major changes in the structure of

[23] Based on Hannah and Kay (1977), the markup over marginal costs at the industry level is equal to *HHI/h*, where *HHI* is the Herfindhal index of concentration and *h* is the elasticity of demand. Another interpretation is provided by Bersnahan (1982, 1989) as it is used in the conjectural variation approach, where Lerner Index is equal to *f/h*, and *f* is the elasticity of conjectural variation, an index of market concentration. If it is also assumed that the industry faces a Cobb-Douglas production function in conjunction with the marginal costs of labour and capital, the price level can be written as a markup over unit costs. This means that the price level is related to the level of excess demand via markup and not the rate of change of prices as in the competitive price models.

the industry may take a considerable time to manifest themselves, only demand conditions, as indicated by the deviation between actual output and its trend, are allowed to have an influence on the price markup.

The equilibrium price level is defined as

$$\ln P^{f*}_{t} = c_0 + c_1(\ln Y_t - \ln \widehat{Y}_t) + \beta_1 \ln ULC_t + \beta_3 \ln UKC_t + \eta_t \tag{27}$$

where P^{f*}_t is the equilibrium price level in time t, Y_t is the actual output in terms of total value added, $\hat{Y}_t$ is the output trend, ULC_t and UKC_t denote the unit labour and capital cost respectively and η_t is a random error term which is assumed to account for all the non-systematic and non-measurable influences. In particular, the wholesale price index is extracted from total value added in order to take into consideration the estimation of capital and investment costs by excluding material costs, plus the percentage of taxes implied on sales[24].

Theoretical exposition suggests that c_1, β_1 and β_3 will be positive, since an increase in unit costs and/or an increase in production indicated by a positive shift in demand curve will drive the price level upwards. In particular, an increase in unit costs will cause an increase in the price level in order to compensate that change, while a positive shift in demand curve will lead to a higher price level in order to exploit consumer surplus. On the other hand, in real world markets firms may have the incentives to maintain a rigid price level for some time despite fluctuations in unit costs or demand due to various reasons, such as maintaining their customers or due to formal (or informal) contracts.

In order to derive the speed of price adjustment, Bedrossian and Moschos (1988) use the partial adjustment mechanism according to which the actual proportional change in prices is a fraction of the desired proportional change

$$\ln P^{f}_{t} - \ln P^{f}_{t-1} = \lambda(\ln P^{f*}_{t} - \ln P^{f}_{t-1}), \qquad 0 \leq \lambda < 1 \tag{28}$$

where λ is the speed of price adjustment which is assumed to be constant over a period of cost and price fluctuations. An additional terminology for λ addresses the speed at which prices

[24] $P^{f}_{t} = \dfrac{\text{Value of Sales}}{\text{Sold Volume}} + Taxes$. The definition of taxes includes the Value Added Tax (*VAT*) in sales as a percentage of the wholesale price level. It is not taken into consideration any taxes on production that consist of taxes on buildings, the ownership or use of land or other capital assets used in production, on the labour employed or any compensation paid to employees.

adjust to increases/decreases in total costs by denoting both the ability and the flexibility of firms to affect the pricing decisions of their products.

In theoretical terms, this value suggests the speed that prices adjust to changes in market clearing factors under the Walrassian concept of equilibrium. Under this rational, in a perfectly competitive environment the value of adjustment would be equal to unity, thus suggesting total flexibility. This means that no frictions from other factors have an influence to pricing decisions. However, in real world economies, there are many factors that can affect production decisions, such as menu costs or market power. Consequently, the price level will not incorprorate changes to market clearing factors immediately as firms may not be willing or able to face the costs of that adjustment. This is a form of price rigidity denoting that changes in input costs or any other factor influencing the price level may take some time in order to be reflected in the price level. This happens in order for firms to maintain their customers and thus, a relatively high profit level.

In addition to the original paper, two extra effects are to be taken into consideration: the effects of the price levels charged in the European Union market (*EU27*) and the effects of taxes on sales (*VAT*). The theoretical intuition suggests that individual state markets which are part of the European Union market should face a price pattern based on price-demand elasticity, cost elasticity and any fiscal or monetary policies implied which may affect their pricing decisions. Since only 19 of the 27 members of the European Union utilize the euro currency, it would be of great interest to see whether fluctuations in policies may cause a significant change in pricing behavior in the Greek markets. On the one hand, changes in monetary policy implied by the European Central Bank may have the same effect upon the economies under the Eurozone and thus, pricing decisions of the interacting markets and sectors. On the other hand, changes in fiscal policy will not have the same effect on markets because fiscal policy can be decided individually by each state. This means that changes in monetary but certainly in fiscal policy may not result in the same outcome for the economies of the *EU27*.

For this reason, two additional price convergence mechanisms are introduced by incorporating the same properties as equation (28). They reflect the actual deviation between domestic and foreign prices with respect to the optimal level under equilibrium and the actual gap between wholesale prices and the portion of taxes added to the optimal level

$$\ln P^f{}_t - \ln P^{eu}{}_t = \lambda^{eu}(\ln P^{f*}{}_t - \ln P^{eu}{}_t), \quad 0 \leq \lambda^{eu} < 1 \tag{29}$$

$$\ln P^f{}_t - \ln P^T{}_t = \lambda^T(\ln P^{f*}{}_t - \ln P^T{}_t), \quad 0 \leq \lambda^T < 1 \tag{30}$$

where $P^{eu}{}_t$ reflects the wholesale price level charged in the *EU27* market and $P^T{}_t$ is the extra percentage of the final price due to added taxes. This shows that λ^{eu} and λ^T correspond to the speed of price deviation between domestic wholesale prices and (*i*) foreign wholesale prices and (*ii*) value added tax respectively. As it is seen, both λ^{eu} and λ^T are positive and less than one which indicates that the actual difference of the left hand side can never be greater than the right hand side. This suggests that when the speed of price adjustment/convergence gets a value equal to unity, then the actual price will be the optimal under equilibrium. By substituting (27), (29) and (30) in (28) it is obtained

$$\ln P^f{}_t = \lambda' c_0 + \lambda' c_1(\ln Y_t - \ln \widehat{Y}_t) + \lambda' \beta_1 \ln ULC_t + \lambda' \beta_3 \ln UKC_t + (1-\lambda)\ln P^f{}_{t-1}$$

$$-\lambda_1'(\lambda^{eu} - \lambda)(1-\lambda^{eu})\ln P^{eu}{}_t + \lambda_2'(1-\lambda^T)\ln P^T{}_t + \varepsilon_t \tag{31}$$

where $\lambda' = \dfrac{\lambda(1-\lambda^{eu}+\lambda)}{\lambda^T}$, $\lambda_1' = \dfrac{\lambda - \lambda^{eu}}{\lambda^T}$, $\lambda_2' = \dfrac{\lambda - \lambda^T}{\lambda^{eu}}$ and $\varepsilon_t = \dfrac{\lambda(1-\lambda^{eu}+\lambda)}{\lambda^T}\eta_t$, $\eta_t \sim NID(0, \sigma_\eta{}^2)$ [25]

Equation (31) is the basic estimation form which takes into consideration the effects of output, unit labour and capital costs, the price level with one time lag (*t-1*), the price level in the European Union market and taxes added on the wholesale price index $P^f{}_t$. Additionally, the coefficients of $lnP^{eu}{}_t$ and $lnP^T{}_t$ may not appear to have the same effect on $lnP^f{}_t$. In particular, it is expected that an increase in taxes will increase the wholesale price level, while an increase in foreign prices may have an uncertain effect. This implies that when those coefficients have the same sign and given that λ^{eu} and λ^T range over zero and unity, by solving the system of (28), (29) and (30) it is found that $\lambda > \lambda^T$ and $\lambda > \lambda^{eu}$. These inequalities suggest that the speed of price adjustment will be greater than both the speed of domestic-foreign price convergence and the speed of price-tax adjustment.

[25] The variance $\sigma_{\eta_t}{}^2$ is not assumed to be identical across time for each 3-digit sector, because each observation of the time series sample has its own variance $var(\varepsilon_t) = \sigma_{\eta_t}{}^2$. This means that the errors ε_t appear to be heteroskedastic and the degree of heteroskedasticity depends on the relative importance of $\sigma_{\eta_t}{}^2$.

However, if the latter inequality is reversed, then the elasticity (coefficient) of lnP^{eu}_t with respect to lnP^f_t will be negative which means that domestic pricing decisions do not follow the same behaviour as foreign pricing decisions. Those cases imply that whenever a change in both foreign pricing and tax pricing policy causes a simultaneous increase in P^f, then the speed of price adjustment will always be greater than the other two measures. Otherwise, it will hold that $\lambda^{eu}>\lambda> \lambda^T$ where the speed of price-tax adjustment will be slower than the speed of price adjustment which in turn, will be slower than the speed of domestic-foreign price convergence.

Since equation (31) is the basic estimation form, the main interest of this study will be focused on the estimation of the elasticity of the key variables with respect to lnP^f_t in order to identify their effects and thus provide an empirical outcome about pricing decisions in the Greek manufacturing industry. As indicated by Bedrossian and Moschos (1988), lagged values of unit labour and capital cost have been used in order to account for possible delayed effects of unit cost changes on pricing behaviour due to real world inflexibilities such as wage contracts, investing decisions and capital equipment provision. In addition, those delayed effects take into account lagged pricing decisions of the EU market and taxation in order to incorporate their effect on lnP^f_t.

In addition, it is worth noting that the variables P^{eu}_t and P^T_t are used as a comparison point to the equilibrium level of P^f_t. This means that the level charged by the EU27 is taken into account in order to calculate the speed of adjustment between the Greek and the European manufacturing industry. However, this rationale is not very clear when the variable of taxation is considered. In particular, this variable has been included in the analysis in order to test whether fluctuations in the VAT are reflected in the final wholesale price level. If that coefficient is equal to unity then a change in VAT is 100 percent reflected in the final price level. If that value is equal to zero then there is no effect and any other value between zero and unity refer to a partial transmission of the VAT increase.

The empirical intuition would suggest that in monopolistic markets, the coefficient should be equal to unity as the monopolist does not face any form of competition and thus, the number of consumers who will stop purchasing his goods will be minimal. On the other hand, in competitive markets where price wars may define market behaviour, firms may choose not to reflect the VAT change in their price level at all. This strategy will result in a persistent low price level which will allow the firm(s) to attract more consumers or maintain the number of existing consumers. In imperfectly competitive markets, it can be expected that this value will range between zero and unity because firms may be able to extract a higher level of consumer surplus. As a result, the coefficient of taxation in this model will reflect part of the pricing strategies of the Greek manufacturing sectors which may complement the evidence obtained about the market structure.

4.2. Second Step: Assessment of the Greek Manufacturing 3-digit Sectors

4.2.1. The Conjectural Variation Approach

In this step of the analysis, the set of equations presented in section 4.1.1 are being taken into consideration in order to estimate the elasticity of conjectural variation for each one of the 56 sectors of the Greek manufacturing industry. The only difference is that both supply and demand functions are modified by including cross-sectional dummy variables which account for changes among the manufacturing sectors (i.e. Breshnahan's cross-sectional specification). In particular, as argued by Görg and Warzynski (2003), since a sectorial level panel data set is taken into account, it is most suitable to estimate the aforementioned elasticity along with the elasticity of the demand function variables for a given sector individually. The assumption of this procedure necessitates that those measures remain fixed over the testing period for a given firm. This technique allows a higher degree of flexibility in the econometrical analysis in order to estimate the conjectural variation elasticity and thus, provide a measure of market power, as discussed in section 4.1.

The modification and formulation of the supply function using cross-sectional dummy variables requires an aggregation of the 3-digit sectors into 13 sets of 2-digit sectors[26]. In particular, by taking into consideration the estimations for the manufacturing industry, the supply function will be estimated for 13 2-digit sector sets in order to test the conjectural variation of each of the constituent 3-digit sectors. This means that the following supply function will be estimated thirteen times, according to the manufacturing industry's demand elasticity h

$$s_{Yt}[1+\frac{f_{pin}}{h}+\sum_{i=1}^{k} DS_i(\frac{f_i}{h})] = a_y + a_{yy}\ln Y_t + g_{ly}\ln(\frac{ULC_t}{UKC_t}) + x_{ty}T \qquad (32)$$

[26] See Table 5 and Table A.

where f_{pin} indicates the conjectural variation of a particular sector chosen as benchmark in the operating 2-digit sector, f_i refers to the change in the conjectural variation elasticity of sector i with respect to the fixed sector and DS_i is a dummy variable ($i=1,..,k$, where k is the number of the constituent 3-digit sectors included in the 13 2-digit sectors) which is set to unity for sector i and zero otherwise. It is worth mentioning that equation (32) could be estimated for every 3-digit sector individually by treating the manufacturing industry as the aggregated sector (1-digit).

However, in order to avoid any bias in the estimations of conjectural elasticity due to heterogeneous product units, it would be useful to provide a more disaggregated methodology by aggregating 3-digit into 2-digit sectors. This approach allows for testing the differences between sectors which appear to have similar characteristics compared to others in order to minimize the degree of product heterogeneity. For instance, the sub-sectors of the food and beverages manufacturing industry may appear to have a different behaviour and heterogeneity compared to the sub-sectors of the chemical industry. The greater the level of disaggregation, the more precise the estimations for the interacting sectors will be. So, in order to estimate the conjectural variation elasticity from equation (32), equations (25) and (25a) must be considered as they provide the estimates of the right hand side variables.

Nevertheless, the estimation of demand elasticity for the manufacturing industry is needed under the cross-sectional approach. In order to extract such estimations, the following set of equations based on (26) is used

$$\ln Y_t = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix} + \begin{bmatrix} h_{101} \ln p_{101t} \\ h^z{}_{101} \ln z_{101t} \\ h^H{}_{101} \ln herf_{101t} \\ h^{liq}{}_{101} \ln ms_{101t} \end{bmatrix} + \sum_{i=2}^{56} DS_i \begin{bmatrix} h_i \ln p_{it} & 0 & 0 & 0 \\ 0 & h^z{}_i \ln z_{it} & 0 & 0 \\ 0 & 0 & h^H{}_i \ln herf_{it} & 0 \\ 0 & 0 & 0 & h^{liq}{}_i \ln ms_{it} \end{bmatrix}$$

$$+ \begin{bmatrix} 0 & h^z \ln z_t & h^H \ln herf & h^{liq} \ln ms_t \\ h \ln p_t & 0 & h^H \ln herf & h^{liq} \ln ms_t \\ h \ln p_t & h^z \ln z_t & 0 & h^{liq} \ln ms_t \\ h \ln p_t & h^z \ln z_t & h^H \ln herf & 0 \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \end{bmatrix} \quad (33)$$

where h_{101}, $h^z{}_{101}$, $h^H{}_{101}$ and $h^{liq}{}_{101}$ denote the elasticity of price, investments, sales concentration and liquidity respectively with respect to output for the sector of production, processing and preserving of meat and meat products (i.e. 101), h_i, $h^z{}_i$, $h^H{}_i$ and $h^{liq}{}_i$ correspond to the change in the elasticity of price, investments, sales concentration and liquidity respectively of sector i (i=102,…, 310 or i=2,…56 which denote the order of those sectors, i.e. sector 102 corresponds to 2, sector 310 to 56 and so on) with respect to sector *101*, DS_i is a dummy variable which is set to unity for sector i and zero otherwise, h, h^z, h^H and h^{liq} are considered to be a measure of elasticity which is fixed across sectors in each equation respectively and $\vec{u}_t$ is a vector of random errors which are correlated with the independent variables, by reflecting the problem of endogeneity as in equation (26).

This system of equations provides detailed estimations for each independent variable by using dummy variables in order to estimate their elasticity in each 3-digit sector. In contrast to (32) where the sample of the 3-digit sectors is categorized into thirteen 2-digit sectors, the present set of equation is aggregated in a 1-digit level (manufacturing industry). This approach is vital in order to extract the aggregate elasticity of demand rather than the elasticity of demand of each 2-digit sector. For this reason, the first sector of the foods industry (i.e. sector 101) is considered as benchmark and any changes in the aforementioned elasticity measures of the remaining 55 sectors are compared to this benchmark.

In particular, in the first equation of this set, elasticity of price with respect to output of the 3-digit sectors with respect to the one of sector 101 is estimated by treating the effects of the remaining three variables (i.e. investments, sales concentration and liquidity) as fixed. In the second equation, the same procedure takes place for the elasticity of investments and so on. As it will be discussed in chapter 6, the elasticity of demand from the last equation is taken into account in the supply function (32), where the effect of liquidity is not fixed. This formulation is selected in order to extract the estimations of the conjectural variation elasticity for each 3-digit sector following the same procedure as Rezitis and Kalantzi (2012, 2013).

The reasoning for adopting this approach rather than estimating fifty six time series regressions lies on the estimation of such measures for a given time period[27]. As discussed in section 4.1, the conjectural variation elasticity provides an estimation of market power by indicating the effect of individual production on aggregate production or sectorial production on industrial production. For this reason, the estimates of market power of each 3-digit sector for every year would not provide an accurate measure of market power over the whole testing period i.e. 1980-2012. This means that this approach is clearly focused on providing an

[27] It is also dependent on the significance of the Breusch-Pagan *LM* test which tests for the presence of cross-sectional dependency between the error terms of the individual entities.

overall measure of market power for both the manufacturing industry and each 3-digit sector individually.

However, this aspect can also be considered as a limitation of this analysis. Since a 3-digit sector data set is used, the conjectural variation indicator cannot account for any changes in production within the 3-digit sectors. If changes in production by the constituent firms of a particular sector occur, then conjectural variation elasticity will not reflect them because output variables correspond to the production activities of the whole sector. As a result, any variation in firms' production decisions will be incorporated as part of the whole production of that particular 3-digit sector. Therefore, this study is focused on production decisions of the aforementioned sectors and not of the constituent firms (i.e. 4-digit level) of those sectors.

4.2.2. A Measure of Price Rigidity: The Speed of Price Adjustment

The last approach of this step concerns the estimations of the degree of nominal price rigidity in each of the 3-digit sectors of this sample. In particular, the pricing equation (31) is used for the manufacturing industry in order to extract the speed of price adjustment (λ) and the other estimators as well. The sole reason of this procedure lies on the acquisition of a possible effect that such variables may have upon fluctuations in the price level p^f over the period 1980-2012. As a result, a time series analysis is adopted for each 3-digit level sector rather than a fixed/random effects model. This action reflects the main concern of estimating the elasticity of all variables throughout a given period and not by considering their effects as fixed[28]. The latter methodology was more suitable under the conjectural variation approach given the necessity of extracting the aggregate elasticity of demand in order to be used in the supply function and thus, acquire the conjectural variation indicator of each 3-digit sector. However, in this case, elasticity of cost variables with respect to output and the remaining three price indices are of great importance in order to test whether they appear to have any significant effect on the wholesale price index p^f [29].

The properties of equation (31) appear to be the same for many 3-digit sectors compared to the manufacturing industry. In conjunction with evidence of serial correlation in

[28] See Table 8. The significance of the Breusch-Pagan (LM) test verifies the absence of cross sectional dependency between the residual terms of the sample's entities.
[29] See Appendix B2 for an Error Correction Model estimation process.

the standard errors in the study of Bedrossian and Moschos (1988), in this study there is evidence of serially correlated errors as well. A possible reason could be, as identified by the authors, that unit capital cost is not considered to be constant throughout the testing period. However, the main arising issue in the estimation of the manufacturing industry and each 3-digit sector respectively corresponds to the presence of heteroskedasticity. This means that a degree of variability may be observed among the 3-digit sectors because the including variables of the pricing equation may appear to have a different effect on the price level index of each individual sector (a more descriptive analysis will be provided in chapter 6).

Intuitively, the selection of such equation was made based on the reasoning that wholesale prices are influenced by changes in cost parameters, past pricing behaviour, foreign pricing behaviour and tax implementations on sales. Specifically, cost parameters reflect the most objective factor that can influence nominal price level directly because changes in input prices and especially, input price increases most of times lead to an increase in the nominal price level. This means that an increase in unit costs may cause an increase in wholesale prices because since the price of inputs has increased, the price of output will be increased as well but not necessarily with the same rate. Secondly, past pricing behaviour may part a crucial role on present pricing decisions. It captures every condition that has formed the nominal price level index at time *t-1* and through a process of adaptation those conditions will be taken into account at time *t*. This implication means that long-term effects or policies, such as tax implementations or any other fiscal policy, will always be captured by present and future pricing decisions.

Lastly, foreign pricing decisions may have an effect on domestic pricing behaviour as well, especially if those sectors are interacting in the same markets. Given that condition, they will behave as competitors and thus, try to influence the level of nominal prices in order to attract the maximum portion of potential demand. An interesting way to test whether such conditions hold between domestic and foreign sectors (*EU27*) would be to take into consideration the level of imports and exports of the Greek manufacturing sectors. However, an examination of the possible role of the European Union suppliers in domestic markets and of exportation of domestic manufacturing products was attempted in the last step. The impact of two additional variables on the speed of price adjustment was tested: *imp* defined as the ratio of imports by sector over sales and *exp* defined as exports by sector over sales, as indicated by Bedrossian and Moschos (1988). The estimations obtained by such variables were highly insignificant in that equation by validating the findings of Bedrossian and

Moschos, while the remaining coefficients were slightly changed[30]. This means that the price of inputs used in production may result in a similar change in both domestic and foreign prices.

4.3.Third Step: Assessment of the Manufacturing Industry Performance over the Period 1980-2012.

In the third step, the study takes into consideration the performance of the manufacturing industry over the period 1980-2012 in order to obtain the estimates of market power and price rigidity indexes. However, the focus of this step is placed on the sub-period 2005-2012, which is a turning point for the Greek economy. In particular, over the latter time sample, the significance of economic fluctuations is quite important. It covers a time range from the post-era of the Olympic Games till the first years of the austerity policies implementation. The first milestone of this period concerns the Olympic Games of 2004 which was expected to be one of the most important projects. As an outcome of this event, aggregate economy was expected to flourish by resulting in increased exports, as well as capital imports due to expectations of an upward trend in output growth (Kasimati, 2003). The second milestone regards the financial crisis occurred in 2008 and its impact upon global economy, while the last milestone regards the beginning of the austerity policies era for Greece in 2010.

The difference of this step compared to the cross-sectional analysis lies on the fact that dummy variables for each sector are replaced by time dummy variables (time series specification) for each year over 1980-2012. According to these estimates, the market conditions over the sub-period 2005-2012 are identified in order to see (*i*) whether positive fluctuations in the Greek economy have affected the performance of the manufacturing industry; (*ii*) whether there was any impact on production decisions or market power over the pre-financial crisis period; and (*iii*) how the Greek economy and particularly the Greek manufacturing industry structure have been affected by the implemented austerity policies. Therefore, the main interest of the present study is to test whether the measures of market power and nominal price rigidities were affected over this period as a result of fluctuations in aggregate economy.

[30] In addition, there is also evidence of non-stationarity persistence in levels for both imports and exports series (see Appendix B2).

4.3.1. *The Conjectural Variation Approach*

As mentioned above, in this step sectorial dummy variables are replaced by time dummy variables which can capture the effects of market power fluctuations within the Greek manufacturing industry. As pointed out by Görg and Warzynski (2003), it is very difficult to assume that the degree of market power has remained constant over time, as it is assumed when cross-sectional dummy variables are used. However, many studies estimate average market power over a certain time period, when other studies, like Levinsohn (1993), take into account firm level data with a smaller time span which attempt to capture structural adjustments. In this study, the measure of market power will be estimated along with the degree of nominal price rigidity for the Greek manufacturing industry over the period 1980-2012.

Nevertheless, it is worth mentioning that this approach cannot capture any fluctuations of such measures over time for each 3-digit sector individually. Since 3-digit level data constitute the micro-part of this analysis, while 1-digit level data part the macro-part, it is needed to include 4-digit level data in order to estimate any changes in such variables for the 3-digit sectors. However, the data set needed for this analysis in a 4-digit level were not available for each sector and therefore, the use of 3-digit data is selected as the basis of this study. Another argument could be that 2-digit level data should have been considered as the macro-part and thus, changes over time for 2-digit level sectors should have been estimated. The reasoning for excluding this element lies on the fact that 2-digit level estimates would not provide the best possible macro aspect of the manufacturing industry. They may be aggregated but they cannot generate the same results as the whole Greek manufacturing industry. This means that 2-digit data may be available but they can be regarded as the second best choice for both the micro and macro-part of this study.

By following a similar procedure as in the previous step, the supply function for the Greek manufacturing industry is given by

$$s_{Yt}[1+\frac{f_{1980}}{h}+\sum_{t=1981}^{2012} DT_t(\frac{f_t}{h})] = a_y + a_{yy}\ln Y_t + g_{ly}\ln(\frac{ULC_t}{UKC_t}) + x_{ty}T \qquad (34)$$

where f_{1980} is the conjectural elasticity for year *1980*, f_t is the change in conjectural elasticity with respect to f_{1980} and DT_t is a time dummy variable ($t=1981,\ldots,2012$) which is set to one for year t and zero otherwise. As in the previous step, the right hand side estimations can be extracted from (25) and (25a), while the aggregate (industry) demand elasticity for this case must be estimated from the relevant demand function. Once again, in the supply function of this form, the first year of the sample is treated as benchmark in order to estimate the changes of the rest sub-periods with respect to 1980.

The demand function is estimated as in the second step by replacing the cross-sectional dummy variables with time dummy variables. However, under this approach, the time dummy variables are applied only to the industry price elasticity and elasticity of liquidity with respect to output, in order to identify their effect over 2005-2012 in the Greek manufacturing industry. Once again, the estimation of the former elasticity is extracted by the second regression, i.e. where the only changing variable is liquidity. The set of demand functions is given by

$$\ln Y_t = \begin{bmatrix} a_5 \\ a_6 \end{bmatrix} + \begin{bmatrix} h_{2005} \ln p_{2005} \\ h^{liq}{}_{2005} \ln ms_{2005} \end{bmatrix} + \sum_{t=2006}^{2012} DT_t \begin{bmatrix} h_t \ln p_t & 0 & 0 & 0 \\ 0 & 0 & 0 & h^{liq}{}_t \ln ms_t \end{bmatrix}$$

$$+ \begin{bmatrix} 0 & h^z \ln z_t & h^H \ln herf_t & h^{liq} \ln ms_t \\ h \ln p_t & h^z \ln z_t & h^H \ln herf_t & 0 \end{bmatrix} + \begin{bmatrix} u_{5t} \\ u_{6t} \end{bmatrix} \qquad (35)$$

where h_{2005} and $h^{liq}{}_{2005}$ denote the industry price elasticity and liquidity elasticity with respect to output for year *2005*, h_t and $h^{liq}{}_t$ denote the change in respect to h_{2005} and $h^{liq}{}_{2005}$ respectively, DT_t is a time dummy variable (t=2006,…,2012) which is set to one for the year t and zero otherwise, h, h^z, h^H and h^{liq} are considered to be measures of elasticity which are fixed across the time sample in each regression respectively and $\vec{u}_t$ represents a vector of random errors which are correlated with the independent variables, by indicating the problem of endogeneity as in the former equations of demand.

This set of equations provides detailed estimations for the industry price and liquidity elasticity with respect to output by using time dummy variables in order to estimate their effect in the Greek manufacturing industry. In particular, the sectorial sample is categorized as a 1-digit level industry, where the effects for each 3-digit sector are considered as fixed. This assumption holds since the manufacturing industry reflects the macro-part of the analysis and therefore, the extracted estimations address the behaviour of the whole industry.

Another characteristic of (35) regards the time sample taken into consideration. A time sample over the whole period 1980-2012 could have been used, as in supply function, by including 33 years. Subsequently, the effects of any changes in industry price and liquidity elasticity with respect to output could have been identified. However, the reason for which this part has limited the testing years into 8 refers to the significance of the estimated values. Whereas the current *t*-statistic values of both demand estimates are significant at the 1% level of significance, they fail to provide similar results when every year is included in the analysis. As the year span is extended, a number of estimates tend to be insignificant even at the 10% level of significance, especially for the liquidity index.

Additionally, time dummy variables have been applied only to the aggregate industry's elasticity of price and liquidity with respect to output. This is chosen because the effects of investments and sales concentration on production decisions (output) were insignificant for a number of years over 1980-2012 as well. However, their effect over the whole period has been found to be significant (see chapter 6), which is treated as fixed. For this reason, a time sample over 2005-2012 has been used by excluding the two extra equations of demand function under which time dummy variables are applied to investments and sales concentration.

The main focus of the conjectural variation approach under this specification is based on the estimation of price and liquidity fluctuations. On the one hand, pricing decisions appear to have an effect on the manufacturing industry's output decisions given fluctuations of the economic policies implied over 1980-2012. On the other hand, it is very interesting to test the effect of such changes in output with respect to money supply. The manufacturing industry is considered to be one of the most important industries due to the provision of commodities that satisfy people's primary needs, such as food or clothing. This means that changes in money supply may have an insignificant or a highly inelastic effect on output since consumption of such products cannot be substituted. Therefore, even if money supply is greatly reduced under the form of income or any other earnings, consumption decisions may remain the same for a category of products which may not have any substitutes and thus, render their purchase as obligatory.

4.3.2. A Measure of Price Rigidity: The Speed of Price Adjustment

The last approach of this step regards the estimations extracted from pricing equation (38) for the Greek manufacturing industry over the period 1980-2012. In particular, it is mentioned in *4.1.3* that the first step will provide the estimates of the pricing equation according to the methodology of Bedrossian and Moschos (1988) over the whole time period. The second step will take into account 56 time series for each 3-digit sector respectively in order to test the elasticity of the wholesale price level P^f with respect to cost fluctuations along with fluctuations in the three price indices taken into account. In this step, the effects of lagged pricing decisions (*t-1)* for the Greek manufacturing industry over the period 1980-2012 are estimated. This means that a time dummy variable will be used, proposed in section 4.3.1, DT_t (*t=1981,…,2012*), which is set to one for the year *t* and zero otherwise. The estimations are provided by the following regression

$$\ln P^f{}_t = \lambda' c_0 + \lambda' c_1(\ln Y_t - \ln \widehat{Y}_t) + \lambda' \beta_1 \ln ULC_t + \lambda' \beta_3 \ln UKC_t + (1-\lambda_{1980}) \ln P^f{}_{t-1}$$
$$+ \sum_{t=1981}^{2012} (1-\lambda_t)(DT_t * \ln P^f{}_{t-1}) - \lambda_1'(\lambda^{eu} - \lambda)(1-\lambda^{eu}) \ln P^{eu}{}_t + \lambda_2'(1-\lambda^T) \ln P^T{}_t + \varepsilon_t \quad (36)$$

In this step as well, unit costs instead of input prices are regarded in order to capture the relationship between total remunerations, gross capital expenditures and output expressed in terms of total value added. Specifically, the effects of unit costs are treated as fixed throughout the time sample while allowing only for variable P^f_{t-1} to vary each year over 2005-2012. This reasoning is based on the interest of this study to test the effects of fluctuations in price indicators rather than input price indicators. The estimations of input prices for a given time period are considered to be sufficient for the necessity of the empirical implications of this step. Also, the error term ε_t is described by the same properties as in the previous steps where there may be no serial autocorrelation but the effects of heteroskedasticity are still present.

The main interest behind this approach is focused on the effect of lagged pricing decisions on the final wholesale price level over the sub-period 2005-2012. Once again, by using this specification for the pricing equation, the estimated results will be identified as whether such decisions have been subject to changes in aggregate economy or resulted in uncorrelated behaviour with such fluctuations. The main intuition for using a time series specification for the Greek manufacturing industry lies on the interest in testing the pricing and production behaviour of the whole industry for a given time period. Instead of limiting this study to the sub-period 2005-2012, it has been chosen to include every year in order to obtain an overall and accurate set of estimates of the speed of price adjustment over the whole period 1980-2012.

The reason of this argument depends on the description of the transition from a prosperous and growing economy (2005-2008), to a slightly declining (2008-2009) and ultimately, to a plunging economy (2011-2012)[31] expressed in terms of Gross Domestic Product and aggregate demand. As a result of such effects which describe the aggregate behaviour of individual sectors, it is of great interest to test whether there has been a significant effect upon the Greek manufacturing industry's activities. Based on that result, it would be beneficial to identify how production and thus, pricing decisions have been shaped according to the unit cost and pricing factors included in the pricing equations.

4.4.Fourth Step: Determinants of the Speed of Price Adjustment

In the previous steps, the estimations regarding the market power indices can be extracted along with the indicator of price rigidity corresponding to the speed of price adjustment. In this final step, one regression is estimated that takes into account a set of supply-side variables that may appear to have an influence on the speed of price adjustment. The estimations extracted from those regressions will be able to provide an interpretation regarding the level of those two indices and their relationship with the undertaken variables.

In particular, Bedrossian and Moschos (1988) argued about the distinction observed between the level of profitability in firm and industry level by analysing the effect of market concentration on the speed of price adjustment. The "leadership effect" which is connected with interfirm profitability differentials within an industry and the "industry profitability effect" are likely to have a negative impact on such adjustment. This means that concentration may appear to have a positive influence only if the first effect overcomes the impact of the latter. Otherwise, the relationship between market concentration and the speed of price adjustment will be negative.

[31] See Tsakalotos (2011) and *EL.STAT.* database.

Another determinant of this indicator may be the volume of sales of each sector that can enhance the leadership effect. In conjunction with market concentration, an indicator of sales may also provide a relationship with the speed of price adjustment as a determinant of the size of the industry (Olive, 2008). The greater the size of the industry, the less rigid the price level will be because bigger firms can defray their costs easier than smaller firms. However, the influence of this indicator on the speed of price adjustment depends on the very nature of the industry and its returns to scale. For instance, industries with constant or diminishing economies of scale (increasing average cost as production increases) may appear to change their prices more often than other industries due to the fact that an increase in sales may lead to an increase in production and thus, an increase in average cost. This means that if average cost reaches a higher level, then the price level must be increased accordingly in order for profits to remain at the same level. Therefore, as sectorial sales increase, the speed of price adjustment may increase by rendering the occurrence of collusive agreements in favour of price rigidities very difficult.

Lastly, even if the volume of sales within an industry may affect the degree of price rigidity, it may not be a sufficient indicator unless average costs are taken into account in order to define the industry profitability effect. The very nature of those costs, both fixed and variables, may be able to capture the rigidity of the nominal price level, especially in sectors where firms are characterized by collusive behaviour. If competition is limited, then downward price rigidities may appear regardless fluctuations in average costs. Otherwise, changes in costs may have a positive effect on the speed of price adjustment. Bloch and Olive (2003) and Olive (2008) take into consideration in their pricing equation only the average variable cost instead of the average total cost. In this study’s pricing equation both unit labour and capital costs are considered in order to test their individual effect on pricing behaviour. For this reason, the average total cost measure is included in the price adjustment equation in order to test the total effect of cost fluctuations. Even if labour input fluctuations are more frequent than capital fluctuations, the latter may have a greater influence compared to the former.

4.4.1. *The Speed of Price Adjustment Formulation*

The regression of this step is concerned with the values of the speed of price adjustment (λ) for the 56 3-digit sectors of the Greek manufacturing industry. The estimations of λ have been extracted from equation (31) for each 3-digit sector and provide an average measure of price rigidity over the period 1980-2012. The analysis estimates this particular equation for each year over the period 2005-2012. These years have been taken into consideration firstly, because of the available data set under which the important indices of this equation can be calculated and secondly, due to their economic significance for the Greek markets. In particular, 2008 may describe how 3-digit manufacturing industry behaved when the global financial and economic crisis erupted; 2010 may capture the behaviour of those sectors when austerity policies were implied on the Greek economy by leading to a plunge of aggregate income and thus, aggregate demand; 2011 and 2012 take into consideration the years after the implication of the austerity policies which may reflect a better description of the effects that those policies have inflicted on the Greek manufacturing industry.

The cross-sectional approach may not provide an average effect of the independent variables of this regression on the speed of price adjustment for the 3-digit manufacturing sectors; however it may offer a better approximation of the values of the structural variables. This means that under small fluctuations between lagged prices (P_{t-1}) and current target prices (P_t), the cross-sectional variation of the average industry should be relatively small compared to the cross-sector variation in the structural variables. This influence refers to an aspect incorporated in the present empirical model (Olive, 2008). The basic estimation of the speed of price adjustment is of the form

$$\lambda_i = \gamma_0 + \gamma_1 CR4_{di} + \gamma_2 SIZ4_{di} + \gamma_3 AC_{di} + \gamma_4 f_i + \upsilon_i \quad (37)$$

where *CR4* is the 3-digit manufacturing sector concentration ratio for the four largest 4-digit level firms, *SIZ4* corresponds to the average sales across the four largest 4-digit level firms in the 3-digit sector, *AC* refers to the average total cost of each sector, f_i represents the conjectural variation elasticity of each sector and υ_i is an independent error term for which $\upsilon_i \sim (0, \sigma^2{}_{\upsilon})$[32].

[32] The speed of price adjustment equation (37) has been formulated according to Domberger (1979), Dixon (1983), Bedrossian and Moschos (1988), Martin (1993) and Olive (2008). The additional variables included in this study refer to the average total cost and the conjectural variation elasticity in order to test the influence of market power and total cost fluctuations on the speed of price adjustment. However, the length of production

To begin with, equation (37) follows the formulation provided by Olive (2008) by adding weighted average indicators across all sectors of the manufacturing industry. This approach has been selected in order to increase the accuracy of the estimations and avoid any extreme temporarily fluctuations of these measures. For instance, assume there is an unexpected fluctuation in a particular sector which had only occurred for one year and does not provide an accurate description of that sector's behaviour. Consequently, by adding a weighted average indicator the impact of that fluctuation can be restricted and be converged towards its average value. Since the selected years may be described by such fluctuations which may or may not persist in the long-run, the use of such method may provide more credible estimations.

In particular, $CR4_d$ is the ratio of sales of the four largest firms of each 3-digit sector to the value of the manufacturing industry over the period 2005-2012[33]. It is obtained by multiplying *CR4* by the ratio of 3-digit sector sales to the value of the manufacturing industry; $SIZ4_d$ corresponds to the average measure of sales for the four largest 4-digit firms over the period 2005-2012. It is obtained by multiplying the four-firm concentration ratio *CR4* by the sales of the sector and dividing by four; AC_{di} represents the average total cost of each 3-digit sector over the period 2005-2012. It is obtained by multiplying *AC* by the ratio of 3-digit sector total cost to the total cost of the manufacturing industry; lastly, f_i is the conjectural variation elasticity of each 3-digit sector and is obtained by the supply function (32)[34].

However, the indicators of market power *CR4* and *f* differ in the nature of their formulation. The first variable is an indicator expressed in terms of sales by capturing the tendnency of the four 4-digit sectors with the highest value of sales over a time period. This means that the *CR4* ratio is an indicator of sales arising in a particular 3-digit and thus, it refers to the conditions of that sector by neglecting any interactions with other 3-digit sectors.

period (production lag) has not been taken into account, despite its inclusion in many of the above studies, due to limited data for the whole set of the manufacturing industry.

[33] The value of the manufacturing industry refers to the value of sales in the domestic market by including changes in the volume of imports. Katics and Petersen (1994) and Ghosal (2000) provide evidence that an increase in the share of imports of the U.S. manufacturing industries, may weaken the market power of the incumbent firms that face a high degree of concentration (Olive, 2008).

[34] $CR4_d = \frac{\sum_{i=1}^{4} Sales_{i,4-digit}}{Sales_{1-digit}} * \frac{Sales_{3-digit}}{Sales_{1-digit}}$, $SIZ4_d = CR4 * \frac{Sales_{3-digit}}{4}$,

$AC_d = \frac{TC_{3-digit}}{Y_{3-digit}} * \frac{TC_{3-digit}}{TC_{1-digit}}$, $f_i = (\frac{\partial Y}{\partial y_i} * \frac{y_i}{Y})$

On the other hand, the conjectural variation elasticity takes into account the behaviour of every 3-digit sector and reflects its influence on the aggregate industry. As a result, this variable captures production decisions upon the aggregate industry and thus, it is an indicator of market power reflecting the structure of the market. For this reason, both measures have been included in order to provide robust results about the profitability effect in the Greek manufacturing sectors.

An additional reson behind the selection of these variables lies on the theoretical significance that concentration and cost indices may have on the speed of price adjustment. Specifically, sales part a very crucial market factor that may affect both production and pricing decisions in the long-run. Persistent increases in demand for a sector's products will tend to drive production up and thus, sales which will in turn increase the concentration ratio of that sector. This means that a boost in production may result in an increase in average or even marginal cost by resulting in an increase of the price level.

On the other hand, even if an increase in production does not have a significant effect on variable costs, the additional portion of demand served by a sector may result in higher market power for that sector. Such effect may also result in higher nominal prices, given the nature of the product, its elasticity of demand, and the number of substitutes which may satisfy the same needs of consumers. According to those characteristics, the conjectural variation elasticity which has been taken into consideration in the previous steps may provide a significant influence on the speed of price adjustment. Intuitively, market power results in lower production accompanied by relatively high prices which may appear to be both upward and downward rigid. Downward rigidity may persist as long as there are not significant changes in the demand curve for the products of that sector for a given price level, while upward rigidities may occur due to the uncertain effect an additional price increase may have on consumers. Based on this rational, a fall in the level of production may appear to have a similar effect on the speed of price adjustment given that market power is exercised on consumers.

As has been argued by Bedrossian and Moschos (1988), since λ_i is estimated from the pricing equation (31), the estimations $\hat{\lambda}_i$ are used instead, which are cross-section observations and have their own variance var($\hat{\lambda}_i$). This means that the estimating equation takes the following form

$$\hat{\lambda}_i = \gamma_0 + \gamma_1 CR4_{di} + \gamma_2 SIZ4_{di} + \gamma_3 AC_{di} + \gamma_4 f_i + w_i \quad (38)$$

where w_i is a composite error terms with variance $\sigma_W{}^2 = \sigma_v{}^2 + var(\hat{\lambda}_i)$, by assuming that the terms of the right hand side are independent. This indicates that the errors w_i appear to be heteroskedastic while the extend of heteroskedasticity depends on the importance of $\sigma^2{}_v$ and var($\hat{\lambda}_i$). However, since $\sigma^2{}_v$ has been assumed to be constant, the properties of var($\hat{\lambda}_i$) are not known. If var($\hat{\lambda}_i$) appears to have linear properties, then the variance of the composite error terms w_i will be of known form; otherwise, their variance will have non-linear properties. Therefore, the type of heteroskedasticity may not be known and thus, only a few tests may be applied (see chapter 5) in order to acquire heteroskedastic-consistent estimations.

Overall, an indicator of market power and of nominal price rigidity will be analysed in three steps in order to identify the market structure and pricing behaviour of the manufacturing industry and the manufacturing sectors over the period 1980-2012. The results obtained by those steps will be considered in the fourth and last step, which incorporates market factors that promote sluggish or flexible pricing decisions. The relationship between nominal price rigidity and market power will be tested in order to investigate whether the former concept is caused by the latter and thus, whether sluggish pricing decisions are affected by market power acquisition. For this reason, the measures of λ_i and f_i have been chosen to test this particular outcome by either validating or rejecting the profitability effect.

5. Econometrics Approach and Estimation Methods

5.1. Panel Data Analysis

The current chapter analyses the econometrical methodology which has been used in order to extract the empirical results of the equation systems presented in chapter 4. In particular, as mentioned above, this study is focused on providing the degree of market power (i.e. conjectural variation elasticity) along with the speed of adjustment in the Greek manufacturing industry. For this reason, the sample comprises data in an annual basis over the period 1980-2012 for 56 3-digit *NACErev2* level sectors of the whole manufacturing industry based on the Statistical Nomenclature of Economic Activity of 2008 (*STAKOD_2008*). The constituent 3-digit sectors of the Greek manufacturing industry are presented in Table A. The selection of the data sample was based on the available data provided by the Hellenic Statistical Authority (*EL.STAT.*) database. In particular, the bulk of data has been obtained from the Annual National Industrial Survey (*AIS*) of the Hellenic Statistical Authority, the European Statistical Authority (*Eurostat*), the Bank of Greece (*BoG*) and the Organization for Economic Co-operation and Development (*OECD*). This means that the secondary data set which has been taken into consideration in this study forms a panel data sample of 56 cross section entities and 33 time points, which conclude the number of total observations to 1840[35].

A panel data analysis will be helpful in order to identify the behaviour of the 3-digit manufacturing sectors regarding their market power and their pricing decisions. In particular, under this kind of analysis it is able to observe any fluctuations of the crucial measures of interest over the time period sample for each of the 56 3-digit sectors (cross sectional specification). Also, it is able to observe such fluctuations for the whole manufacturing industry for each year individually (time-series specification). This means that panel data analysis allows for individual estimations, either in terms of cross-section or time series, which may result in sufficient estimations for the purpose of this study[36].

[35] The statistical software used to estimate the model of the present study are *Stata 10* and *Eviews 8*.

[36] If it is assumed that the number of sectors is *N* and the number of years *T*, a solely cross-sectional analysis takes into consideration the estimations for each sector for only one year (*Nx1*), while a time series analysis regards the estimations of one sector throughout the whole time sample (*1xT*). On the other hand, a panel data analysis allows for the dimension of the above matrices to be *NxT*, where $N>1$ and $T>1$.

It is worth mentioning that the estimation process of the present model could also be carried out by employing the VAR methodology for panel data. However, given the presence of panel series stationarity, a simple regressions analysis of fixed and random effects is chosen. In addition, given that the same methodology is adopted by the studies of Rezitis and Kalantzi (2012, 2013), it is of great significance to compare the results under the same methodological procedure. In addition, the cross section approach of the pricing equation is estimated both as a simple regression and as a vector error correction model in order to compare and contrast the results and thus, their consistency to the study of Bedrossian and Mochos (1988). Therefore, the underlying methodology is in accordance to the aforementioned studies in order to validate and extend the significance of the results in a policy framework.

Hsiao (2014) argues that panel data analysis may provide more accurate inference of the parameters taken into consideration, since they appear to have both great sample variability and a satisfactory number of degrees of freedom. Some other benefits of this analysis correspond to the possibility of controlling individual heterogeneity or allowing studying the dynamic behaviour of the sample. Individual heterogeneity may appear to have a significant role to the interpretation of the estimated results due to the fact that past implications adopted under the assumption of homogeneity may be falsified. In the present case, the 3-digit level analysis may be considered to appear an intermediate degree of heterogeneity, as discussed in section 4.2.1.

Therefore, the interactions and pricing decisions, along with any other parameters that may affect the market power of each sector must be treated carefully. The reason for this argument results from the necessity of acquiring efficient estimations of the degree of market power without allowing any biases to rise due to any type of misspecification. On the other hand, dynamic relationships among the undertaken measures of the analysis rely on the differences observed among the inter-individual sectors. The validity of such relationships lies on the reduction of the degree of collinearity between current and lag variables, which may provide more robust estimates for unrestricted time-adjustment patterns (Pakes and Griliches, 1984).

Another element which is of great importance to this study regards the micro-foundations of aggregate data analysis. As Hsiao (2007) argues, aggregate data analysis often takes into consideration the assumption of the "representative agent", or in this case, the assumption of the "representative firm". However, since the sample (among others) consists of heterogeneous micro units, the acquired properties under a time series analysis may result in different estimates of aggregate compared to disaggregate data (Granger, 1991; Lewbel, 1994; Pesaran, 2003). This means that such estimations may be biased and thus, indicate an incomplete or even falsified interpretation of market behaviour.

For this very reason, this study intends to include the most disaggregate level of the manufacturing industry possible, based on the limitation of data acquisition and the transformation necessary for the undertaken analysis. Although a moderate degree of heterogeneity emerges under the consideration of 3-digit level data, the underlying methodology (see chapter 4) attempts to minimize that effect. It also intends to provide robust estimations according to both cross-sectional and time series specifications for each sector and generally, for the Greek manufacturing industry.

Following the choice of forming a set of panel data in this study, the next step regards the methodology which will provide the analysis of that set and result in the estimation of the important coefficients. In particular, the main issue that may arise under a panel data analysis corresponds to the importance of the error term's properties. It can determine the type of methodology it should be used to obtain both unbiased and efficient estimations. Those properties may address the problem of whether the error term may vary non-stochastically or stochastically over time t or sector i, which requires a special treatment of the error variance-covariance matrix. Based on those assumptions, the following approaches/models were selected: the *Fixed Effects* model, when at least one explanatory variable is correlated with the heterogeneous individual effects term and the *Random Effects* model, when the error term of the constituent entities is serially correlated but there is no correlation between the explanatory variables and the individual effects (Wooldridge, 2002).

The fixed effects model is used to explore the relationship between the independent and dependent variables within an entity, which in this case corresponds to the manufacturing sectors. The very definition and nature of that entity can result in a unique set of individual characteristics that may influence the value of the estimated parameters. The major market variables in this study are considered to be conjectural variation elasticity and the speed of price adjustment. This means that based on the characteristics of the manufacturing sectors, the market variables will get the analogous values consistent with the behaviour and market characteristics of the manufacturing industry.

According to Baltagi (2001), a general case of a one-way linear unobserved individual effects model for *N* individual observations and *T* dated periods has the following form

$$y_{it} = \alpha + X'_{it}\beta + \mu_i + u_{it}, \text{ for } i=1,\ldots,N \text{ and } t=1,\ldots,T \tag{39}$$

where y_{it} is the dependent variable for individual i and time t, α denotes the overall constant term of this regression, X'_{it} represents the transpose time variant regressors' vector ($1xk$), μ_i corresponds to the time invariant individual effects term which also addresses the cross-sectional effects (random or fixed) and u_{it} is the idiosyncratic error term. Unlike the vector of regressors X'_{it}, the time invariant individual effect μ_i cannot be easily estimated (i.e. due to historical or institutional factors). The fixed effects model considers that the heterogeneous individual effects term is correlated with the vector of regressors. Since μ_i cannot be controlled directly, the fixed effects model demeans (39) by using the following transformation

$$y_{it} - \bar{y}_i = (X'_{it} - \overline{X'}_i)\beta + (\mu_{it} - \bar{\mu}_i) + (u_{it} - \bar{u}_i) \tag{40}$$

where $\bar{y}_i = \frac{1}{T}\sum_{t=1}^{T} y_{it}$, $\overline{X}'_i = \frac{1}{T}\sum_{t=1}^{T} X'_{it}$ and $\bar{u}_i = \frac{1}{T}\sum_{t=1}^{T} u_{it}$. Since the time invariant individual effect is fixed, then the difference from its mean will be zero and thus, its impact from regression (39) is eliminated. In order to extract the estimator for the fixed effects model $\hat{\beta}_{FE}$, the analysis has to take into account the degree of correlation between the individual effects term and the vector of regressors. For this reason, the problem of endogeneity arises under which the OLS estimator may not result in unbiased and consistent estimates (see section 5.3)[37].

The main assumption behind the consideration of this approach lies on the fact that a set of characteristics within that entity may affect or bias the market variables. Therefore, a solution must be found in order to control and avoid any biased estimations. This problem occurs due to the presence of correlation between the individual effects term of the entity and the independent variables by raising the problem of endogeneity. In order to eliminate the effects of those time invariant characteristics from the independent variables, as well as acquire consistent estimations, the fixed effects approach is considered to be the most suitable (Kohler and Kreuter, 2005). As Bell and Jones (2015) mention, the problem of endogeneity

[37] A different specification of equation (40) may be provided by including dummy variables as has been presented in sections 4.*2* and 4.*3*. By doing this, the fixed effects model corrects the estimations from heterogeneity bias by taking into account the variation between the time variant variables (i.e. regressors) and the time invariant effects.

may result in inconsistent estimates due to omitted variables, simultaneity, sample selection or measurement error.

However, as mentioned above, the panel sample used in this analysis is subject to a degree of heterogeneity which is caused by the selection of 3-digit level data. Consequently, any bias that may occur due to the presence of endogeneity may be addressed as "heterogeneity bias" (Bento, Li and Roth, 2012)[38]. The reasoning behind this argument lies on the fact that the fixed effects model uses orthogonal projections in order to remove any cross-section or period specific means from the dependent and the independent variables[39]. This procedure is performed on the specified regression of the demean as presented above (Baltagi, 2001).

Another important aspect of the fixed effects approach is that time invariant characteristics are unique to each individual entity, the 3-digit level sectors, and should not be correlated with other individual characteristics. This model incorporates all time invariant differences between the individual entities in order for the estimated coefficients to be unbiased and consistent. Each individual entity is different and thus, its error and constant term should not be correlated with others. When the individual effects term of each entity is correlated with the error term, the fixed effects approach cannot provide efficient inferences. As a result, a different method must be used that takes into consideration the *between* correlation of those terms for each of the constituent entities.

A limitation that arises from such correlation addresses the fact that the fixed effects model cannot be used to investigate time invariant causes of the explanatory variables. This limitation occurs because time invariant characteristics are perfectly collinear with the individual entities (Kohler and Kreuter, 2005). This means that the fixed effects model is solely designed to study changes within a set of entities. That property may fail to produce efficient inferences whenever there is evidence of correlation between the individual effects and the error term of the entities.

Since the fixed effects model may not be suitable to address the presence of serial correlation, the second methodology refers to the random effects model. In particular, under

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[38] This form of bias may persists whenever the random effects estimation is used in order to analyse data with non-zero correlation between the regressors and the individual effects term. Under such cases, the fixed effects model is more suitable because it accounts for a stochastic error term.
[39] In this case, a one-way linear model has been included by allowing only for individual time invariant characteristics. An extra term γ_t could have also been added which would account for periodic specific effects.

this approach the variation across individual entities is assumed to be random and uncorrelated with the independent or predictor variables included in every regression. However, the problem of endogeneity must not rise when the random effects model is taken into consideration. Green (2008) argues that the most important distinction between the fixed and the random effects model concerns the fact whether the unobserved individual effects involve several elements that are correlated with the regressors in each equation. As a result, the latter model does not account the presence of endogeneity. This means that the presence of a stochastic behaviour, which introduces variations in the dependent variable that cannot be explained on the basis of the independent variables, is important for the use of the fixed effects model whenever there is no serial correlation. Otherwise, the random effects model is chosen where the error term is random from one measurement to another.

A simple random effects model that addresses the characteristics of this study has the following form

$$y_{it} = \beta_{0i} + X'_{it}\beta_1 + u_{it}, \text{ for } i=1,\dots,N \text{ and } t=1,\dots,T \quad (41)$$

and $\beta_{0i} = \beta_0 + w_i$

By substituting the latter into the former equation, it is obtained

$$y_{it} = \beta_0 + X'_{it}\beta_1 + (w_i + u_{it}) \quad (42)$$

where y_{it} is the dependent variable for individual i and time t, β_0 denotes the overall constant term and X'_{it} represents the transpose time variant vector of regressors ($1xk$). Those terms can be viewed as the "fixed part" of this model, as was introduced in equation (41). On the other hand, the "random part" consists of the two error terms w_i and u_{it} which are correlated. In particular, w_i is the individual effect for each entity $i=1,\dots,N$, which allows for differential intercepts over the given time sample and u_{it} corresponds to the individual entity error term $i=1,\dots,56$ for each year $t=1980,\dots,2012$. If it is assumed that both of those terms are independent identically distributed with zero mean and constant variances σ^2_w and σ^2_u respectively, then each individual entity i, along with the time sample t, come from a single distribution which is estimated based on the available data set.

The term w_i which reflects the individual specific within effect may follow the same properties with the individual effect μ_i in equation (39). In addition, if in equation (42) each individual entity was treated as an average or as an aggregate entity (i.e. 1-digit level), then the average effect of w_i would be zero. This means that if a time series specification under an average entity is to be taken into consideration, the error term w_i could be replaced by a different error term i.e. w_t, which would allow for differential intercepts for every time t. This term can be identified as the γ_t periodic specific effect and can also be added in equation (39) to provide a two-way linear unobserved effects model.

The random effects model is best suited when there is evidence that differences across individual entities (i.e. individual effects) may have an influence on the dependent variable of a specific regression. An interpretation of this approach may address the assumption that cross-sectional (μ_i) and periodical effects (w_t), which emerge in this sample, are treated as realizations of independent random variables with zero mean and constant finite variance. Consequently, the error term of the constituent entities may not appear to have any correlation with the independent or predictor variables. This outcome allows for time invariant variables to be treated as explanatory variables. In contrast, the fixed effects model cannot be used to investigate the influence of time invariant variables on the dependent variable. This happens because such characteristics are assumed to be collinear with each individual entity and thus, they are absorbed by the intercept.

Another aspect of the random effects model regards the fact of specifying individual characteristics that part each entity which may or may not influence the independent variables. The problem in this argument lies on the fact that some observations may not be available for some years, which means that they will be excluded from the analysis. However, such omissions may lead to biased estimations which will result from misspecified regressions and thus, they will fail to provide correct inferences. A similar disadvantage that comes from using the random effects model regards the assumption of exogeneity due to the fact that the error term is not correlated with the explanatory variables.

In particular, the presence of endogeneity arises when multiple processes are related to a given time varying covariate (Bell and Jones, 2015). The time varying regressors X'_{it} may include two sub-vectors: one that regards the time period t and does not vary over the individual entities; and one which regards the differences between those entities i for each t (i.e. heterogeneous individual effects). Those parts of the vector of regressors address the effects occurring at time t, by treating each individual entity as given, and the effects occurring for each individual entity over the whole time period $t=1,\ldots,T$. In general, when the above misspecifications are avoided and unbiased results are obtained under the consideration of those two parts of X'_{it}, the random effects model may appear to be efficient. Its significance is important in cases where the fixed effects specification fails to provide sufficient interferences, under the assumption of the presence of correlation between the error term and the heterogeneous individual effects.

The estimation process of the set of regressions presented and analyzed in chapter 4 takes into account the manufacturing panel data set of this study. Therefore, the fixed and random effects models have been applied in most of those regressions. However, it may be rather difficult to accurately observe whether the individual effects term appears to be correlated with the regressors. Both models will result in different estimations but it may not be observed which one will provide the most accurate results[40]. The following section provides the econometrical methods that will be employed. The selection of such methods is based on the characteristics of the individual entities and the properties of the error term that arise in each regression.

5.2.Estimation Tests

The presence of heteroskedasticity and serial correlation in the error term of a single model may result in incorrect inferences under the implication of a number of estimation tests. In particular, some problems that may affect the selection of the appropriate test are based on the obtained value of the standard errors of the coefficients; the degree of multicollinearity observed among the predictor variables; the presence of endogeneity; and the correct specification of the model. Those issues reflect a part of the conditions that have to be taken into consideration in order to obtain correct inferences. For this reason, the estimators must be unbiased, consistent and efficient in order to provide the best available interpretation of the explanatory variables' influence on the dependent variable. Therefore, in this section, the estimation methods taken into account in this study are going to be analyzed, mostly based on the econometrics textbooks provided by Hayashi (2000) and Wooldridge (2002) and the guide of the econometrical software *Eviews 8*.

If a model is assumed under which none of the above problems occur, then the most suitable estimation method corresponds to the *Least Squares* (*OLS*) estimator. On the one hand, the use of this method is strictly connected with a set of assumptions which may be

[40] See Appendix B3 for the relevant diagnostic tests.

difficult to occur simultaneously in a single model. On the other hand, if such assumptions are satisfied, then the *OLS* estimator provides the best available inferences for the estimated coefficients. In particular, this technique is used for linear regression models in which the sum of squares of the vertical distances between the observed and the predicted measures of the linear approximation is minimized. It also accounts for any cross-equation restrictions on the parameters of the model that may determine the way of estimating the system of regressions. If such restrictions are absent, then each regression can be estimated separately[41]. By considering, once again, the simple regression form of (54), the distance between the observed and the predicted characteristics of the linear model refers to the sum of squares of the residual term for each observation

$$SSR = \sum_{i=1}^{N} \hat{u}_{it}{}^{2} = \sum_{i=1}^{N}(y_{it} - x'_{it}b)^2 = (y - Xb)'\,(y - Xb) \tag{61}$$

where $\hat{u}_{it}$ is the residual term of the regression model, y_{it} and x'_{it} correspond to the vector of the dependent variable and the transpose vector of the independent variable respectively, symbol $(')$ represents the matrix transpose and b denotes the estimator for which the *SSR* is minimized. This estimator reflects the *OLS* estimator of the β coefficient and it is extracted by the following expression

$$b_{OLS} = \text{argmin}_{b \in R}\, SSR(b) = \left(\frac{1}{N}\sum_{i=1}^{N} x_{it}x'_{it}\right)^{-1} \frac{1}{N}\sum_{i=1}^{N} x_{it}y_{it}) \tag{62}$$

The *SSR(b)* function is a quadratic form in respect with the estimator b with a positive-definite *Hessian matrix*, by indicating the existence of a unique global minimum under which $b_{OLS}=b$. Therefore, the *OLS* estimator will be expressed as

$$b_{OLS} = (X'X)^{-1}(X'y) \tag{63}$$

However, in order for the *OLS* estimator to provide correct inferences, a set of assumptions must be satisfied. Otherwise, the estimations suggested by this method may be subject to different types of misspecifications. These assumpitions refer to the linearity of the model, the strict exogeneity of the error term and the absence of multicollinearity between the regressors, the absence of serial correlation and heteroskedasticity from the error term. If all

[41] If the presence of cross-equation restrictions are present, such as cross-equation heteroskedasticity, then the cross-equation weighting technique is applied, under which the weighted sum of residuals' squares is minimized. Those weights are the inverse of the estimated standard deviations of vector *X* and they are derived by dividing them to the unweighted parameters of the model.

assumpitons are satisfied, then the error term follows normal distribution with zero mean and σ^2 variance.

Whenever the assumptions about the error term are valid, then the method which will result in unbiased, consistent and efficient estimations refers to the *Least Squares* technique. However, if one of those assumptions, such as the absence of heteroskedasticity and/or serial correlation in the error term is not valid, then different techniques must be adopted in order to result in correct inferences. The application of those methods depends on the nature of the occurring problem within the regression model and the necessary modification that has to be made to account for or eliminate those issues. A general case which treats the presence of both heteroskedasticity and serial correlation in the error term regards the *Generalized Least Squares* (*GLS*) method.

In particular, the same equation (44) is taken into consideration as before under which the error term has a mean equal to zero, but its variance is given by $Var(\varepsilon_i|X)=\Omega$, where Ω is a known variance matrix. If the error term appears to have a constant variance $\sigma^2 I_N$ and zero serial correlation, then the diagonal entries of Ω will be equal to $\sigma^2 I_N$, while the off-diagonal entries will be zero. However, if the presence of both heteroskedasticity and serial correlation in the error term is observed, this implies that the error term variance will not be constant anymore. In addition, their correlation will be different than zero, by denoting that $E(\varepsilon_i^2|X)=\Omega \neq \sigma^2 I_N$ and $E(\varepsilon_i\varepsilon_J|X) \neq 0$.

Given those conditions, it is assumed that an estimator b for the unknown vector of coefficients β of the regressors X exists, which is different than the *OLS* estimator. This estimator is extracted from the vector of the residual term and therefore, by following a similar procedure as in the *OLS* estimation, it is obtained that

$$b_{GLS} = arg\, min_{b \in R}\, SSR(b) = (y - Xb)'\, \Omega^{-1}(y - Xb) \quad (64)$$

The *GLS* technique estimates b_{GLS} by minimizing the squared *Mahalanobis* (1936) *distance* of the known and unknown parameters of this model in order to extract the *GLS* estimator

$$b_{GLS} = (X'\Omega^{-1}X)^{-1}(X'\Omega^{-1}y) \quad (65)$$

In particular, the *GLS* estimator, which accounts for the presence of heteroskedasticity and serial correlation in the variance-covariance matrix Ω, is considered to be unbiased, consistent and efficient (*BLUE*), while the *OLS* estimator fails to satisfy the last property in such cases. The *GLS* estimator is also asymptotically normal as it follows the same properties as the *OLS* estimator in a linearly transformed version of the model, where disturbances in the Ω matrix arise. Therefore

$$\sqrt{n}(b_{GLS} - \beta) \xrightarrow{d} N(0, (X'\Omega^{-1}X)^{-1} \tag{66}$$

The equivalence of those two estimators under different conditions may be proved if it is consider that $\Omega = BB'$, where B denotes a Hermitian, positive-definite matrix which is comprised by the variance-covariance matrix Ω. Therefore, by multiplying equation (44) with the inverse of matrix B, the variance of the new error term $u^* = uB^{-1}$ will be equal to the identity matrix I, because $Var(u^*|X) = B^{-1}\Omega(B^{-1})' = I_N$. For this reason, the coefficient estimator b can be easily calculated by applying the *OLS* technique to the transformed data and minimizing the difference between $b^*_{GLS} - b_{GLS}$, extracted by equation (65). This difference indicates the effect of standardizing the scale of errors and thus, the *GLS* estimator is considered as the best linear unbiased estimator for the vector of regressors' coefficients β.

A different application of this estimator concerns the case under which there is no serial correlation in the error term, but there is still evidence for the presence of heteroskedasticity. This indicates that the off-diagonal entries of the Ω variance-covariance matrix will be zero, while the diagonal entries will still be different than $\sigma^2 I_N$. If the heteroskedasticity is of known form, then the *GLS* estimator can be transformed into the *Weighted Least Squares* (*WLS*) estimator which corrects for this type of heteroskedasticity.

Suppose that there exist a series w, whose values are similar to the reciprocals of the error term's standard deviation (Aitken, 1946). The *WLS* method uses the series w as weights to the estimation of the linear regression in order to correct for heteroskedasticity by initially, dividing those weighted series by its mean and subsequently, multiplying the data set of each observation by their scaled weights. This procedure is a normalization that appears to have no effect on the estimated parameters of the model, but renders the weighted residuals more comparable to the unweighted residuals. Therefore, the condition for acquiring the *WLS* estimator is similar to (65), by minimizing the sum of squares residuals

$$b_{WLS} = arg \min_{b \in R} SSR(b) = \sum_{i=1}^{N} {w_{it}}^2 (y_{it} - X'_{it} b)^2 \tag{67}$$

If it is also assumed that W is a diagonal matrix (NxN) which includes the scaled weight w along the diagonal and the off-diagonal entries are zero, then the *WLS* estimator is provided by

$$b_{WLS} = (X'W'WX)^{-1}(X'W'Wy) \tag{68}$$

Therefore, by introducing the weighted scales w to treat the presence of heteroskedasticity of known form, the *WLS* method provides efficient estimations, while the variance estimator s^2_{WLS} appears to be consistent, given the fact that

$$s^2{}_{ij,WLS} = \frac{SSR(b_{WLS})}{\max(N_i,N_j)} = \frac{(y_i - X_i b_{WLS})'(y_j - X_j b_{WLS})}{\max(N_i,N_j)} \tag{69}$$

where the max function of N_i and N_j is designed to account for the case of unbalanced data by weighting down the covariance terms. This is a fact that renders this estimator as consistent, assuming that any missing values are asymptotically negligible.

However, a problem which may arise in the case of both *GLS* and *WLS* estimations regards the fact that both matrices Ω and W may not be easily observed. Generally, the covariance of the error term between different entities or periods may not be observable, meaning that a different formulation has to be used in order to overcome this kind of problem. The most popular technique corresponds to the *Feasible Generalized Least Squares* (*FGLS*), an implementable transformation of the *GLS* estimator that takes into consideration an estimated version of the variance-covariance matrix. In particular, the *FGLS* method is developed in two steps. In the first step, the regression model is estimated by the *OLS* estimator (or any other consistent but inefficient estimator) in order to extract the residual term and build a consistent estimator from the error term variance-covariance matrix. After the extraction of the residual term, in the second step the *GLS* procedure is adopted and therefore, results in an unbiased, consistent and efficient estimator similar to the *GLS*.

Nevertheless, the *FGLS* estimator is considered to be similar to the *GLS* only in large samples. In finite small samples, its properties may not be known or unable to be observed. This happens because in small samples the extraction of the *FGLS* distribution may be very difficult due to the very small number of observations compared to the dimension of the variance-covariance matrix. This fact may render the computation of the new estimator impossible. However, an alternative method under which the accuracy of the *FGLS* estimator can be improved in finite samples is to use the residuals from the *FGLS* estimation. This action is necessary in order to update the variance-covariance matrix of the error term and subsequently, adjust it to the new *FGLS* estimator to improve its efficiency, such that the variance between those two estimators is very small. In particular, the *FGLS* method takes into account the estimated Ω_{OLS} variance-covariance matrix obtained in the first step and afterwards, it results in the first *FGLS* estimator

$$b_{FGLS1} = (X'\hat{\Omega}_{OLS}{}^{-1}X)^{-1}(X'\hat{\Omega}_{OLS}{}^{-1}y) \quad (70)$$

where $\hat{\Omega}_{OLS} = diagonal(\hat{\sigma}_1{}^2, \ldots, \hat{\sigma}_N{}^2)$. By extracting the residual term from this model in order to obtain the new variance covariance matrix Ω_{FGLS1}, it is known that $\hat{u}_{FGLS1} = Y - Xb_{FGLS1}$. Therefore, the new *FGLS* estimator will be defined as

$$b_{FGLS2} = (X'\hat{\Omega}_{FGLS1}{}^{-1}X)^{-1}(X'\hat{\Omega}_{FGLS1}{}^{-1}y) \quad (71)$$

where $\hat{\Omega}_{FGLS1} = diagonal(\hat{\sigma}_{FGLS1,1}{}^2, \ldots, \hat{\sigma}_{FGLS1,N}{}^2)$. This means that under regularity conditions both of these *FGLS* estimators are normally asymptotically distributed with mean zero and variance $Var(b_{FGLSi}) = p\,lim_{N\to\infty}(X'\Omega^{-1}X|N)$.

In this study, however, the implementation of the *(F)GLS* and *WLS* estimators depends on the pattern of correlation within and between the residual terms of different entities. This implies that based on the nature of that correlation, the variance-covariance matrix will be shaped by including different values of variance-covariance estimations. The emergence of such correlation refers to the cases of cross-section specific and periodic heteroskedasticity on the one hand, while on the other hand, the cases of contemporaneous and between period covariance. The reason which those cases are accounted for lies on the extraction of the residual weights that can be used to estimate a *GLS* weighting transformation. Subsequently, the re-estimation on the weighted data is calculated until the coefficients and weights converge (efficient estimator).

The first case addresses the presence of cross-sectional heteroskedasticity, under which different residual variances may be allowed for each cross-section, by assuming that the residual terms between different cross-sections and time periods are zero. This implies that $E(u_{it}{}^2|X^*) = \sigma_i{}^2$ and $E\big(u_{it}, u_{j,t-s}\big)|X^*) = 0$, where $i \neq j$, $t \neq s$ and X^* reflects the regressors matrix *X*. If estimated by assuming fixed/random effects, it also reflects the cross-section (individual) or periodical effects. By using the cross-section specific residual vector, it is seen that $E(u_i u'_i|X^*) = \sigma_i^2 I_T$, where *T* denotes the time dimension. Therefore, the steps for acquiring the *FGLS* estimator in this case concerns the extraction of the cross-section residual vectors and subsequently, their implementation as weights in a *WLS* procedure in order to obtain efficient *FGLS* estimations.

The second case regards the presence of periodic heteroskedasticity within each individual entity. By following the same procedure as before, in this case as well the residuals between different cross-sections and periods are assumed to be zero. Therefore, it is obtained that $E(u_{it}^2|X_t^*) = \sigma_{it}^2$ and $E(u_{it}u_{j,t-s}|X_t^*) = 0$. By using the period specific residual vector in the same procedure described above, it is also found that $E(u_t u'_t|X_t^*) = \sigma_t^2 I_N$, where *N* is the number of individual entities. The estimation of *FGLS* occurs when the weights extracted from this type of heteroskedasticity are used in order to form the weighted variance-covariance matrix.

The third case concerns the presence of contemporaneous correlation which allows for conditional correlation between the residuals for different individual entities, by restricting them in different periods to be uncorrelated. The contemporaneous covariances are provided by $E(u_{it}u_{jt}|X_t^*) = \sigma_{ij}$ and $E(u_{it}u_{j,t-s}) = 0$, under which the correlation between the residual terms of different entities is not dependent on time *t*. By using the period specific residual vectors, it is obtained that $E(u_t u'_t|X_t^*) = \Omega_N$ for all $t \in [0, \dots, T]$. The variance-covariance matrix between the *N* cross-sections is denoted by Ω_N, in which the elements indicate the *FGLS* estimations for the system where the residual term is both cross-sectional heteroskedastic and contemporaneous correlated. The residual terms are employed from the first stage of the estimation (*OLS*) to obtain an estimate of Ω_N, while in the second stage the *FGLS* method is applied in order to acquire efficient estimations.

The last case corresponds to the presence of both period heteroskedasticity and serial correlation in the error term of a given individual entity, but restrains the residuals of different cross-sections from being correlated. Therefore, the results of the formulation are captured by $E(u_{it}u_{i,t-s}|X_t^*) = \sigma_{t,t-s}$ and $E(u_{it}u_{j,t-s}|X_i^*) = 0$, where in this case, heteroskedasticity depends on time. By using the cross-section specific residual vectors, it is obtained that $E(u_i u'_i|X_i^*) = \Omega_T$ for all $i \in [1, \dots, N]$. The variance-covariance matrix between the time periods *T* is denoted by Ω_T which includes the covariances across periods for a given individual entity. When estimating a specification with this matrix, the residual terms from the *OLS* estimation are considered to be subject to both heteroskedasticity and serial correlation. As a result, the *FGLS* method is applied in order to obtain efficient estimations.

According to the nature of such problems, the most suitable adjustments must be taken into consideration in order to acquire efficient estimates to account for the presence of the four aforementioned cases. An additional methodology that can be used in order to account for the presence of heteroskedasticity and contemporaneous correlation corresponds to the *Seemingly Unrelated Regressions* (*SUR*) method, developed by Zellner (1962). In particular, this method regards a generalization of a linear regression model (multivariate regression) which takes into consideration the estimation of a set of regressions of the form $Y = X'\beta + u$, under the assumption that the vector of regressors strictly consists of exogenous regressors. This means that this model accounts for the presence of heteroskedasticity and contemporaneous correlation in the error terms across equations, while the estimated entries of the variance-covariance cross-equation matrix are based on the estimated parameters of the unweighted system.

The set of equations included in this model can be estimated by the *SUR* estimator which will provide both consistent and efficient estimations, while the *OLS* estimator may appear to be consistent but not efficient if it is applied on each equation individually. Specifically, the *SUR* estimator is equivalent to the *OLS* under two cases. In the first case, there must be no contemporaneous correlation between the error terms of different equations. In the second case, each equation has to include the same number of exogenous variables, i.e. the rows and the columns of the *X* matrix must be the same. On the other hand, if those conditions are not valid, then the *SUR* estimator will be equivalent to the *FGLS* method with a specific formation of the variance-covariance matrix.

In particular, Zellner (1962) assumed a model which includes a set of *N* regressions of the following form

$$y_{it} = X'_{it}\beta + u_{it},\ i=1,..,N \text{ and } t=1,\dots,T \quad (72)$$

where *i* denotes the number of equations of the system, which is fixed, and *t* corresponds to the number of this model's observations (time periods), which is assumed to be large and thus, tend to infinity. This shows that the vector of regressors *X* is a (*NxM*) dimension matrix, while the remaining vectors have a dimension of (*Nx1*). The main assumption of this model is that the error terms u_{it} are considered to be independent across different time periods, but they may appear to be contemporaneous correlated, as mentioned before. Therefore, these assumptions indicate that $E(u_{it}, u_{i,t-s}|X) = 0$, for $t \neq s$, while $E(u_{it}, u_{jt}|X) = \sigma_{ij}$, for $i \neq j$, where $\Sigma = [\sigma_{ij}]$ denotes the (*NxN*) matrix of skedasticity between cross-equation error terms. This means that the variance-covariance matrix of the error term *u* will be

$$\Omega = E(uu'|\mathrm{X}) = \Sigma \otimes I_T \tag{73}$$

where I_T is the (*TxT*) identity matrix and $\otimes$ represents the *Kronecker product* (Zehfuss, 1858) which is a combination of two matrices of arbitrary size that result in a blocked matrix. In other words, the blocked matrix consists of the product of each observation of the one matrix multiplied with each observation of the other matrix.

Based on those transformations, the *SUR* model is estimated by applying the *FGLS* procedure and following the two steps procedure as presented above. In the first step, an *OLS* regression is applied on the system of equations (72), from which the residual terms are extracted in order to estimate the matrix of skedasticity $\Sigma = \hat{\sigma}_{ij} = (1/T)\hat{u}'_i\hat{u}_j$. In the second step, the *GLS* method is applied by regarding the variance-covariance matrix and thus, the *SUR* estimator will be

$$b_{SUR} = (X'(\hat{\Sigma}^{-1} \otimes I_T)X)^{-1}X'(\hat{\Sigma}^{-1} \otimes I_T X)y \tag{74}$$

This estimator is considered to be unbiased in small samples, when the error term is assumed to have symmetric distribution. On the other hand, in large samples, it is considered to be consistent and asymptotically normal with distribution[42]

$$\sqrt{T}(b_{SUR} - \beta) \xrightarrow{d} N(0, \left(\frac{1}{T}\left(X'(\hat{\Sigma}^{-1} \otimes I_T)X\right)^{-1}\right)) \tag{75}$$

As a result, the *SUR* estimator can provide a more efficient alternative in order to account for the presence of both heteroskedasticity and contemporaneous correlation in the error terms of an equation system. The main restriction refers to the fact that the vector of regressors must consist of exogenous variables. In the case where at least one of those regressors is endogenous, then this model can be generalized into the *simultaneous equation model*, which allows for endogenous variables in matrix *X*.

[42] For more information, see Amemiya (1985).

The aforementioned process and estimation techniques have been discussed, under the assumption that the error terms of the system regressions appear to be heteroskedastic and serially correlated. However, if the problem of endogeneity is identified, then all the above techniques will not result in unbiased and consistent estimations and thus, they will not provide the best alternative estimator. The most suitable method for this problem is considered to be the *Instrumental Variables* (*IV*) estimation procedure, developed by Wright (1921), which results in consistent estimates when at least one of the explanatory variables are correlated with the error term (i.e. $E(X'u|X) \neq 0$).

According to Pearl (2003), a reason for this problem may regard the misspecification of the regression model, when there are explanatory variables which have not been included. Under this case, and given the fact that the error term is homoscedastic and not serially correlated, these omitted variables can be used as instruments, in order to obtain consistent estimates. In particular, a variable can be considered as an instrument for a specific regression, when it is not included in the set of explanatory variables, but it is correlated with at least one of them. This means that if two variables are correlated, one included in the regression model and another one which is not part of that model, then the latter variable can be used as an instrument to obtain the desirable results.

The second condition that must hold in order for the *IV* estimation to be adopted, regards the fact that the instrument must not be correlated with the error term of the regression, in order to avoid the problem of endogeneity. Therefore, the *IV* estimation is regarded as the best alternative technique when there exists an instrument which is correlated with at least one (endogenous) explanatory variable and does not appear to be correlated with the error term of the regression.

Once again, equation (44) is considered to be the regression model, where in this case, the set of explanatory variables X is correlated with the error term u. In addition, the error term is considered to have a constant variance through time (homoscedastic errors) and no serial correlation. If the *OLS* estimator (62) is used, then

$$b_{OLS} = (X^{'}X)^{-1}(X^{'}y) = (X'X)^{-1}(X'(X\beta + u)) = \beta + (X'X)X'u \quad (76)$$

Whenever the error term is not correlated with the set of regressors X, then by using the *method of moments*, suggested by Pearson (1894), it holds that $E(X'u|X)=0$). This means that $E(b_{OLS})=\beta$, where the *OLS* estimator is considered to be unbiased and consistent. On the other hand, if the set of regressors X is correlated with the error term, then the *OLS* estimator will be both biased and inconsistent because $E(X'u|X) \neq 0$ and thus, $E(b_{OLS}) \neq \beta$. For this very reason, a set of instrumental variables z is included in a (NxK) matrix of instruments Z. This indicates that the mean of the elements of (44) will be obtained, conditional on z, equal to $E(y|z) = \beta E(x|y) + E(u|z)$. Since the instrumental variables are uncorrelated with the error term, then $E(u|z)=0$. Therefore, the *IV* estimator will be formulated as

$$b_{IV} = (Z'X)^{-1}Z'y \tag{77}$$

This estimator is consistent only when the aforementioned conditions are valid. However, in order to take this estimation into account, it is assumed that the size of the instrumental matrix Z is equal to the size of the explanatory variables matrix X (NxK). This indicates that the model is *exactly identified*. If the number of instruments is equal to $M>K$, then the model is over-identified and the most suitable estimation methods to use are the *Two Stage Least Squares* or the *Generalized Method of Moments,* which will be presented below. In the case where $M<K$, the model is *under-identified* and therefore, it cannot result in consistent inferences.

A special computational approach of the *IV* estimation, which is going to be taken into consideration in this study, concerns the *Two Stage Least Squares* (*2SLS*) method, developed by Theil (1953) and Basmann (1957). This estimation technique is used to calculate the *IV* estimations in two distinct stages. In the first stage, the *2SLS* procedure calculates the portion of the endogenous and exogenous variables which can be used as instruments by using an *OLS* regression of each variable on the set of instruments Z. In the second stage, a regression of the original equation is estimated, under which both explanatory and instrumental variables are replaced by their fitted values estimated during the first stage. The coefficients of this regression are the *2SLS* estimations.

In particular, during the first stage, each column of X on Z is regressed by regarding the expression $X=Z\delta+\varepsilon$, where the estimation of δ is $d = (Z'Z)^{-1}Z'X$ and ε represents a homoscedastic, non-serially correlated error term. The predicted values of this expression are indicated as

$$\hat{X} = Zd = Z(Z'Z)^{-1}Z'X = P_Z X \tag{78}$$

These values are saved for the second stage of this procedure, under which the original regression is estimated, which results in the *2SLS* estimator

$$b_{2SLS} = (X'P_Z X)^{-1} X'P_Z y \quad (79)$$

while the estimated variance-covariance matrix of these estimates is provided by

$$\hat{\Sigma}_{2SLS} = s^2 (X'P_Z X)^{-1} \quad (80)$$

where s^2 is the estimated residual variance-covariance matrix from the *OLS* regression. This procedure is able to provide consistent estimates when the explanatory variables are correlated with the error term, by introducing the use of a set of instruments of the aforementioned properties, in order to account for this issue.

Nevertheless, as has been mentioned, the use of the *IV/2SLS* estimation technique assumes the absence of heteroskedasticity of any form, along with the absence of serial correlation in the error term of each regression. If one or both of those issues co-exist with endogeneity, then the *IV* estimates will not be efficient, thus resulting in underestimated standard errors. For this reason, a different transformation of the *IV* methodology must be provided in order to acquire correct inferences which will account for the presence of both heteroskedasticity and contemporaneous correlation in the error term of each regression. Suppose there are two cases: in the first case there is no contemporaneous correlation between the error terms of the system's regressions but there is evidence of heteroskedasticity. In the second case, both of those problems are observed. Based on the methodology that has been presented so far, a transformation of the *IV* or otherwise, the *2SLS* method can be based on the procedure followed by the *WLS* estimation, which results in a new estimator called *Weighted Two Stage Least Squares* (*W2SLS*).

In the second case, where the error term is assumed to be both heteroskedastic and contemporaneous correlated, in conjunction with the presence of endogeneity, an extended estimator of the *2SLS* technique is regarded; the *Three Stage Least Squares* (*3SLS*). In particular, this procedure was developed by Zellner and Theil (1962) which combines the *2SLS* with the *SUR* methodology. The *3SLS* estimator provides consistent and efficient properties by applying the *SUR* implications on a *2SLS* procedure of the unweighted system, by enforcing any cross-parameter restrictions. The resulting estimates are used to form a full cross-section variance-covariance matrix which is taken into account to transform the equations and eliminate cross-equation correlation.

In particular, the *2SLS* is a single-equation estimator which does not take into consideration serial or contemporaneous correlation and thus, it is not fully efficient. On the other hand, the *3SLS* is a system technique that estimates all the included coefficients of the regression model and subsequently, forms weights and re-estimates the model by using the estimated weighting matrix[43]. The first two stages are estimated as the ones of the *2SLS* as described above. In the third stage, the *FGLS* procedure is applied on the system equations, analogous to the *SUR* procedure. The latter method accounts the *OLS* residuals to obtain a consistent estimate of the cross-section variance-covariance matrix Σ, only when the independent variables are exogenous. In any other case, the estimated matrix *Σ* is inconsistent. For this reason, the *3SLS* method replaces the *OLS* with the *2SLS* residuals in order to account for the presence of endogeneity and therefore, generates a consistent matrix *Σ*. By taking into consideration the *2SLS* estimator (79) and by applying the *FGLS* technique, the *3SLS* estimator is denoted by

$$b_{3SLS} = (Z(\hat{\Sigma}^{-1} \otimes X(X'X)^{-1}X')Z)^{-1}Z(\hat{\Sigma}^{-1} \otimes X(X'X)^{-1}X')y \tag{81}$$

where the elements s_{ij} of *Σ* are given by

$$s_{ij} = ((y_i - Z_i b_{2SLS})'(y_i - Z_i b_{2SLS}))/max(N_i, N_j) \tag{82}$$

Therefore, the *3SLS* estimator by regarding the *SUR* combined with the *2SLS* procedure, results in efficient inferences where the estimation of the variance-covariance matrix is subject to consistency.

The last estimation technique which is going to be part of the analysis concerns one case under which the number of instruments is greater than the number of regressors. Since there has been mentioned that in the case of equality, the *IV* estimator will result in efficient estimates, in this case, the most appropriate estimator is obtained by the *Generalized Method of Moments* (*GMM*) method, developed by Hansen (1982). The application of this technique is regarded in the context of semi-parametric models, where the parameters are finite-dimensional and the exact distribution function may not be observable.

[43] This procedure is the endogenous variable case of the *SUR* estimator, since the regression system and the latter method assume that the independent variables must not be correlated with the error term of a single equation.

In particular, the main point of the *GMM* estimator represents a theoretical relation that all the involving parameters must be able to satisfy. For this reason, this methodology tries to provide a set of estimations as close as possible to the actual values of these parameters. The estimated parameters are used in order to minimize the weighted distance between the theoretical and the actual values. In addition, the *GMM* estimator is considered to be robust due to the fact that it does not require any information about the exact distribution of the disturbances. This is a property which renders it more preferable to other estimators.

Suppose that the available data set includes T observations ($t=1,\dots,T$), where Y_t corresponds to a *N-dimensional* multivariate random variable and θ is a vector of parameters, for which the model must provide estimates as close as possible to the actual values. A theoretical relationship that these parameters have to satisfy is usually the *orthogonality conditions* between some function $f(\theta)$ and a set of instrumental variable z_t, such that

$$m(\theta) = E(f(\theta)'Z) = E\big(f(Y_t, \theta)\big) \tag{83}$$

where m is the sample of moments. A general assumption of this estimation technique regards the fact that the dependent variables' set Y_t may be obtained by a *weakly stationary ergodic stochastic process*. This means that the error term of such regression is not necessarily *IID*. The estimated sample average of (83) is denoted by

$$\hat{m}(\theta) = \frac{1}{T}\sum_{t=1}^{T} f(Y_t, \theta) \tag{84}$$

Consequently, if this expression is minimized with respect to θ, the estimation of θ_0 will be very close to its actual value. This outcome is expected because as the number of observations T increases, the estimated value of (84) will tend to converge to its actual value (83), by indicating that $\widehat{m}(\theta) = m(\theta) = 0$. This condition shows that in order for this equality to exist, there must be at least one $\theta_0 \in \theta$ for which the estimated value will be converging towards its actual value, which is equal to zero. The properties of the *GMM* estimator will greatly depend on the nature of the f function, meaning that under this method, an entire family of norms is considered for f, defined by

$$||\widehat{m}(\theta)||^2{}_A = \widehat{m}(\theta)' A \widehat{m}(\theta) \tag{85}$$

where A is a positive definite weighting matrix, which is computed based on the available data set $\hat{A}$. Thus, the *GMM* estimator can be defined as

$$\hat{\theta} = arg\, min_{\theta}\, \widehat{m}(\theta)'\hat{A}\widehat{m}(\theta) \tag{86}$$

This estimator is subject to consistency; it is asymptotically normal and given the weights of matrix A it can also be asymptotically efficient according to the presence of heteroskedasticity and/or serial correlation.

To conclude with, the aforementioned estimation methods have been considered in this study due to the emergence of the corresponding problems they are called to correct. Given the specification of the four-step regression model analysis and based on the suggested estimators under each methodology, the obtained results are considered to be robust to the presence of heteroskedasticity, serial and/or contemporaneous correlation and endogeneity. Consequently, the next chapter of this study presents the set of regressions, discussed in chapter 4, in which the appropriable methodological techniques are applied in order to result in correct inferences. Based on the value of those estimates, the competitive conditions and the speed of price adjustment in the manufacturing industry will be identified, along with the significance that particular variables may appear to have on the Greek economy.

6. Empirical Procedure and Results

This chapter presents the estimations obtained from the equations presented in chapter 4 which will result in evidence that reflect the market structure and the speed of price adjustment of the Greek manufacturing industry. The presentation and analysis of those results will be discussed by the following order: initially, the conjectural approach will be regarded and thus, the cost, demand and supply functions will be analysed throughout the three undertaking steps. Subsequently, the second part refers to the discussion of the pricing equation and the degree of price adjustment according to fluctuations in the pricing equation factors. The last part includes the equation presented in the fourth step, under which the relationship between the speed of price adjustment and a set of market factors suggested by previous studies is investigated. Based on those estimates, the market structure of the manufacturing sectors and the structure of the whole manufacturing industry is going to be identified, in conjunction with the pricing behaviour and its sensitivity to changes in costs[44].

6.1.The Conjectural Variation Approach

6.1.1. First Step

The first approach is divided into three different specifications that capture the conjectural variation elasticity of the whole manufacturing industry, the 3-digit sectors and each year individually over the time period sample. As mentioned before, the reason for considering the division of this methodology in three different steps corresponds to the identification of market power in terms of production decisions (Bresnahan, 1982, 1989; Lau 1982) which denotes the degree of oligopolistic power. The first specification represents the estimation of this measure for the whole manufacturing industry over the period 1980-2012 by aggregating the panel data set of the 3-digit sectors[45]. It considers the system of equations (25), (25b), (25c) and (26), which correspond to the cost, capital share, supply and demand function respectively. The index of conjectural variation is captured by the supply function, while in

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[44] Such costs in the present study refer to input costs, price adjustment costs, foreign competition in terms of price changes and taxes.

[45] The estimation process of the manufacturing industry does not correspond to a time series analysis. It takes into account the panel set of the 3-digit sectors in order to generate the estimates for the aggregate industry.

order to obtain such estimation, a set of variables have to be estimated from the cost and demand function as well.

The estimation method used for the estimation of the system is the *3SLS* technique due to the emergence of endogeneity, along with the presence of heteroskedasticity and serial correlation in the error terms. In particular, the presence of endogeneity is observed in the cost, output, unit cost and sales concentration variables based on the formulation of the cost, supply and demand function respectively. Therefore, the instrumental variables taken into consideration in the *2SLS* procedure correspond to the exogenous input prices of labour and capital (w and u) and the lagged values of investment, sales concentration and money supply. In addition to these variables, cross-section and time dummy variables are included, along with time trend, as indicated by Rezitis and Kalantzi (2012, 2013) so that the number of instruments to be at least equal to the number of regressors in each equation.

The precedent corresponding test to the estimation method refers to the identification of cross-sectional independence between the cross-sections of this sample. The reason for this test lies on the fact of choosing between a simple *OLS* regression, where individual effects do not arise between the 3-digit sectors (independency), and a random effects model under the alternative hypothesis of cross-section correlation (dependency). If the latter hypothesis is valid, then the Hausman test is performed to identify whether the problem of endogeneity holds and thus, whether the fixed effects model has to be selected over the random effects model[46]. Given the results of these tests, in conjunction with the Likelihood Ratio and the Wooldridge test for identifying heteroskedasticity and serial correlation respectively, the estimation technique is chosen.

In the case of the manufacturing industry, the results indicate that the fixed effects model is more suitable than the random effects, and given the presence of heteroskedasticity, the *3SLS* estimation technique will be preferable for the cost and the supply function. However, the demand function is not found to be subject to either heteroskedasticity or serial correlation. This means that the *2SLS* technique would provide consistent and efficient estimates without requiring a *FGLS* transformation. Therefore, the conjectural variation

[46] Initially, the fixed effects approach is conducted by using the least squares dummy variable (*LSDV*) estimation method in order to correct the estimations from heterogeneity bias. The random effects approach is conducted by employing the generalized least squares method (*GLS*) in order to correct the presence of serial (between) correlation.

system is broken down into two sub-systems; the first one comprises of the cost and supply functions while the second one only of the demand function.

Table 2. *Estimation of the Cost, Supply and Demand Function in the Greek Manufacturing Industry over the period 1980-2012 (Bresnahan Specification).*

Parameters	**Estimations of (25) and (25c)**		**Parameters**	**Estimations of (26)**
a_0	8.014872 (67.144500)		*a (constant)*	19.765642 (46.890982)
a_y	0.764166 (52.61546)		*h (price)*	-0.982261 (-3.108433)
a_{yy}	0.127243 (3.644083)		h^z *(investment)*	0.208304 (3.588869)
g_{ly}	0.055571 (13.25223)		h^H *(herf)*	0.047251 (2.212013)
g_{ky}	-0.055571 (-9.736153)		h^{liq} *(ms)*	0.551947 (5.813401)
a_l^a	0.795333 (26.246601)			
a_k	0.204667 (4.138255)			
g_{ll}^a	0.084286 (12.07033)			
g_{kl}^a	-0.084286 (8.138194)			
x_t	-0.013236 (-2.531320)			
x_{ty}	0.001557 (3.201825)			
x_{tl}	-0.001731 (-3.196618)			
f_{man}	0.513468 (3.195944)			
Estimation Method	3SLS[1]	3SLS[2]	**Estimation Method**	2SLS
Breusch-Pagan Test (LM test)[b]	6.1512 [0.0329][1]	5.0188 [0.0461][2]	**Breusch-Pagan Test (LM test)**[b]	6.2061 [0.0307]
Likelihood Ratio Test[c]	130.7746 [0.0000][1]	142.9185 [0.000][2]	**Likelihood Ratio Test**[c]	38.9635 [0.9499]
Hausman Test[d]	49.7083 [0.0000][1]	34.7611 [0.0000][2]	**Hausman Test**[d]	75.1574 [0.0000]
Wooldridge Test[e]	1.0627 [0.3182][1]	7.0162 [0.0193][2]	**Wooldridge Test**[e]	0.8164 [0.5718]
Wald Test[f]	1757.4126 [0.0000][1]	13.2793 [0.0003][2]	**Wald Test**[f]	14.7990 [0.0000]

Notes: The values in parentheses indicate *t-statistics*. The numbers in brackets indicate *p-values*.

If $|z| \geq |z_{0.1}|=1.645$, it indicates significance at the 10% level for a two-tailed t-test.

If $|z| \geq |z_{0.05}|=1.960$, it indicates significance at the 5% level for a two-tailed t-test.

If $|z| \geq |z_{0.01}|=2.576$, it indicates significance at the 1% level for a two-tailed t-test, where *z* denotes the estimated value.

[a] $a_k=1-a_l$. $g_{kl}=-g_{ll}$. $g_{ky}=-g_{ly}$.

[b] H_0: *Cross sectional independence* (*OLS*) versus H_1: *Cross sectional dependence* (*Random Effects Model*).

[c] H_0: *Homoskedasticity* ($\sigma^2_1=\ldots\sigma^2_T=\sigma^2$).

[d] H_0: *Random Effects Model* versus H_1: *Fixed Effects Model*.

[e] H_0: *No first-order serial-correlation* [$Corr(\Delta u_{it}. \Delta u_{it-1})=-0.5$].

[f] The *F-test* is used to test the joint significance of the including regressors.

[1] Diagnostic tests obtained from the cost function.

[2] Diagnostic tests obtained from the supply function.

The empirical results and the diagnostic tests applied for the manufacturing industry (Bresnahan specification) are presented in Table 2. The estimations of the cost, supply and demand parameters are obtained as indicated in chapter 4. It is expected that the translog cost function must satisfy the conditions of concavity and monotonicity[47], while the estimated parameters must be statistically significant at least at the 5% level of significance. A negative relationship between the output and price variables is also expected, if it is assumed that the goods produced by the manufacturing industry are normal.

The value of the estimated parameters along with their sign seem to be consistent with economic theory, while all the estimates are statistically significant at the 1% level of significance (except from sales concentration). The parameters of the cost function having the greatest theoretical importance are considered to be the elasticity of cost with respect to output (a_y), labour (a_l) and capital (a_k), such that the aforementioned conditions are valid. According to the value of these elasticities, the shape of the average cost curve can be defined conditional on output.

In particular, the elasticity of cost with respect to output is found to be close, but less than unity (i.e. a_y*=0.764166*), thus indicating that an increase in output equivalent to 1 percent, will cause the total cost of the industry to increase by *0.764166* percent. Since the elasticity equivalence is less than unity, it can be argued that the industry is characterized by economies of scales, which implies that average cost is a declining function with respect to output. This means that the manufacturing industry is facing cost advantages due to various factors, such as size and/or operating scale because unit cost tends to increase by a slower rate than it should be per extra unit of production. In fact, by introducing the formulation provided by Brown et al. (1979), the degree of economies of scales is expressed as:

$$SCE = 1 - a_y - x_{ty}{}^{*}\bar{T} \tag{87}$$

where $\bar{T}$ corresponds to the average value of the time trend of this sample. In the case of the manufacturing industry the value of this measure is *SCE=0.209365*, which is positive and

[47] The condition of concavity implies that the Hessian matrix of the cost function must be negative semi-definite, under which each partial derivative of second order must result in a negative value. A different interpretation of this condition implies that all own partial elasticities of substitution as introduced by Allen (1938) and Uzawa (1962) are negative at their sample mean. The condition of monotonicity implies that the contribution of inputs in the production process must be positive, i.e. a_l>0 and a_k>0, in order for the cost function to be increasing in terms of those inputs (positive first-order derivative).

thus, provides evidence that the industry is facing a falling average cost curve with respect to output[48].

An arguable reason for this outcome may be related to the increasing technological progress by investing in fixed capital (or human capital as well) which would result in decreasing unit costs. An additional reason may concern a relatively high level of labour intensity (or high labour cost share), which could also lead to decreasing costs through an increase in total productivity. Based on the available dataset, the highest ratio of investments to sales is observed in the 2-digit industry of chemicals and chemical products (i.e. 20) and the industries of electrical, machinery and motor equipment (i.e. 27, 28 and 29). On the other hand, the industries with the lowest ratio of investments to sales are considered to be the industry of food and beverages (i.e. 10), along with the industry of textiles and wearing apparel (i.e. 13 and 14). Intuitively, it can be expected that a negative relationship would exist between labour and capital intensity, since lack of investments can be substituted by extra labour productivity.

In addition, even if such negative relationship exists between total labour and capital expenses as indicated in Table 2, the intensity of these two measures may not follow the same pattern. For instance, in the food and beverages industry, even if there is lack of investments in capital improvement, labour intensity tends to fall over the period 2005-2012 as reflected by the dataset of the manufacturing industry and IOBE (2013). This fact indicates that either the remuneration of the employed is decreasing[49] by a faster rate than a fall in sales or the growth rate of sales is higher than that of remunerations or both of those measures have a different sign. However, the intensity of cost factors may also change due to fluctuations in sales, even if input costs are fixed. In this case, the level of sales is either increasing or decreasing, while the use of inputs remains the same. This outcome may be caused due to a

[48] A negative value of *SCE* would indicate that the manufacturing industry faces decreasing economies of scale, under which an increase in output would cause an approximately same or higher increase in total cost (i.e. $a_y + x_{ty} * 17 \geq 1$).

[49] The remuneration of the employed is expressed in terms of labour man-hours. This indicates that even if remunerations are decreased, labour man-hours may decrease as well, remain the same or even increase. The former case reflects a positive relationship between these two measures, which may refer to an investment oriented industry that chooses to reduce its labour force. However, the two latter cases address a flexible negative relationship which might be observed in markets with excess labour supply, thus being independent of investing decisions.

boost in total productivity by the present labour force or due to the inability of industries to change their inputs (i.e. because of rigid contracts)[50].

Furthermore, there exist two additional elements of the translog cost function that have to be identified. They refer to the value of a_{yy}, g_{ly} and g_{ky} which denote the presence of homogeneity and homotheticity respectively. In order for homogeneity to hold, a change in the elasticity of cost with respect to output, as output changes, is denoted by a_{yy} and has to be equal to zero. On the other hand, homotheticity renders necessary that the sum of any change in the elasticity of cost with respect to every input, as output changes, must be equal to zero as well.

As presented in Table 2, the production function of the manufacturing industry appears to be consistent with the property of homotheticity, because $g_{ly}+ g_{ky}=0$; however, the property of homogeneity does not hold, since $a_{yy}=0.127243 \neq 0$. A value of a_{yy} which is different than zero indicates that any scale effect will start to run out as output reaches sufficiently high levels. This means that given the fact that economies of scales persist, under which $a_y<1$ at low output levels, the average cost curve will appear to have a *U*-shape. This happens because the partial second-order derivative denoted by a_{yy} shows that there exist a local minimum for the total cost curve. Additionally, cost elasticity with respect to output is equivalent to the ratio of marginal over average cost (*MC/AC*). Consequently, economies of scale suggest that marginal cost is below average cost, which in turn suggests that the average cost is falling with respect to output (Zardkoohi, Rangan and Kolari, 1986).

The following significant set of results concerns the estimates of cost elasticity with respect to labour and capital unit costs, the two inputs included in this analysis. In Table 2, it is seen that the sum of these measures (i.e. $a_l= 0.795333$ and $a_k= 0.204667$) is equal to unity. This outcome confirms the assumption that a proportional increase in the price of every input causes a shift of the cost curve by the same amount, while output is held constant. However, an important factor in the translog cost function is the value of inputs as a share of total cost. In order to calculate the cost share measures, the following equations are taken into consideration:

[50] Generally, it holds that changes in factor intensity depend on the technology of production, the elasticity of substitution between input factors and the pattern of relative input prices over a period.

$$LCS = a_l + x_{tl} * \bar{T} \quad (88)$$

$$CCS = 1 - LCS = 1 - (a_l + x_{tl} * \bar{T}) \quad (89)$$

The values of labour and capital cost share are equal to *LCS=0.765906* and *CCS=0.234094* respectively, an outcome suggesting an approximately 75% use of labour in production, while the use of capital is determined at a 25% level. The positive value of labour and capital inputs indicates that their share has a positive effect on the total cost of the industry. Also, since their sum is equal to unity, it is shown that there is no misspecification of the translog cost function. If that sum was less than unity, it would mean that either the variable of total cost lacks labour and capital data, or there exist additional input factors which have not been taken into consideration. Additionally, since cost elasticity with respect to labour and capital unit costs is positive, then input shares increase with their prices. The higher the contribution of a particular input to the total cost function, the higher its demand inelasticity will be, since a_l and a_k express the effect of a change in labour and capital unit costs respectively on total cost[51]. Therefore, given that the share of labour is 75%, then its demand can be considered to be strongly inelastic in the production process of the Greek manufacturing industry.

The remaining parameters of the translog cost function refer to the trend of total cost and its elasticity with respect to output and unit labour cost respectively, in order to identify their path over the period sample 1980-2012. The percentage change of total cost with respect to time trend, denoted by x_t, shows evidence in favour of a significant reduction by *0.013236* from 1980 until 2012. However, this fact does not mean that C_t has declined individually, but rather the ratio of total cost to unit capital cost. Therefore, the falling trend x_t is the result of either a faster increasing unit capital cost compared to a slower increasing total cost or a faster declining total cost compared to a slower declining unit capital cost (or a combination of both cases).

In addition, the value of x_{ty} and x_{tl}, which correspond to the elasticity of total cost with respect to the sum of output and unit labour cost with the time trend, appears to be equal to *0.001557* and *-0.001731* respectively. Such results suggest that changes in output have a significant positive but very low effect on total cost over time, while changes in unit labour

[51] The parameters g_{ll} and g_{kl} denote a change in the elasticity of cost with respect to labour and capital respectively, as labour unit cost changes. This means that if the translog cost function is homogenous with respect to inputs, then these variables must satisfy the condition $g_{ll}+ g_{kl}=0$, since they reflect the partial second-order derivative of total cost to labour and the cross-partial derivative of g_k to labour.

cost appear to have a significant but very low negative effect on total cost over time as well. The necessity of these estimates lies on the calculation of the degree of economies of scales and labour cost share respectively. This indicates that output and unit labour cost over time appear to have an opposite, but very low, effect on total cost over 1980-2012.

The second function of the estimated set corresponds to the demand function and particularly, the effects of pricing, investment, sales concentration and liquidity upon production decisions. As aforementioned, the concept of endogeneity appears in the variable of sales concentration and therefore, the *2SLS* estimation technique is selected. The value of the Bresuch-Pagan test provides evidence that the null hypothesis of cross-sectional independence is rejected. This means that contemporaneous correlation exists between the error terms of the manufacturing sectors for the demand function. As a result, either the random or the fixed effects model will be used in order to validate the presence of endogeneity in the demand equation. The Hausman test provides evidence in favour of the fixed effects approach over the random effects and thus, it supports the presence of endogeneity within the 3-digit sectors. Lastly, the likelihood test for heteroskedasticity and the Wooldridge test for serial correlation in the error term of each entity respectively do not reject the null hypothesis. This suggests that the residual terms of the demand function appear to be homoscedastic and no serially correlated.

By taking into consideration the results of the diagnostic tests, the demand function is estimated under the *2SLS* technique, without applying *FGLS* as a third step, since both heteroskedasticity and serial correlation are absent. The estimates obtained by this method are both individually and jointly significant at the 1% level of significance (excluding the endogenous variable of sales concentration) based on the indicated values of the *t-statistic* and the *F-statistic*. In particular, the industry elasticity of output with respect to price appears to be negative and equal to $h=-0.982261$. Since the absolute value of the elasticity index is less than unity, the demand curve of the manufacturing industry appears to be marginally inelastic because a change in price by *1*% will reduce net output of the industry by approximately *0.98*%. The proportional change is less than 1 and therefore, producers may exert a degree of overpricing behaviour whenever a change in the price and output level results in higher profit rates.

An additional interpretation of the aforementioned elasticity value lies on the nature of the manufacturing industry's products and the needs of consumption they are called to satisfy. As presented in Table A, many of the constituent sectors supply products that are considered to be highly important for the satisfaction of people's primary needs, such as food and clothing. Under the assumption that many related goods produced in the Greek economy are part of the same 3-digit sector, it would be very difficult for consumers to change their consumption level or turn to substitute goods, if there exist any. For this reason, changes in the price level of such products may not result in greater changes in their consumption level and thus, their production.

The second estimate concerns the elasticity of output with respect to investments. The theoretical intuition behind the selection of such variable in the demand function refers to the fact of whether consumers tend to change their preferences given the undertaking investments of a particular sector. Such action would provide evidence that consumers may prefer quality (reflected by higher price) over quantity by gaining higher satisfaction in the former rather than the latter case. For instance, low price products may be viewed as low quality products, assuming this is not a result of intense competition. Consequently, they may not satisfy the same needs of consumption as a higher priced product in which a certain amount of resources has been invested. The interpretation of this elasticity measure, if positive, would suggest two different results: the first one concerns the preferences of consumers for products supplied by sectors that appear to be investing in their production; and the second one refers to investment decisions as a result of an increase in demand for the supplied product of a particular sector[52]. Either way, investment in capital equipment that results in production improvement may draw consumers' attention and motivate them to choose the products of such sectors.

In fact, the estimate for the manufacturing industry provides evidence that the elasticity of output with respect to investment is equal to $h^z=0.208304$. This means that an increase in the level of investment by *1*% in the manufacturing industry has led to an increase by approximately *0.20*% in aggregate output over the period 1980-2012. This outcome provides evidence that changes in the level of investment can lead to significant, but inelastic changes in net output. This measure appears to be in favour of a causation by investment to output. Consequently, this value suggests that investment decisions are important for the Greek manufacturing industry because investment can lead to increased production.

[52] However, it can also be assumed that if the latter case holds, an expansion of investment in capital equipment would not be the only way of an increase in production. An additional increase could be invested in wages or additional labour force by enhancing total productivity and thus, total production.

The third estimate refers to the sales concentration indicator, as presented in section 4.1. This particular index provides an interpretation of market concentration in terms of sales rather than production level, in order to test whether a higher volume of sales leads to changes in net output. The sign of the elasticity of output with respect to the current measure of concentration can determine whether these two variables can move in the same direction. On the one hand, if that elasticity is positive, then a larger concentration index leads to a higher volume of production. This outcome indicates that output and concentration move in the same path and based on the value of elasticity, the effect of changes in the latter variable can be identified by changes in the former variable.

For instance, if elasticity of output with respect to concentration is greater than unity, then an increase in sales concentration caused by an increase in sales of an individual sector (numerator) or by a reduction in industrial sales (denominator) will lead to higher production. This may indicate an increase in demand for the products of that sector, assuming that its price has remained fixed. A different interpretation may address an increase in sales concentration due to a fall in the industrial price level. This effect would mean that a higher level of output results from a price reduction which may lead to an increase in quantity demanded for that industry's products and therefore, cause an increase in production. However, if that elasticity value is positive and less than unity, then the intensity of increased production will be less than a proportional increase of the concentration index.

On the other hand, if the value of elasticity of output with respect to sales concentration is negative, an increase in concentration will lead to a lower volume of output. That effect would suggest the presence of waste in production caused by two effects: an increase in the price level by a number of individual sectors (in conjunction with the declining level of production); or a higher fall in industrial output rate in comparison with changes in the industrial price level. In the former case the numerator would increase by a higher rate than the denominator, while in the latter case, the denominator would decline by a higher rate than any change of the numerator. Either way, when this particular elasticity index appears to be negative, then output is increased/decreased due to a reduction/increase of sales concentration.

The value of the elasticity of output with respect to sales concentration for the manufacturing industry over the period 1980-2012 is found to be equal to $h^H=0.047251$, which is significant at the 5% level of significance. This particular value provides evidence that concentration and output decisions appear to have a positive sign but their relationship is highly inelastic. This estimate suggests that if the manufacturing industry becomes more concentrated in terms of sales, then its net output will increase by a very small percentage equal to *0.047251*. Therefore, sales concentration and output decisions may appear to be positively correlated, however, their connection has been found to be very weak. This could indicate that changes in the present concentration index of the Greek manufacturing industry may be dominated by changes in the price level rather than changes in quantity produced.

The fourth estimate corresponds to the effects of liquidity in the Greek economy and in this case, in the Greek manufacturing industry, expressed in terms of money supply (*M2*). The studies of Rezitis and Kalantzi (2012, 2013) take into consideration Gross National Income (*GNI*) as an index of income in order to identify its effect on production decisions and thus, on observed demand. As explained in section 4.1, the present study treats the measure of money supply as a liquidity rather than income factor. This happens to identify whether any changes in available liquidity can cause a change in the level of demand for the products of the manufacturing industry. This particular indicator has been selected because money is considered to be perfectly liquid and thus, it can be used for immediate transactions.

On the other hand, *GNI* reflects the level of income as argued by Todaro and Smith (2011), which is defined as the desirable level of consumption and savings obtained, given that all necessary expenses have been deducted. This means that savings or investments (if any) may not be immediately retrievable, a fact that may postpone consumption. Therefore, the *GNI* indicator does not provide a general view of liquidity flow in aggregate economy as money supply, and for this reason it is replaced in the present study. In addition, the measure of money supply reflects the aggregate amount of money that has flown in the Greek economy over the period 1980-2012 without distinguishing between consumption, savings or expenses. It is a general indicator that is used to capture any changes in the available level of liquidity to production decisions and thus, to net output of the manufacturing industry.

Elasticity of output with respect to money supply may appear to have a positive or an insignificant sign; however, it is rather unlikely to have a negative sign. In particular, a negative sign would mean that an increase in available liquidity of consumers through an increase of money supply would lead to a fall in net output or otherwise, to a reduction in total value added. This would indicate, given that consumers have a higher amount of money that consumption has shifted from the manufacturing to a different industry. This outcome could not be consistent with reality because there is no other industry that can be considered as a substitute to the manufacturing industry[53].

Consequently, it is expected that the current elasticity index will be positive. Indeed, elasticity of output with respect to money supply is found to be significant at the *1*% level of significance and equal to *0.551947*. This value provides evidence of a positive relationship between output and money supply by indicating that changes in money supply appear to have an inelastic effect on manufacturing output decisions over the period 1980-2012. In particular, an increase in money supply by 1 percent results in an increase of manufacturing output by 0.55 percent. This means that the sensitivity of the manufacturing industry to additional liquidity is more than one half of that extra amount of money. This outcome, in conjunction with the aforementioned elasticity measures, verifies the argument that the Greek manufacturing industry is very important to the Greek economy because it serves the primary needs of consumers.

The last equation which is taken into consideration in the first step's system is the supply function (25c) in order to estimate the conjectural variation elasticity of the manufacturing industry over the period 1980-2012. By definition of the supply function of this form, the estimation process necessitates the use of the elasticity of output with respect to price for the industry, which is found to be $h=-0.982261$. When this value is substituted in the supply equation, the estimation process can occur such that the index of competition, conjectural variation elasticity, to be extracted. The *3SLS* estimation technique is used, given the presence of both heteroskedasticity and serial correlation in the error term φ_{2t}, in conjunction with the presence of endogeneity caused by the variables of unit costs and output. The Breusch-Pagan *LM* test is found to be significant at the 5% level of significance, by suggesting the presence of cross-sectional dependence in the supply function of the manufacturing industry as well. Additionally, given that the Hausman test suggests once again the consideration of the fixed effects model, the estimation process of the system[54] is performed by using the *2SLS* technique and subsequently, by applying the *FGLS* transformation to correct for both heteroskedasticity and contemporaneous correlation.

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[53] In addition to this argument, Betti et al (2007) showed that a significant proportion of Greek households over 1990-2000 were indeed liquidity constrained.

[54] The system refers to equations (25), (25a), (25b) and (25c).The diagnostic tests were conducted for the total cost and supply function separately in order to identify the properties of the error terms.

The conjectural variation elasticity f_i, given its definition, expresses an indicator of competitiveness in a particular sector, according to the contribution of an individual sector in terms of production, to the output level of the whole industry. The value of this contribution ranges between *0* and *1*, where the former value indicates conditions of perfect competition, while the latter one indicates a monopolistic structure. In the case of the Greek manufacturing industry overall, conjectural variation elasticity is found to be equal to $f_{man}=0.513468$, which is a significant estimate at the *1*% level of significance.

This particular estimate ranges between *0* and *1*, a result consistent with theory, while it also provides evidence that there exist a degree of imperfect competition in the manufacturing industry. Bresnahan (1982) supported that the higher the value of this measure, the higher the degree of concentration in that market. This means that a value of conjectural variation equal to *0.5* would indicate that the particular industry behaves in terms of a duopoly. This holds because a change in production of each individual sector on average would cause the same increase in total output equal to one half. Therefore, a value of *0.513468* in the Greek manufacturing industry provides evidence of a significant degree of imperfect competition, under which the individual sectors on average appear to have a value of conjectural variation elasticity similar to the one of duopoly. This means that the Greek manufacturing industry is either dominated by a few large 3-digit sectors or by a few large producers operating in particular sectors, or both.

The results obtained from the translog cost, demand and supply function for the whole manufacturing industry over the period 1980-2012 provide evidence in favour of imperfect competitive conditions, given the value of conjectural variation elasticity. In addition to this result, price demand elasticity is found to be inelastic, while investment, sales concentration and money supply indicators are found to have a significant positive, but highly inelastic effect on industrial output. The value of these measures which have been taken into account in the demand function can justify the presence of imperfect competition in the manufacturing industry. Inelastic values may lead to a degree of market power since producers may be able to observe that changes in their pricing decisions may result in lower percentage changes in quantity demanded and thus, try to acquire higher levels of profit. Either way, this step has provided an overall interpretation of the manufacturing industry in terms of production decisions, including 56 3-digit sectors over 33 years. For this reason, two additional steps will be presented, under which the examination of each individual sector and each year will be tested respectively.

6.1.2. Second Step

The second specification of the conjectural variation approach refers to the panel estimation of conjectural variation elasticity of each constituent 3-digit sector. As in the first step, the cost function (25) along with the cost share equations of labour and capital (25a) and (25b) are taken into account. However, the supply and demand functions used in the first step are transformed in order to fit in the 3-digit level panel analysis which will reflect the estimates of the manufacturing sectors.

In this step, as mentioned in section 4.2.1, a cross sectional dummy variable DS_i ($i=1,..,k$), which is set to unity for the *i* sector and zero otherwise, is going to be added in the aforementioned supply and demand functions to capture the individual effects of each sector. Therefore, the equations of supply and demand are transformed into (32) and (33) respectively which incorporate the cross-sectional specification of this study. This specification of panel data analysis has been chosen over an individual time series analysis under which the demand equation would be estimated for each sector separately. The main reason for choosing the panel data approach lies on the presence of cross-sectional dependency between the error terms of the individual entities. If there is evidence of such dependency, then the cross-sectional specification of panel data analysis can take into account that form of dependency by applying either the fixed or the random effects model.

As in the previous step, the system of the cost, demand and supply function must be estimated and thus, the indicators of conjectural variation elasticity have to be obtained. For this reason, it is necessary to extract the value of price elasticity of each sector and particularly, the value of elasticity of aggregate output with respect to each 3-digit sector's wholesale price level. However, since the demand equation consists of four explanatory variables (i.e. wholesale price, investment, sales concentration and liquidity indicator), it would not be feasible to estimate the cross-sectional effects of each variable simultaneously. This holds because the number of regressors would exceed the number of instruments and therefore, the model would be under-identified. For this reason, the demand function is divided into four equations, where each one of them satisfies the assumption of *ceteris paribus*.

In particular, the equation set of (33) consists of four equations. The first equation allows the estimation of the price elasticity indicator of each 3-digit manufacturing sector over the period 1980-2012, but it constraints the estimation of the three remaining variables to an average long-run value. This means that the remaining variables reflect an average estimation of the 56 constituent manufacturing sectors over the period 1980-2012[55]. The second equation treats investment decisions as the cross-sectional variable, and so on.

[55] Note that such estimations are not equivalent to the ones provided by equation (26). The latter equation results in estimates reflecting the whole manufacturing industry, while the estimates of (33) result in an average value of the constituent 56 3-digit sectors of this analysis when individual effects are accounted for each sector.

Table 3. *Estimations of the Demand Function of the 3-digit Sectors in the Greek Manufacturing Industry over the period 1980-2012 (Bresnahan Cross-Sectional Specification)*

Parameters	**Estimation of (33): First regression**	**Estimation of (33): Second regression**
a (constant)	18.227654 (12.26058)	18.372131 (13.514238)
h (price)	-	-0.969517 (-4.431229)
h^z *(investment)*	0.226404 (5.413808)	-
h^H *(herf)*	-0.055765 (-2.233745)	-0.022645 (-2.097789)
h^{liq} *(ms)*	0.476254 (4.483182)	0.527516 (3.845215)
$h_{101} \| h^z_{101}$	-0.952531 (-5.000731)	0.218583 (3.682585)
$h'_{102} \| h'^z_{102}$	-0.789774 (-4.527045)	0.140618 (1.691878)
$h'_{103} \| h'^z_{103}$	-1.061923 (-5.997912)	0.246652 (3.964877)
$h'_{104} \| h'^z_{104}$	-0.954497 (-5.056293)	0.219088 (3.891635)
$h'_{105} \| h'^z_{105}$	-0.842937 (-4.822564)	0.226383 (3.911973)
$h'_{106} \| h'^z_{106}$	-0.901376 (-4.901627)	0.192472 (2.701135)
$h'_{107} \| h'^z_{107}$	-1.049981 (-5.995958)	0.183651 (2.511825)
$h'_{108} \| h'^z_{108}$	-0.842638 (-4.834071)	0.254136 (4.079477)
$h'_{109} \| h'^z_{109}$	-0.877128 (-4.898470)	0.256665 (4.094659)
$h'_{110} \| h'^z_{110}$	-0.761936 (-4.434082)	-0.003641 (-0.485806)
$h'_{120} \| h'^z_{120}$	-0.870744 (-5.680441)	0.230965 (2.511402)
$h'_{131} \| h'^z_{131}$	-0.986032 (-5.836623)	0.282952 (4.271138)
$h'_{132} \| h'^z_{132}$	-0.799842 (-5.645146)	0.212122 (3.180135)
$h'_{139} \| h'^z_{139}$	-0.885056 (-5.916582)	0.239366 (3.849333)
$h'_{141} \| h'^z_{141}$	-1.445907 (-6.523222)	0.228721 (3.436184)
$h'_{143} \| h'^z_{143}$	-1.057333 (-5.968075)	0.213362 (3.112401)
$h'_{151} \| h'^z_{151}$	-0.884947 (-5.614131)	0.226746 (3.865178)
$h'_{152} \| h'^z_{152}$	-0.917940 (-5.805087)	0.255191 (4.099595)
$h'_{161} \| h'^z_{161}$	-0.855978 (-5.867018)	0.132051 (2.022143)
$h'_{162} \| h'^z_{162}$	-0.940651 (-5.901258)	0.164289 (2.165547)
$h'_{171} \| h'^z_{171}$	-1.124961 (-6.362332)	0.271991 (4.125107)
$h'_{172} \| h'^z_{172}$	-1.290055 (-6.427803)	0.265709 (4.137404)
$h'_{192} \| h'^z_{192}$	-0.908495 (-5.811596)	0.283347 (4.386759)
$h'_{201} \| h'^z_{201}$	-0.827914 (-5.492551)	0.179044 (2.270926)
$h'_{202} \| h'^z_{202}$	-0.861758 (-5.595018)	-0.125477 (-2.930603)
$h'_{203} \| h'^z_{203}$	-0.818619 (-5.576136)	0.220679 (3.706848)
$h'_{204} \| h'^z_{204}$	-0.744985 (-5.180191)	0.225298 (3.754735)
$h'_{205} \| h'^z_{205}$	-0.729280 (-4.985732)	0.141897 (2.018199)
$h'_{221} \| h'^z_{221}$	-1.070195 (-5.975562)	0.111307 (1.859751)
$h'_{222} \| h'^z_{222}$	-1.285984 (-6.479175)	0.188123 (2.299697)
$h'_{231} \| h'^z_{231}$	-1.519206 (-6.881614)	-0.032534 (-1.973403)
$h'_{233} \| h'^z_{233}$	-1.435121 (-6.729528)	-0.028275 (-1.884414)
$h'_{234} \| h'^z_{234}$	-1.249278 (-6.164139)	-0.057056 (-2.063649)
$h'_{235} \| h'^z_{235}$	-1.146913 (-6.032616)	0.167058 (2.053447)
$h'_{236} \| h'^z_{236}$	-1.633038 (-7.045673)	0.190394 (2.228056)
$h'_{237} \| h'^z_{237}$	-1.047770 (-5.836492)	-0.022641 (-2.042773)
$h'_{239} \| h'^z_{239}$	-1.349345 (-6.371013)	0.147669 (2.002506)

(Table 3 continue)

$h'_{241}\|h'^{z}_{241}$	-0.880851 (-5.842858)	0.212362 (3.595069)
$h'_{242}\|h'^{z}_{242}$	-0.831536 (-5.737318)	0.223098 (3.687359)
$h'_{243}\|h'^{z}_{243}$	-0.881054 (-5.851643)	-0.062241 (-2.335382)
$h'_{244}\|h'^{z}_{244}$	-0.920842 (-5.924564)	-0.026375 (-2.109596)
$h'_{251}\|h'^{z}_{251}$	-0.906673 (-5.908401)	0.001906 (0.604807)
$h'_{252}\|h'^{z}_{252}$	-0.910975 (-5.906493)	0.150812 (2.064741)
$h'_{253}\|h'^{z}_{253}$	-0.829649 (-5.717329)	0.242318 (3.551509)
$h'_{257}\|h'^{z}_{257}$	-0.840842 (-5.722714)	0.189142 (2.225731)
$h'_{259}\|h'^{z}_{259}$	-0.900367 (-5.896523)	0.263597 (4.499264)
$h'_{271}\|h'^{z}_{271}$	-1.027825 (-5.984226)	0.225135 (4.012668)
$h'_{273}\|h'^{z}_{273}$	-1.113791 (-6.021342)	0.192617 (2.245638)
$h'_{274}\|h'^{z}_{274}$	-1.195172 (-6.061394)	0.131659 (2.083795)
$h'_{275}\|h'^{z}_{275}$	-1.097168 (-6.028376)	0.007772 (0.999341)
$h'_{281}\|h'^{z}_{281}$	-1.044960 (-5.951689)	0.178251 (2.143513)
$h'_{282}\|h'^{z}_{282}$	-1.026055 (-5.934536)	0.213505 (3.861793)
$h'_{283}\|h'^{z}_{283}$	-1.011110 (-5.874053)	0.182474 (2.191317)
$h'_{289}\|h'^{z}_{289}$	-1.173291 (-6.065186)	0.228719 (4.036404)
$h'_{292}\|h'^{z}_{292}$	-1.038342 (-5.946828)	0.189825 (3.745407)
$h'_{310}\|h'^{z}_{310}$	-0.867587 (-5.804937)	0.199671 (3.889384)
Estimation Method	3SLS	3SLS
Breusch and Pagan Test (LM Test)	3.2512 [0.0791]	3.5187 [0.0692]
Likelihood Ratio Test	235.3432 [0.0000]	286.3918 [0.0000]
Hausman Test	64.2573 [0.0000]	54.1294 [0.0000]
Wooldridge Test	0.0915 [0.7918]	0.1183 [0.7895]
Wald Test	8.3827 [0.0000]	10.7146 [0.0000]

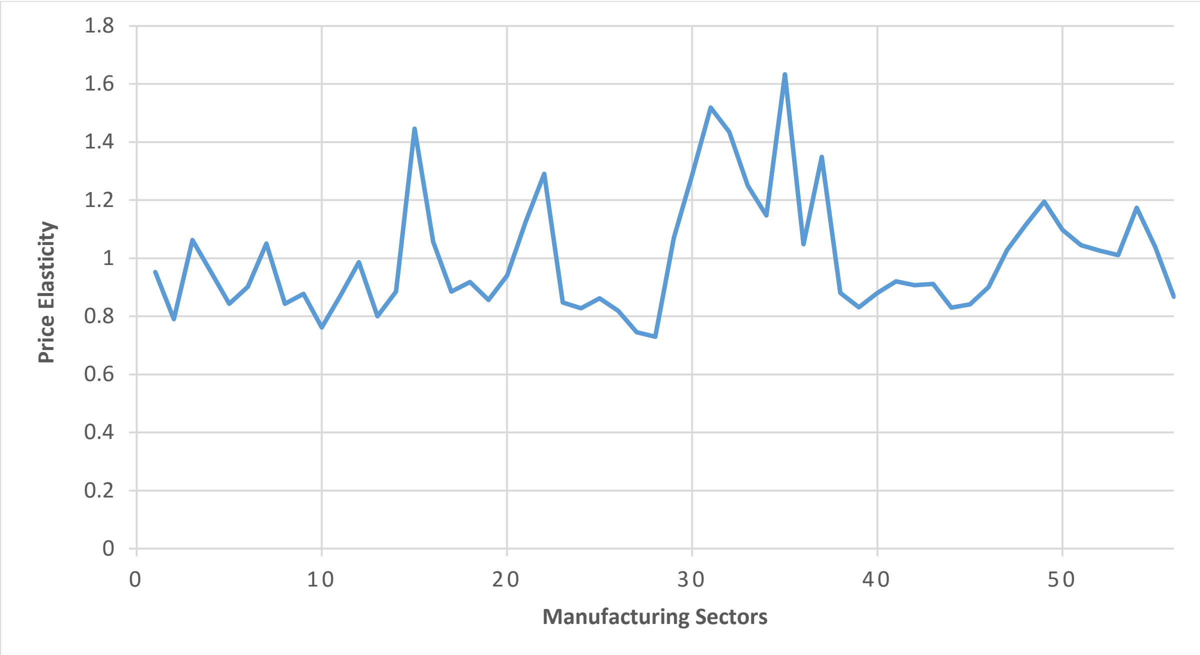
Notes: See notes in Table 1.
The values presented in this table correspond to the total value of each elasticity index, as the sum between the sector *101* and the change of the corresponding sector i (i.e. $h'_i=h_{101}+h_i$).

The results are presented in Tables 3 and 4. As in equation (26), the presence of endogeneity between the explanatory variables (excluding P_t) and output does not allow the use of the *OLS* estimation method. This means that the necessity for the inclusion of instruments corresponds to the application of the *2SLS* estimation method. Table 3 presents the estimated equations by considering the wholesale price (P_t) and the investment level (Z_t) as the cross-sectional variables. In particular, the Breusch-Pagan *LM* test is found to be insignificant at the 5% level of significance by indicating the presence of cross-sectional independency[56]. Additionally, the likelihood ratio and the Wooldridge test provide evidence in favour of the presence of both heteroskedasticity and serial correlation at any conventional level of significance. Therefore, both equations are estimated by employing the *FGLS* estimation method. However, given the presence of endogeneity, the *3SLS* estimation technique is used in order to treat the issue of endogeneity and subsequently, the presence of heteroskedasticity and serial correlation.

The estimates obtained by the first equation of (33) treat the wholesale price indicator as the cross-sectional variable. Therefore, the indexes of investment, sales concentration and liquidity reflect an average value of the constituent 3-digit sectors over the sample period 1980-2012. In particular, elasticity of aggregate output with respect to investment and liquidity are found to be significant at any conventional level of significance and their values are consistent with the extracted estimates of (26). Elasticity of aggregate output with respect to sales concentration has been found to be significant at the 5% level of significance; however, its value is negative and equal to *-0.055765*, which is different from the estimate obtained for the whole manufacturing industry during the first step. Such value indicates that under this particular cross-sectional specification, the 3-digit sectors of this sample on average face an inelastic reduction in aggregate production as they become more concentrated in terms of sales. More details about the relationship between aggregate production and sales concentration will be provided below, where the latter index will be considered as the cross-sectional variable.

[56] However, since the estimations of the Breusch-Pagan *LM* test are significant at the 10% level of significance and the remaining demand equations result in significant results at the 5% level of significance, the cross-sectional specification of panel data analysis is chosen.

Figure 1: Elasticity of nominal wholesale price with respect to output of the 3-digit manufacturing sectors over 1980-2012.



The inclusion of a cross-sectional dummy variable, as mentioned before, results in individual estimations of the elasticity of aggregate output with respect to wholesale price of each constituent 3-digit sector of this study. In particular, all of the estimates are significant at any conventional level of significance and their value is less than unity. As in the first step, the price elasticity index for each sector is inelastic by reflecting that positive (negative) fluctuations in wholesale pricing decisions of each sector will result in negative (positive) fluctuations in aggregate production by a lower percentage. The reason for this outcome, as argued in the previous step, lies on the fact that the products of the manufacturing industry are considered to be important for consumption. The estimates of price elasticity of this sample range between *-0.729280* and *-1.633038*. This set of estimates provides evidence in favour of the main assumption of this study that the constituent 3-digit manufacturing sectors are crucial to domestic consumption.

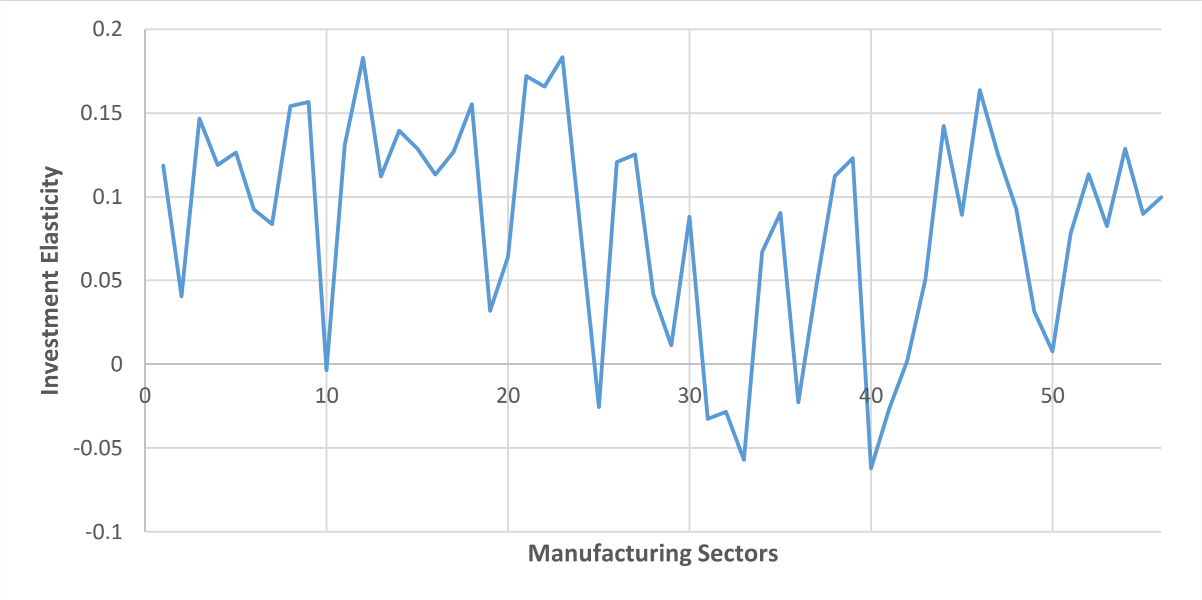
In particular, the most inelastic estimates have been obtained by the sectors of chemical products (i.e. 205), of cleaning and polishing preparations (i.e. 204) and of beverages (i.e. 110). On the other hand, the most elastic estimates fluctuate around *1.6* and result from the sectors of articles of concrete, cement and plaster (i.e. 236), of glass and glass products (i.e. 231) and of wearing apparel (i.e. 141). The remaining sectors, as illustrated in figure 1, fluctuate around *0.9* on average. This means that sectors facing a relatively low price elasticity index may be able to charge higher prices in contrast to sectors which are found to have a higher price elasticity indicator. The group of sectors experiencing the lowest absolute elasticity is the group of chemical products (i.e. 20) and the group of furniture (i.e. 31). On the other hand, the groups which have been found to have the highest absolute value of elasticity refer to the group of non-metallic mineral products (i.e. 23) and the group of wearing apparel (i.e. 14).

On the basis of theory and intuition, the index of price elasticity could be an indicator of market power and a mean of consumer surplus exploitation for every sector, especially when the particular elasticity index is less than unity. However, an approach which is considered to be closer to reality has to incorporate additional variables that might result in contradicting results. Regardless the value of the estimates extracted from this equation, the same procedure has to be repeated for the remaining indicators in order to observe their behaviour. The main reason of this part is to understand the decision process of both producers and consumers which result from their interactions in the market of manufacture.

The second indicator which is treated as the cross-sectional variable in the second regression of (33) corresponds to the level of investments undertaken by each sector of the manufacturing industry over the period 1980-2012. Therefore, as in the previous case, the remaining three variables (i.e. P_t, $Herf_t$ and MS_t) are considered as fixed across the manufacturing industry over the same period. In particular, the average value of elasticity of aggregate output with respect to the wholesale price index is *-0.769517*, which is consistent with the estimations for the whole manufacturing industry. Sales concentration elasticity corresponds to a negative value *-0.022645* as in the first equation of the demand set by indicating that the sectors of this study face a highly inelastic reduction in aggregate production as they become more concentrated in terms of sales. Lastly, liquidity elasticity is *0.527516*, a value which is also consistent with the aforementioned estimations.

The cross-sectional estimates of investment elasticity obtained for the 3-digit manufacturing sectors of this study vary in terms of significance. In particular, elasticity of aggregate output with respect to investment for sectors 102, 110, 221, 233, 251 and 275 is not found to be significant at the 5% level of significance. This outcome indicates that in the particular sectors, investment decisions did not result in additional significant changes in the level of the manfuacturing industry’s output. On the other hand, the estimates obtained for the remaining manufacturing sectors are found to be significant at least at the 5% level of significance. The value of the estimated elasticities range between *-0.125477* and *0.283347*, where the lowest value corresponds to the sector of pesticides and other agrochemical products (i.e. 202) and the highest value to the sector of refined petroleum products (i.e. 192).

Figure 2: Elasticity of investment with respect to output of the 3-digit manufacturing sectors over 1980-2012.



Such evidence suggest that investment decisions appear to have an inelastic effect on aggregate output of the manufacturing industry by verifying the estimated value obtained for the industry as a whole in the first step. In some sectors, investment decisions appear to have no additional significant effect at all or even a negative effect on production decisions. The reason for such outcome may lie on the fact that investing decisions are made in order to improve the quality of a particular product, to reduce the costs of production or even improve the reputation of a particular sector (or firm) in the industry of manufacture. According to the type and the effectiveness of investment, production decisions may be affected along with the demanded quantity of supplied products.

However, one of the restrictions of this study involves the fact that the dataset of investment does not distinguish between different types of investment. For this reason, there is an aggregated formulation of such types given the significance and the magnitude of investment elasticity. For instance, a significant positive elasticity value could suggest that investment decisions have been made in favour of a boost in production which may be a result or may result in a boost of demand for particular products. The sectors with the highest value of investment elasticity are the sectors of refined petroleum products (i.e. 192), of preparation and spinning of textile fibres (i.e. 131) and of pulp, paper and paperboard (i.e. 171). On the other hand, the sectors with the lowest (negative) value are the sectors of pesticides and other agrochemical products (i.e. 202), of other products of first processing of steel (i.e. 243) and of other porcelain and ceramic products (i.e. 234).

Nevertheless, an additional consideration has to be regarded, where investment decisions have not resulted in the desirable outcome. If a particular sector invests in improving the quality of its product but quantity demanded for this product is not increased, then that sector will have to reduce its output by resulting in a *ceteris paribus* reduction of aggregate output. Whichever the case, the indicator of investments has been taken into account in this study in order to test whether such decisions have an impact on the level of output of the manufacturing industry. Despite a number of sectors, the majority of the constituent sectors proved to have a significant positive effect on production by indicating that investments in the manufacturing industry result in a positive inelastic change of aggregate output.

Table 4 presents the estimations obtained by the remaining two equations of (33) concerning elasticity of aggregate output with respect to sales concentration and liquidity respectively. In particular, in contrast with the aforementioned equations of price and investment, the Breusch-Pagan *LM* test provides evidence in favour of cross-sectional dependency for both indicators, significant at the 5% level of significance. This means that since there is dependency across the individual entities of this study, the type of dependency must be identified by using the fixed or the random effects model. The results obtained by the Hausman test reflect strong evidence in favour of endogeneity within each individual entity, significant at any level of significance.

Therefore, the fixed effects approach is going to be used for the equations of sales concentration and liquidity. In addition, the likelihood ratio test suggests the presence of heteroskedasticity at any conventional level; however, the Wooldridge test provides no evidence of serial correlation. For this reason, the equations should be estimated by using the least squares dummy variables (*LSDV*) method, but given the presence of endogeneity in the demand function and the presence of heteroskedasticity, the *3SLS* estimation technique is taken into consideration.

Table 4. *Estimations of the Demand Function of the 3-digit Sectors in the Greek Manufacturing Industry over the period 1980-2012 (Bresnahan Cross-Sectional Specification)*

Parameters	**Estimation of (33): Third regression**	**Estimation of (33): Fourth regression**
a (constant)	18.205451 (12.062081)	18.926414 (12.961212)
h (price)	-0.902089 (-3.943660)	-0.880925 (-4.952327)
h^z *(investment)*	0.219834 (5.868810)	0.182373 (7.208786)
h^H *(herf)*	-	-0.019396 (-2.019626)
h^{liq} *(ms)*	0.519121 (4.540391)	-
$h^H_{101}\|h^{liq}_{101}$	0.251905 (2.059035)	0.478927 (4.494816)
$h'^H_{102}\|h'^{liq}_{102}$	0.131366 (1.827194)	0.416813 (4.273284)
$h'^H_{103}\|h'^{liq}_{103}$	0.185617 (2.019534)	0.505425 (4.588752)
$h'^H_{104}\|h'^{liq}_{104}$	0.148733 (1.896890)	0.487502 (4.530662)
$h'^H_{105}\|h'^{liq}_{105}$	-0.115427 (-2.029102)	0.501935 (4.575083)
$h'^H_{106}\|h'^{liq}_{106}$	0.144583 (1.918994)	0.532510 (4.682710)
$h'^H_{107}\|h'^{liq}_{107}$	0.295393 (2.078131)	0.464481 (4.445032)
$h'^H_{108}\|h'^{liq}_{108}$	0.192377 (2.035352)	0.497307 (4.563299)
$h'^H_{109}\|h'^{liq}_{109}$	0.130597 (1.878071)	0.507282 (4.596290)
$h'^H_{110}\|h'^{liq}_{110}$	0.169224 (1.980823)	0.463331 (4.443513)
$h'^H_{120}\|h'^{liq}_{120}$	-0.126787 (-2.064368)	0.422104 (4.288454)
$h'^H_{131}\|h'^{liq}_{131}$	-0.076107 (-1.980870)	0.537816 (4.699775)
$h'^H_{132}\|h'^{liq}_{132}$	-0.039882 (1.815482)	0.465321 (4.440137)
$h'^H_{139}\|h'^{liq}_{139}$	-0.091207 (-2.028395)	0.510197 (4.606262)
$h'^H_{141}\|h'^{liq}_{141}$	-0.047744 (-1.862548)	0.552404 (4.746553)
$h'^H_{143}\|h'^{liq}_{143}$	-0.080349 (-1.991514)	0.537570 (4.689303)
$h'^H_{151}\|h'^{liq}_{151}$	-0.050202 (-1.880868)	0.487743 (4.527819)
$h'^H_{152}\|h'^{liq}_{152}$	-0.087483 (-2.009051)	0.576231 (4.839301)
$h'^H_{161}\|h'^{liq}_{161}$	0.124198 (1.765218)	0.505074 (4.582767)
$h'^H_{162}\|h'^{liq}_{162}$	0.233364 (2.040337)	0.528356 (4.671100)
$h'^H_{171}\|h'^{liq}_{171}$	-0.148641 (-2.148948)	0.522858 (4.646669)
$h'^H_{172}\|h'^{liq}_{172}$	-0.091425 (-2.027491)	0.537467 (4.697886)
$h'^H_{192}\|h'^{liq}_{192}$	-0.232517 (-2.651690)	0.538745 (4.708112)
$h'^H_{201}\|h'^{liq}_{201}$	-0.187298 (-2.053015)	0.530945 (4.676061)
$h'^H_{202}\|h'^{liq}_{202}$	-0.140875 (-2.139933)	0.434249 (4.337362)
$h'^H_{203}\|h'^{liq}_{203}$	-0.131998 (-2.059699)	0.491089 (4.540219)
$h'^H_{204}\|h'^{liq}_{204}$	-0.192989 (-2.203436)	0.500169 (4.572667)
$h'^H_{205}\|h'^{liq}_{205}$	-0.063775 (-1.978266)	0.498514 (4.572448)
$h'^H_{221}\|h'^{liq}_{221}$	0.091748 (1.659969)	0.468727 (4.463815)
$h'^H_{222}\|h'^{liq}_{222}$	-0.050229 (-1.861708)	0.544779 (4.727111)
$h'^H_{231}\|h'^{liq}_{231}$	-0.107454 (-2.072357)	0.307308 (3.858637)
$h'^H_{233}\|h'^{liq}_{233}$	0.156542 (1.940784)	0.423711 (4.293581)
$h'^H_{234}\|h'^{liq}_{234}$	0.131776 (1.813848)	0.319964 (3.895844)
$h'^H_{235}\|h'^{liq}_{235}$	0.141969 (1.834321)	0.526300 (4.662186)
$h'^H_{236}\|h'^{liq}_{236}$	0.217488 (2.045170)	0.539791 (4.699226)
$h'^H_{237}\|h'^{liq}_{237}$	0.104496 (1.691126)	0.439424 (4.359833)
$h'^H_{239}\|h'^{liq}_{239}$	0.077115 (1.563115)	0.478292 (4.483579)

(Table 4 continue)

$h'^{H}_{241}\|h'^{liq}_{241}$	-0.060609 (-1.908251)	0.551807 (4.744959)
$h'^{H}_{242}\|h'^{liq}_{242}$	-0.057800 (-1.896595)	0.479276 (4.495695)
$h'^{H}_{243}\|h'^{liq}_{243}$	-0.094836 (-2.014162)	0.399633 (4.233325)
$h'^{H}_{244}\|h'^{liq}_{244}$	-0.168352 (-2.217316)	0.455561 (4.432202)
$h'^{H}_{251}\|h'^{liq}_{251}$	-0.140168 (-2.164833)	0.487807 (4.526464)
$h'^{H}_{252}\|h'^{liq}_{252}$	-0.127857 (-2.120988)	0.492508 (4.532063)
$h'^{H}_{253}\|h'^{liq}_{253}$	-0.154691 (-2.184180)	0.298065 (3.801526)
$h'^{H}_{257}\|h'^{liq}_{257}$	-0.137519 (-2.157786)	0.438007 (4.342921)
$h'^{H}_{259}\|h'^{liq}_{259}$	-0.063901 (-1.913746)	0.534115 (4.699490)
$h'^{H}_{271}\|h'^{liq}_{271}$	0.167844 (1.971444)	0.485937 (4.524934)
$h'^{H}_{273}\|h'^{liq}_{273}$	0.136813 (1.901893)	0.545689 (4.730053)
$h'^{H}_{274}\|h'^{liq}_{274}$	0.041874 (1.208693)	0.471959 (4.467512)
$h'^{H}_{275}\|h'^{liq}_{275}$	0.124148 (1.772211)	0.451441 (4.389891)
$h'^{H}_{281}\|h'^{liq}_{281}$	-0.063073 (-1.931853)	0.456298 (4.416351)
$h'^{H}_{282}\|h'^{liq}_{282}$	-0.059692 (-1.898919)	0.552741 (4.749066)
$h'^{H}_{283}\|h'^{liq}_{283}$	-0.085425 (-1.985838)	0.518179 (4.640944)
$h'^{H}_{289}\|h'^{liq}_{289}$	-0.166473 (-2.235464)	0.486038 (4.524355)
$h'^{H}_{292}\|h'^{liq}_{292}$	0.020234 (1.055629)	0.516816 (4.618815)
$h'^{H}_{310}\|h'^{liq}_{310}$	0.066103 (1.354427)	0.548315 (4.738051)
Estimation Method	3SLS	3SLS
Breusch and Pagan Test (LM Test)	5.1093 [0.0437]	6.5238 [0.0342]
Likelihood Ratio Test	258.2014 [0.0000]	301.8371 [0.0000]
Hausman Test	48.5193 [0.0000]	63.9183 [0.0000]
Wooldridge Test	0.0734 [0.8012]	0.1587 [0.7279]
Wald Test	9.4817 [0.0000]	9.1874 [0.0000]

Notes: See notes in Table 1.

The values presented in this table correspond to the total value of each elasticity index, as the sum between the sector *101* and the change of the corresponding sector i (i.e. $h'_i=h_{101}+h_i$).

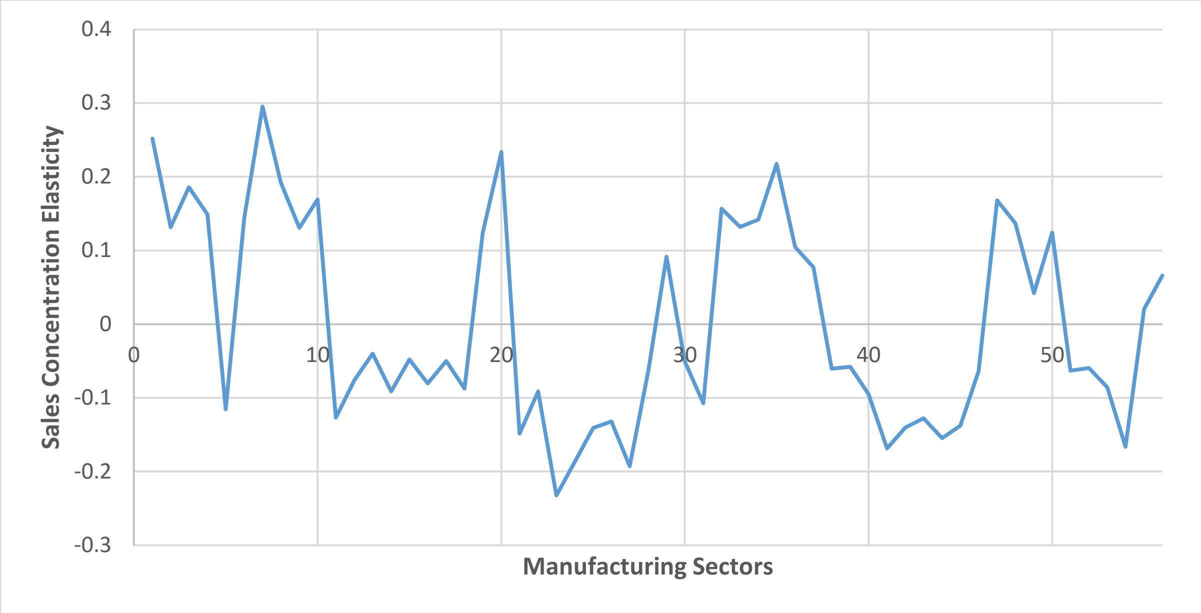
The estimation of sales concentration is constructed by treating *herf* as the cross-sectional variable, while the remaining variables are kept constant for the 56 constituent sectors over the period 1980-2012. In particular, the estimate of elasticity of aggregate output with respect to the wholesale price, investment and liquidity index is found to be equal to -*0.902089*, *0.219834* and *0.519121* respectively at any conventional level of significance. These values are consistent with the estimations obtained by equation (26) and the demand equations of price and investment. However, the cross-sectional concentration estimates obtained for the 3-digit sectors of this study do not appear to be as significant as the estimates of the aforementioned equations. There are no significant estimations at the 1% level of significance, while 22 sectors of the sample appear to have an additional insignificant effect on the manufacturing industry's aggregate output.

The value of output elasticity with respect to sales concentration, as argued above, does not have the same sign in every 3-digit sector. There is a number of positive elasticity estimations, which sugegst that an increase in the rate of sectorial concentration will lead to an increase in output of the manufacturing industry. However, there are negative signed estimates as well, which are interpreted as a negative relationship between sales concentration and industrial output. This means that a greater degree of sales concentration leads to a reduction of the manufacturing industry's output. Intuitively, a positive elasticity value of this index reflects that if the level of sales of a particular sector is increased relatively to the sales of the whole manufacturing industry, then aggregate output will be increased as well. The reason for this outcome is partially due to an increase in the level of production of this sector, given a higher rate of sales, and partially due to a potential increase in production of the remaining sectors[57].

On the other hand, a negative value indicates that despite a relative increase in the level of sales of a particular sector, aggregate output of the manufacturing industry falls. A possible reason for this outcome could be the acquisition of market power. If that sector increases its level of sales by reducing the level of production, then increased concentration has a negative effect on the production level of the manufacturing industry. This outcome might emerge only if the remaining sectors make such production decisions that result in a decrease of aggregate output through increased wholesale price levels. For this reason, sales concentration which may reflect a form of market power is taken into account in the demand equation of this study. By estimating this equation, there is evidence obtained regarding the effects of this particular indicator on production decisions and therefore, on consumer preferences captured by the demand function of this type.

[57] An increase of the sales concentration index is a relative increase in sales between the particular sector and the remaining sectors. Therefore, this could mean that there may be an increase in the level of sales of every sector, but the highest rate is achieved by that particular sector.

Figure 3: Elasticity of sales concentration with respect to output of the 3-digit manufacturing sectors over 1980-2012.



The estimates of sales concentration elasticity, appear to have both negative and positive effects on the manufacturing industry's level of output. In particular, the lowest values significant at least at the 5% level of significance are obtained by the sector of refined petroleum products (i.e. 192), of soap and detergents, cleaning and polishing (i.e. 204), of basic chemicals and plastics and synthetic rubber in primary forms (i.e. 201) and of basic precious and other non-ferrous metals (i.e. 244). On the other hand, the highest concentration values of elasticity significant at least at the 5% level of significance are estimated for the sector of bakery and farinaceous products (i.e. 107), of processing and preserving of meat and production of meat products (i.e. 101), of products of wood, cork, straw and plaiting materials (i.e. 162) and of articles of concrete, cement and plaster (i.e. 236).

In both cases where changes in sales concentration have a respective effect on aggregate output, the value of sales concentration elasticity is quite inelastic. This means that changes in sales decisions undertaken by the constituent sectors of the manufacturing industry will result in weak and inelastic changes in the output level of the whole manufacturing industry. Production decisions and sales can partially reflect fluctuations in the quantity demanded and supplied by the 3-digit manufacturing sectors. Therefore, the index of sales concentration may reflect the degree of market power or the acquisition of market power by a number of these sectors as a result of demand fluctuations[58].

The last element of this study's demand equation addresses the effect of fluctuations in the available level of liquidity on aggregate output of the manufacturing industry. As discussed in chapter 4, this particular indicator is based on the theoretical foundations provided by Rotemberg (1982a), under the assumption of a demand function subject to real price changes and real money balances. As nominal money balances, this study considers the money supply index (*M2*) for the Greek economy in order to estimate the relationship between the level of available liquidity and the manufacturing industry's aggregate production.

Rezitis and Kalantzi (2012, 2013) took into account the indicator of Gross National Income in the demand function of their study in order to identify the value of elasticity of aggregate output with respect to national income. This factor can also be treated as an index of liquidity since income is expressed in monetary units. However, by definition, economists interpret income as the amount of money which is used for consumption and savings that individuals have earned over a particular time period. Consequently, the available income that consumers have to use for consumption corresponds to their net spending or otherwise, the amount of available money excluding savings. This indicator may be subject to fluctuations of consumption, savings or labour decisions; however, it does not reflect directly fluctuations in money provision and thus, money supply. Changes in monetary policy are reflected by the available level of money supply but an income indicator may not be able to capture such changes without being subject to additional variations.

In conjunction to this line of reasoning, Davidson (2002) argued that an additional factor which is able to affect consumption, savings and any other liquidity decisions corresponds to uncertainty. When the degree of future uncertainty is very high, individuals will choose to have liquid assets, such as cash, instead of choosing to invest in illiquid assets. This happens because due to exogenous factors, such as the state of the economy or economic policies, people form lower expectations about the returns from investing in an illiquid asset. This case holds because they may not be able to immediately convert these assets into cash when an unexpected urgent liability emerges. For such reasons, in this study it has been

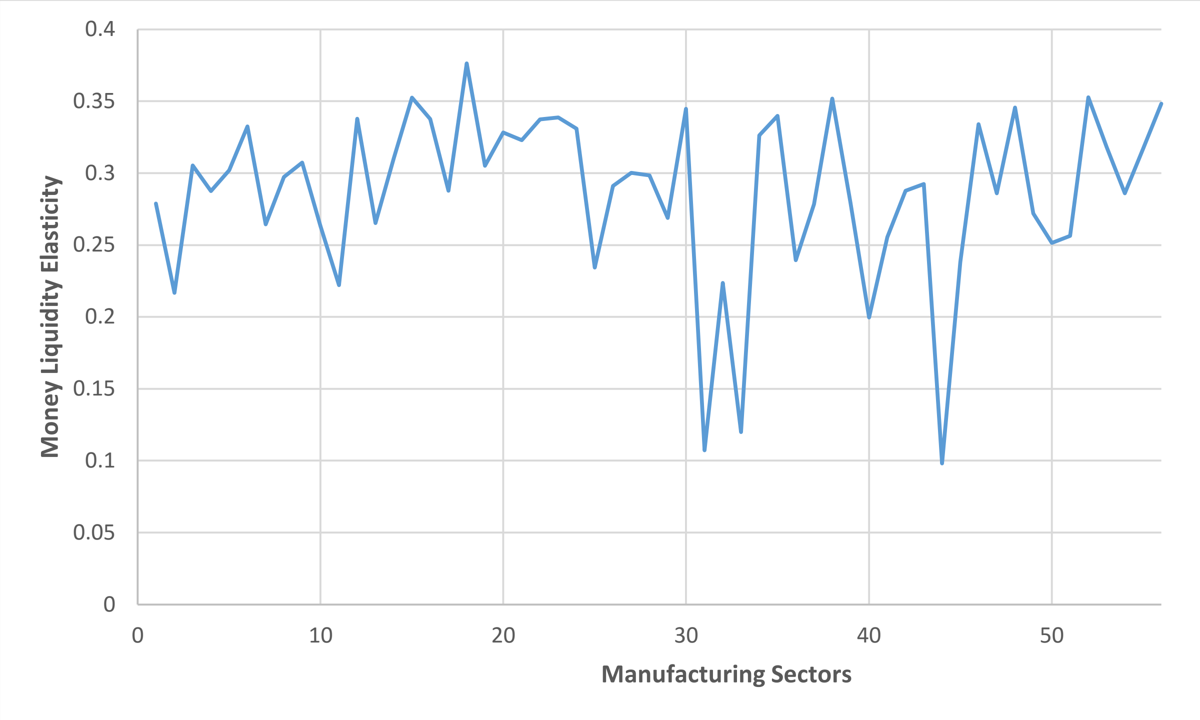
[58] The best indicator of demand behaviour in this study is considered to be the index of sales. Since the volume of sales reflect the purchasing choices of consumers, it can also be viewed as an indicator of consumer behaviour and thus, as an indicator of demand decisions.

chosen to replace the indicator of *GNI* with the indicator of money supply (*M2*) as a mechanism that reflects the quantity of monetary units and does not include any external monetary factors (i.e. consumption or savings decisions)[59].

The last part of the demand equation set treats the liquidity index as the cross sectional variable, while the indicators of price, investment and sales concentration are considered as fixed across the industry over the sample period 1980-2012. The estimated values of the non-cross sectional variables are *-0.880925*, *0.182373* and *-0.019396* for the wholesale price, investment and sales concentration index respectively significant at the 5% level of significance. The cross-sectional estimates of liquidity index have a positive sign and they are significant at the 1% level of significance as expected. This outcome verifies the rational presented in section 5.1.1 under which positive fluctuations in money supply result in higher production levels in the manufacturing industry. This happens due to either actual or expected higher demand for the products of this particular industry. However, a crucial factor which may affect the flow of liquidity in the Greek economy concerns the state of the economy. If for instance, there are limited expectations about inflation and growth, then an expansionary monetary policy through money provision may result in absence from liquidity and consumption (Davidson, 1968, 1972, 2002).

[59] The money supply index (*M2*) may be a better indicator for explaining fluctuations in the available level of money in the Greek economy; however it is not the best available indicator which reflects choices between liquid or illiquid assets. An alternative indicator could be the value of the Greek stock market and particularly, the value of the 3-digit manufacturing sectors' stocks.

Figure 4: Elasticity of money liquidity with respect to output of the 3-digit manufacturing sectors over 1980-2012.



The estimates obtained from the constituent 3-digit sectors of this study do not provide evidence in favour of a negative value of elasticity of aggregate output with respect to liquidity. In particular, the highest elasticity values are obtained by the sector of other general purpose machinery (i.e. 282), of wearing apparel except fur apparel (i.e. 141), of basic iron and steel (i.e. 241) and of furniture (i.e. 310). On the other hand, the lowest values are observed in the sectors of steam generators (i.e. 253), of other products of first processing of steel (i.e. 243), of glass and glass products (i.e. 231) and of other porcelain and ceramic products (i.e. 234). The values of elasticity of aggregate output with respect to liquidity are also inelastic but their magnitude fluctuates around *0.50*. This means that expansion in money supply over the period 1980-2012 has resulted in significantly lower increase in manufacturing production.

The consideration of the particular demand function, under which the indexes of wholesale price, investment, sales concentration and liquidity are estimated, has resulted in significant estimates for the constituent sectors of the manufacturing industry. The theoretical intuition regarding the value of the above variables has been found to be consistent with empirical evidence and therefore, there were no violations of economic theory. However, the only variable which appears to have different signs among sectors is sales concentration which represents a market power index. For this reason, depending on the market significance expressed in terms of sales, sectors with greater power will be able to manipulate their pricing decisions and therefore, their production.

In addition to the importance of the above estimations for the manufacturing industry, the secondary concern for estimating a demand function of this form regards the estimation of the first index of market power of this study, which is conjectural variation elasticity. As discussed in chapter 4, this particular indicator developed by Bresnahan (1982) and Lau (1982) provides evidence of market power expressed in terms of production; the closer the value of this index to unity, the greater the market power of a particular sector or firm will be.

The main rational concerning the formulation of the present elasticity indicator corresponds to the identification of market structure depending on production decisions. If the value of a particular firm or sector is close to *0*, then this firm is considered to behave as if the market structure is one of competition; a value of *0.5* reflects decisions equivalent to the production levels indicated by Cournot duopoly; a value greater than *0.5* and less than *1* represents an imperfectly competitive market structure because production decisions are not considered to be consistent with the corresponding decisions under competition; and lastly, a value equal to unity indicates that firms behave as if they were monopolists and therefore, their production level is equivalent to the one of monopoly.

Table 5. *Estimations of the Conjectural Variation Elasticity of the 3-digit sectors in the Greek manufacturing industry over the period 1980-2012 (Bresnahan Cross-Sectional Specification).*

Parameters	**Estimations of (32)**				
f'_{101}	0.468333 (2.013847)	f'_{201}	0.421357 (2.126354)	f'_{271}	0.554826 (2.193842)
f'_{102}	0.457895 (1.971381)	f'_{202}	0.423908 (2.009781)	**f_{273}**	0.556346 (2.361514)
f'_{103}	0.466525 (2.071635)	**f_{203}**	0.440199 (2.109580)	f'_{274}	0.553154 (1.981737)
f'_{104}	0.461913 (1.941374)	f'_{204}	0.419091 (1.983746)	f'_{275}	0.553728 (1.876192)
f'_{105}	0.474167 (1.991830)	f'_{205}	0.446917 (1.993472)	f'_{281}	0.533082 (2.091837)
f'_{106}	0.476332 (2.048173)	**f_{221}**	0.522522 (2.058772)	f'_{282}	0.522592 (2.059181)
f'_{107}	0.465013 (2.158173)	f'_{222}	0.520256 (2.374613)	f'_{283}	0.515564 (1.950193)
f'_{108}	0.467736 (2.128379)	f'_{231}	0.558117 (2.065748)	f'_{289}	0.516797 (1.940192)
f'_{109}	0.467259 (2.291833)	f'_{233}	0.551608 (2.048179)	**f_{292}**	0.493549 (2.410394)
f_{110}	0.483398 (2.219384)	f'_{234}	0.556167 (1.998751)	f'_{310}	0.468359 (2.119486)
f'_{120}	0.446334 (1.973615)	f'_{235}	0.553599 (2.019384)		
f_{131}	0.421517 (2.081736)	f'_{236}	0.554052 (1.973516)		
f'_{132}	0.413755 (1.761376)	f'_{237}	0.559975 (2.183746)		
f'_{139}	0.414021 (2.001938)	**f_{239}**	0.563671 (2.387168)		
f_{141}	0.422511 (2.139183)	f'_{241}	0.479512 (1.978371)		
f'_{143}	0.418466 (1.073612)	**f_{242}**	0.480346 (2.201938)		
f_{151}	0.470411 (1.998137)	f'_{243}	0.479796 (2.103948)		
f'_{152}	0.462028 (0.839155)	f'_{244}	0.470792 (2.057161)		
f'_{161}	0.406755 (0.731438)	**f_{251}**	0.544819 (2.149188)	**Estimation Method**	3SLS
f_{162}	0.413886 (1.976691)	f'_{252}	0.538944 (0.871635)	**Breusch and Pagan Test (LM Test)**	5.3817 [0.0372]
f_{171}	0.523012 (1.893842)	f'_{253}	0.533322 (1.564713)	**Likelihood Ratio Test**	164.7837 [0.0000]
f'_{172}	0.517631 (1.018374)	f'_{257}	0.543993 (2.071665)	**Hausman Test**	59.1837 [0.0000]
f'_{192}	0.601123 (0.987681)	f'_{259}	0.549742 (0.981709)	**Wooldridge Test**	6.6912 [0.0277]

Notes: See notes at Table 1.

The diagnostic tests presented correspond to the first regression (101-120 sectors) by indicating that similar estimations have been obtained for the rest 12 regressions.

The values presented in this Table correspond to the total value of the conjectural variation elasticity, as the sum between the fixed sector *pin* and the change of the corresponding sector *i* (i.e. $f'_i=f_{pin}+f_i$).

The 2-digit sectors in this analysis have been formed as: (101-120), (131-139), (141-143), (151-152), (161-162), (171-172), (192-205), (221-222), (231-239), (241-244), (251-259), (271-275), (281-310).

The 13 sets of the 3-digit sectors have been formed as follows:

(i) 101-120 (110 as fixed point)
(ii) 131-139 (131 as fixed point)
(iii) 141-143 (141 as fixed point)
(iv) 151-152 (151 as fixed point)
(v) 161-162 (161 as fixed point)
(vi) 171-172 (171 as fixed point)
(vii) 192-205 (203 as fixed point)
(viii) 221-222 (221 as fixed point)
(ix) 231-239 (239 as fixed point)
(x) 241-244 (242 as fixed point)
(xi) 251-259 (251 as fixed point)
(xii) 271-275 (273 as fixed point)
(xiii) 281-310 (292 as fixed point)

The *Wald Test* (H_0: $f_i=f_j=\ldots=0$) applied for each regression results in the following values:

(i) 17.5981 [0.0000]
(ii) 10.3823 [0.0000]
(iii) 0.5281 [0.6948]
(iv) 8.1383 [0.0000]
(v) 6.5727 [0.0000]
(vi) 0.8973 [0.4728]
(vii) 9.8573 [0.0000]
(viii) 10.3155 [0.0000]
(ix) 15.4831 [0.0000]
(x) 10.3754 [0.0000]
(xi) 0.6918 [0.6367]
(xii) 13.5787 [0.0000]
(xiii) 12.9946 [0.0000]

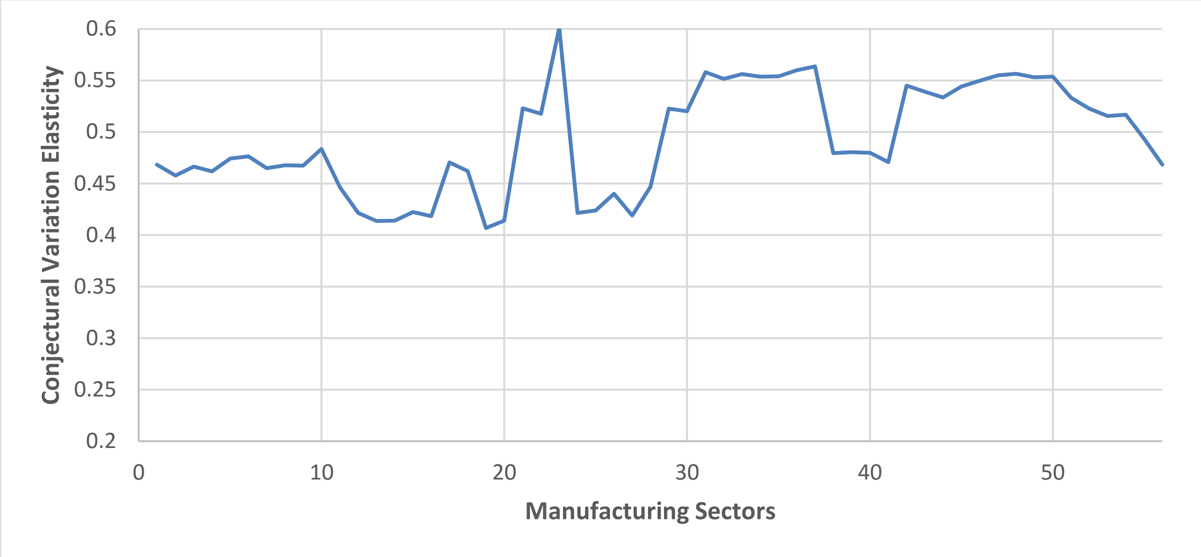
Table 5 presents the conjectural variation estimations obtained for the constituent 3-digit sectors of the manufacturing industry. The first step of this procedure takes into consideration the cost function (25) in conjunction with the supply function (25c) of the manufacturing industry. In addition, the cross sectional dummy variable is applied to the indicator of conjectural variation elasticity by following a similar procedure as before. The value of the industry's elasticity of output with respect to the wholesale price level is extracted from the fourth equation of the demand function set (33) and it is applied on the estimation procedure of the supply function[60]. However, the supply function in this step is estimated 13 times based on the 2-digit level categorization formed in this study.

In particular, according to the nature of the products produced by the constituent sectors, there is a division of the industry sample into 13 categories instead of treating the manufacturing sectors as a whole. Rezitis and Kalantzi (2012, 2013) do not distinguish their industrial sample. They use a similar formulation by estimating a single supply function for the corresponding sectors under the consideration of a single fixed point. In the present case, 13 categories are formed which can also be considered as aggregated 3-digit sectors (i.e. 2-digit) that result in more significant estimates compared to a case where the supply function is estimated one time only[61].

[60] The main motivation of choosing the value of the industry's elasticity of output with respect to wholesale price from the fourth demand equation corresponds to the magnitude of this index. Compared to the price elasticity indexes obtained by the second and third equation, the fourth index is lower in absolute value than the rest and therefore, the ratio of conjectural variation over price elasticity will be higher by maximizing the difference between those two measures (Rezitis and Kalantzi, 2013).

[61] By estimating 13 supply equations, the 13 3-digit sectors are treated as the fixed sectors in each estimated equation in order to identify the difference between that particular sector and the remaining when the cross sectional dummy variable is applied.

Figure 5: Conjectural variation elasticity of the 3-digit manufacturing sectors over 1980-2012.



The estimates of conjectural variation elasticity provide evidence in favour of an imperfectly competitive market structure in each of the 3-digit sectors of the manufacturing industry as a result of production decisions. The values of elasticity index range between *0.406755* and *0.601123* by indicating that 47 out of 56 sectors operate in terms of imperfect competition. The majority of sectors are found to have a significant degree of market power in the whole manufacturing industry with the exception of 9 sectors. The estimation method which is taken into account for the cross sectional supply equation (32) corresponds to *3SLS*, as in the previous step due to the presence of endogeneity in conjunction with the presence of both heteroskedasticity and serial correlation in the cross sectional error terms.

In particular, the *LM* test results in significant value at the 5% level of significance by indicating the existence of cross sectional dependency and therefore, that the random effects model is more suitable than the *OLS* estimation. In addition, the Hausman test provides significant evidence at the 1% level of significance by validating the presence of endogeneity within the cross sections and thus, the selection of the fixed effects model. Lastly, the likelihood ratio and the Wooldridge test are significant at least at the 5% level of significance which results in the presence of periodic heteroskedasticity and serial correlation respectively.

The aforementioned diagnostic values reflect the estimation of the first cross-sectional supply equation, or otherwise, the supply equation of the industry of food, beverages and tobacco. However, since the values of the diagnostic tests provide evidence in favour of endogeneity, heteroskedasticity and serial correlation for the remaining 12 2-digit level supply equations as well, the fixed effects model along with the *3SLS* estimation technique is used for each supply equation[62]. Conjectural variation elasticity estimations for each sector excluding the fixed (or pinpointed) sector reflect differences compared to the elasticity value of the latter sector. The estimation of the supply equation under the consideration of the cross sectional dummy variable DS_i, results in a particular value for the fixed sector. This value is treated as a benchmark, and subsequently, conjectural variation elasticity is estimated for the remaining sectors, expressed as the difference from the value of the fixed sector. For this reason, the estimations presented in Table 5 reflect the final value $f'_i=f_{pin}+f_i$ of each sector, where f_{pin} corresponds to the conjectural variation of the fixed sector and f_i refers to the change in conjectural variation elasticity of sector *i* with respect to the fixed sector *pin*.

The conjectural variation elasticity of the constituent 3-digit sectors of the manufacturing industry is presented in Table 5 and illustrated in Figure 5. Since the value of elasticity ranges over *0.413886* and *0.556346*, the manufacturing sectors operate in terms of imperfect competition, under which their production decisions tend to be close to duopolistic decisions. In particular, the lowest conjectural variation elasticity value (aside from the insignificant values) is observed by the sector of saw milling and planning of wood (i.e. 161), of weaving of textiles (i.e. 132), of manufacture products of wood, cork, straw and plaiting materials (i.e. 162) and of manufacture of other textiles (i.e. 139). On the other hand, the highest conjectural variation elasticity value and therefore, the highest degree of market power is observed by the sector of manufacture of coke and refined petroleum products (i.e. 192), of cutting, sharping and finishing of stone (i.e. 237), of manufacture of other porcelain and ceramic products (i.e. 234), and of manufacture of wiring and wiring devices (i.e. 273). Consequently, such evidence suggest that the majority of the 3-digit sectors of the manufacturing industry have been operating under imperfect competitive conditions over the period 1980-2012, by resulting in lower production than it should be under competitive (or perfectly competitive) conditions.

The estimations obtained by this step under the cross sectional approach have resulted in evidence in favour of imperfectly competitive, wholesale price inelastic markets, where investment and liquidity decisions influence production decisions undertaken by each sector. The magnitude of these effects may not be the same for every sector, but the

[62] Since the results of significance are very similar, Table 4 includes only the diagnostic tests of the first supply equation.

theoretical intuition regarding production and consumption decisions has been validated by the obtained estimates. On the one hand, imperfect competitive markets tend to face inelastic prices and in this case, wholesale prices because the greater the market power, the higher the flexibility of pricing decisions might be. On the other hand, consumers may tend to value the degree of quality of each sector or firm, expressed in terms of investment and sales; the higher the value of these measures, the greater the interest of consumers may be in choosing the best alternative by considering both price and quality level.

6.1.3. Third Step

The third step of the conjectural variation estimation approach corresponds to the time series specification of panel analysis. In this step, the constituent variables are going to be estimated for the manufacturing industry as a whole, for each year over the period 1980-2012 and 2005-2012 respectively by utilizing the panel set of this study. The main motivation of undertaking this particular specification reflects the investigation of market conditions in the manufacturing industry before and after the financial collapse of 2008, along with the beginning of the austerity period of the Greek economy in 2010 (Tsakalotos, 2011). According to this line of reasoning, the expected period sample under the time series specification was 2005-2012. However, the estimation of the price adjustment equation (38) necessitates the estimation of conjectural variation elasticity over 1980-2012. Therefore, the supply equation is estimated over the period 1980-2012 and the demand equation over the sub-period 2005-2012 respectively.

The estimation of the cost, supply and demand equation takes into consideration the panel aggregation of the 3-digit sectors into the manufacturing industry for each year individually. This is reflected by the time individual effect which applies a time dummy variable DT_{t} (t=1980,…,2012), that is set to one for the t sub-period and zero otherwise, to the corresponding variables of conjectural variation, wholesale price and money supply. The estimation procedure is the same as the cross sectional specification of panel data by replacing the cross sectional dummy DS_i with the time dummy variable DT_t. The estimates obtained by this particular specification reflect the behaviour of the whole manufacturing industry over the aforementioned period samples. The introduction of the time dummy variable distinguishes the panel set into individual years rather than individual sectors. This means that the individual effects reflect the difference between the starting year (i.e. 1980) and the 32 remaining years up to 2012[63].

An additional step in this analysis could be the time series specification of the constituent 3-digit sectors rather than the whole manufacturing industry over the period 1980-2012. However, the manufacturing industry data set is subject to two restrictions which do not allow an analysis reflecting 3-digit level time estimates. The first restriction corresponds to the bulk of available data. If there were sufficient data for the 4-digit sectors of the manufacturing industry, then by applying the time series specification, the degree of market power in the corresponding 3-digit manufacturing sectors could be estimated. The second restriction lies on the formulation of the time dummy variable DT_t. As discussed in the previous step, both cross sectional and time series specification in panel data are considered to treat any other factor as fixed (i.e. *ceteris paribus*). The cross sectional specification allows only the number of the constituent sectors to change, by treating time period as fixed. On the other hand, the time series specification allows only time to change, by considering the number of sectors as fixed and therefore, as an average entity reflecting the manufacturing industry. Given those restrictions, the best option in this study is to treat the manufacturing industry as a whole and thus, estimate the degree of market power for each year.

[63] As in the second step, this is not a cross section estimation for each year separately as cross dependency rises in the panel set. For this reason, the time dummy variable reflects the individual effects occurring over 1980-2012 for each year individually for the whole manufacturing industry.

Table 6. *Estimations of the Cost, Demand and Supply Function of the 3-digit Sectors in the Greek Manufacturing Industry over the period 1980-2012 (Bresnahan Time-Series Specification)*

Parameters	**Estimation of (25) and (34)**	**Parameters**	**Estimation of (35)**	**Estimation of (35)**
a_0	7.834202 (66.09271)	*a (constant)*	15.300621(14.081239)	13.714196 (9.01683)
a_y	0.725135 (7.357960)	*h (price)*	-	-0.668471 (-2.99837)
a_{yy}	0.059836 (10.230472)	h^z *(investment)*	0.164614 (2.118841)	0.118412 (2.129546)
g_{ly}	-0.101488 (-2.664674)	h^H *(herf)*	-0.017786 (-1.976839)	-0.035398 (-1.99450)
g_{ky}	0.101483 (2.746162)	h^{liq} *(ms)*	0.308271 (2.956173)	-
a_l	0.781334 (4.414935)			
a_k	0.218666 (2.519322)			
g_{ll}	0.061394 (2.943402)			
g_{kl}	-0.061397 (2.138739)			
x_t	-0.017912 (-2.587643)			
x_{ty}	0.032496 (2.360634)			
x_{tl}	-0.002087 (-2.165653)			
f_{1980}	0.482195 (2.201823)			
f'_{1981}	0.462176 (2.141826)			
f'_{1982}	0.486291 (2.182133)			
f'_{1983}	0.456041 (2.071287)			
f'_{1984}	0.421737 (2.012936)			
f'_{1985}	0.442612 (2.048131)			
f'_{1986}	0.494141 (2.190282)			
f'_{1987}	0.386331 (1.991827)			
f'_{1988}	0.407041 (2.011892)			
f'_{1989}	0.354642 (1.962635)			
f'_{1990}	0.381113 (1.995283)			
f'_{1991}	0.361625 (1.901288)			
f'_{1992}	0.415732 (2.037893)			
f'_{1993}	0.386486 (1.989271)			
f'_{1994}	0.364137 (1.971822)			
f'_{1995}	0.315331 (1.948178)			
f'_{1996}	0.433785 (2.059837)			
f'_{1997}	0.471727 (2.138121)			
f'_{1998}	0.512201 (2.229185)			
f'_{1999}	0.459486 (2.132917)			
f'_{2000}	0.528932 (2.240192)			
f'_{2001}	0.531902 (2.488171)			
f'_{2002}	0.541603 (2.538192)			
f'_{2003}	0.577965 (3.380092)			
f'_{2004}	0.516328 (2.399188)			
f'_{2005}	0.553453 (3.196351)	$h_{2005}\|h^{liq}_{2005}$	-0.856155 (-2.235950)	0.556778 (2.697877)
f'_{2006}	0.549271 (2.448374)	$h_{2006}\|h^{liq}_{2006}$	-1.013228 (-2.451637)	0.561732 (2.817362)
f'_{2007}	0.555259 (3.158377)	$h_{2007}\|h^{liq}_{2007}$	-1.077780 (-2.318471)	0.572771 (3.133158)
f'_{2008}	0.561316 (3.279836)	$h_{2008}\|h^{liq}_{2008}$	-1.212549 (-3.168937)	0.548173 (2.581736)

(Table 6 continue)

f'_{2009}	0.552918 (3.161831)		$h_{2009}\|h^{liq}_{2009}$	-1.022132 (-2.873541)	0.514246 (2.279809)
f'_{2010}	0.533716 (2.498374)		$h_{2010}\|h^{liq}_{2010}$	-1.071333 (-2.901630)	0.493847 (2.213948)
f'_{2011}	0.531371 (2.519138)		$h_{2011}\|h^{liq}_{2011}$	-1.004613 (-2.841938)	0.443768 (2.771653)
f'_{2012}	0.551832 (3.138173)		$h_{2012}\|h^{liq}_{2012}$	-1.072777 (-2.751133)	0.524615 (2.418374)
Estimation Method	3SLS[a]	3SLS[b]		2SLS	2SLS
Breusch and Pagan Test (LM Test)	6.5092 [0.0346][a]	5.5017 [0.0388][b]		5.0133 [0.0453]	5.2184 [0.0417]
Likelihood Ratio Test	109.7841 [0.0000][a]	147.1855 [0.0000][b]		6.2578 [1.0000]	5.8173 [1.0000]
Hausman Test	50.7623 [0.0000][a]	38.8143 [0.0000][b]		50.0713 [0.0000]	52.3617 [0.0000]
Wooldridge Test	0.5471 [0.7517][a]	6.5519 [0.0341][b]		0.4183 [0.8391]	0.5136 [0.7694]
Wald Test	130.8371 [0.0000][a]	13.7878 [0.0002][b]		9.1736 [0.0000]	9.5134 [0.0000]

Notes: See notes in Table 1 and Table 5.
[a] Diagnostic tests obtained from the cost function
[b] Diagnostic tests obtained from the supply function
The values presented in this Table correspond to the total value of the conjectural variation elasticity, as the sum between year 1980 and the change of the corresponding years t (i.e. $f'_t=f_{1980}+f_t$).

The time series estimates of the cost, supply and demand equation are presented in Table 6. The estimates obtained by the cost function represent the same theoretical implications for the manufacturing industry as in the first step. The estimates of the supply equation reflect the value of conjectural variation elasticity and therefore, the degree of market power in the manufacturing industry in each year over the period 1980-2012. The demand equation estimations are consistent with the results obtained in the first and second step. They account aggregate output elasticity with respect to the level of wholesale price and liquidity respectively.

However, the time series specification of the demand function is subject to the following conditions; the first part refers to the variables analyzed under this particular specification. Instead of estimating the values of all demand factors as in the cross-sectional specification, this step is restricted to the estimation of output elasticity with respect to the wholesale price and liquidity indicator[64]. The second condition corresponds to the time range of the time dummy variable DT_t. Instead of including the whole time sample (i.e. 1980-2012),

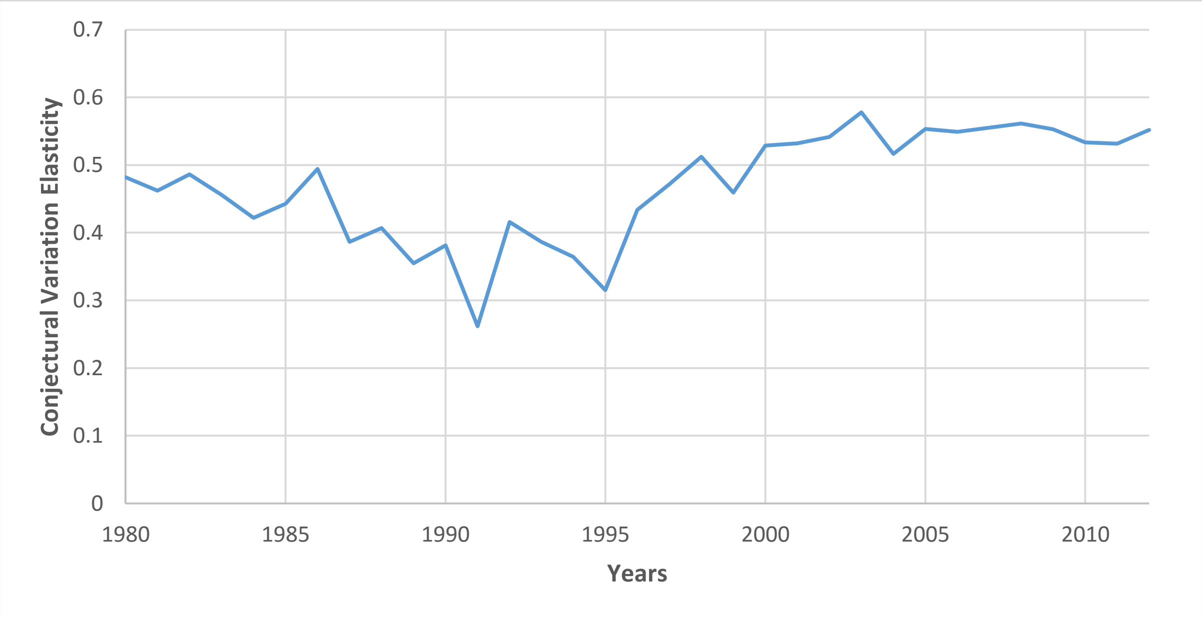
[64] The wholesale price level and the available money in the economy (*M2*) are considered to be of great importance for this study and in particular, for the manufacturing industry. For this reason, the estimations of the investment and sales concentration indicators are not presented in Table 6 which means that discussion will only be focused on the two former indicators of demand.

the time range over 2005-2012 has been selected given its significance for the Greek economy as a whole (see section 4.3 or above).

The time series specification of panel data analysis has been chosen in this step as well, given the results obtained by the diagnostic tests. In particular, the results of the cost and supply equation are very similar; the Breusch and Pagan test is significant at the 5% level of significance by indicating the presence of cross-sectional dependency between the error terms of the cross-sections and thus, the use of the random or fixed effects model. The Hausman test is found to be significant at the 1% level of significance by suggesting the formulation of the fixed effects model due to the presence of correlation between the individual effects and the explanatory variables. In addition, the likelihood ratio test provides significant results in favour of heteroskedasticity, but the Wooldridge test suggests the absence of first-order serial correlation in the cost function's residual term. On the basis of the aforementioned results, the *3SLS* estimation procedure is applied to both equations due to the presence of endogeneity in the second stage and the emergence of heteroskedasticity in the error term in the last stage.

By taking into account the diagnostic tests, the fixed effects model under the time series specification is used in order to extract the estimations of conjectural variation elasticity of the Greek manufacturing industry for each year over the period 1980-2012.

Figure 6: Conjectural variation elasticity of the manufacturing industry for each year over the period 1980-2012.



As illustrated in Figure 6, the value of this indicator of market power based on production fluctuates between *0.354642-0.577965*, by suggesting that the Greek manufacturing industry has been operating under conditions of imperfect competition for the majority of this time period. However, there was a decline in the degree of market power over 1986-1991 and over 1992-1995. The main reason of this outcome corresponds to the mechanism of the Single European Market (*SEM*). In particular, this set of policy implications took effect in 1987 and was completed in 1992-1993 in order to enhance free trade among the countries of the European Union. As a result, competition was enhanced in the Greek manufacturing industry by causing a fall in the profit margin and an increase in production of the firms. This action forced the Greek manufacturing firms and sectors to abide by the rules of the European Union by leading some problematic firms to leave the industry (Rezitis and Kalantzi, 2011a)[65].

In addition, during the period 1989-1991, there was a number of acquisitions and joint ventures that took place in the manufacturing industry and specifically, in the industry of food and beverages (Rezitis and Kalantzi, 2012). The main motivation of those actions was for the Greek sectors to gain access to new markets and establish a position which will improve the reputation of Greek products and result in a degree of power. According to OECD Economic Outlook (2000), the share of the European Union of global M&A (mergers and acquisitions) increased from 10% in 1985-1987 to 29% in 1993, which has also led to a burst of foreign direct investment and therefore, to improved technology.

After 1995, there was a continuous increase of market power in the Greek manufacturing industry, with the highest peak reached in 2003, where the value of conjectural variation elasticity was *0.577965*. This number denotes a high degree of imperfect competition which can be viewed as a result of a demand boom in the Greek economy (IOBE, 2013). An additional interpretation for the persistence of imperfect competition could be the lack of improvement of capital equipment (Giokas, Eriotis and Dokas, 2015). The capital stock of the Greek manufacturing sectors was not improved significantly over 1995-2003 which means that technology was not used as a mean of competition. The reason for this outcome lies on the lack of investments in advanced technologies, which could improve the

[65] According to the Greek National Documentation Centre (NDC), in 1993 there was an attempt to enhance the competitive forces of the manufacturing firms by increasing production and reducing wholesale prices. In particular, many Developmental Laws and Operational Programs, such as the "Operational Programme for Research and Technology II" and the "Industrial Research Development Programme" contributed to the research and technological infrastructure of the Greek firms.

efficiency of the firms and therefore, allow them to be more competitive. Another explanation could be the launch of the euro currency in 2000, when Greece became part of the Eurozone. Given the fact that the Greek manufacturing industry was already part of the *SEM*, a new currency in conjunction with free trade in the European Union resulted in increased market power in the domestic market for two reasons. The first one refers to the the higher exchange value of the euro compared to the one of the drachma currency, while the second corresponds to the demand increase due to the aforementioned reason. This means that increased aggregate demand resulted in market power acquisition by the manufacturing industry.

The last and most important period of this sample corresponds to 2005-2012. In particular, following the financial and economic crisis of 2008, the conjectural variation indicator slightly declined from *0.561316* to *0.531371*. This change does not indicate a significant reduction of market power; however, it also does not indicate an increase of market power. In particular, according to the Annual National Industrial Surveys (*AIS*) of the Hellenic Statistical Authority, there has been a decrease in the number of firms in the Greek manufacturing industry over the period 2010-2012 (see section 7.2). This fact could indicate that the remaining firms should start exercising their market power given that a number of firms were forced to exit their sectors due to their inability to operate under such conditions (Khanna and Tice, 2005).

However, this action is not observed according to the present data set. A possible interpretation could be that since aggregate income has declined, there is no point in acquiring additional market power through lower production and higher prices because consumers will not be willing to spend more in consumption under these conditions[66]. A different explanation could refer to the fact that given the availability of the current data set, there is no evidence in favour of an increase in the degree of market power. In the following years, there is an upward trend of this indicator which suggests that the manufacturing firms exercise their power in their sector respectively. Either way, the variations of conjectural variation elasticity over the period 2005-2012 are not considered to be intense compared to the other sub-periods of this sample.

[66] In particular, many states tried to minimize the impact of the financial crisis to their economies by implementing contractionary fiscal policies (Alesina, Favero and Giavazzi, 2015).

In addition, it is worth noting that market power acquisition may also be a result of informal/illegal activities between firms. According to OECD (2015), there have been a few cases of corruption identified in the Greece economy. For instance, there is prosecution against two tobacco firms for bribery in order to promote their interests in domestic and foreign markets. The firms were trying to acquire market power by bribing individuals in forming agreements that would be of disadvantage to their competitors. There are also bribery allegations for firms trying to secure EU funds in order to gain competitive advantage over their competitors through increased credit access. There are more similar cases identified in the Greek economy overall, but the main outcome is that such behaviour creates an unequal advantage to those particular firms. It can be treated as a barrier to entry or as a force to exit for some incumbent firms.

Moreover, tax evasion may also contribute to market power. If firms do not pay their fair share of taxes, they can use that amount of money to acquire additional market power through a higher level of available liquidity. According to Ethnos (2006), in 2005 49% of the firms inspected by the Greek tax authorities were found to have committed tax evasion, while in 2006 that percentage fell to 41.6%. It is evident that given the incomplete tax collecting mechanism, firms (and individuals) are able to take advantage of such gaps in the regulatory framework and thus, secure additional funding with unofficially avoiding to paysome of their liabilities. Consequently, the estimates of the conjectural variation elasticity may also reflect such factors that have to be investigated by the competition authorities.

The second equation estimated for the Greek manufacturing industry over the period 2005-2012 refers to the demand function (35) in order to identify the variations of aggregate output elasticity with respect to the wholesale price and liquidity level of the industry. The restrictions imposed in this equation correspond to the estimated sub-period. In particular, in order to estimate the magnitude of those indicators during the sub-period 2005-2012, the time series specification of panel data analysis was estimated for $t=2005,\ldots,2012$, which means that the time dummy variable DT_t was applied eight times, according to the number of years. An additional restriction of this equation refers to the absence of the investment and sales concentration indicator. In order to simplify the analysis and highlight the most important elements of demand over this particular sub-period, the latter indicators have been excluded from the time series specification process.

The Breusch and Pagan *LM* test is found to be significant at the 5% level of significance, by indicating the presence of cross sectional dependency and therefore, it necessitates the time series specification of panel data rather than a time series analysis. The Hausman test is also found to be significant at the 1% level of significance by indicating that the fixed effects model is preferable to the random effects model. The likelihood ratio and Wooldridge tests are found to be insignificant by suggesting the absence of both heteroskedasticity and serial correlation in the error terms of the manufacturing entities. According to these results, the *2SLS* estimation method is used to obtain the estimations of the wholesale price and liquidity indicator respectively.

The first estimation of (35) treats the wholesale price indicator as the time effect variable and the remaining as fixed. The average value of aggregate output elasticity with respect to investment, sales concentration and liquidity are found to be significant at least at the 5% level of significance over the sub-period 2005-2012. Their magnitude and signs are not surprising; elasticity with respect to investment and liquidity is positive and inelastic, as in the first step, while elasticity of sales concentration is negative and highly inelastic, by suggesting an inverse relationship between aggregate production and sectorial sales. In addition, elasticity of aggregate output with respect to wholesale price over the sub-period 2005-2012 is found to be significant at the 5% level of significance and elastic over 2006-2012, which is close to the estimated values of the first and second step respectively. The highest degree of elasticity in absolute value was reached in 2008 (*–1.212549*), while the lowest is found to be in 2005 *(-0.856155*) and 2011 (-*1.004613*).

The second estimation of (35) treats the liquidity indicator as the time variable and the remaining as fixed. The average value of aggregate output elasticity with respect to wholesale price, investment and sales concentration are found to be significant at the 5% level of significance by following the same results as before. In particular, elasticity of investment is found to be significant and inelastic by expressing a positive relationship to aggregate output. Elasticity of wholesale price and sales concentration is found to be negative by suggesting an inverse relationship with aggregate output over the sub-period 2005-2012. Elasticity of aggregate output with respect to liquidity appears to be inelastic and positive according to the aforementioned results. In particular, the highest value of elasticity is found to be *0.572771* in 2007, while the lowest degree of elasticity is found to be *0.443768* in 2011.

The significance of the indicators of wholesale price and liquidity reflect the economic conditions faced by the Greek economy over the period 2005-2012. In particular, the lowest value of aggregate output elasticity with respect to liquidity is found to be in 2011. This year can be considered to be the year of realization of the austerity policies implemented in 2010 by indicating that a percentage change in available liquidity results in a *0.443768* change in production. In general, this particular indicator of elasticity is quite inelastic, even over the sample period 1980-2012. However, the lowest value is observed in the second year of austerity policies which can be used as an interpretation that additional liquidity is not spent in the manufacturing industry as it used to. The value of this index was *0.572771* in 2007, the year before the financial crisis, but in 2011 this indicator was reduced by 34.6%, reflecting an economic environment of future uncertainty (Tsakalotos, 2011).

On the other hand, aggregate output elasticity with respect to the wholesale price indicator of the manufacturing industry was found to have the lowest effect in 2005, a year following the successful hosting of the Olympic Games. This fact could indicate that the manufacturing firms were adjusting to the needs of the market by exercising their power according to consumer behaviour (Porter, 1974). If people were still influenced by the exogenous demand shock, then firms could use this particular information in order to limit their production, increase their prices and still maintain the same number of consumers, which could increase their profits.

Either way, it is clear that the financial crisis of 2008 and the implementation of austerity policies in 2010 have manipulated the effects of nominal price levels and liquidity on aggregate output and therefore, on consumer demand. According to the psychology of the public which is influenced by the economic environment, firms can identify and adjust their production in order to satisfy both the needs of consumers and their own needs as well. This behaviour can be suggested by the indicator of conjectural variation elasticity that reflects a fall of market power of the manufacturing industry in 2009 and 2011 respectively. In addition, before 2008, the indicators of market power, wholesale price and liquidity elasticity appear to have their highest values, which could validate the prosperity of the Greek economy following the Olympic games of 2004.

The conjectural variation elasticity indicator for the Greek manufacturing industry and the constituent 3-digit sectors has resulted in evidence in favour of imperfect competition. In particular, the market structure of the Greek manufacturing industry over the period 1980-

2012 has been found to be oligopolistic and equal to *0.513468*. This value indicates that the included individual sectors appear to have on average a value of conjectural variation elasticity similar to the one of a duopoly, by resulting in a degree of market power. In general, the 3-digit sectors have been found to have significant market power over the period 1980-2012, while the manufacturing industry as a whole has experienced fluctuations according to the economic developments in the Greek and the EU economy. Therefore, according to the estimated results of the conjectural variation elasticity methodology, it can be argued that production decisions of the Greek manufacturing 3-digit sectors reflect a degree of market power exercised over 1980-2012 in the Greek economy.

The results of the present study seem to validate the findings of Rezitis and Kalantzi (2012, 2013) in favour of imperfect competition in the Greek manufacturing industry. Elasticity of conjectural variation for the whole industry was found to be equal to *0.4568* by the aforementioned authors, while the elasticity value of this study is found to be equal to *0.513468*. Both values indicate a degree of oligopolistic conduct, but the latter value reflects a higher degree of imperfect competition. The reason for this slight divergence may lie on the fact that the present analysis takes into account a 3-digit sector sample, while the study of Rezitis and Kalantzi (2013) uses 2-digit sector data. An additional reason could reflect the selected time sample; this sample is extended up to 2012, compared to the sample of Rezitis and Kalantzi which stops at 2007. Furthermore, the cross-sectional and time series specification in the panel data resulted in the same propositions about the behaviour of the manufacturing sectors and the whole industry over the period sample. To this end, the present study validates the existing findings of imperfect competition in the Greek manufacturing industry, expressed in terms of production.

An indicator of market power can be used in order to test the relationship between market power acquisition and the degree of price rigidity. For this reason, the following measure concerning pricing decisions is reflected by the pricing equation (31). The following approach is going to result in evidence of either rigid or flexible pricing decisions by employing the mechanics of *NEIO* introduced in section 4.1.2.

6.2. The Speed of Price Adjustment: The Pricing Equation

6.2.1. First and Third Step

The second and final concept that is of great significance and the main core of this study corresponds to the degree of price rigidity. In particular, the main objective of this analysis refers to the relationship between the speed at which prices change and the degree of market power in the Greek manufacturing sectors. The previous section present the results concerning the latter concept in terms of production decisions. In this section, the study is focused on a concept which has been used intensively by the existing literature (see chapter 2) and can be employed to identify the degree of price rigidity in industries and sectors.

This concept corresponds to the speed of price adjustment, as has been introduced in the empirical literature by Means (1935a) and developed by Domberger (1983, 1993), Dixon (1983) and Bedrossian and Moschos (1988). According to this particular methodology (see section 4.1.2.), lags in pricing decisions are expressed in terms of changes in input costs. If there is an increase in unit costs then total flexibility would result in a proportional increase of the wholesale price level of the final good. Any other case which would reflect a lower or no increase of the price level at all can be considered to be a case of slow price adjustment to changes in the unit cost of inputs. However, in this study the concept of the speed of price adjustment also takes into account possible lags in foreign pricing decisions (i.e. EU27) and taxation (i.e. VAT) on the final product. Therefore, the speed at which prices adjust according to changes in output, the unit cost of inputs, foreign wholesale price levels and VAT at time *t-1* reflects the indicator of price rigidity[67].

The main intuition of this study necessitates the estimation of this particular variable in order to identify and extend the main contribution of Bedrossian and Moschos (1988) in the Greek manufacturing industry. In particular, the authors argued that the speed at which prices adjust and the degree of market power of particular sectors take into account "the leadership effect" and "the profitability effect". According to these concepts the size and the degree of market power of sectors respectively can influence the pricing decisions of those

[67] These factors will be referred to as the lagged pricing equation factors.

sectors by exploiting their market characteristics. Bedrossian and Moschos (1988) showed that the Greek manufacturing industry over the period 1963-1977 appeared to exercise its market power by estimating a negative relationship between price adjustment and sectorial profitability, as well as a positive relationship between price adjustment and leadership. This means that profitable sectors and firms prefer to keep their prices stable over time for various reasons such as profit and market power acquisition (Dixit and Stiglitz, 1977; Rotemberg, 1982). On the other hand, large sectors and firms may prefer to adjust their prices according to fluctuations in their cost factors in order to maintain their fame and attract more consumers (Olive, 2008).

The main rationale of such results may lie on the ability of particular sectors to exercise their market power or maintain the trust of their customers. Sluggish prices do not always reflect exploitation of consumer surplus or intention of gaining additional profits. It may refer to an action of maintaining the trust of consumers and preventing them to switch over rival firms (Kano, 2013). The aforementioned effects are strictly connected to pricing decisions in order to identify how the market structure and the size of the firms may affect the speed at which prices adjust to changes in the lagged pricing equation factors of this study.

The contribution of this part to empirical literature is considered to be very important since there are no relevant studies that capture the aforementioned effects in the Greek manufacturing industry over the period 1980-2012. To this end, the main question which is going to be tested in section 6.3 corresponds to the relationship between market conditions and pricing decisions. Therefore, the last variable that has to be identified is the speed of price adjustment for the Greek manufacturing 3-digit sectors over the period sample. The methodological procedure is going to be the same as in the case of conjectural variation; however, there is a slight difference about the order of steps. This section presents the first step and the time series specification of panel data analysis, while it leaves the cross sectional analysis for last. The only reason for this change lies on the presentation and discussion of results. The estimated results are categorized from the first and third step in the same table given the significance of the diagnostic tests. This means that a different approach is attempted for the second step which needs further discussion about the methodology and the importance of the estimates. Consequently, the analysis begins by presenting the results obtained for the Greek manufacturing industry over the period 1980-2012 and its performance for each year individually.

6.2.1.1.First Step

The first step of this procedure corresponds to the estimation of the pricing equation (31) for the Greek manufacturing industry as a whole over the period 1980-2012 by aggregating the 3-digit level panel sample. In particular, the pricing equation consists of five variables as presented in section 4.1.2; the output gap of the industry, input unit costs, relevant wholesale prices charged in the European Union market (*EU27*), the level of taxation (*VAT*) and lagged pricing decisions. The incentives for including those variable in this analysis follows the existing literature and in particular, the study of Bedrossian and Moschos (1988) who applied their pricing equation to the 2-digit level manufacturing sectors. However, the pricing equation of the present study takes into account two additional variables (p^{eu} and p^{T}) in order to test their effect on the final wholesale pricing decisions of the manufacturing sectors.

The main rationale of this equation lies on the effect that particular variables may have over pricing decisions. Equation (31) reflects an inverse demand equation under which the final wholesale price level p^{f} depends on the aforementioned variables of this study. This means that their total effect must influence the final wholesale price level by 100%. In other words, there must be no other variable excluded from this analysis that could affect pricing decisions. This is reflected by the value of the Wald test which is going to be discussed below. According to this intuition, output and input decisions, as well as competitive foreign prices and taxation may affect the pricing decisions of the industry.

However, the most important factor that contributes to the identification of nominal price rigidities refers to past pricing decisions. This means that the price level at time *t* can be shaped by the price level at time *t-1*, despite any changes that may occur in input costs or production decisions. According to the degree of dependence of the price level (p^{f}_{t}) on the lagged price level (p^{f}_{t-1}), this discussion is focused on whether the speed of price adjustment is fast or slow. If that adjustment (λ) is close to zero, then pricing decisions are highly affected only by past pricing decisions and thus, the speed of price adjustment to changes in the pricing equation factors at time *t-1* is very slow. On the other hand, if the degree of adjustment is close to unity, then present pricing decisions are not affected by past pricing decisions. As a result, the speed of price adjustment is very flexible to changes in the lagged effects of the pricing equation factors.

On the basis of the above mechanism, the presentation of the estimations of the pricing equation (31) for the Greek manufacturing industry as a whole will be presented. This will test whether the speed of price adjustment is fast or slow according to wholesale price elasticity with respect to lagged pricing decisions.

The estimations are presented in Table 7 along with the value of the diagnostic tests. To begin with, the Breusch and Pagan (LM) test results in evidence of cross-sectional independency. This means that the error terms of the constituent entities (sectors) are independent which permits a pure time series estimation process for the constituent entities individually without taking into account a fixed or random effects model[68]. The likelihood ratio test is also found to be significant by indicating the presence of heteroskedasticity, while the Wooldridge test does not provide significant evidence in favour of serial correlation. According to those results, the estimation technique which is used to estimate the pricing equation is the *3SLS* technique due to the presence of heteroskedasticity and endogeneity between the dependent and the explanatory variables[69].

[68] See section 6*.2.2*.
[69] The instrument list consists of the lagged values of the explanatory variables of first and second lag order.

Table 7. *Estimation of the Pricing Equation in the Greek Manufacturing Industry over the period 1980-2012.*

Parameters	**Estimation of (31)**	**Estimation of (36)**	λ_t	$(1-\lambda_t)/\lambda_t$
a_0^1	-0.167367 (-3.174779)	0.032872 (0.830862)		
a_1^1	-0.035931 (-1.608133)	0.005935 (0.365447)		
b_1^1	0.153817 (12.07060)	0.100003 (1.993147)		
b_3^1	0.056696 (4.507480)	0.068241 (1.988665)		
$1-\lambda$ (price(-1))	0.664555 (45.17623)	-		
$\lambda^{eu'}$ (priceeu)[1]	0.015263 (1.943596)	0.032965 (1.187221)		
$\lambda^{T'}$ (pricevat)[1]	0.106841 (9.476707)	0.127371 (6.736157)		
λ	0.335445	-		
$(1-\lambda)/\lambda$	1.981114	-		
$1-\lambda_{1980}$		0.736153 (15.183712)	0.263847	2.790075
$1-\lambda'_{1981}$		0.518279 (12.812938)	0.481721	1.075891
$1-\lambda'_{1982}$		0.608173 (13.891286)	0.391827	1.552147
$1-\lambda'_{1983}$		0.618724 (13.201933)	0.381276	1.622772
$1-\lambda'_{1984}$		0.418277 (11.239371)	0.581723	0.719031
$1-\lambda'_{1985}$		0.548737 (12.392012)	0.451263	1.216003
$1-\lambda'_{1986}$		0.680616 (20.120394)	0.319384	2.131027
$1-\lambda'_{1987}$		0.561873 (12.023981)	0.438127	1.282443
$1-\lambda'_{1988}$		0.621877 (13.716235)	0.378123	1.644642
$1-\lambda'_{1989}$		0.551879 (12.102339)	0.448121	1.231540
$1-\lambda'_{1990}$		0.770616 (19.001927)	0.229384	3.359502
$1-\lambda'_{1991}$		0.532862 (14.100291)	0.467138	1.140695
$1-\lambda'_{1992}$		0.428168 (11.591283)	0.571832	0.748765
$1-\lambda'_{1993}$		0.380613 (9.1283872)	0.619387	0.614499
$1-\lambda'_{1994}$		0.298274 (6.7626331)	0.701726	0.425058
$1-\lambda'_{1995}$		0.428717 (10.793847)	0.571283	0.750446
$1-\lambda'_{1996}$		0.673847 (15.002932)	0.326153	2.066046
$1-\lambda'_{1997}$		0.816254 (20.119281)	0.183746	4.442295
$1-\lambda'_{1998}$		0.748369 (18.193848)	0.251631	2.974073
$1-\lambda'_{1999}$		0.698997 (15.192783)	0.301003	2.322226
$1-\lambda'_{2000}$		0.608979 (14.192838)	0.391021	1.557407
$1-\lambda'_{2001}$		0.526183 (11.394857)	0.473817	1.110519
$1-\lambda'_{2002}$		0.580717 (13.192831)	0.419283	1.385024
$1-\lambda'_{2003}$		0.681525 (15.182373)	0.318475	2.139964
$1-\lambda'_{2004}$		0.808163 (19.192831)	0.191837	2.426570
$1-\lambda'_{2005}$		0.898318 (26.366315)	0.101682	8.834582
$1-\lambda'_{2006}$		0.846136 (24.173642)	0.153864	5.499246
$1-\lambda'_{2007}$		0.773864 (22.210197)	0.226136	3.422118
$1-\lambda'_{2008}$		0.618137 (15.581731)	0.381863	1.618740
$1-\lambda'_{2009}$		0.539633 (13.753778)	0.460367	1.172180
$1-\lambda'_{2010}$		0.571384 (14.138426)	0.428616	1.333091

$1-\lambda'_{2011}$		0.651376 (17.391832)	0.348624	1.868420
$1-\lambda'_{2012}$		0.788992 (23.473776)	0.211008	3.739157

(Table 7 continue)

Estimation Method	3SLS	3SLS	
Breusch and Pagan Test (LM Test)	0.9512 [0.6442]	7.5163 [0.0218]	
Likelihood Ratio Test	327.3399 [0.0000]	329.7396 [0.0000]	
Hausman Test	91.4224 [0.0000]	81.5099 [0.0000]	
Wooldridge Test	0.6173 [0.7183]	0.9173 [0.9584]	
Wald Test (joint)	112.2056 [0.0000]	101.2711 [0.0000]	

Notes: See notes in Table 1.
[1] $a_0=\lambda' c_0$. $a_1=\lambda' c_1$. $b_1=\lambda'\beta_1$. $b_3=\lambda'\beta_3$. $\lambda^{eu'}=\lambda_1'(\lambda^{eu}-\lambda)(1-\lambda^{eu})$. $\lambda^{T'}=\lambda_2'(1-\lambda^{T})$.
The value of the Wald test for testing the hypothesis H_0: $b_1+b_3+(1-\lambda)+\lambda^{eu'}+\lambda^{T'}=1$ is 0.9211 [0.3378].
The values presented in this table correspond to the total value of the speed of price adjustment, as the sum between year 1980 and the change of the corresponding years *t* (i.e. $\lambda'_t=\lambda_{1980}+\lambda_t$).

An additional point that has to be highlighted refers to the significance of the Wald test in order to test whether the sum of the coefficients of the pricing equation is equal to unity or not. If it is not, this means that there exist additional effects on the wholesale price level that are not taken into account in the pricing equation and thus, additional variables must be added to fix this omission. The Wald test is estimated under the null hypothesis of $H_0: b_1 + b_3 + (1-\lambda) + \lambda^{eu'} + \lambda^{T'} = 1$ and it is found to be insignificant at any level of significance[70]. To this end, this result indicates that the effect of the explanatory variables is always equal to unity or that the wholesale price level is affected only by those particular variables.

The estimation of the parameters presented in Table 7 reflects final wholesale price elasticities with respect to each variable, given that the pricing equation is expressed in logarithmic terms. Elasticity of price with respect to output gap is found to have an insignificant and low effect on pricing decisions (a_1= *-0.035931*). This value indicates that changes in the output gap of the manufacturing industry over the sample period did not have a significant effect on the price level. This means that pricing decisions were not affected by changes in production and as a result, the output gap cannot be used as a credible factor that can reflect a significant effect on industrial decisions.

[70] It is assumed that $b_1 = \lambda'\beta_1$, $b_3 = \lambda'\beta_3$, $\lambda^{eu'} = -\lambda'_1(\lambda^{eu} - \lambda)(1 - \lambda^{eu})$ and $\lambda^{T'} = \lambda'_2(1 - \lambda^{T})$.

Elasticity of price with respect to input unit costs is found to be significant at the 1% level of significance both for labour and capital per unit of production. In particular, it is found that a change in unit labour cost will affect the final wholesale price level by *0.153817*, while a change in unit capital cost will cause a change in that level by *0.056696*. The effect of unit labour cost is almost three times greater than the one of unit capital cost. An interpretation of this outcome could lie on the variability of those factors. Capital is considered to be fixed in the short run and therefore, its price may not change as frequently as the price of labour (Zanias, 1991). Given that the price of labour (wage) is more volatile compared to the price of capital, it can have a greater effect on the final wholesale price of output. This happens because variability in one of the two determinants of output will influence the pricing decisions of the industry.

The new variables introduced in the present pricing equation correspond to the pricing level of the EU27 manufacturing sectors and the level of taxation on the final product. The former factor is found to have an insignificant effect on the 5% level of significance on the final wholesale price ($\lambda^{eu'}=0.015263$). This shows that the price level charged by the manufacturing industries of the EU27 does not have a significant effect on the Greek manufacturing industry's pricing decisions. An interpretation of this result could refer to the market forces occurring in the Greek domestic market. It could be argued that in the Greek market, the degree of competition between Greek and EU products is not significant. However, there is no clear distinction of that degree in the EU market in general. As discussed in section 4.2.2, the effect of imports and exports on the final wholesale price level of the industry was found to be highly insignificant and for this reason it was removed from equation (31). Therefore, there is no visible differentiation between domestic and foreign competition. This fact may be one of the main limitations of this equation. For this reason, the pricing equation is treated as applicable on the Greek market by neglecting any additional effects implied by the EU market.

The latter factor is found to have a significant effect on the 1% level of significance on pricing decisions ($\lambda^{T'}=0.106841$). This value suggests that taxation has significantly affected the final wholesale price of the manufacturing industry over the period sample. In particular, taxation refers only to the VAT factor imposed on the final product. Any other form of taxation is excluded (see Appendix A). This means that it is only rational to assume that whenever there is a change in VAT, the final wholesale price level will change as well in order to reflect an exogenous shock imposed by the government. However, if there is no such significant change, then this action would imply that the industry did not take into account the new VAT in its pricing decisions[71]. The case of the Greek manufacturing industry indicates that changes in taxation were reflected by 10% in the final wholesale price level. This result provides evidence that changes in the VAT were not fully embodied in the final wholesale price.

It can be assumed that a value close to unity suggests that additional taxation is transmitted to the price level per se, while a value close to zero shows that the manufacturing sectors chose to absorb additional taxation without reflecting it to their customers. A value close to unity possibly reflects the behaviour of monopolistic firms which face an inelastic demand curve and thus, they will not suffer a fall in their profits as they will lose only a few customers. A value close to zero may reflect the behaviour of competitive firms as they wish to charge the lowest price level in order to attract as many customers as possible. Consequently, the value obtained by this study suggest that only a portion of additional taxation has been transferred to the final wholesale price level of the manufacturing sectors by suggesting an imperfect competitive structure.

The last and most important factor refers to lagged pricing decisions and the degree on which present prices are affected by past price levels. In particular, elasticity of p^f_t with respect to p^f_{t-1} reflects the degree of dependence of the final price level at time *t* on the corresponding level at time *t-1*. This measure is found to be equal to *0.664555* for the Greek manufacturing industry by denoting a degree of dependence of 66.45 per cent. This result shows evidence that the pricing decisions of the industry over the period 1980-2012 were not irrelevant to lagged pricing decisions despite changes in the pricing equation factors. That degree is found to be close to unity by suggesting evidence of nominal price rigidity. On the basis of the formulation of (31), the speed of price adjustment is denoted by λ and thus, it can be calculated by taking into account the aforementioned measure of elasticity. This means that the speed of price adjustment of the Greek manufacturing industry is equal to *0.335445*. In particular, this value reflects elasticity or the speed at which prices adjust according to changes in the lagged pricing equation factors. A value of *0.335445* indicates that if changes

[71] This action may denote that the industry chose to absorb an increase of VAT in order to avoid an additional increase of the final wholesale price level. However, if the VAT change is negative and there is no change in the final price level, then that would indicate a profit seeking behaviour as the new price of products should have been lower (ceteris paribus).

in the present factors occur, they will be reflected only by 33.5% on the final wholesale price level by suggesting a relatively slow adjustment.

This result partially verifies one of the arguments of Bedrossian and Moschos (1988) that suggest the presence of sluggish prices in the Greek manufacturing industry. However, an estimation process about the industry as a whole was not conducted and therefore, all steps of this analysis must be completed in order to find solid evidence that will either verify or contradict the results of the former study. Given the identification of rigid prices in this sample, the following question rises of how much time is needed for the price level to embody those changes in the lagged pricing equation factors. There is a process of whether prices are considered to be sluggish or not. Nevertheless, the main question should be about the time needed to eliminate that gap between changes in input costs and the final wholesale price level. Olive (2008) in his study for the Australian manufacturing industry incorporates a mean lag formula denoted as the ratio of [$(1-\lambda)/\lambda$], under which the number of annual lags are identified in order for the adjustment process to be completed. In this case, the time that the industry price level needs to adjust to changes in output, unit cost of inputs, foreign pricing decisions and taxation is equal to *1.981114* years. This means that *ceteris paribus,* the adjustment process will last approximately two years in order for the aforementioned changes to be reflected on the final wholesale price level.

This result validates the intuition of this study that prices in the Greek manufacturing industry are quite rigid. According to various conditions that manifested in this particular industry (see sections 4.1 and 4.2), the speed of price adjustment is found to be very slow by suggesting that two years of adjustment are required in order for changes in the pricing equation factors at $t-1$ to be reflected on the industrial price level at time t. The immediate contribution of input changes is found to be approximately equal to *0.21* by suggesting that pricing decisions are influenced only by 21% by labour and capital unit costs respectively. The factor of taxation (VAT) also contributes by 10% and the remaining percentage is reflected by lagged pricing decisions, which is found to be the most significant factor. Whenever the degree of dependence between present and past wholesale price levels is close to unity, the speed of price adjustment will be very slow and it may take several years for this process to complete. Consequently, the next step of this analysis refers to the pricing behaviour of the manufacturing industry for each year over the sample period. If, in general, the manufacturing price level is rigid, then the corresponding annual values and subsequently, the value of each sector have to be estimated in order to verify those results.

6.2.1.2. Third Step

The following step takes into account the same process adopted in sections 4.1.2 and 4.2.2 by using a time dummy variable in equation (31) in order to estimate the degree of price rigidity of the Greek manufacturing industry for each year over the period 1980-2012. The main intuition of this approach refers to the behaviour of the industry's annual pricing decisions in order to identify whether the price level has been sluggish or not depending on market conditions.

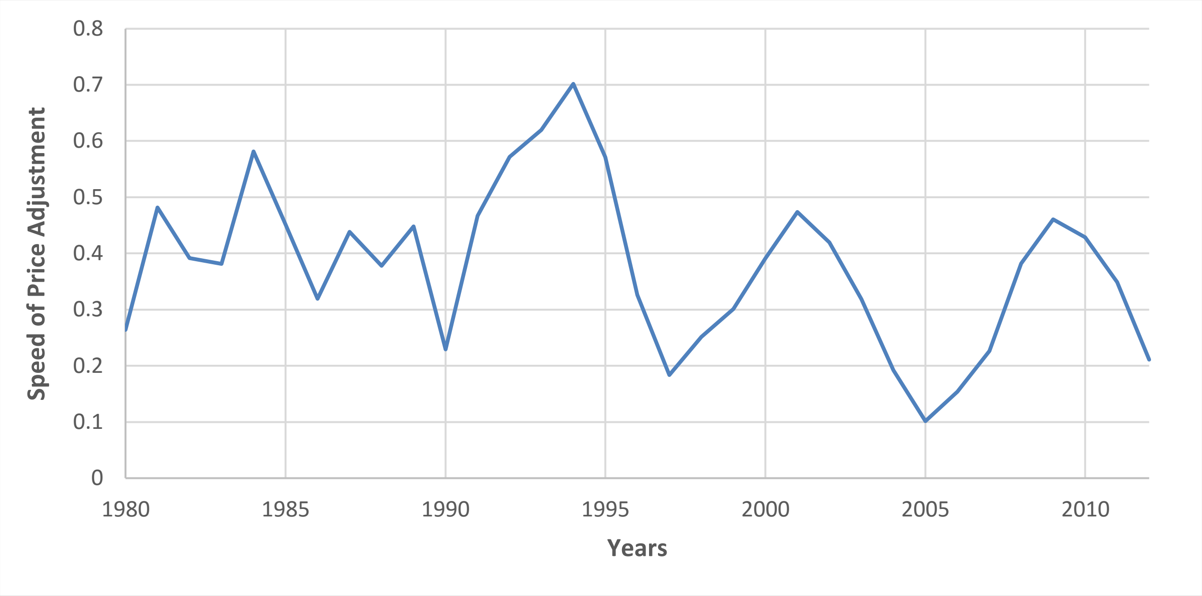
It is worth noting that the time series panel data specification for this particular pricing equation was not the only available option of estimation. Instead, 33 cross sectional regressions for each year could have been estimated that take into account every entity of this study. This means that each regression would consist of 56 observations and therefore, annual results could be extracted. However, this approach was not chosen as there is no evidence of time series independency between the error terms of the cross sectional regressions[72]. To this end, in order to avoid any inaccurate results, the fixed effects model has been used to estimate the industrial speed of price adjustment in an annual basis.

As developed in the conjectural variation approach, the time dummy variable DT_t ($t=1981,\ldots,2012$) is applied on the variable of lagged pricing decisions (p^f_{t-1}), which is set to one for the t sub-period and zero otherwise. The limitation of this approach lies on the fact that the estimates of the remaining variables will reflect an average value over the period sample. Nevertheless, the main interest of this study is to focus on the estimations of λ and as a result, the analysis takes into account the estimation of one panel regression including 33 time dummy variables. The new equation estimated under this approach corresponds to (36), under which 1980 is used as the fixed year. The estimated changes obtained by the time dummy variable will be expressed in terms of the value of λ_{1980}. The diagnostic tests appear

[72] The Breusch-Pagan LM test was applied by inversing the NxT matrix, where N is the number of sectors and T the number of years. Therefore, instead of testing for cross-sectional independency, this formulation accounts for time-series independency.

to provide the same results as in the first step and thus, the *3SLS* technique is used to estimate equation (36).

Figure 7: The speed of price adjustment of the manufacturing industry for each year over the period 1980-2012.



The results are presented in Table 7 as well. To begin with, the fixed estimations of price elasticity with respect to output, the unit cost of inputs, foreign prices and taxation appear to have the same sign and contribution (approximately) to p^f as in the first step of this approach. Figure 7 reflects the estimates of (36) concerning the annual speed of price adjustment of the manufacturing industry. The range of those values fluctuates between *0.101682* and *0.701726* by showing that the industry experienced periods of both rigid and flexible price adjustments. The highest degree of adjustment is found to have occurred in 1994, while the lowest degree is found in 2005. As mentioned in section 6.1.3, 1994 is considered to be the first year following the implementation of the Single European Market conditions in the Greek markets in order to promote and enhance competitive behaviour through various developmental programs. This means that following the evidence of low price-cost margins and declining market power (Rezitis and Kalantzi, 2011), the price level of the industry became very flexible. This happened because competition was more intense and regulations had reduced the incentives of any collusive agreements.

On the other hand, 2005 is considered to be the first year following the successful hosting of the Olympic Games and as a result, the state of the Greek economy was flourishing (Kasimati, 2003). This fact could be considered as evidence of increased demand for the Greek manufacturing products, both domestically and internationally, given that aggregate income had increased over the last years by this particular exogenous shock. Consequently, the economic environment in the manufacturing industry would not promote any intensive competitive behaviour and thus, there was no significant reason to render the aggregate price level subject to flexible adjustment.

Figure 7 illustrates the variations of the speed of price adjustment and the sub-periods in which the industrial price level is considered to be rigid or flexible. In particular, the first spike of flexibility occurred in 1984, which corresponds to the introduction of the SEM implementation in the Greek markets. This means that under the introduction of developmental programs that provided the incentives and regulations to increase the degree of competition, pricing decisions became more flexible compared to the four previous years (i.e. 1980-1983). However, the first significant under-spike is observed in the following year and after a slightly increase over 1986-1989, the second significant under-spike is estimated in 1990 equivalent to *0.229384*. Given the fact that this particular year is included in the implementation period of the SEM, this result is complemented by conjectural variation value. As introduced in section 6.1.3, the value of conjectural variation elasticity over 1990 was equal to *0.3811* (production above duopoly) which can be interpreted as evidence of low market power. If there is simultaneous evidence of high prodcution backed by rigid pricing decisions, then it can be assumed that in 1990 there were falling but rigid price levels in the manufacturing industry as a result of higher production and thus, higher competition.

Nevertheless, over the period 1991-1994, the speed of price adjustment significantly increased by reaching its climax in 1994, when the degree of flexibility is found to be *0.701726*. This means that changes in the lagged pricing equation factors were reflected by 30% in the final wholesale price, which can be interpreted as a successful outcome of the SEM implementation. In addition, if the conjectural variation value at that year (i.e. f_{1994}= *0.3641*) is accounted for, it can be argued that the degree of competition was enhanced. Consequently, flexible pricing decisions were caused by an improvement in competitive conditions.

Over the three following years (i.e. 1995-1997) there was a sharp decrease of price flexibility by resulting in the second under-spike in 1997 equal to *0.183746*. This means that following the outcome of the aforementioned policies, the speed of price adjustment was drastically reduced. An interpretation of this fact could be that the effects of the SEM implementation began to fade away after the completion of particular programs. This might mean that the manufacturing industry tended to return to its initial pricing behaviour level. Given that the tendency of price rigidity used to be on average around *0.40*, the effects of a forced degree of flexibility would result in a higher rigid price level afterwards. This rationale can also be validated by the conjectural variation value which increased but still, it was slightly above the production level of duopoly (i.e. $f_{1997} = 0.4717$).

Over the following period 1998-2001 there was a gradual increase of price flexibility by reaching a peak in 2001 equal to *0.473817*. The most dominant interpretation lies on the introduction of the euro currency in the Greek economy which resulted in a significant degree of appreciation of domestic prices (Fischer, 2004). This may be the reason for an increase in the conjectural variation value which might have caused an increase in the speed of price adjustment. Therefore, an additional interpretation of market power could be that production decreased because final wholesale prices were appreciated along with aggregate income[73], a fact that could also be reflected by flexible price levels.

The period over 2001-2005 the speed of price adjustment became more sluggish by reaching the highest under-peak in 2005 equal to *0.101682*. This means that the increase in demand as a result of the Olympic Games, allowed the manufacturing industry to maintain the wholesale price level very rigid. In conjunction with the estimates of market power, it can be assumed that this is a result of the manufacturing industry taking advantage the temporary spike in demand. To this end, it can be argued that this particular sub period can be treated as the one over which the manufacturing industry acquired a high degree of market power, complemented by the results of conjectural variation elasticity (see figure 6).

The following period over 2006-2009, the degree of price flexibility gradually increased to *0.460367*; however, from 2010 and afterwards, the speed of price adjustment became more sluggish. The former result could be validated in the context of the financial crisis of 2008 which, however, was not fully realised in the Greek manufacturing industry as reflected by the flexibility of pricing decisions. Nevertheless, the following years under which austerity policies were implemented (Tsakalotos, 2011), a gradual decrease of price

[73] In order for this intuition to be valid, it is assumed that the cost of inputs was not affected by the same degree as the final price level by the euro currency. This fact may be validated if capital equipment had been purchased from the Eurozone market.

adjustment occurred. In conjunction with the estimates of conjectural variation, the intension of rigidity in the industry after 2010 may be an act of market power exercise, since the effects of austerity forced many firms to exit the industry[74]. This means that if the degree of competition is reduced, then opportunities of exploiting consumer surplus can emerge faster.

Overall, the Greek manufacturing industry over the period 1980-2012 is characterised by stable but not violent changes in the degree of price rigidity. There are sub-periods of high rigidity and flexibility, but the transition from one state to another is gradually achieved. According to the estimates of conjectural variation elasticity and speed of price adjustment, the concluding outcome indicates that the manufacturing industry has been operating under non-competitive conditions by seizing available opportunities to exercise its market power. There are periods over which imperfect competition weakened as a result of policies and programs that tried to promote competition. However, overall evidence point to the fact that the Greek manufacturing industry is characterised by rigid pricing decisions and oligopolistic behaviour. For such reasons, the average time needed for final wholesale prices to fully reflect changes in output, unit cost of inputs, foreign pricing decisions and taxation is approximately equal to two years.

6.2.2. Second Step

The second step of this approach corresponds to the identification of the degree of price rigidity in the Greek manufacturing sectors (see Table A). The main intention of this step is to estimate a particular effect that captures the behaviour of each 3-digit sector individually, which refers to the speed of price adjustment. However, the methodology used in this step differentiates the analysis compared to the conjectural variation approach. It does not take into account the cross sectional approach of panel data analysis. In particular, in section 6.2.1, the panel of the manufacturing sectors that form the aggregate industry was found to be subject to cross sectional independency given the significant result of the Breusch and Pagan (LM) test. This means that instead of estimating a panel random or fixed effects model, it is more useful to run time series regressions for the constituent sectors individually given the absence of dependency between the error terms of each entity. For this reason, the pricing equation is estimated for each manufacturing sector by running a time series system with 33

[74] See Annual Industrial Survey 2010, 2011 and 2012 and Figures 10 and 11.

observations (i.e. 1980-2012). To this end, 56 regressions were run and the estimated results are presented in Table 8.

Table 8. *Estimations of the Pricing Equation (31) of the 3-digit Sectors in the Greek Manufacturing Industry over the period 1980-2012.*

Sector	a_0	a_1	b_1	b_3	*1-λ*	$\lambda^{eu'}$	$\lambda^{T'}$	*λ*	*AR(1)*	*Durbin-Watson Test*	*Breusch and Godfrey Test*
101	-0.354132 (-1.720054)	0.025832 (1.22735)	-0.059237 (-0.223594)	0.040749 (2.233499)	0.603757 (7.554146)	-0.083413 (-0.961956)	0.349007 (5.717769)	0.396243	-	2.038471	-
102	0.026312 (0.928142)	0.013311 (0.567151)	0.051273 (2.851391)	-0.095367 (-0.572569)	0.652325 (8.045522)	0.060212 (0.934707)	0.216209 (4.463945)	0.347753	0.781926 (2.249182)	1.449102	0.298178
103	-0.731647 (-2.918232)	0.035832 (1.662473)	0.082512 (2.701307)	0.042631 (4.676976)	0.656313 (8.053836)	-0.073612 (-1.675022)	0.083319 (3.567523)	0.343687	0.961721 (2.280017)	1.118374	0.119032
104	-1.928337 (-3.911288)	0.025661 (1.064125)	0.416624 (5.955781)	-0.225731 (-1.243786)	0.693657 (8.388797)	-0.260493 (-0.674153)	0.198497 (4.388221)	0.306343	-	2.281736	-
105	0.837462 (3.622329)	0.024538 (1.195142)	-0.046526 (-1.346347)	0.073143 (5.116965)	0.642188 (6.202863)	-0.175615 (-0.974134)	0.350327 (5.818257)	0.357812	-	3.018374	-
106	0.918279 (3.971148)	0.035339 (1.501453)	0.575987 (6.499821)	-0.025283 (-1.486021)	0.523051 (3.036755)	-0.020189 (-0.063679)	-0.042214 (-0.904642)	0.476992	0.983726 (2.301938)	1.383741	0.276152
107	-0.092831 (-0.72651)	0.022656 (1.091245)	-0.110675 (-1.772446)	0.044933 (1.492453)	0.757608 (9.799886)	-0.049436 (-0.351601)	0.242483 (4.725113)	0.242392	-	3.193784	-
108	-0.823848 (-1.877826)	0.034565 (1.637019)	0.170656 (2.035412)	0.059329 (2.286686)	0.827931 (10.261603)	-0.157544 (-1.653965)	0.091878 (3.272029)	0.172069	-	2.491831	-
109	- 1.073841 (-2.182899)	0.043225 (1.787732)	0.157245 (1.978668)	0.109498 (3.671685)	0.476492 (5.285457)	0.132321 (2.239794)	0.088323 (3.337977)	0.523508	-	2.001838	-
110	0.192835 (1.283742)	0.036113 (1.707587)	0.144544 (2.763297)	0.047901 (2.348985)	0.734973 (7.710602)	-0.073198 (-1.412157)	0.033648 (2.659584)	0.265027	0.638137 (2.148273)	1.783613	0.098371
120	0.837166 (2.126277)	-0.078217 (-2.090751)	0.109516 (2.108097)	0.069531 (3.810642)	0.614831 (6.427932)	0.140353 (2.970258)	0.071609 (3.934504)	0.385269	0.713843 (2.201374)	1.871364	0.183746
131	1.029381 (3.625261)	0.038095 (1.683479)	-0.052134 (1.642531)	0.155635 (5.030296)	0.618458 (6.608125)	-0.087618 (-1.723809)	0.155961 (4.387703)	0.381525	-	2.817331	-
132	-0.847465 (-1.982276)	-0.030897 (-1.101793)	-0.191087 (0.900115)	0.256564 (7.693491)	0.689352 (7.124253)	0.021265 (0.196286)	0.226312 (4.537863)	0.310648	0.678172 (2.140394)	1.183811	0.220911
139	0.192835 (1.292637)	0.017448 (0.798674)	0.097315 (2.685873)	-0.046634 (-1.157248)	0.745517 (9.109683)	0.009114 (0.178869)	0.086199 (2.104587)	0.254483	-	2.018374	-
141	0.857468 (2.616162)	-0.002861 (-0.130375)	0.131425 (3.514698)	-0.082414 (-0.386981)	0.845517 (10.374645)	0.075506 (1.399574)	0.122659 (2.858519)	0.154483	0.561372 (2.071263)	1.691837	0.436132
143	-0.92814 (-2.918377)	0.041157 (1.668261)	0.110381 (3.020199)	0.037953 (2.195538)	0.527597 (2.699914)	-0.081355 (-1.291722)	0.220371 (4.583882)	0.472403	-	2.761351	-
151	-1.271761 (-2.918374)	-0.009612 (-0.364542)	0.116344 (2.012734)	0.086315 (2.791731)	0.697336 (8.022137)	0.040063 (0.838868)	0.188621 (3.742946)	0.302664	-	2.914738	-
152	0.391788 (1.987464)	0.017193 (0.769881)	0.173421 (4.838093)	-0.153665 (-1.584021)	0.731415 (8.394594)	-0.025941 (-0.681872)	0.114058 (2.727367)	0.268585	0.971623 (2.310988)	1.057289	0.449102
161	-0.894875 (-2.381737)	0.022768 (0.915482)	0.249624 (5.724725)	-0.095963 (-0.852149)	0.600278 (6.149752)	0.013179 (0.160754)	0.159717 (3.418422)	0.399722	0.578132 (2.110394)	1.810773	0.691832
162	-0.475724 (-1.273849)	-0.005382 (-0.251483)	0.308979 (1.934484)	-0.083121 (-0.809107)	0.637676 (6.202173)	0.044209 (0.729054)	0.132004 (2.729748)	0.362324	0.481371 (2.047122)	1.929188	0.010183
171	-0.382273 (-0.99837)	0.045334 (1.874176)	0.308958 (1.875153)	0.009549 (0.082681)	0.659544 (6.395407)	-0.124013 (-1.931173)	0.016441 (1.310342)	0.340456	-	2.991736	-
172	-0.736623 (-1.283747)	0.041036 (1.889241)	0.097841 (2.939002)	0.038492 (2.320012)	0.737868 (7.580442)	-0.084336 (-2.208972)	0.042288 (2.055738)	0.262132	-	2.618304	-
192	0.849213 (2.918374)	0.055784 (2.308762)	0.065141 (2.340243)	0.137376 (3.963647)	0.875036 (10.813684)	-0.395916 (-3.171134)	0.011042 (1.916582)	0.124964	0.651348 (2.153827)	1.919384	0.118374
201	0.657421 (1.547193)	0.026457 (1.934855)	0.345576 (4.554615)	0.599549 (3.390575)	-0.004715 (-0.125784)	0.099481 (0.857038)	0.189451 (4.833692)	1.004749	-	2.163899	-
202	-0.947546 (-2.817364)	0.019143 (0.821825)	0.460434 (5.771729)	-0.047157 (-1.690227)	0.543194 (6.185174)	-0.022986 (-0.543462)	0.138671 (2.767363)	0.456806	0.916658 (2.271257)	1.771622	-
203	-1.645378 (-3.192938)	0.029838 (1.348016)	0.247501 (3.658987)	0.120153 (3.897946)	0.548864 (6.169873)	-0.079692 (-1.068652)	0.101785 (2.416131)	0.451136	-	2.109936	-
204	-0.281723 (-0.517394)	-0.047932 (-2.094631)	-0.158784 (-0.634183)	0.457002 (3.077402)	0.625614 (6.361738)	-0.164273 (-3.215959)	0.048029 (1.985583)	0.374386	0.725364 (2.182172)	1.827163	0.219347
205	0.837461 (2.103487)	0.038413 (1.601954)	0.054624 (2.698163)	0.076717 (2.394205)	0.758793 (8.514349)	-0.034187 (-0.325201)	0.011537 (1.871501)	0.241206	-	2.337461	-
221	0.192986 (1.192039)	0.029675 (1.266573)	0.150164 (3.743213)	0.059392 (2.442146)	0.636775 (7.320969)	-0.046821 (-0.829284)	0.128439 (2.656267)	0.363225	-	3.947562	-
222	0.118834 (0.637492)	0.040898 (1.919783)	0.377976 (3.489765)	-0.018056 (-1.582161)	0.624797 (7.151548)	-0.160579 (-2.112737)	0.061649 (2.122271)	0.375203	0.651632 (2.130193)	1.549013	0.291837
231	-0.292835 (-0.918273)	-0.009961 (-0.375057)	0.189074 (2.815601)	0.107583 (3.368003)	0.759874 (8.486612)	0.025553 (0.651922)	0.127474 (2.279391)	0.240126	-	2.491831	-
233	0.081821 (0.291837)	0.032638 (1.376974)	0.495823 (5.334183)	0.005566 (0.024466)	0.567692 (5.574466)	-0.072178 (-0.496593)	0.153725 (2.842115)	0.432308	-	2.710395	-
234	-0.837257 (2.103948)	-0.007645 (-0.281648)	-0.013647 (3.516915)	0.035408 (1.977776)	0.775147 (8.150964)	0.034792 (0.660214)	0.290537 (3.112231)	0.224853	0.513226 (2.051622)	1.818176	0.118378
235	0.958779 (2.183776)	0.047716 (1.974827)	0.115318 (2.926278)	-0.085247 (-0.549102)	0.869332 (9.123491)	0.040199 (1.013791)	-0.102935 (-0.761349)	0.130668	-	3.173849	-
236	-0.918276 (-2.103948)	0.077314 (3.129374)	0.194177 (3.786844)	0.076357 (2.130991)	0.631866 (7.625304)	0.088771 (4.521278)	-0.105872 (-1.675324)	0.368134	0.831253 (2.192831)	1.568137	0.318441

(Table 8 continue)

237	0.091823 (0.192384)	0.044995 (1.875473)	0.128259 (3.195168)	0.101595 (4.328813)	0.509908 (5.575271)	0.143044 (1.420132)	0.045405 (2.049773)	0.490092	0.710394 (2.071623)	1.139484	0.285937
239	-0.514281 (-1.837475)	-0.074342 (-2.730428)	0.172923 (3.825738)	0.063998 (2.463522)	0.708726 (7.925811)	0.078779 (2.777315)	0.054435 (2.338031)	0.291274	-	3.771932	-
241	-0.746583 (-1.928374)	0.032095 (1.409259)	0.124829 (3.172418)	0.128054 (3.686513)	0.422154 (3.860087)	0.090538 (0.382362)	0.164803 (2.795728)	0.577846	-	2.193847	-
242	-1.437917 (-3.173645)	0.033435 (1.329415)	-0.001771 (-3.451674)	-0.003243 (-2.213671)	0.840304 (9.651163)	0.059197 (0.541079)	-0.029541 (-0.716372)	0.159696	0.539188 (2.008137)	1.867164	0.209183
243	0.814593 (2.019387)	0.033286 (1.279582)	0.117826 (2.645972)	0.041165 (2.011026)	0.504744 (2.601607)	0.047948 (0.172898)	0.067176 (2.219762)	0.495256	-	2.973642	-
244	0.983121 (2.103848)	0.015592 (0.741813)	-0.002159 (3.947892)	-0.026596 (-1.619862)	0.815902 (9.534371)	0.082841 (0.848218)	0.136879 (2.971243)	0.184098	-	2.103947	-
251	-0.499812 (-1.461839)	0.023047 (1.083635)	0.447866 (1.745536)	0.141372 (2.015713)	0.627848 (6.381531)	-0.075134 (-0.707316)	0.141537 (2.988135)	0.372152	0.871362 (3.018235)	1.958181	0.516733
252	-0.716268 (-1.837163)	0.038513 (1.354466)	0.147192 (1.584992)	0.068423 (2.355154)	0.747458 (8.097881)	-0.097031 (-2.872335)	0.112446 (2.937432)	0.252542	-	2.139451	-
253	-0.991782 (-1.990193)	0.1375012 (3.800892)	0.131369 (3.870352)	0.067581 (3.672588)	0.778855 (8.403824)	0.049806 (2.669026)	-0.039153 (-2.736133)	0.221145	0.609182 (2.078819)	1.449138	0.109372
257	0.374728 (1.281734)	-0.029548 (-1.142136)	0.105074 (2.501156)	0.017565 (3.035648)	0.804189 (9.398799)	0.052326 (0.770118)	0.057873 (1.980421)	0.195811	-	2.184726	-
259	1.098337 (3.103845)	0.034619 (1.336561)	0.189262 (3.390241)	0.067622 (2.083027)	0.837046 (9.598239)	0.030164 (2.511153)	0.019173 (2.352467)	0.162954	-	2.874613	-
271	0.847152 (2.871839)	0.021465 (0.921279)	0.240786 (3.763102)	0.158107 (3.874363)	0.686231 (6.267942)	-0.008492 (-0.140372)	0.135119 (2.468269)	0.313772	0.761739 (2.658193)	1.458129	0.339186
273	-0.646625 (-1.989031)	0.023942 (1.061123)	0.166049 (3.014817)	0.085947 (2.031958)	0.711032 (8.632966)	0.002919 (0.060541)	0.019773 (2.037334)	0.288968	-	2.381374	-
274	-0.764513 (-2.013741)	0.013296 (0.552486)	0.135959 (2.944761)	0.098418 (2.265104)	0.773379 (8.746883)	0.005873 (0.148365)	0.200035 (4.119066)	0.226621	0.891782 (2.271039)	1.193841	0.461531
275	0.192834 (1.103947)	0.040932 (1.915619)	-0.007995 (-1.642991)	0.054415 (2.302782)	0.740546 (8.386422)	0.076094 (2.459605)	0.286961 (4.827261)	0.259508	-	2.817376	-
281	-0.300195 (-1.035261)	0.106305 (3.508367)	0.254093 (2.625379)	0.135709 (2.676093)	0.598406 (9.514315)	0.043085 (2.665758)	0.181989 (3.716894)	0.401594	0.639128 (2.193847)	1.218371	0.219362
282	-0.837612 (-1.998364)	0.040767 (1.888547)	0.152974 (3.794672)	0.101026 (2.226237)	0.584532 (9.678531)	0.037449 (1.527173)	0.142155 (3.576858)	0.415476	-	2.741837	-
283	0.118372 (0.963521)	0.153677 (3.116483)	0.117539 (3.614699)	0.098112 (3.182441)	0.577826 (9.850941)	0.038242 (1.587865)	0.121643 (3.217484)	0.422174	-	2.074813	-
289	-0.344617 (1.184645)	0.113976 (2.452343)	0.237094 (3.780827)	0.131194 (2.502491)	0.592575 (8.216933)	0.052563 (2.266856)	0.177917 (2.152446)	0.407425	0.886152 (2.259015)	1.726542	0.239189
292	0.884613 (2.3219320	0.081851 (3.428348)	0.227465 (4.583894)	0.108118 (3.531688)	0.499137 (6.067661)	0.073865 (2.804224)	0.035191 (1.864561)	0.500863	0.601293 (2.061273)	1.671392	0.291831
310	-0.716351 (-2.173646)	0.005693 (0.285855)	0.259351 (6.085537)	0.062654 (2.566314)	0.506252 (6.182124)	0.027548 (0.985033)	0.184751 (3.611581)	0.493748	0.558137 (2.029127)	1.781938	0.138474

Notes: See notes in Table 1 and Table 7.

The estimation method applied in the equations of this table is the *Generalized Method of Moments*.

The pricing equation (31) along with its variants including the lagged factors of unit costs, output, foreign pricing decisions and taxation was estimated initially by the OLS method. However, the OLS estimations would be inconsistent due to the presence of endogeneity caused by the dependent variable and the explanatory variable of taxation. As mentioned in section 4.1.2, p^T reflects the VAT percentage embodied in the final wholesale price. This means that p^T is equal to the VAT percentage of the wholesale price charged by the manufacturing sectors, thus reflecting the simultaneous dependency of these variables. For this reason, the problem of endogeneity arises in the pricing equation of this study.

In addition, there is evidence in favour of first-order serial correlation in the residual terms of 25 sectors as a result of Durbin's *h* statistic to be lower than 2[75]. The results of the Breusch and Godfrey test indicate that there is no higher order of serial correlation in any of those sectors. Moreover, the Breusch, Pagan and Godfrey test suggests the absence of known form of heteroskedasticity, but White's test provides significant evidence of heteroskedasticity in the residual term of every manufacturing sector. This means that heteroskedasticity is of unknown form in every regression. Consequently, in order to account for the presence of endogeneity, first order serial correlation and heteroskedasticity in the residual terms of the manufacturing sectors, the *GMM* estimation technique is employed. It is treated as a convenient method of accounting the aforementioned problems in order to get unbiased, consistent and efficient estimates of the speed of price adjustment[76]. In addition, in order to correct serial correlation, an autoregressive error term *AR(1)* is added by considering that the residual terms depend on their lagged value at $t\text{-}1$[77].

Table 8 presents the estimates of the 56 time series regressions along with the diagnostic tests for first-order serial correlation. To begin with, the excess demand proxy variable expressed as the difference between output and output trend is found to be significant at the 5% level of significance in 11 manufacturing sectors. However, the sign of a_1, when significant, is not found to be the same across the sectors. In particular, three sectors (i.e. 120, 204, 239) appear to have a negative excess demand coefficient on the final

[75] A possible source of misspecification could be the exclusion of unit material cost as the level of output is expressed in terms of total value added. A broader formulation of (31) could be to express output in terms of gross value added and include an additional unit cost variable of materials. However, given the range of our observations (i.e. 33 years), an additional explanatory variable could result in biased estimations because the number of the included variables would necessitate for additional years to be taken into account.
[76] See Appendix B2 for an Error Correction Model estimation process.
[77] This is known as the Cochrane–Orcutt (1949) transformation (see Wooldridge, 2005).

wholesale price level, while the remaining have a positive effect which is consistent with the findings of Bedrossian and Moschos (1988).

The theoretical intuition implies that the difference between actual output and output trend reflects additional levels of demand compared to the average expected level reflected by the trend of production. If pricing decisions are adjusted according to the latter expectations, then any additional level that results in excess demand should reflect a price increase of the sectorial wholesale price, especially in oligopolistic markets. This intuition is violated only by 3 sectors, which responded to such changes by reducing their price level and this is why the effect, or otherwise wholesale price elasticity with respect to excess demand, is found to be negative. There are three additional sectors experiencing negative signs as well, but their significance is very low. Overall, the excess demand proxy is not significant in the majority of the constituent 3-digit sectors of this sample which means that there are only 11 sectors that reflect fluctuations of excess demand in their pricing decisions.

The theoretical intuition concerning the coefficients of the unit cost variables necessitates their positive sign by suggesting that changes in costs are transferred to the final wholesale price level. The majority of the constituent sectors, once again, validate this intuition by providing evidence that unit costs of capital and labour are incorporated in pricing decisions. In addition, there is a number of sectors which appear to have an insignificant coefficient of either unit labour or capital cost, by suggesting that changes in unit costs may not be totally transferred to the final wholesale price level. A possible explanation for this outcome could lie on the degree of competition within the sector or on the nature of consumer demand curve. If firms or sectors in general, cannot afford to change their prices (i.e. because of intense competition or menu costs), then they will choose not to reflect any changes in unit costs by absorbing and incorporating them into their total cost function (Rotemberg 1982a, 1982b).

In addition, a more extended case of this phenomenon could be a result of significant negative price elasticity with respect to unit labour or capital cost. Sector 242 appears to have a significant negative coefficient equal to *-0.003243*, which provides evidence that changes in unit capital cost were not reflected in the final wholesale price at all. Instead, there were absorbed by the sector in order not to be transmitted to consumers. Overall, even if this case is not among the dominant cases in terms of theory, it can be adopted by particular sectors and firms which do not prefer to incorporate such changes in their pricing decisions.

However, the majority of this study's sample is in accordance to the main theoretical intuition that changes in unit costs are transferred in the wholesale price of the final product[78].

The following concept taken into account as a potential determinant of pricing decisions corresponds to competing foreign price levels charged by the EU27 manufacturing sectors. Bloch and Olive (1999) found that competing foreign prices are strongly positive correlated to the pricing decisions of highly concentrated sectors exposed to a degree of foreign competition in the Australian industry. However, the results provided by the present study contradict this outcome. In section 6.2.1, it is found that competing foreign prices do not have a significant effect on the pricing decisions of the Greek manufacturing industry at the 5% level of significance. A similar outcome is also found for the majority of the constituent 3-digit sectors. In particular, there are only 14 sectors that appear to have a significant price elasticity with respect to competing foreign prices and at the same time, the sign of that effect is different among the corresponding sectors.

There are 9 of those sectors facing a positive signed elasticity by indicating that changes in pricing decisions of the EU27 manufacturing sectors move in the same direction the wholesale price level of the Greek manufacturing sectors. An interpretation of this outcome could reflect the market principle of price leadership and/or collusive behaviour (Rotemberg and Saloner, 1990). If there is an agreement, formal or informal, among the firms of a particular sector, then imperfect competitive conduct could emerge. The first case refers to a price leading firm which owns private information about consumers' preferences and thus, fluctuations in demand. This fact forces the following firms to adjust their decisions according to the leading firm's decisions. The second case may reflect a collusive contract, under which the participating firms will have to adopt the same pricing policy according to the terms of that contract.

On the other hand, there are 5 of those sectors that appear to have a negative signed elasticity with respect to foreign prices. This outcome suggests that changes in the latter decisions are inversely reflected by the Greek manufacturing sectorial pricing decisions. A reason that could justify such outcome may refer to the degree of competition and lack of

[78] However, in order for this proposition to hold, it is assumed that the equilibrium price level must be a markup over unit labour and capital costs by implying that $\beta_1 + \beta_3 = 1$. This rationale is based on the Wald test of equation (31). Therefore, the Wald test was also applied in the equilibrium equation (27) under which $H_0: \beta_1 + \beta_3 = 1$. Once again, the result is insignificant for all sectors which proves that the price level of the manufacturing sectors is a markup over unit costs.

collusive agreements. If, for instance, competing foreign prices increase as a result of input cost appreciation, then the Greek sectors can take advantage of this action by reducing their prices to attract more customers. Another case of competition could reflect a wholesale price reduction adopted by the EU27 sectors. However, instead of competing in similar terms (i.e. Bertrand competition), the Greek sectors may choose to increase their price level as a result of product differentiation captured by improvement in technology and/or productivity (Giokas, Eriotis and Dokas, 2015). As a result, this outcome would suggest a form of competition with two effects; pricing and quality differentiation.

The remaining sectors, which reflect the overall outcome, appear to have an insignificant value of price elasticity with respect to competing foreign prices at the 5% level of significance. The majority of those values are found to be negative but their significance is very low and therefore, they cannot be treated as credible indications. To this end, 42 out of 56 sectors in the Greek manufacturing industry do not incorporate fluctuations in competing foreign prices into their own pricing decisions. This sugegsts that the degree of influence of the EU27 manufacturing sectors is not very strong in the Greek market[79]. This outcome validates the reports of IOBE (2013, 2014) supporting that the Greek manufacturing industry is one of the most important contributors to Greek GDP and employment by neglecting exogenous price shocks originated from the European manufacturing markets.

An additional factor taken into account in the pricing equation of this study refers to government intervention in terms of value added tax (VAT) in the wholesale price charged by the manufacturing sectors. As discussed in section 6.1.2, p^T reflects the percentage of the VAT as part of the final wholesale price that buyers have to pay for the final product of a particular sector. According to changes in the wholesale price and the VAT level over the period 1980-2012, the effect of p^T was estimated on the final wholesale price of the constituent manufacturing sectors.

In particular, according to the tax report of the European Commission and Eurostat (2014), the initial VAT rate introduced by the Greek government in 1987 was a universal rate for the Greek economy equal to 18 percent. However, in 2000, there were discussions about a fair rate given the heterogeneity and importance of various goods in the Greek markets. This

[79] A very important limitation of this process lies on the fact that the aforementioned estimates reflect changes in nominal prices. This means that the comparison process occurs between the nominal price level charged by the Greek and the EU27 manufacturing sectors respectively. However, any differences between the aforementioned price levels do not reflect a real effect, as the rate of inflation is not taken into account.

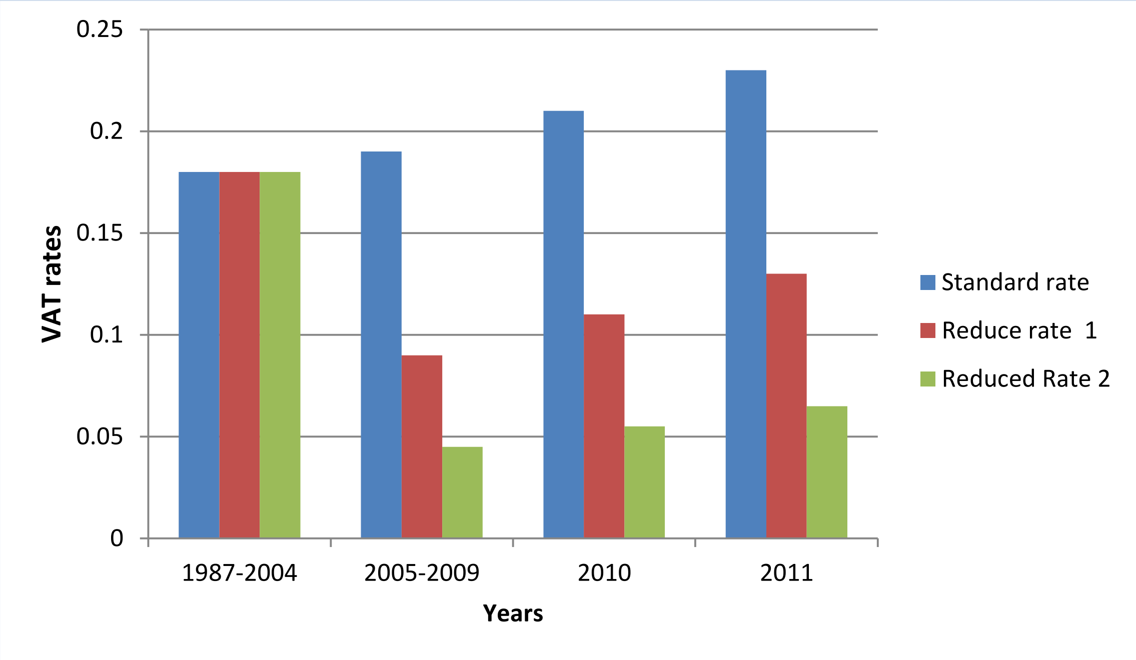
proposition was legislated in 2005, under which a three-tiered VAT system was established; the standard rate was 19 percent and the new reduced rates were 9 percent and 4.5 percent respectively. In 2010, given the economic condition of the Greek economy and the implementation of the Adjustment Programme, the standard rate increased to 21 percent, while the reduced rates also increased to 11 percent and 5.5 percent respectively.

One year later, there was an additional increase in those rates, under which the new standard rate raised to 23 percent and the reduced rates to 13 percent and 6.5 percent respectively[80]. In the following months, there were discussions about lowering the standard rate in the main region of the Greek economy but there was no actual implementation of such policy. In addition, the tax report highlights the fact that the Greek economy has the sixth highest standard VAT rate in the EU and the second highest rate in eating-out, as a result of fiscal contraction caused by the implementation of austerity policies.

The standard VAT rate of 23 percent is applied on the majority of manufacturing products such as clothes, alcoholic and non-alcoholic beverages, furniture, chemicals, plastics and paper products. The reduced rate of 13 percent refers to products such as food at the supermarkets and grocery stores, ready-made or prepared meals, fresh baked goods and pastry from bakeries. The second reduced rate of 6.5 percent is applied on pharmaceutical products, books, magazines and newspapers. To this end, according to the nature of the constituent manufacturing sectors, the analysis took into account the appropriate VAT rate in every year over 1980-2012 and therefore, the formulation of p^T has been made according to the wholesale price level of each 3-digit manufacturing sector.

[80] Those rates may vary in particular Greek islands according to the number of tourists and the level of demand.

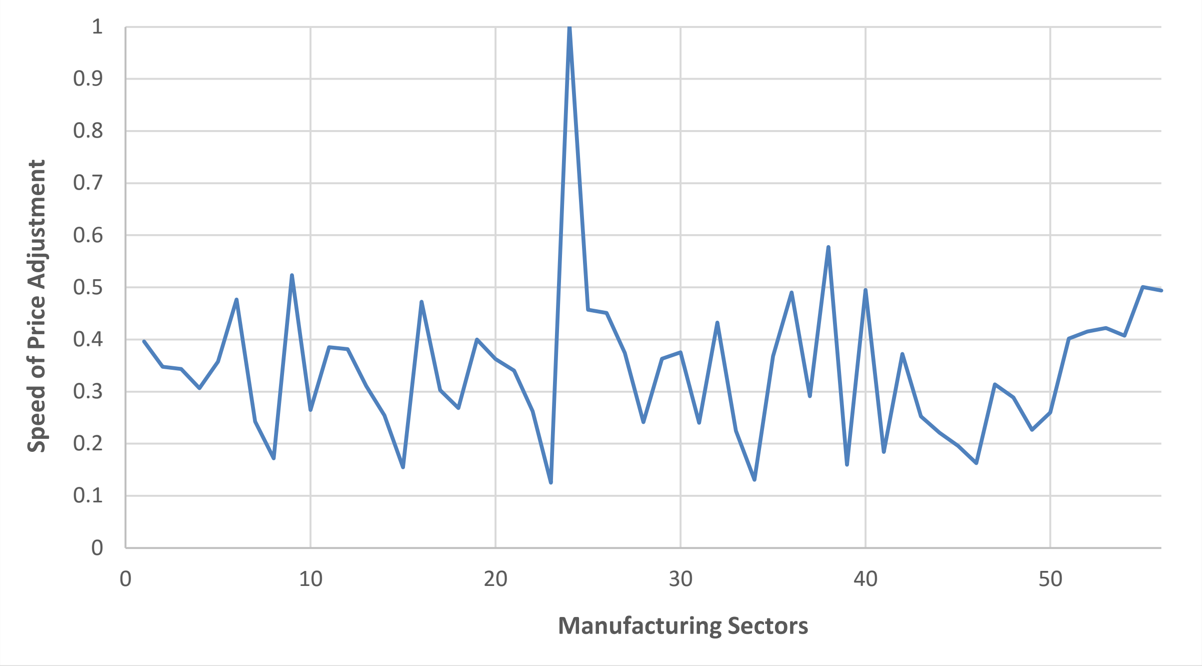
Figure A: The VAT rates over 1987-2011 in the Greek economy.



As presented in Table 8, the final wholesale price elasticity with respect to taxation is found to be significant at least at the 5% level of significance in 48 out of 56 sectors. This reflects that the VAT rate has affected the pricing decisions of the manufacturing sectors over the period 1980-2012. This fact shows that the final wholesale price charged by the manufacturing sectors takes into account the corresponding VAT rate over the years. The estimates suggest that fluctuations in the VAT rate and/or the initial wholesale price (before tax) have a significant effect on the final wholesale price, which is also the source of endogeneity in the pricing equation (31).

The value of $\lambda^{T'}$ suggests that changes in the formulated variable p^T were reflected in the final wholesale price by a range over *-0.039153* to *0.350327*. The positive signed values refer to the percentage change of p^T incorporated in the final wholesale price. Since that percentage is lower than unity, it indicates that pricing decisions took into account changes of VAT in p^f only by that percentage, thus suggesting the imperfect competitive nature of the industry. The highest value estimated for sector 105 suggests that changes in p^T have influenced p^f only by 35 percent over the period sample. On the other hand, the negative value obtained for sector 253 denotes that changes in p^T had a negative effect on p^f. An interpretation of this result could be in accordance to the overall behaviour of that sector not to reflect a VAT rate increase in its final wholesale price level, given that there was no reduction of VAT over 1980-2012. Therefore, the main implication of those estimates suggests that the majority of the Greek manufacturing sectors incorporated the VAT rate into their pricing decisions by transmitting a percentage of such changes to consumers.

Figure 8: The speed of price adjustment of the manufacturing sectors over the period 1980-2012.



The last, and most important, factor included in the pricing equation of this study refers to lagged pricing decisions at time *t-1*. In particular, the main rationale of this factor refers to the degree of dependence between present and past pricing decisions in the manufacturing sectors. The pricing equation of this study is based on the initial formulation of Bedrossian and Moschos (1988). It takes into account the partial adjustment mechanism (28) in order to incorporate lagged pricing decisions in the equilibrium state expressed by equation (27). In addition, this analysis includes two additional adjustment mechanisms expressed by equation (29) and (30) in which the adjustment between the equilibrium price and competing foreign prices and taxation are presented respectively. The main intuition of this step refers to the identification of the speed of price adjustment (λ) of the manufacturing sectors to changes in the pricing equation factors at time *t-1*.

The estimates presented in Table 8 validate the proposition of Bedrossian and Moschos (1988) that the Greek manufacturing industry faces a significant degree of nominal price rigidity. In particular, in conjunction with the results of Table 7, the value of $1-\lambda$ is found to be significant for every manufacturing sector (except 201). The value of wholesale price elasticity with respect to lagged pricing decisions reflects the degree of dependence between p^f_t and p^f_{t-1}. Therefore, if that value is subtracted from unity, then the speed of price adjustment will be obtained by reflecting the degree of price rigidity[81]. As mentioned by Olive (2008), the speed of price adjustment is affected by target output when a particular sector has economies or diseconomies of scale with respect to the costs of adjustment. In the present study, those costs refer to the lagged pricing equation factors as the crucial determinants of price adjustment.

The value of λ ranges over *0.124964* to *0.577846* by excluding the insignificant value estimated for sector 201. The estimates of price adjustment suggest that the majority of the manufacturing sectors appear to have a rather rigid pricing behaviour below 0.5 which can be considered as the boundary between partial rigidity and flexibility. The results obtained by the time series analysis also validate the indications of the first and third step respectively in favour of a significant degree of nominal price rigidity in the manufacturing industry. The theoretical implications of the partial adjustment model and thus, the speed of price adjustment lie on the degree of dependence between present and lagged pricing decisions in the manufacturing sectors. However, there exists a single sector (i.e. 201) that does not appear to have a significant value of λ. This means that over the period 1980-2012, the pricing decisions of the sector of basic chemicals were not influenced by changes in the pricing equation factors at time *t-1*. This is the sole reason for which the values of wholesale price elasticity with respect to unit input costs appear to be higher compared to the remaining sectors.

As mentioned in section 6.1.2, the speed of price adjustment is modelled in the pricing equation as fixed for every sector over the period sample, but as a linear function of the structural factors across 3-digit sectors. This fact indicates a linear dependency between the final wholesale price level and the pricing equation factors at time *t*. Nevertheless, the theoretical intuition of rigid price adjustment can also be interpreted on the basis of market conditions. As Dixon (1983) and Bedrossian and Moschos (1988) argued, the nature of price rigidities cannot refer only to oligopolistic conditions. For instance, a collusive behaviour among firms or sectors could force the market price level to be quite rigid for a number of years by not considering any fluctuations in the remaining pricing equation factors.

[81] It is always assumed that a value of $\lambda=0$ refers to complete price rigidity and a value of $\lambda=1$ corresponds to complete flexibility.

However, intense competitive conditions can also result in a slow speed of price adjustment through intensive or even secret price cutting. As discussed by Green and Porter (1984), whenever there is an exogenous demand shock in a particular sector under collusion, there may be at least one firm that will try to take advantage of that shock by violating the collusive contract. That violation will lead to a reduced price level charged by that firm and thus, excess demand will turn to that particular firm. If this rationale is adopted by every participant of the collusion, given the assumption of rationality, the collusion will enter a temporary reversionary episode. Under this episode, competitive behaviour will be dominant in the short run, and maybe in the long run, meaning that the price level will remain at the competitive level despite changes in the cost of inputs or any other significant factor.

As a result, the analysis of the speed of price adjustment concept provided evidence in favour of a significant degree of nominal price rigidity in the Greek manufacturing sectors. This outcome suggests that present pricing decisions are influenced by lagged pricing decisions which show that the adjustment process will need some time to accurately reflect changes in the pricing equation factors at time *t-1* and *t*. In addition, factors such as competing foreign prices and taxation also displayed a significant effect on the wholesale price level of the manufacturing sectors' final product, in conjunction with unit input costs and production decisions. Overall, the implication of this step corresponds to the fact that on the basis of the aforementioned pricing equation factors, the Greek manufacturing sectors and the whole industry have faced a slow speed of price adjustment over 1980-2012.

In addition, the values obtained in this study validate the values of Bedrossian and Moschos (1988) suggesting that price tend to change relatively slow in the Greek manufacturing industry. The authors estimated a range of λ over *0.1246-0.7206* which is consistent with the sluggish adjustment results of this study. By taking into account the time sample of the aforementioned study over 1963-1977 and of this study over 1980-2012, it can be argued that the Greek manufacturing industry always faced a relatively slow speed of adjustment. However, the contribution of the present study extends the analysis to the aggregate level (i.e. 1-digit level), to the 3-digit level and to the annual behaviour of the manufacturing industry. This means that both studies contribute to the literature of price adjustment in the Greek manufacturing industry by validating the theoretical and empirical intuition of sluggish adjustment. In conjunction with the results of imperfect competition, the next and final step of this study is to test whether such pricing behaviour results from the presence of imperfect competition due to various factors, such as collusive agreements.

Therefore, the following and final step refers to the nature of the estimated results of market power and price rigidity which is the main scope of this study. In particular, in sections 6.1 and 6.2 the conjectural variation elasticity and the speed of price adjustment were estimated for the Greek manufacturing sectors and the whole industry over the period 1980-2012. However, it is still not very clear why the degree of market power and price rigidity were found to have the aforementioned values. To this end, the final process that must be taken into account in order to identify and complete the main scope of this study corresponds to potential factors introduced by literature that may influence the speed of price adjustment. Consequently, the following sections reflect the results of the formulation of the price adjustment equation, as presented in section 4.4, in order to identify the sources of market power and nominal price rigidity in the Greek manufacturing sectors.

6.3.The Speed of Price Adjustment Formulation

According to Dixon (1983) and Bedrossian and Moschos (1988), the speed at which prices adjust to changes in costs is found to be negatively correlated to the degree of market power. This effect is identified by the authors as the profitability effect by highlighting the fact that higher volume of sales in conjunction with rigid prices result in a higher level of profits. The empirical evidence of those studies suggest that sectors are able to offset price adjustment costs, such as unit and menu costs, by sustaining a slow speed of price adjustment (Kano, 2013). In addition, the second effect identified as the leadership effect, captures the relationship between the speed of price adjustment and the size of the manufacturing sectors. It is expected that the larger the size, the more flexible pricing decisions will be as sectors can defray price adjustment costs through flexible production decisions. As a result, they have less reason to sustain a rigid price level compared to firms exercising their market power (Olive, 2008).

The main objective of the present study corresponds to the identification of the aforementioned effects in the Greek manufacturing industry by considering the findings of sections 6.1.2 and 6.2.2 and the respective variables introduced by the existing literature. The speed of price adjustment formulation is reflected by equation (38) according to the analysis of Bedrossian and Moschos (1988) and Olive (2008). In particular, the variables through which the profitability effect will be identified correspond to the degree of market concentration in terms of sales (*CR4*) and conjectural variation elasticity (*f*) (Martin, 1993). On the other hand, the leadership effect has been identified in the existing literature by the production lag indicator and the size of the firms in terms of sales (*SIZ4*). However, given the unavailability of data for the constituent sectors of this sample, the former indicator has been excluded from this study and replaced by average cost (*AC*). The average cost indicator can capture the effect of leadership according to the ability of the manufacturing sectors to adjust their prices more often when changes in the average cost of inputs occur at any time *t*[82]. Therefore, according to the sign and the magnitude of the coefficients, the effects of profitability and leadership will be identified.

Following the methodology adopted by the aforementioned papers, the speed of price adjustment formulation will be estimated under a cross-sectional approach for each year over 2005-2012. Given the significance of this particular sub-period, it is of great interest to identify the two effects in the manufacturing industry according to the behaviour of the constituent 3-digit sectors. A limitation of this approach corresponds to the inability of identifying the two effects in the 3-digit level individually by including a full set of firm-level data. If the present data set comprised of input costs of the manufacturing firms, then the analysis could involve the characteristics of a 4-digit level specification in full scale. For this reason, the present study is limited to the estimation of those effects in the manufacturing industry, but the accuracy of the observations reflects the indicators obtained by 3-digit and 4-digit level concentration and size data respectively.

[82] Olive (2008) takes into account the average variable cost (*AVC*) for the Australian manufacturing sectors by neglecting the influence of capital investment in pricing decisions. In this study, the volatility of investments is a very important factor which may also capture the relationship of the speed of price adjustment to changes in average total cost of the manufacturing sectors.

Table 9. *Estimations of the Speed of Price Adjustment Equation (38) of the 3-digit Sectors in the Greek Manufacturing Industry for each year over the period 2005-2012*.

Parameters	**2005**	**2006**	**2007**	**2008**
γ_1 $(CR4_d)$	-0.159182 (-2.549121)	-0.098615 (-2.341726)	-0.129181 (-2.419285)	-0.143641 (-2.52845)
γ_2 $(SIZ4_d)$	0.108517 (2.851829)	0.051726 (2.351944)	0.071829 (2.591823)	0.078575 (2.613163)
γ_3 (AC_d)	0.031722 (2.159772)	0.019182 (1.990182)	0.028171 (2.019231)	0.058882 (2.711216)
γ_4 (f)	-0.261728 (-2.018471)	-0.381625 (-2.980195)	-0.281762 (-2.139185)	-0.394811 (-3.05716)
Estimation Method	WLS	WLS	WLS	WLS
Durbin-Watson Test[a]	2.057182	2.118475	2.009175	2.173542
Breusch and Godfrey Test[b]	-	-	-	-
Breusch, Pagan and Godfrey Test[c]	4.081726 [0.0274]	4.118172 [0.0256]	3.861729 [0.0353]	3.1276 [0.0491]
White Test[d]	2.549128 [0.0396]	3.679182 [0.0000]	4.771681 [0.0000]	5.113334 [0.0000]
Wald Test[e]	14.1928 [0.0000]	16.9182 [0.0000]	13.5571 [0.0000]	10.7215 [0.0000]

Notes: See notes in Table 1.

[a] If $d \geq 2$. there is no evidence of first order positive serial correlation in the error term. where *d* is the value of the *DW test*.
[b] H_0*: No serial correlation of* ρ*-order in the error term* ($\rho_1 = \ldots = \rho_\rho = 0$).
[c] H_0: *Homoskedasticity* versus H_1: *Heteroskedasticity of known form* ($\sigma_t^2 = h(a_1) = \sigma^2$).
[d] H_0: *Homoskedasticity* versus H_1: *Heteroskedasticity of unknown form*.
[e] The *F-test* is used to test the joint significance of the including regressors.

(Table 9 continue)

Parameters	**2009**	**2010**	**2011**	**2012**
γ_1 $(CR4_d)$	-0.081724 (-2.318471)	-0.139997 (-2.505212)	-0.159816 (-2.577958)	-0.178371 (-2.63812)
γ_2 $(SIZ4_d)$	0.097261 (2.737182)	0.068492 (2.482706)	0.136375 (3.056953)	0.121985 (2.991928)
γ_3 (AC_d)	0.049182 (2.373910)	0.026348 (2.009718)	-0.068838 (-2.298546)	-0.041827 (-2.04917)
γ_4 (f)	-0.258744 (-1.998155)	-0.461536 (-3.381825)	-0.149909 (-1.398274)	-0.292716 (-2.19273)
Estimation Method	WLS	WLS	WLS	WLS
Durbin-Watson Test[a]	2.038172	2.187697	2.179473	2.139281
Breusch and Godfrey Test[b]	-	-	-	-
Breusch, Pagan and Godfrey Test[c]	3.589811 [0.0375]	4.097136 [0.0288]	3.349351 [0.0431]	4.017162 [0.0305]
White Test[d]	2.761744 [0.0328]	3.209626 [0.0018]	7.521841 [0.0000]	2.918273 [0.0284]
Wald Test	18.1928 [0.0000]	11.6125 [0.0000]	15.8646 [0.0000]	10.1825 [0.0000]

Notes: See notes in Table 1.

[a] If $d \geq 2$. there is no evidence of first order positive serial correlation in the error term. where *d* is the value of the *DW test*.
[b] H_0*: No serial correlation of* ρ*-order in the error term* ($\rho_1 = \ldots = \rho_\rho = 0$).
[c] H_0: *Homoskedasticity* versus H_1: *Heteroskedasticity of known form* ($\sigma_t^2 = h(a_1) = \sigma^2$).
[d] H_0: *Homoskedasticity* versus H_1: *Heteroskedasticity of unknown form*.
[e] The *F-test* is used to test the joint significance of the including regressors.

To begin with, the diagnostics tests presented in Table 9 correspond to the ones introduced in section 5.2, given the exclusion of a panel data approach. There are 8 estimated cross-sections constituted by 56 observations, according to the number of the 3-digit sectors of the sample. The Durbin-Watson test is found to be higher than 2 in the undertaken cross-sections by suggesting the absence of first order positive serial correlation in the residual terms of equation (38) over 2005-2012. However, the heteroskedasticity tests of White and Breusch-Pagan-Godfrey are found to be significant at least at the 5% level of significance in every cross-section. Such evidence suggests the presence of heteroskedasticity of known form by indicating that the variance of the error term for each year is not constant (see section 5.2). In conjunction with the evidence provided by the White test, which identifies additional forms of heteroskedasticity and misspecifications, it can be argued that heteroskedasticity of the speed of price adjustment formulation is of known and linear form.

To this end, the estimation method that has been chosen and considered to be the most accurate according to the diagnostics results corresponds to the *Weighted Least Squares* technique. In particular, since the form of heteroskedasticity appears to be linear, the error term's standard deviation will be equal to ${\sigma_i}^2 = {\sigma_{w_{ij}}}^2 = {\sigma_v}^2 + var(\hat{\lambda}_i)$, where w_{ij}reflects the source of heteroskedasticity across the entities. Therefore, the scaled weights that correct this problem correspond to $({\sigma_v}^2 + var(\hat{\lambda}_i))^{-1/2}$. They are applied to the *OLS* estimation of (38) in order to obtain efficient estimators and homoscedastic residual terms.

The estimates of market power are reflected by the coefficients of the concentration ratio and elasticity of conjectural variation. Both of them are found to be significant at least at the 5% level of significance in every year across 2005-2012, with the sole exception of 2011, where the latter estimator is insignificant. The sign is negative in every case by reflecting an inverse relationship between market power and price flexibility. Such results validate the findings of Bedrossian and Moschos (1988), as well as additional studies that argue in favour of negative correlation between the speed of price adjustment and the degree of market power.

The magnitude of market concentration ranges over *-0.081724* in 2009 and reaches a value of *-0.178371* in 2012. On the other hand, the magnitude of market power in terms of production (*f*) appears to have a stronger effect on the speed of price adjustment. The lowest value is found for 2011, which is insignificant and equal to *-0.149909*, while the highest absolute value appears in 2010 equal to *-0.461536*. These estimates indicate that production decisions, according to which the market structure is reflected, have a greater effect on pricing decisions than the concentration indicator. In particular, the *CR4* formulation was presented by Martin (1993) by taking into account the volume of sales of the four largest domestic firms to the value of the sector in a particular time period. However, the remaining firms are excluded by assuming an insignificant effect on the concentration ratio.

On the other hand, the advantage of that measure compared to conjectural variation elasticity refers to whether production decisions accurately reflect demand conditions. Bresnahan (1982) and Lau (1982) assumed that production decisions are formed under rational expectations (Muth, 1961; Sargent, 1987) which reflect an accurate estimation of demand. This means that production is equal to expected consumption and therefore, the former indicator may accurately capture market conditions. However, in terms of reality, production tends to be close to the volume of sales but never equal. In the case of the Greek manufacturing industry, the data sample shows that production is always close to sales which reflects no misinterpretation of the market conditions in the manufacturing sectors.

In spite of the difference in the magnitude of the market power indicators, the rationale remains the same. The speed of price adjustment in the manufacturing industry is inversely related to the degree of market power. An interpretation of this outcome could reflect the presence of informal agreements among the constituent firms of the manufacturing sectors. If demand fluctuations are not very intense over the years, then the profitability of the firms will be increased by sustaining a rigid price level which does not incorporate fluctuations in the pricing equation factors. On the other hand, such agreements could also be justified in terms of menu costs (Rotemberg, 1982b). Consumers may not prefer changes in the price level of products and therefore, they may prefer firms that tend to sustain a stable price over a period of time. Such behaviour reflects both upward and downward price rigidities with the sole purpose of satisfying the needs of consumers.

According to the estimation of the market power coefficients, it can be argued that firms in concentrated sectors appear to be able to take price adjustment costs into account by choosing not to reflect them in their final wholesale price level. This action does not necessarily reflect a profit seeking behaviour as firms may be interested in the number of their consumers rather the level of their profits. They may prefer to build their reputation by sacrificing additional profits in the short-run in order to ensure the sustainability and survivability of the firm in the long-run (Rogerson, 1983). As a result, the profitability effect matters in the long-run if the aforementioned incentives are taken into account.

In addition, the presence of the profitability effect in the manufacturing industry validates the theoretical suggestion of the collusion model that price rigidities emerge as a result of market power. In particular, the formation of collusion reflects market power acquisition because firms sign contracts that limit competition by restraining production and increasing the price level. This means that the profitability effect is the main objective of colluding firms that wish to maintain their profits at a satisfactory level in times of low demand. As a result, increased market power leads to a rigid price level. This theoretical intuition is confirmed by the negative relationship between market structure and price flexibility.

However, as Berossian and Moschos (1988) argued, interfirm differences among the profitability of the participant firms can affect the speed of price adjustment. If those differences are not significant, then the degree of competition will be intensive by resulting in more flexible and lower prices as a tool of attracting consumers. On the other hand, if such differences are significant, then the level of competition will be low by providing additional market power to the firms with the highest level of profitability. Either way, the results of this study show that the profitability effect in the Greek manufacturing industry is inversely related to the speed of price adjustment; as market power increases, firms and sectors will use that power in order to sustain a rigid price level which will result in profit acquisition in the long-run.

The two remaining measures correspond to the size of the manufacturing sectors, as an expression of the four largest firms, and to the average cost of those sectors for each year over 2005-2012. In particular, the size of the sectors is expressed in terms of sales, as presented by Olive (2008), while the average cost variable comprises of both labour and capital costs[83]. These indicators will identify the leadership effect of the manufacturing industry which captures the relationship between pricing decisions and the size of the sectors, accompanied by fluctuations in average total cost. As argued by Rotemberg and Saloner (1990), large firms may appear to have more flexible pricing decisions due to economies of scales. This indicates that if through innovation and improved technology the average cost of production falls over the years, then unit costs will also decrease. To this end, if large firms wish to enhance competition in the short-run as a form of acquiring greater market power in

[83] Many studies such as Domberger (1983) and Olive (2008) take into account the average variable cost indicator which reflects fluctuations only in the input of labour. They neglect any fluctuations of capital investment because it is treated as fixed and very inflexible cost in the short-run.

the long-run, then economies of scales will provide them the opportunity to engage in competitive actions.

In addition, assuming that the degree of competition is intense and at the same time, there are menu costs occurring as per Rotemberg (1982b) and Kano (2013), then the largest firms will be able to exercise the aforementioned strategy. They will have the opportunity to choose between flexible or rigid prices according to actual and expected levels of demand. If they have the ability to reduce prices by both attracting additional customers and minimizing losses, then the leadership effect will also influence the profitability effect in the long-run. The largest sectors can defray any price adjustment costs due to economies of scales and therefore, they have less reason to prefer rigid over flexible prices by resulting in additional consumers.

The findings presented in Table 9 reflect a positive and significant effect at least at the 5% level of significance of the size of the sectors on the speed of price adjustment. The values of the estimates range over *0.051726* and *0.136375*, where the former is observed for 2006 and the latter for 2011. In particular, the leadership effect is found to be relatively strong in 2005 but over the sub-period 2006-2010, its magnitude fluctuates around *0.07* by reaching a climax in 2009. The most interesting observation refers to the years following the austerity programme implementation over 2010-2012. The value of the leadership effect is *0.068492* in 2010 which is in accordance to the former values over 2006-2009. However, in the period over 2011-2012, which is considered to be the starting period of economic depression, the leadership effect is found to be approximately two times higher compared to the previous years.

In 2011 and 2012, the estimate is equal to *0.136375* and *0.121985* respectively. This means that under the effects of falling aggregate demand, the largest manufacturing sectors chose to increase the flexibility of their pricing decisions in order to incorporate fluctuations of the pricing equation factors in their wholesale price level. Moreover, if it is also considered that the cost of inputs followed a slightly increasing trend[84], then it can be argued that relatively higher unit costs were reflected in the final wholesale price. This action can be interpreted on the basis of large sectors being confident about the level of demand for their products even if the degree of uncertainty about future expected demand is accounted for.

[84] See Eurostat, Economic Accounts for Agriculture (EAA).

In addition, the second factor that partially validates the aforementioned rationale refers to the effect of average cost on the speed of price adjustment. The main argument corresponds to the fact that large firms can take advantage of economies of scales in order to defray the costs of price adjustment. Nevertheless, the first set of estimations (2005-2010) that reflect the effect of average total cost fluctuations on the speed of price adjustment contradict this particular rationale. As presented in Table 9, the estimates are positively signed over 2005-2010, negatively signed over 2011-2012, significant at least at the 5% level of significance and they range over *-0.068838* and *0.058882*. Despite the fact that their influence is very low, their significance captures the main proposition of Peltzman (2000) that prices rise faster than they fall only over 2005-2010. In particular, a positive sign between the flexibility of pricing decisions and average cost reflects the fact that an increase in the latter variable will be partially transferred to the wholesale price by resulting in price flexibility and thus, higher price level.

On the other hand, if there is a decrease in average cost, the wholesale price will become more rigid. This action refers to the fact that firms and sectors are not willing to give up any additional profit opportunities in the short-run by adjusting their prices to such changes. This rationale does not validate the leadership effect as economies of scale do not result in more flexible prices. An interpretation may be that the majority of the manufacturing sectors prefer to pursue a potential increase of their market power in the short run by neglecting to reflect adjustment costs in the final wholesale price (that is a form of collusion).

However, this assumption is valid only when fluctuations in demand can be predicted. If the degree of future uncertainty is too intense, then firms and sectors may choose to act in accordance to the leadership effect under which they will try to secure the maximum number of consumers possible. This fact is reflected by the negative signs appeared in the estimations of 2011 and 2012 equal to *-0.068838* and *-0.041827* respectively. By assuming that the imposition of austerity policies results in a slump of aggregate demand, economies of scale will provide the opportunity to the manufacturing sectors to adjust their prices according to fluctuations in average cost. A negative sign reflects the fact that firms are willing to adjust their prices when there is a fall in average cost. On the other hand, an increase in average cost is followed by a slow price adjustment that reflects the intention of firms/sectors not to transmit additional costs to the final wholesale price level. The exploitation of such changes will manifest according to market conditions and thus, they can contribute to both profitability and leadership effect.

The main implications of this study reflecting the behaviour of the Greek manufacturing industry are in accordance with the studies of Bedrossian and Moschos (1988) and Olive (2008). In particular, it has been supported that the speed of price adjustment of the manufacturing sectors increases with production when there are economies of scale with respect to the costs of price adjustment. In addition, sectors exercising their market power will prefer to offset such costs by maintaining a slow speed of price adjustment which will either increase their profitability or secure their number of consumers (or both). Finally, the size of the sectors is positively related to the speed of price adjustment as large firms may consider additional alternatives than taking advantage of economies of scales. As suggested by the findings of this study, the manufacturing sectors also take into account competing foreign pricing decisions and value added after tax in order to adjust their wholesale prices by defraying price adjustment costs. This shows that average total cost is not the only factor that large firms consider to affect the flexibility of their pricing decisions. Consequently, the results of this study can complement the proposition of Olive (2008) that large firms can defray additional pricing decision factors by resulting in lower incentives to maintain a slow speed of price adjustment.

The main limitation of this approach corresponds to the lack of average cost data for the manufacturing firms (4-digit level) which could have enhanced the validity and accuracy of the results. In addition, the omission of the production lag variable, which has been included in the empirical literature of price adjustment, was replaced by the average cost variable. The estimations were in accordance to the theoretical intuition and thus, it can be concluded that it is a very effective replacement of the former variable, both in theoretical and empirical terms.

6.4.Policy Implications

The significant evidence of market power and slow price adjustment suggest that the Greek manufacturing industry operates under non-competitive conditions by resulting in social inefficiency. Figures 5 and 6 illustrate the fluctuations of market power over 1980-2012 according to production decisions. As discussed in chapter 6, the sub-period over 1988-1994 was subject to the structural reforms imposed by the Single European Market (SEM) in order to enhance the degree of competition. However, over the following years, the outcome of those reforms faded away as production and thus, pricing decisions returned to even more intense oligopolistic levels. In particular, the two exogenous shocks of the euro currency and the Olympic Games contributed to that fact by creating a temporary boost in domestic demand and thus, to a speculative chance for profit-making (Green and Porter, 1984). Moreover, the two additional shocks of 2008 and 2010 (global financial crisis and austerity policies respectively) seem to have stabilized the degree of imperfect competition but still, oligopolistic forces were very intensive.

According to such evidence and in conjunction with the speed of price adjustment illustrated in figures 7 and 8, the degree of imperfect competition should converge to the 1994 levels when the SEM implementation reached its climax. This means that a second imposition of the SEM policy framework must be reintroduced in the Greek markets in order to intensify competitive forces. In particular, the European Commission (2012) is formulating a policy framework for the European Union members under which they will achieve new levels of growth by developing fully integrated networks and enhancing the economies overall. One of the most important factors corresponds to the enhancement of business environment by facilitating the survival of businesses and introducing opportunities for active and new entrepreneurs. The Greek business environment leaves little place for new inexperienced businesses to operate in highly regulated and monitored markets dominated by oligopolistic firms (IOBE, 2014). If the degree of competition is very low, then new entrepreneurs will be discouraged from starting their business in particular sectors and therefore, they may choose a different alternative by throwing away the potential of manufacturing growth.

However, aside from new entrants, there are many cases of entrepreneurs who are forced to exit particular sectors either because of little market share or because of business failure due to unexpected circumstances. The current framework in many EU countries does not allow for a second chance in entrepreneurship as those people are stigmatized as failures due to insolvency (Eurobarometer, 2010). This action has a negative impact on the whole society because there are wasted potential capabilities of welfare efficiency. In particular, a failed entrepreneur may become an experienced entrepreneur who learned from his/her mistakes and his/her investment decisions. If this case holds, then by re-entering the market he/she will be able to succeed and thus, enhance the degree of competition and efficiency. To this end, the European Union must establish a policy framework that will be taking into account insolvent and debt-discharge schemes which will provide a second opportunity to enterprises to operate in particular sectors[85].

In conjunction with the aforementioned policy, the Greek judiciary of competition authorities must also control for any collusive actions that enhance the forces of oligopoly. In particular, according to SEM, markets must be allowed to operate independently without any government intervention, with the sole exception of competition violations. This means that competition authorities must intervene in cases of ill competition or actions that damage social efficiency and prevent enterprises from utilizing part of the market share.

However, as argued by this study, the degree of imperfect competition in the manufacturing industry is similar to duopoly accompanied by sticky nominal prices. This means that competition authorities have to intensify competitive interactions in highly concentrated sectors. They can inform potential entrepreneurs about existing opportunities that will introduce new entrants to those sectors by limiting the market power of the incumbent firms. To this end, any barriers to entry will be overlapped and any informal actions of collusion will be easily prevented as the competition authorities will be actively involved in the first steps of the new entrants in the manufacturing industry.

An additional factor which may be treated as a barrier to entry refers to the available access to finance. Given the imposition of austerity policies and the financial collapse of 2008, the financial institutions may be reluctant to provide additional funding to start-up firms in an economic environment full of uncertainty (Dinopoulos, Kalyvitis and Katsimi, 2015). This decision limits investment actions and therefore, discourages people to be engaged in entrepreneurship. Investment is considered to be the motivating power of growth and development through which firms and the whole economy will be benefited (IOBE, 2014). For this reason, long-term investment can stimulate the productivity capabilities of firms by improving their products through various ways of diversification. If every operating firm is exposed to that scheme, then competition will be intensified as the most productive and successful firms will attract more consumers. Under such conditions, long-term costs may be increased but the wholesale price will be kept to a low level as a tool of competition (i.e. price-cost margin).

[85] See the *European Insolvency Regulation*.

In particular, this factor may be treated as the most constraining element of investment and production decisions. As Fairlie and Krashisky (2011) argued, liquidity and entrepreneurship are strongly correlated because cash flows can automatically be invested and as a result, affect the decisions of the private sector (both households and firms). Following the financial collapse of 2008, banks have become reluctant in providing credit and loans to firms and especially to start-up projects given the degree of economic uncertainty and the low level of interest rates (Lane, 2012). Consequently, the Greek manufacturing firms face such liquidity constraints which may be part of the interpretation of the inflexible wholesale prices in conjcntion with the decrease in the net number of manufacturing firms (see figures 9 and 10).

The conjectural variation estimates may provide an interpretation to the limited access of the manufacturing sectors to finance. As aforementioned, a major side-effect of the imposition of austerity polcies is the limited credit provision from banks to manufacturing firms. This is a result of the current economic conditions filled with uncertainty that prevent banks from providing loans under low interest rates. This means that many firms have been forced to exit their sectors, thus leaving only few operating by exercising their market power on pricing and production decisions. This argument is validated by the increasing trend of market power, which resulted in a market structure similar to a duopoly[86].

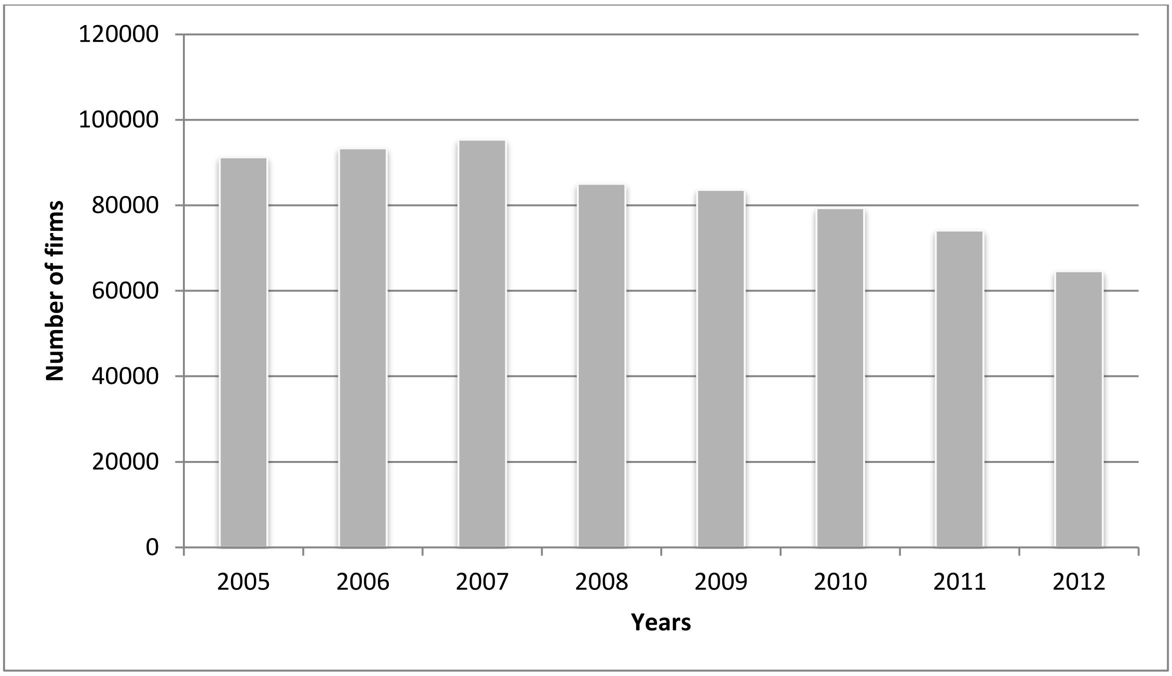
According to the estimates presented in section 6.1, output elasticity with respect to the degree of liquidity is significant and positive signed for the 3-digit manufacturing sectors. This fact indicates that additional liquidity in terms of money inflows will result in increased demand for manufacturing products. If demand is increased, then supply must increase well in order to avoid a acondition of underproduction and higher prices. An interpretation of this outcome can be based on consumer expectations and confidence according to the state of the economic environment. If they are confident about their Purchasing Power Parity, then entrepreneurs will receive that signal as a temporary shock of demand and thus, they will increase their production (Rotemberg and Saloner, 1986). Such temporary shocks also necessitate a higher level of short-term investment in order to finance the additional part of production due to that particular demand shock. This action strengthens social entrepreneurship by providing additional motives to new entrepreneurs to be engaged in the manufacturing production process. Through such actions, consumer confidence will be

[86] Such constraints can also be viewed as barriers to entry because firms with access to finance will be more flexible in repaying their liabilities.

restored as the social aspect of entrepreneurship will be promoted and as a result, increased demand will be reflected by additional investment leading to higher production levels.

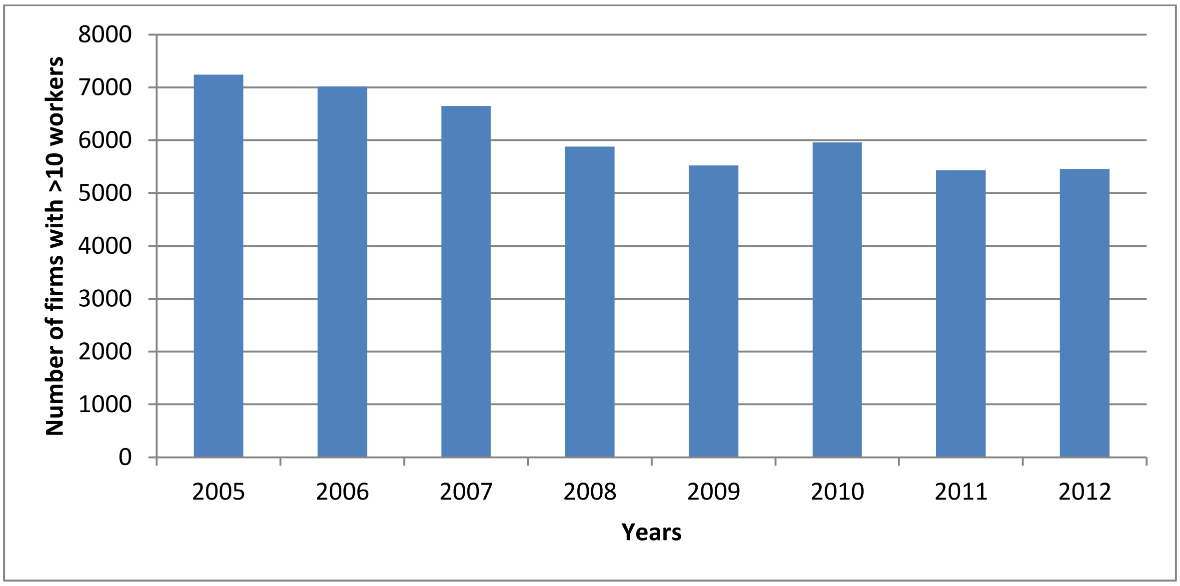
Nevertheless, such actions are partially constrained by the European Union as the European Central Bank (ECB) is maintaining a fixed level of liquidity for every Eurozone country through the Emergency Liquidity Assistance (ELA). Consequently, the only option left corresponds to fund provision by the European Investment Bank (EIB). The acquisition of funding by the EIB supports private investment and promotes engagement by small and medium sized firms. Over the period 2008-2012 the EIB provided more than 11 billion euros to the Greek economy by promoting competition and encouraging new firms to enter the Greek market (see *European Investment Bank in Greece)*. As a result of the austerity policy mixture, it is expected that since aggregate demand sharply decreased, the number of the manufacturing firms would decrease as well. The following figures illustrate the net number of firms in the manufacturing industry over the sub-period 2005-2012.

Figure 9: Net Number of firms operating in the manufacturing industry over the period 2005-2012.



Source: EL.STAT. ProdCom database.

Figure 10: Net Number of manufacturing firms employing more than 10 workers over the period 2005-2012.



Source: EL.STAT. ProdCom database.

Figure 9 reflects the net overall number of firms in the manufacturing industry, while figure 10 illustrates the net number of firms employing more than 10 people over the sub-period 2005-2012. The former figure validates the theoretical intuition that the exogenous shock of recession resulting in diminishing aggregate output has a negative effect on the net number of active firms in the manufacturing industry. In particular, following 2008, the net number of firms has been decreasing by reaching a climax of negative growth rate in 2012 equal to 13.8 percent.

According to IOBE (2014), austerity policies and limited access to credit had a significant effect on investment decisions and especially, on innovation. Over 2009-2011, Greek enterprises were ranked in the 4th place in terms of innovative ideas in a pool of advanced and innovative countries. However, in 2012, Greece's ranking dropped down to the 12th place as the degree of innovation was drastically reduced. The main factor that contributed to this outcome corresponds to the fact that 2012 is considered to be an intensive year of fiscal adjustment and consolidation. Over 2012, aggregate nominal output fell by approximately 20 percent compared to 2009[87]. Since the fall of aggregate output was caused mainly by plunging aggregate demand, Greek firms and especially, the manufacturing

[87] See *EL.STAT.* database.

entrepreneurs shifted away from innovative to survival opportunities in order to ensure the long-run operation of their firms.

A crucial factor that also contributes to this outcome is the limited credit provision by the Greek banks. According to Louzis et al. (2015), the non performing loans and the low interest rates in the Greek economy are the major factors that cause limited credit provision to the private sector. Such limitations are related to the state of the economy and in particular, to the pattern of macroeconomic variables. For this reason, banks try to build an arsenal against future uncertainty through stronger and more qualitative balance sheets, in addition to investing in less risky assets.

The same results are also validated for the Eurozone by Makri et al. (2014) by rendering the manufacturing firms vulnerable to current liabilities and future shocks such as increased taxation and lower demand. Even if innovative firms were excelling in their sectors before 2010, unfavourable conditions may have forced them to stop operating. Such conditions may refer to limited access to finance or to the inability of serving their liabilities. This means that solvent firms may face possible payment delays by other firms/individuals which will result in further payment delays to employees, suppliers or even banks. Thereby, these firms will become insolvent because of liquidity constraints and not because of inefficient production. As a result, the remaining firms in the market will acquire market power if possible, they will exercise that power on their pricing decisions.

To this end, figure 9 in conjunction with the estimates of market power validate the theoretical intuition of this study; negative exogenous demand shocks result in market power through either oligopolistic pricing and production decisions that force the weakest firms to exit their sectors. An interesting result can be observed in the indicators of market power and price rigidity. Given that production decisions remain very close to the ones of a duopolistic market, the speed of price adjustment of the industry follows a downward trend after 2009 by reaching a low average level compared to the post-1999 period. This means that the pricing decisions of the manufacturing sectors may reflect a stabilization of the market structure close to duopoly due to the slump of aggregate demand in order to secure a minimum number of consumers. Consequently, according to such actions, the aforementioned policies of drastically reducing market power are justified along with the significance of investments. Given that recessionary forces do not provide the opportunity to firms to invest in innovation, an institution like the EIB must step in and create such openings by motivating and encouraging entrepreneurs to be actively engaged in innovative actions.

Figure 10 illustrates optimistic evidence that entrepreneurship in the Greek manufacturing industry is not neglected. In particular, the net number of firms employing more than 10 people reflects a different pattern compared to the overall number of manufacturing firms. Over the sub-period 2005-2009, the number of those firms was steadily declining by suggesting that the driving force of the manufacturing industry lied on firms employing up to 10 people. Even if the former group refers to the minority of the manufacturing industry, entrepreneurial decisions are somewhat different compared to the latter group. In 2010, the net number of firms employing more than 10 people increased by 7.8 percent when the overall number was decreased by 6 percent.

However, the most important and promising observation is reflected in 2012. As mentioned above, the net overall number of firms was reduced by 13.8 percent. Nevertheless, the net number of firms employing more than 10 people was marginally increased by 0.04 percent. This indicates that despite the fact that 2012 is considered to be an intensive year of austerity implementation, new firms and thus, new entrepreneurs chose to start operating in the manufacturing industry. Such actions support that despite the hardships of depression, entrepreneurial opportunities are always taken into account by new entrepreneurs.

However, it is worth noting that such opportunities are exploited by medium and large sized firms capable of employing more than 10 people. The remaining (small sized) firms do not face the same outcome as indicated by figure 9. It seems that the latter group does not have the opportunity to secure financial resources that will be used as a stimulating power of innovation. In other words, given the current framework adopted by the EIB and the Greek banks, it is very difficult for new and young entrepreneurs to secure a start-up loan to establish their own business activities. This means that small sized firms are not equally treated compared to medium and large sized firms by the financial institutions. For this reason, the EIB in conjunction with the EU and the Greek policy framework must be able to provide liquidity to new entrepreneurs to utilize their ideas by promoting growth and development in various markets. This action can also be viewed as a mean of competition as new firms will struggle to attract customers by utilizing their available resources and thus, by efficiently competing with the incumbent firms. If innovation allows for such competitive forces to be active, at least in the short-run, then competition will be intensified by increasing the degree of market efficiency.

In addition, the results of this study complement the arguments and findings of the OECD that the Greek economy and in particular, the manufacturing industry is under-performing (OECD 2012, 2014)[88]. In the first report, there were 555 problematic regulations identified where 329 of them could be improved by bolstering competition. This means that the Greek manufacturing industry is heavily regulated by constraining its efficiency and capacity which in turn results in welfare losses and market power exploitation. The second report was focused on the manufacturing industry and in particular, on the sectors of beverages (i.e. 11); textiles, clothing apparel and leather (i.e. 13, 14 and 15); machinery and equipment (i.e. 28); and coke and refined petroleum products (i.e. 19). The findings were once again in favour of regulations that hurt competition and as a result, OECD made 88 recommendations on improving legal frameworks by taking into account the EU legislation that promotes competition and minimizes barriers to entry.

Consequently, the estimates of market power of this study can be justified by the constraining regulations in the manufacturing sectors that also result in rigid price levels. This means that if a set of policies is imposed under which firms cannot exercise their market power on the wholesale price level, then competition may be restored and thus, production decisions will converge to the one close to perfect competition. If this outcome is achieved, then it will be a sign of healthy competition under which barriers to entry are minimized and new entrepreneurs can contribute to the manufacturing production. However, even if such regulations are abolished or improved, there are still exogenous factors that have to be taken into account, such as limited access to credit and fluctuations in the VAT rate. These factors cannot be influenced by entrepreneurial actions and as a result, the state must ensure that the best outcome can be accomplished in order to minimize uncertainty and boost investment decisions.

To this end, innovation can be considered as a significant factor of competition through which firms will reduce their costs and diversify their products in order to increase their sales. If the final outcome of production as a result of diversification is accomplished, then particular firms will gain advantage compared to their competitors. Therefore, if the

[88] It is worth noting that OECD and the IMF identifies that the Greek markets are considered to be the most heavily regulated within OECD members (OECD, 2012; IMF 2014).

same rationale is adopted by every market participant, then the degree of imperfect competition will be reduced. However, as mentioned before, a very important factor illustrated in figure 10 refers to opportunities for new entrepreneurs amidst the Greek recession. This means that even if the economic environment is not investment-oriented as the degree of uncertainty is very intense, new entrepreneurs may seize that opportunity to start their business.

According to IOBE (2014), the willingness of young entrepreneurs to be involved in industrial activities is equal to 6.4 percent of the whole population in 2012. This percentage is approximately equivalent to the one observed in 2004 and higher compared to the ones of 2007 and 2010. The outcome of such evidence shows that new entrepreneurs find depressing periods attractive to start their business, even if uncertainty about aggregate economy is very intense. This particular behaviour may also contribute to the fact that pricing decisions were not rapidly increased as a result of the exogenous negative demand shock of austerity.

According to the aforementioned results, young entrepreneurship is very important and crucial for the manufacturing industry. The economic environment may discourage such entrepreneurial actions but young people choose to take advantage of the process of creative destruction, as introduced by Schumpeter (Reinert and Reinert, 2006). This means that under extreme conditions (that is unexpected recession) the weakest firms will be forced to stop operating but at the same time, new firms will emerge by adjusting to the new business and economic environment. However, a barrier that new firms may face corresponds to the incumbent firms and the degree of market power. If the latter group has the ability to block new entries, then creative destruction will result in greater market power, while innovation may not be a choice after all. If a market structure is highly concentrated and very close to monopoly, then entrepreneur(s) may not have any incentives to invest, thus resulting in the deterioration of the whole market.

Consequently, the Greek competitive authorities must be able to identify such opportunities and regulate any action that may be treated as a barrier to entry. Innovation is more important than market power and causation is not always twofold. Innovative firms may acquire market power but firms exercising that power may not always be innovative. This means that young entrepreneurs must be protected over the first steps of starting their own business by initially acquiring business loans and subsequently, being protected by the regulatory authorities. Such protection should not violate or result in the acquisition of market power but rather be treated as a safety net to the incumbent firms' market power.

Therefore, the significant evidence of market power and slow price adjustment to changes in input costs, foreign price levels and taxation reflect a rather under-performing condition in the Greek manufacturing sectors. As a result, the Greek regulatory authorities have to create a business environment in which new entrepreneurs will be able to seize available opportuinities and efficiently operate in the Greek markets. By doing so, efficiency wil be restored as imperfectly competitive motives will be reduced and thus, social welfare will be increased. This means that the Greek authorities must abolish regulations that constraint managerial actions and enhance oligopolistic behaviour through efficient intervention. The form of intervention can be either in terms of improving regulations or abolishing them in order to allow incumbent and new entrepreneurs to interact efficiently in a competitive market environment.

7. Conclusions and Future Research

The New Empirical Industrial Organization models suggest that individual production and pricing decisions can affect the degree of competitive interactions in particular markets. Regardless of the degree of that power, pricing decisions may reflect the effects of demand shocks as the degree of price flexibility can improve the understanding of business cycles.

This study modified and incorporated the conjectural variation elasticity model of Bresnahan (1982) and Lau (1982) to identify the degree of market power in the Greek manufacturing industry in terms of production decisions. The variables of pricing decisions, investment, sales concentration and money supply were introduced as potential demand shocks that could affect the production level of the manufacturing sectors. In the majority of the constituent 3-digit sectors, these variables are found to be statistically significant. This outcome indicates that over the period 1980-2012, production decisions were being affected by investment, concentration and liquidity fluctuations occurring in the Greek manufacturing market. As a result, in conjunction with the total cost of the industry, the market power indicator in terms of production decisions reveals significant evidence in the majority of the manufacturing sectors. The magnitude of that power fluctuates around the value suggested by the Cournot duopoly, as individual production levels had an influence on the level of the aggregate industry approximately equal to *0.5*. Therefore, the manufacturing sectors were producing as if they were involved in a duopolistic market by exploiting consumer surplus.

As a result of market power, the next research objective concerns the identification of the degree of price rigidity or otherwise, the speed at which prices adjust to changes in particular lagged variables (unit costs, taxation, foreign competing prices and excess demand). The partial adjustment model of this study provides evidence that the manufacturing industry overall, experienced a *0.335445* speed of adjustment. This result suggests that two years' time is approximately needed for the industry to incorporate the aforementioned changes in the final wholesale price level. Such changes are not easily reflected in the price level of the manufacturing sectors. The majority of those sectors are found to be subject to slow price adjustment, ranging from one to five years, over the sample period by complementing the findings of Bedrossian and Moschos (1998). The main intuition of this study corresponds to the fact that market power causes sluggish nominal price changes, as sectors exercising their power have less reason to adjust their prices in any changes of the pricing equation factors.

The final and most important step of this study corresponds to the validation of the profitability and leadership effect by testing the speed of price adjustment formulation. This approach introduces the relationship between the speed of price adjustment, the degree of market power and the size of the manufacturing sectors. According to the value of the estimates, the effects of profitability and leadership have been identified along with their significance in the manufacturing industry.

The empirical results obtained by the speed of price adjustment formulation verify the theoretical intuition of the model that the degree of price flexibility is inversely related to market power and positively related to the mean size of the manufacturing firms. Given that the included variables of market power (*CR4* and *f*) and size (*SIZ4* and *AC*) change relatively slow, the speed of price adjustment appears to be somewhat stable as there are not volatile fluctuations over the sample period. The main conclusion that can be drawn from this equation is that large firms have economies of scales with regard to adjustment costs and more reason to increase their speed of price adjustment. On the other hand, firms that exercise their market power can slow the speed of price adjustment by avoiding to incorporate cost changes to the final wholesale price level. This outcome contradicts the belief that market power and firm size move the speed of price adjustment to the same direction (Olive, 2008).

The Greek manufacturing sectors have been found to operate under non-competitive conditions over the period 1980-2012. The main policy implication should refer to the intensification of competition and the abolishment/improvement of inefficient frameworks by introducing various investment-oriented policies that can reduce the market power of the incumbent firms. In addition, such policies will provide the opportunity to both existing and new firms to focus on innovation and diversify their products by attracting consumers, thus increasing their market share. However, given the degree and experience of firms exercising their market power, the regulatory authorities have to prevent any act of informal agreements that will result in barriers to entry. Given such actions, young entrepreneurs will be able to establish their business in the manufacturing industry and based on loan provision, they will be able to improve their production through investment-oriented actions.

Nevertheless, a crucial factor which is not taken into account in this study refers to aggregate demand behaviour about the products of the Greek economy. Even if output elasticity with respect to the wholesale price level is found to be significant and less than unity, consumer behaviour highly depends on the conditions of the aggregate economy. This means that austerity policies had an overall effect on aggregate consumption and as a result, on aggregate demand. Such factors are not included in the present NEIO model as the constituent variables are suitable for micro analysis. The scope of this study lies on the identification of market power and the speed of price adjustment to micro variables such as unit costs, value added tax and foreign competitive price levels. Any fluctuations of aggregate variables are excluded which could be considered as a possible limitation. If such measures are taken into account, then the present model could be extended in international trade analysis by incorporating both fiscal and monetary factors that reflect international competition between different economies.

In addition, the inclusion of the fixed/random effects model and in particular, the inclusion of the dummy variables approach corresponds to the lack of 4-digit level data of fixed and variable costs. If a complete dataset was available, then a time series or a 4-digit level panel analysis would be more accurate as the estimates would reflect fluctuations in firm and not in sectorial level. To this end, the results would be more disaggregated and therefore, they would be addressing the behaviour of the manufacturing firms compared to sectors. Nevertheless, the degree of market power and price flexibility would not change for the manufacturing sectors as the 3-digit analysis reflects sectorial behaviour, which is more disaggregated compared to industrial behaviour. As a result, the estimates of the present study accurately provide evidence of imperfect competition in the Greek manufacturing sectors and thus, in the Greek manufacturing industry.

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Appendix A

Table A. Classification of sectors *NACE Rev. 2*.

10		Manufacture of food products
	101	Processing and preserving of meat and production of meat products
	102	Processing and preserving of fish, crustaceans and molluscs
	103	Processing and preserving of fruit and vegetables
	104	Manufacture of vegetable and animal oils and fats
	105	Manufacture of dairy products
	106	Manufacture of grain mill products, starches and starch products
	107	Manufacture of bakery and farinaceous products
	108	Manufacture of other food products
	109	Manufacture of prepared animal feeds
11	**110**	Manufacture of beverages
12	**120**	Manufacture of tobacco products
13		Manufacture of textiles
	131	Preparation and spinning of textile fibres
	132	Weaving of textiles
	133*	Finishing of textiles
	139	Manufacture of other textiles
14		Manufacture of wearing apparel
	141	Manufacture of wearing apparel, except fur apparel
	142*	Manufacture of articles of fur
	143	Manufacture of knitted and crocheted apparel
15		Manufacture of leather and related products
	151	Tanning and dressing of leather; manufacture of luggage, handbags and saddlery
	152	Manufacture of footwear
16		Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	161	Saw milling and planning of wood
	162	Manufacture of products of wood, cork, straw and plaiting materials
17		Manufacture of paper and paper products
	171	Manufacture of pulp, paper and paperboard
	172	Manufacture of articles of paper and paperboard
18		Printing and reproduction of recorded media
	181*	Printing and service activities related to printing
19		Manufacture of coke and refined petroleum products
	192	Manufacture of refined petroleum products
20		Manufacture of chemicals and chemical products
	201	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms
	202	Manufacture of pesticides and other agrochemical products
	203	Manufacture of paints, varnishes and similar coatings, printing ink and mastics

(Table A continue)

	204	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
	205	Manufacture of other chemical products
21		Manufacture of basic pharmaceutical products and pharmaceutical preparations
	212*	Manufacture of pharmaceutical preparations
22		Manufacture of rubber and plastic products
	221	Manufacture of rubber products
	222	Manufacture of plastics products
23		Manufacture of other non-metallic mineral products
	231	Manufacture of glass and glass products
	232*	Manufacture of refractory products
	233	Manufacture of clay building materials
	234	Manufacture of other porcelain and ceramic products
	235	Manufacture of cement, lime and plaster
	236	Manufacture of articles of concrete, cement and plaster
	237	Manufacture of cutting, shaping and finishing of stone
	239	Manufacture of abrasive products and non-metallic mineral products n.e.c.
24		Manufacture of basic metals
	241	Manufacture of basic iron and steel and of ferro-alloys
	242	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel
	243	Manufacture of other products of first processing of steel
	244	Manufacture of basic precious and other non-ferrous metals
25		Manufacture of fabricated metal products, except machinery and equipment
	251	Manufacture of structural metal products
	252	Manufacture of tanks, reservoirs and containers of metal
	253	Manufacture of steam generators, except central heating hot water boilers
	254*	Manufacture of weapons and ammunition
	256*	Treatment and coating of metals; machining
	257	Manufacture of cutlery, tools and general hardware
	259	Manufacture of other fabricated metal products
26		Manufacture of computer, electronic and optical products
	263*	Manufacture of communication equipment
27		Manufacture of electrical equipment
	271	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus
	273	Manufacture of wiring and wiring devices
	274	Manufacture of electric lighting equipment
	275	Manufacture of domestic appliances
28		Manufacture of machineryand equipment n.e.c
	281	Manufacture of general purpose machinery
	282	Manufacture of other general-purpose machinery

(Table A continue)

	283	Manufacture of agricultural and forestry machinery
	289	Manufacture of other special-purpose machinery
29		Manufacture of motor vehicles, trailers and semi-trailers
	292	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
31	**310**	Manufacture of furniture
32		Other manufacturing
	321*	Manufacture of jewelry, bijouterie and related articles
	324*	Manufacture of games and toys
	325*	Manufacture of medical and dental instruments and supplies
	329*	Manufacturing n.e.c.
33	**331***	Repair of fabricated metal products, machinery and equipment

*These sectors have been omitted from the analysis due to data inadequacy for calculating the included market measures.

A.1. Definition of variables

Y corresponds to total value added at 2005 constant prices and is formulated by dividing total value added in current prices by the total value added deflator (2005=100), as reported in *AIS*.

P indicates the wholesale price index of the manufacturing sectors (2005=100), obtained by dividing the value of sales over the sold volume of each sector, as reported in *AIS*.

L denotes man-hours of labour and is formulated by multiplying the annual number of employees with the number of average working hours per year, as reported in *OECD*.

W^l is the wage rate per man-hour (labour compensation) and is formulated by dividing the number of remuneration of the employed by the number of total man-hours, as reported in *AIS*.

ULC denotes the unit labour cost and is formulated by dividing the remuneration of the employed by output (*Y*), as reported in *AIS*.

K refers to gross capital expenditures, formulated by the sum of gross asset formation and the level of investments at 2005 constant prices. Gross asset formation includes as investment assets buildings and installations, transport means, machinery and furniture. The rate of depreciation of the investment assets is defined as 3, 9 and 5 percent respectively, as indicated by Rezitis and Kalantzi (2012).

U^k is the user cost of capital, formulated as $u_t = \eta_{t-1} * (1 + r_t) + \eta_t * (1 + \mu_t)$, where η is the price of new capital formation (Zanias, 1991), r_t is the rate of return of capital obtained from the Bank of Greece and μ is the average rate of investment asset depreciation.

UKC corresponds to the unit capital cost and is formulated by dividing gross capital expenditures by output (*Y*), as reported in *AIS*.

C is the total cost of the industry, formulated by the sum of labour and capital cost, as reported in *AIS*.

b refers to the consumer price index (2005=100), as reported in *AIS*.

Z is the level of investment in capital equipment at 2005 constant prices, as reported in *AIS*.

Herf represents an index of concentration in terms of sales, similar to the *Herfindhal-Hirschman index* (*HHI*). The *HHI* is defined as $H = \sum_{i=1}^{N} {s_i}^2$, where s_i is the share of each firm (or sector) to industry output and *N* is the number of the firms. The *HHI* ranges from *1/N* (high competition) to *1* (monopoly). The Horizontal Mergers Guidelines of the *U.S.* Department of Justice and the Federal Trade Commission (2010) suggest that a *HHI* less than *0.01* indicates high competitive market conditions, while an index above *0.25* indicates a high degree of concentration. Therefore, in this study, the sales concentration index is defined as $Herf = \sum_{i=1}^{N} {S_i}^2$, where S_i is the ratio of the volume of sales to aggregate sales.

MS denotes the indicator of liquidity, which is the money supply (*M2*) for Greece at 2005 constant prices, obtained by the Bank of Greece.

POP is the population of Greece, as reported in *AIS*.

P^f is a price index formulated as the sum of wholesale price plus the value added tax (*VAT*) on sales at 2005 constant prices, as reported in *AIS* and *OECD*. As value added tax, it is defined the percentage of *VAT* added in sales. It is not taken into consideration any taxes on production that consist of taxes on buildings, the ownership or use of land or other capital assets used in production, on the labour employed or compensation of employees paid.

P^{eu} corresponds to the wholesale price index of the manufacturing industry of the European Union (*EU27*) at 2005 constant prices, as reported in *Eurostat* and *EU KLEMS*.

P^T is the value added tax (*VAT*) on sales at 2005 constant prices, as reported in *Ernst and Young Global Limited* (*EY*) and *OECD*. There are three *VAT* rates in the Greek economy; the standard rate which is at the 23 percent level, and two reduced rates at the 13 and 6.5 percent level respectively.

$CR4_d$ represents the ratio of sales of the four largest firms of each 3-digit sector to the value of the manufacturing industry over the period 2005-2012[89]. It is obtained by multiplying *CR4* by the ratio of 3-digit sector sales to the value of the manufacturing industry.

$SIZ4_d$ corresponds to the average measure of sales of the four largest 4-digit firms over the period 2005-2012. It is obtained by multiplying the four-firm concentration ratio *CR4* by the sales of the sector and dividing by four.

AC_d represents the average total cost of each 3-digit sector over the period 2005-2012. It is obtained by multiplying *AC* by the ratio of 3-digit sector total cost to the total cost of the manufacturing industry.

[89] The value of the manufacturing industry reflects the value of sales in the domestic market by including changes in the volume of imports. Katics and Petersen (1994) and Ghosal (2000) provide evidence that an increase in the share of imports of the *U.S.* manufacturing industries, may weaken the market power of the including firms which face a high degree of concentration (Olive, 2008).

Appendix B1

A similar approach adopted by Green and Porter (1984) is accounted under which the observed output process $\{Y_t\}_{t\in \mathrm{N}}$ is determined by three processes; $\{Q_t^m\}_{t\in \mathrm{N}}$ that refelcts the output process when t is normal (if the industry sets p_i^m monopoly price for $k=0$), $\{Q_t^B\}_{t\in \mathrm{N}}$ the output process which would ensue $\forall k$ if t is reversionary (if the industry is under Bertrand competition by charging $p_i^B=mc_i$) and $\{Q_t^k\}_{t\in \mathrm{N}}$ the output process that occurs when $k>0$ and t is normal (if the industry sets a new price set $p_i^k<p_i^{k-1}<p_i^m$) when the formation of new collusion manifests. As in original model, it is assumed that the time period ends at $k=1$ which shows that up to two new collusions can be formed. Whether the observed output level is obtained by one of the three sets, it is determined by a process $\{W_t\}_{t\in \mathrm{N}}$ that specifies the condition the industry is under (normal, reversionary or normal after punishing a reversionary episode). Also, $\{Y_t\}_{t\in \mathrm{N}}$ is the only component of the joint process $\{(W_t, Q_t^m, Q_t^B, Q_t^1, Y_t)\}_{t\in \mathrm{N}}$ which is observed.

In this point, define a *switching process* to be determined by a probability space (Ω, β, m), a state space S, a subset $N \subseteq S$, and five sequences of random variables $\{W\}= \{W_t\colon \Omega\rightarrow S\}_{t\in \mathrm{N}}$, $\{Y\}= \{Y_t\colon \Omega\rightarrow R\}_{t\in \mathrm{N}}$, $\{Q^m\}= \{Q_t^m\colon \Omega\rightarrow R\}_{t\in \mathrm{N}}$, $\{Q^B\}= \{Q_t^B\colon \Omega\rightarrow R\}_{t\in \mathrm{N}}$ and $\{Q^1\}= \{Q_t^1\colon \Omega\rightarrow R\}_{t\in \mathrm{N}}$ that satisfy the following conditions

$(Q^m) \cup (Q^B) \cup (Q^1)$ is a set of independent random variables (I)

(Q^m) is identically distributed with *c.d.f. G*, (II)

(Q^B) is identically distributed with *c.d.f. H*, (III)

(Q^1) is identically distributed with *c.d.f.*, *J*, (IV)

(W) is a Markov process with stationary transition probabilities[90] (V)

For $k=0$ and $\forall t$, $S_t \in N \Rightarrow Y_t= Q_t^m$ (VI)

For $k=1$ and $\forall t$, $S_t \in \mathrm{N} \Rightarrow Y_t= Q_t^1$ (VII)

[90] A Markov process is described by memorylesness which is why the current decisions of pricing strategies have embodied the interactions of previous strategies. In this way, past observations are not needed and thus, the Markov properties can be used in order to test the stochastic process of output.

For $\forall k$ and $\forall t$, $S_t \notin N \Rightarrow Y_t = Q_t^B$ (VIII)

The special case of a switching process usually studied occurs when $S=\{0,1\}$ and $N=\{0\}$, where $\{W\}$ is a Bernoulli process which is independent of (I). In the case of a collusive output process, G, J and H denote the *c.d.f.*'s normal (under no punishment and punishment actions) and reversionary output distribution when $S=\{0,1,\ldots,T\text{-}1\}$ and $N=\{0\}$. The Markov process $\{W\}$ is defined recursively by starting with an arbitrary initial $W_0: \Omega \rightarrow S$, and then imposing

If $W_T=0$ and $Q_T^m \geq \hat{q}^m$, then $W_{T+1}=0$ (IX)

If $W_T=0$ and $Q_T^1 \geq \hat{q}^1$, then $W_{T+1}=1/2$ (X)

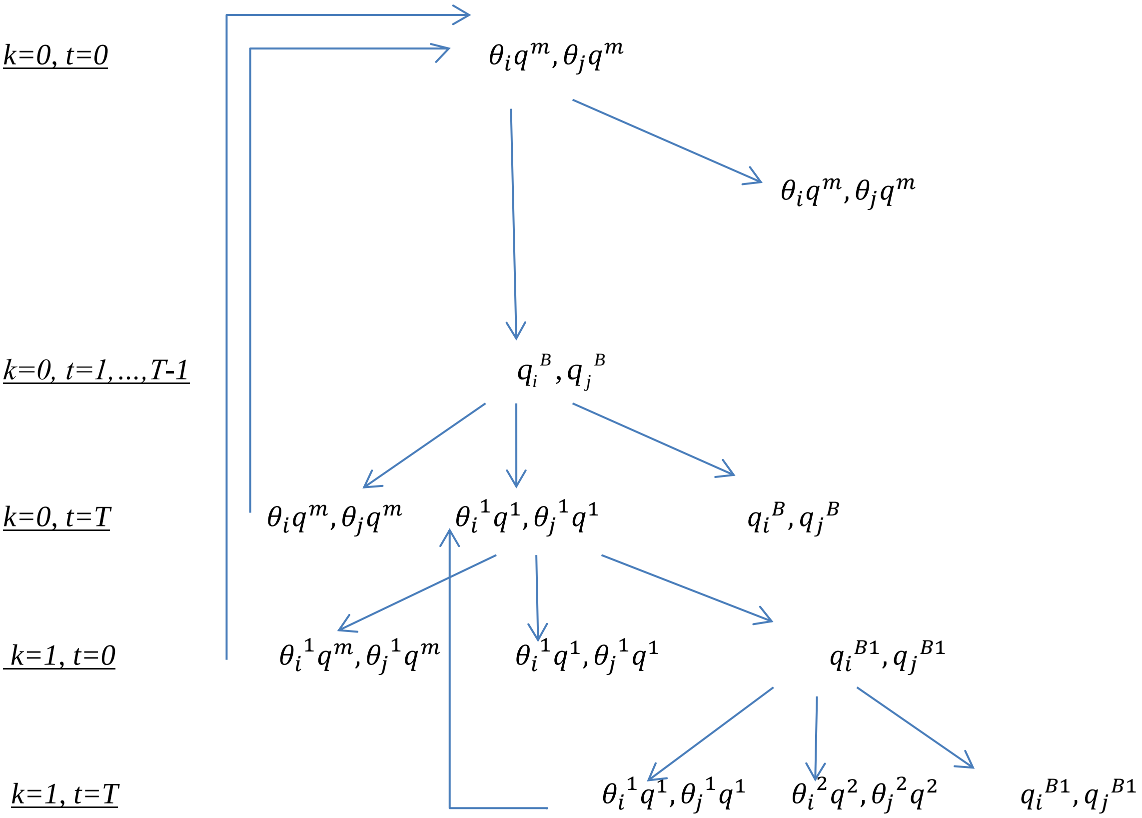
If $W_T=0$ and $Q_T^m \leq \hat{q}^m$ or $Q_T^1 \leq \hat{q}^1$, then $W_{T+1}=1$ (XI)

If $W_T=v$, $1 \leq v < T\text{-}1$, then $W_{T+1}=v+1$ (XII)

If $W_T=T\text{-}1$, then $W_{T+1}=0$ or $W_{T+1}=1/2$ (XIII)

The process $\{W\}$ defined by *(IX)*-*(XIII)* is a Markov process with stationary transition probabilities because $\{Q^m\}$ is *i.i.d*, based on *(I)* and *(II)*. The transition graph of $\{W\}$ is shown in Figure 11 as a sequential game, in which each arrow reflects a transition probability. The aim is to show that W_0 can be chosen in such a way that $\{Y\}$ will be a stationary ergodic process. Conditions *(VI)*-*(VIII)* show that if Y_t is a function of (Q_t^m, Q_t^1, Q_t^B) it will be sufficient to prove that the joint process $\{Q^m, Q^1, Q^B\}$ is ergodic. As argued in the Appendix of the original paper (Green and Porter, 1984), this process is ergodic if it is a stationary Markov process having a unique invariant distribution, such that if W_1 is defined by *(IX)*-*(XIII)*, then $\{Y_0, Q_0^m, Q_0^1, Q_0^B\}$ and $\{Y_1, Q_1^m, Q_1^1, Q_1^B\}$ have identical distributions according to Breiman (Theorem 7.18, 1968).

Figure 11: *Strategies that firms can choose when a temporary shock in demand occurs.*



According to this figure it is seen that the dominant strategy under certainty would be the one where firm *i* maximizes its long-run value function by maximizing its $\theta_i{}^k q^m$. This occurs when $\theta_i{}^k$ tends to unity by reflecting that monopolistic power has been acquired by the remaining firm(s), thus preventing any threat of competition. For this very reason, Bertrand competition will be the optimal choice for firm *i* only if

$$\sum_{k=0}^{K} \beta^k \sum_{t=0}^{T} \beta^t \, \delta_i{}^k (p_i{}^{Bk}) \geq \sum_{k=0}^{K} \beta^k \sum_{t=0}^{T} \beta^t \, \delta_j{}^k (p_j{}^{Bk}) \qquad \text{(B1.1)}$$

This expression shows that if the expected value of entering a Bertrand competition is greater than the expected value of any other competitor, then firm *i* will have the incentives to enter an infinite reversionary episode and cause a breakdown in collusion in order to acquire monopolistic power.

On the other hand, when uncertainty is introduced as presented in this model, then Bertrand competition will not be the optimal solution as long as two conditions are met: there is no overconfidence about individual cost functions being much lower than the remaining firms'; and there is no total collapse in trust among the participating firms. For this reason, as in the model of Green and Porter, the optimal solution would be the sustainability of collusive actions and if punishment is necessary, then firms will have the incentives to form a new agreement. The resulting collusion will be sustained only in the short-run and return to the initial (optimal) agreement ($p = \bar{p}^m$) afterwards, if trust is restored among the remaining participants. This means that charging a common price $\bar{p}^1$ from a price set p_i^1 will be a short-run solution since in normal periods holds that

$$\gamma_i{}^k(p_i{}^m) \geq \gamma_i(p_i{}^m) \geq \gamma_i{}^1(p_i{}^1) \qquad \text{(B1.2)}$$

This shows that the lower the number of the remaining firms in the operating sector, the greater the incentives to return to the initial charging price $\bar{p}^m$ will be in order for profits to be maximized under the constraint of uncertainty. As a result, based on inequality (15), $\forall k$ it will also hold that

$$V_i{}^k(p_i{}^m) \geq V_i(p_i{}^m) \geq V_i{}^1(p_i{}^1) \Leftrightarrow$$

$$\sum_{k=0}^{K} \beta^k \sum_{t=0}^{T} \beta^t \gamma_i{}^k(p_i{}^m) \geq \sum_{k=0}^{K} \beta^k \sum_{t=0}^{T} \beta^t \gamma_i(p_i{}^m) \geq \sum_{k=0}^{K} \beta^k \sum_{t=0}^{T} \beta^t \gamma_i{}^1(p_i{}^1) \qquad \text{(B1.3)}$$

Consequently, the long-run equilibrium choices under uncertainty can either result in firms sustaining a collusive act by charging $\bar{p}^k$ in the short-run and $\bar{p}^m$ in the long-run or by charging $p_j{}^{Bk}$when there are no incentives in forming a new collusion by at least one firm (through firm *i*'s lack of trust or expectations for eliminating its competitors).

Appendix B2

An alternative method of estimating the pricing equation (31) for the 3-digit manufacturing sectors corresponds to the Vector Error Correction model, introduced by Johansen (1991). In particular, if the included series (either panel or time) do not appear to be stationary (independence of variable at time *t* from lagged values), then an empirical equation of the form of (31) may result in non-stationary errors which in turn may result in a spurious OLS regression that over-rejects the null hypothesis. However, even in the case of stationarity, it would be useful to check whether a simple regression and an error correction model generate similar empirical estimations of the market variables.

The Im, Pesaran and Shin (2003) statistical test for unit root in panel data is taken into account in order to identify whether the panel data series are stationary. This means that the error term of the 3-digit sectors over the period 1980-2012 will be subject to the former test in order to identify the presence of stationarity. In addition, Maddala and Wu's (1999) Fisher-Johansen group ADF test for panel data can identify whether the variables of the pricing equation are co-integrated by identifying the presence of unit root. Therefore, the equation used in the *IPS* test of stationarity is the following:

$$\Delta x_{it} = \gamma_0 + \gamma x_{it-1} + \sum_{j=1}^{p} \theta_{ij} \Delta x_{it-j} + a_{mi} d_{mt} + u_{it},\ m=1,2,3 \quad \text{(B2.1)}$$

where $d_{1t}=\varphi$ denotes the empty set with no individual effects, $d_{2t}= \{I\}$ refers to the x_{it} panel series with an individual specific mean but no time trend and $d_{3t}=\{I,t\}$ corresponds to the x_{it} panel series with an individual specific mean and linear time trend. The panel unit root test concerns the null hypothesis of non-stationarity (H_0: $\gamma=0$) for all *i* versus the alternative hypothesis of panel stationarity (H_1: $\gamma<0$). The lag order *p* is chosen based on the Akaike Information Criteria (1987), which in this case is equal to $p=3$. In addition, the *IPS* test allows for a number of the individual time series to have unit roots under the alternative hypothesis. However, the fraction of the panel stationary series is positive.

According to the results presented in Table 10, the empirical industry pricing equation is formulated as per Olive (2008):

$$\Delta p^f{}_t = \gamma + \sum_{j=1}^{2} b_{0j}\Delta p^f{}_{t-j} + \sum_{j=1}^{2} b_{1j}\Delta(y-\hat{y})_{t-j} + \sum_{j=1}^{2} b_{2j}\Delta ulc_{t-j} +$$

$$\sum_{j=1}^{2} b_{3j}\Delta ukc_{t-j} + \sum_{j=1}^{2} b_{4j}\Delta p^{eu}{}_{t-j} + \sum_{j=1}^{2} b_{5j}\Delta p^T{}_{t-j}$$

$$-\lambda ECM_{t-1} + \varepsilon_t \qquad \text{(B2.2)}$$

$$ECM_{t-1} = p^f{}_{t-1} - \varphi_1(y-\hat{y})_{t-1} - \varphi_2 ulc_{t-1} - \varphi_3 ukc_{t-1} - \varphi_4 p^{eu}{}_{t-1} - \varphi_5 p^T{}_{t-1} \qquad \text{(B2.3)}$$

where Δ indicates first difference, parameters b_{0j} up to b_{5j} and φ_1 up to φ_5 correspond to short-run and long-run positive constants respectively that vary across the manufacturing industry, j refers to the number of lags in first differences, ECM_{t-1} reflects the error correction mechanism that captures the long-run value of the pricing equation factors and λ is the speed of price adjustment to long-run equilibrium.

Finally, the initial model corresponds to a third-order autoregressive distributed lag model as indicated by the Box-Pierce-Ljung (Ljung and Box, 1978) *Q*-test and the Akaike Information Criteria (Akaike, 1987). Johansen's (1991) approach provides evidence of whether the variables are stationary at levels or not, and whether a long-run relationship exists. This particular approach employs the full information maximum likelihood method, which is developed in the following steps:

Step 1. Apply a unit root test to identify stationarity of time series.

Step 2. Determine the lag structure k under which the residual terms of the pricing equation of the *VECM* will be uncorrelated.

Step 3. Estimate regression (B2.2) and obtain the cointegrating vectors from the Canonical correlations of the set of the residual terms.

Step 4. Identify the order of cointegration r.

The test statistics used for identifying the order of cointegration (r) in panel data are constructed as follows:

$$LR_{trace,i}(r|k) = -T\sum_{j=r+1}^{p}\log(1-\hat{\lambda}^g{}_j) \qquad \text{(B2.4)}$$

$$LR_{max,i}(r|r+1) = -Tlog\left(1-\hat{\lambda}^g{}_{r+1}\right) = LR_{trace,i}(r|k) - LR_{trace,i}(r+1|k) \qquad \text{(B2.5)}$$

where λ^g is the estimated number of eigenvalues. Equation (B2.4) refers to the trace statistic which tests the null hypothesis of *r* cointegrating relations against the alternative of *p* cointegrating relations, for *r=1,…p-1*. The alternative hypothesis of *p* cointegrating relations denotes the case where all linear transformations are stationary (no unit root) and thus, a stationary *Vector Auto Regression* can be estimated at levels instead of first differences. The *LR* statistic follows the χ^2 distribution with *p-r* degrees of freedom. On the other hand, equation (B2.5) reports the maximum eigenvalue statistic that tests the null hypothesis of *r* cointegrating relations against the alternative of *r+1* cointegrating relations. The reason for including both of those test statistics lies on the fact that conflicting results may emerge. However, in such cases, Johansen and Joselius (1990) appear to favour the LR_{max} statistic. To this end, Maddala and Wu's (1999) test takes into account the aforementioned trace statistics for panel data series and as a result, the ADF procedure is applied on the pool of the available data[91].

Table 10. *Stationarity Tests*

Variable	Level	First Difference	Test Type
p^f_t	-9.89693 (0.0000)	-	IPS
$y_t - \hat{y}_t$	-2.19977 (0.0032)	-	IPS
ulc_t	-3.35300 (0.0004)	-	IPS
ukc_t	-3.67946 (0.0001)	-	IPS
p^{eu}_t	-3.74163 (0.0001)	-	IPS
p^T_t	-3.01351 (0.0013)	-	IPS
y_t	-1.37484 (0.0712)	-4.21547 (0.0000)	IPS
imp_t	-1.15250 (0.1246)	-6.76657 (0.0000)	IPS
exp_t	-0.04974 (0.4802)	-6.09305 (0.0000)	IPS
cointegration (ε_t)	-6.92444 (0.0000)	-	Group ADF

Notes: Panel data tests were carried out using *Stata 10* and time series tests by using *Eviews 8*.
The *IPS* test refers to Im, Pesaran and Shin (2003) test for unit root in panel data, where H_0: Non-Stationarity (presence of unit root) versus H_1: Stationarity of panel data residual terms.
Group ADF corresponds to Maddala and Wu test (Maddala and Wu, 1999) for cointegration in panel data where H_0: Non-Stationarity (presence of unit root) versus H_1: Stationarity of cointegrating residual term.
The panel data test statistics are *z* distributed under the null and all panel tests have three lags and no time trend, according to the indications of the Akaike Information Criteria (Akaike, 1987).

[91] This is one out of the seven approaches used by Pedroni (1999).

Table 10 provides evidence in favour of stationarity for all panel data series excluding imp_t, exp_t and y_t. As mentioned in section 4.1.2, the variables of imports and exports have been excluded from the analysis for two reasons; the first one refers to the insignificant results generated by the estimation techniques and the second one lies on the non-stationary nature of those variables. To this end, it has been concluded that the analysis would be simpler if these variables were excluded. The last variable corresponds to y_t which reflects the level of output of the manufacturing sectors over the period 1980-2012. As the *IPS* test resulted in insignificant evidence of stationarity, the formulation of an excess demand proxy variable was decided based on the study of Bedrossian and Moschos (1988). The excess demand proxy takes into account the output trend of each sector and thus, it represents the sectorial production gap which is found to be stationary.

The estimation of the vector error correction model of the pricing equation necessitates the error term of (B2.2) to be stationary and no serially correlated by reflecting the presence of cointegration of the pricing equation factors. Nevertheless, it is expected that the error term of stationary series will also be stationary, as argued by Maddala and Wu's test (Maddala and Wu, 1999). The error term is found to be stationary in levels and therefore, the vector error correction model (B2.2) can be estimated in order to extract the long-run values of the pricing equation factors. The long-run estimates φ_1 up to φ_5 are presented in Table 11 and they are expected to provide similar empirical evidence as the ones obtained by the estimates of equation (31).

Table 11. *Long-run elasticity and speed of price adjustment estimates when the time series variables are in natural logarithms*

Sector	$y_{t-1} - \hat{y}_{t-1}$	ulc_{t-1}	ukc_{t-1}	p^{eu}_{t-1}	p^{T}_{t-1}	λ
101	0.0249817 (1.217826)	-0.029237 (-0.209983)	0.010749 (1.998172)	-0.059188 (-0.730192)	0.321938 (5.187573)	0.309082 (7.099821)
102	0.017283 (0.569921)	0.081928 (3.047188)	-0.129381 (-0.691826)	0.081938 (1.058172)	0.193874 (3.717821)	0.310806 (8.193875)
103	0.025991 (1.261193)	0.128391 (3.061725)	0.010931 (2.651542)	-0.059019 (-1.329012)	0.109381 (3.491009)	0.379807 (7.890128)
104	0.019827 (1.018276)	0.328916 (5.283712)	-0.318271 (-1.761728)	-0.028172 (-0.301928)	0.158177 (3.918815)	0.289005 (8.456166)
105	0.028193 (1.210294)	-0.109382 (-1.667163)	0.1481772 (4.891885)	-0.020192 (-0.571621)	0.401983 (6.098871)	0.408163 (5.918372)
106	0.039183 (1.549183)	0.4091844 (5.198283)	0.081726 (2.019283)	-0.018273 (-0.281928)	-0.091831 (-1.192837)	0.429038 (3.109382)
107	0.018921 (1.061736)	-0.019255 (-1.829001)	0.089111 (1.998175)	-0.038918 (-0.567612)	0.301928 (4.878924)	0.318163 (8.671644)
108	0.035711 (1.631029)	0.071829 (2.018928)	0.169144 (2.898177)	-0.129182 (-1.549109)	0.201938 (4.118273)	0.281609 (9.417372)
109	0.036177 (1.730192)	0.209182 (2.109331)	0.050991 (2.018564)	0.110993 (2.109883)	0.130193 (3.071892)	0.559801 (4.489182)
110	0.030198 (1.609121)	0.089192 (2.291882)	0.109182 (2.388717)	-0.050091 (-1.320091)	0.150198 (2.481877)	0.398072 (3.918722)
120	-0.019382 (-1.989281)	0.159182 (2.391833)	0.019287 (1.978817)	0.139019 (2.819283)	0.109381 (3.971763)	0.428179 (5.671723)
131	0.050192 (1.750191)	-0.029019 (1.716623)	0.128875 (3.778182)	-0.058918 (-1.610092)	0.130199 (4.281773)	0.369808 (6.781724)
132	-0.001928 (-0.891823)	-0.098177 (1.289883)	0.201857 (4.189822)	0.019883 (0.168923)	0.189032 (4.490192)	0.359802 (6.678919)
139	0.038918 (0.990182)	0.178291 (2.788172)	0.021552 (1.861892)	-0.008172 (-0.201928)	0.030198 (1.872663)	0.209808 (9.391872)
141	-0.006571 (-0.539185)	0.209918 (3.716662)	-0.0291877 (-0.667182)	0.058912 (1.189901)	0.250198 (4.019281)	0.298072 (8.781921)
143	0.019821 (1.291827)	0.157182 (2.667145)	-0.028183 (-0.981772)	-0.090172 (-1.378179)	0.301928 (5.120931)	0.559808 (2.401496)
151	0.002938 (0.401992)	0.059187 (1.989912)	0.1481923 (2.678912)	0.039182 (0.819092)	0.261902 (4.501021)	0.390074 (6.887192)
152	0.057162 (1.289185)	0.258192 (4.289991)	-0.078819 (-1.871162)	-0.037162 (-1.109281)	0.240193 (3.817231)	0.398072 (6.897271)
161	0.049182 (0.991827)	0.309182 (4.899182)	-0.039199 (-0.908861)	0.006783 (0.140196)	0.190192 (3.689126)	0.440898 (5.557182)
162	-0.019082 (-0.871623)	0.198371 (1.877616)	0.067581 (-1.989027)	0.060192 (0.981923)	0.210934 (3.781924)	0.421802 (5.291993)
171	0.039481 (1.558172)	0.257187 (2.918273)	0.059188 (1.881726)	-0.140193 (-1.978912)	0.009293 (1.057182)	0.320807 (6.103098)
172	0.019283 (1.118271)	0.189283 (2.481826)	-0.067182 (-1.657168)	-0.097162 (-2.319283)	0.110923 (3.089926)	0.331099 (6.678813)
192	0.078192 (2.381726)	0.167381 (2.219835)	0.098827 (2.671662)	-0.309381 (-2.898175)	0.069198 (1.990013)	0.199811 (10.290193)
201	0.060192 (2.018283)	0.4891827 (4.817726)	0.4566712 (3.718726)	0.059671 (0.530199)	0.201983 (4.910317)	1.002019 (-0.281731)
202	0.025182 (1.001825)	0.209183 (3.187723)	0.228177 (2.019983)	-0.050192 (-1.019283)	0.101938 (2.491022)	0.389707 (6.699105)

(Table 11 continue)

203	0.036918 (1.360912)	0.140918 (2.556162)	0.229183 (2.788871)	-0.069109 (-1.010903)	0.059182 (2.201061)	0.410896 (6.418773)
204	-0.050192 (-2.129106)	-0.059188 (-1.109922)	0.348817 (2.192835)	-0.139012 (-2.956772)	0.159128 (2.109382)	0.479602 (5.391025)
205	0.019289 (0.871823)	0.109382 (2.887172)	0.029918 (1.89092)	-0.010993 (-0.301929)	0.120998 (3.103928)	0.361808 (7.478192)
221	0.036172 (1.319384)	0.089183 (2.198387)	0.129378 (2.491117)	-0.030119 (-0.788912)	0.201928 (3.199831)	0.450898 (6.019284)
222	0.038911 (1.757162)	0.250192 (3.201993)	0.119391 (2.298177)	-0.147718 (-2.089124)	0.158172 (2.918273)	0.490811 (6.591823)
231	-0.001625 (-0.301726)	0.209198 (2.491871)	0.129198 (2.300912)	0.059102 (1.188732)	0.158918 (2.491982)	0.279808 (7.779185)
233	0.021883 (1.019282)	0.401928 (4.667162)	0.056716 (1.989193)	-0.059192 (-0.481283)	0.109182 (2.281835)	0.352812 (6.109883)
234	0.018273 (0.891827)	-0.057187 (-1.878199)	0.078198 (2.045938)	0.010938 (0.488192)	0.350192 (4.102931)	0.309895 (7.771829)
235	0.059182 (2.030192)	0.159193 (2.391002)	-0.128367 (-0.977615)	0.078127 (1.298831)	-0.019323 (-1.420019)	0.221808 (7.918236)
236	0.059182 (2.571823)	0.157138 (2.414432)	0.128374 (2.095181)	0.090019 (4.281831)	-0.057183 (-1.501922)	0.428171 (6.718293)
237	0.030192 (1.768127)	0.158173 (2.616253)	0.071872 (2.078814)	0.099832 (1.401993)	0.010193 (1.918282)	0.430867 (5.882392)
239	-0.068172 (-2.473321)	0.137889 (2.891773)	0.109985 (2.298175)	0.069109 (2.419382)	0.178391 (2.991029)	0.418074 (6.109932)
241	0.019766 (1.318293)	0.069187 (2.056162)	0.109183 (2.391092)	0.062291 (0.371920)	0.129033 (2.918231)	0.498071 (4.182701)
242	0.049182 (1.871626)	-0.019382 (-1.871663)	-0.029198 (-2.001837)	0.049102 (0.609913)	0.050293 (1.882942)	0.290018 (8.788183)
243	0.011983 (1.018374)	0.157681 (2.391982)	0.018374 (1.989001)	0.081920 (1.109384)	0.019182 (1.909273)	0.430817 (3.012938)
244	0.029881 (1.546172)	0.048187 (2.009913)	-0.056596 (-1.817663)	0.050192 (0.689122)	0.049289 (2.291023)	0.270804 (8.391283)
251	0.019827 (1.019283)	0.187361 (1.657717)	0.381726 (2.817632)	-0.090193 (-1.290193)	0.089126 (2.201925)	0.301088 (6.679901)
252	0.010981 (1.102938)	0.109189 (1.971832)	0.109387 (2.008916)	-0.108819 (-2.657182)	0.201928 (3.440192)	0.332716 (7.019281)
253	0.101928 (3.491827)	0.167182 (2.183746)	0.038192 (1.756152)	0.097761 (2.330291)	0.009283 (0.701923)	0.270987 (8.103926)
257	-0.011928 (-1.098821)	0.159183 (2.399817)	0.056661 (2.019374)	0.067661 (0.988891)	0.240192 (3.491827)	0.387107 (6.901928)
259	0.028172 (1.251623)	0.138177 (2.651672)	0.117361 (2.109873)	0.059102 (2.210932)	0.090918 (2.812773)	0.232808 (8.658133)
271	0.016172 (0.781923)	0.209918 (3.188742)	0.198713 (3.298681)	-0.007829 (-0.172839)	0.059193 (2.102925)	0.261088 (7.199823)
273	0.028918 (1.381772)	0.201833 (2.877169)	0.038716 (2.086154)	0.001983 (0.109832)	0.130198 (2.517892)	0.390872 (7.129831)
274	0.019182 (0.817233)	0.121736 (2.481762)	0.109371 (2.198417)	0.009182 (0.148365)	0.283913 (4.110938)	0.270872 (8.167182)
275	0.047718 (1.991827)	0.029183 (1.718273)	0.041237 (1.998147)	0.080183 (2.399812)	0.178102 (3.891901)	0.339808 (7.810074)
281	0.110938 (3.618273)	0.190397 (2.201938)	0.151823 (2.183749)	0.020198 (2.198374)	0.090193 (2.950192)	0.310076 (5.912883)

(Table 11 continue)

282	0.038192 (1.651623)	0.208915 (2.918374)	0.068171 (2.193826)	0.029019 (1.401983)	0.190392 (2.949102)	0.380818 (6.198374)
283	0.139182 (2.891827)	0.159183 (2.781923)	0.041873 (2.817364)	0.019387 (1.509928)	0.178392 (3.390112)	0.479808 (6.102395)
289	0.120191 (2.558172)	0.281736 (2.626153)	0.098172 (2.109832)	0.049981 (2.110932)	0.229102 (3.220391)	0.499809 (6.871293)
292	0.091827 (3.102938)	0.189301 (2.758173)	0.147716 (2.399018)	0.069102 (2.657881)	0.001291 (0.871829)	0.480178 (6.192837)
310	-0.009182 (-0.678172)	0.189384 (2.981763)	0.109382 (2.388195)	0.035172 (1.178739)	0.120199 (3.110938)	0.432816 (6.391029)

Notes: See notes in Table 1 and Table 8. Estimations were carried out by using *Eviews 8*.

The estimated values obtained by the vector error correction version of the pricing equation appear to reflect the same empirical suggestions as the estimates of equation (31). In particular, the excess demand proxy still results in insignificant estimates by denoting that excess demand did not play an important role in the final wholesale pricing decisions of the majority of the manufacturing sectors. The same outcome holds for the foreign competing price level of the EU27 manufacturing sectors. There exist a number of sectors that appear to have a significant effect on domestic pricing decisions but the majority of the latter sectors remain unaffected by foreign competition in the domestic market. The unit costs of labour and capital do not deviate from the initial estimations, thus indicating that the ratio of labour to capital contribution remains the same. Finally, the effect of taxation on fluctuations of the final wholesale price level appears to be highly significant by verifying the fact that VAT is a very crucial determinant of pricing strategies.

Given the above estimates, the speed at which prices adjust to changes in the lagged pricing equation factors is similar to equation (31). In particular, the empirical evidence obtained from the Vector Error Correction Model suggests that pricing decisions in the manufacturing sectors are indeed sluggish given that the average time of adjustment corresponds to *1.5* years. However, the only notable fact under this approach refers to the magnitude of λ. According to the estimates presented in Table 11, the average sectorial speed of price adjustment appears to be *3.7* per cent more sluggish under the Generalized Method of Moments estimation technique compared to the Vector Error Correction Model. This means that the former approach results in slightly underestimated values of adjustment.

An interpretation of this outcome may lie on the structure of both models, where the latter focuses on the nature of cointegration of the endogenous variables (pricing equation factors) by eliminating the effects of potential unit roots and serial correlation. On the other hand, the former model takes into account the presence of endogeneity, heteroskedasticity and serial correlation in the error term of each sector individually and attempts to generate unbiased, consistent and efficient estimates. Either way, both models point to a similar empirical outcome in favour of sluggish wholesale pricing decisions based on the fluctuations of excess demand, unit costs, competing foreign prices and taxation.

Appendix B3

B3.1 Panel Data

The main models that will be regarded in the panel data analysis are the fixed and the random effects model. There are parts as well where those models are neglected in favour of a solely cross-sectional or time series analysis. In each of those cases, where the coefficients are estimated in every regression, the most appropriate econometrical method would be the one that provides unbiased and consistent estimations. In order to choose which of those methods will be used, the behaviour of the regressors and the error term in each case must be identified.

In particular, the cases which will determine the methods that will be taken into account are the following; the first case corresponds to whether the error term appears to be correlated with the individual effects and whether there is correlation between the independent/predictor variables and the error term; the second case regards whether there is cross-sectional dependence in the selected panel; the third case addresses the issue of heteroskedasticity in the error term; and the fourth case concerns the presence of serial correlation when the error term of a given time period has an impact on future time periods. Based on those diagnostics and the indications they provide, the most suitable method will be considered in the present analysis.

The first diagnostic test addresses the issue of choosing between the fixed effects and the random effects model. This test is called the *Hausman Test* (or the Hausman-Wu Test) which evaluates the significance of an estimator versus an alternative estimator (Wu, 1973; Hausman, 1978). In the case of panel data, it tests whether the individual effects term is correlated with the regressors (fixed effects) against the null hypothesis where there is no correlation (random effects). In particular, as has been argued by Hausman (1978), this test in general can be applied to all hypotheses testing problems under which two different estimators are available. By considering a simple linear regression $y = X'b + e$, where b consists of two estimators b_0 and b_1, he regarded two hypotheses: under the null hypothesis both of these estimators are consistent, but only the first one is efficient, while under the alternative hypothesis only the second estimator is consistent. Therefore, in order to compare those hypotheses, he formed the following statistic test which is also known as the *Hausman-Wu* statistic

$$H = (b_1 - b_0)'(Var(b_0) - Var(b_1))^{-1}(b_1 - b_0) \quad (43)$$

Since both estimators are consistent under the null hypothesis, their difference will converge to zero. In this case, this statistic appears to asymptotically follow the χ^2 distribution where the number of degrees of freedom are equal to the rank of the matrix $Var(b_0) - Var(b_1)$. On the other hand, under the alternative, the difference between b_1 and b_0 will be significantly different than zero since b_0 will be inconsistent (Kunst, 2010). In the case of panel data, where b_0 corresponds to the random effects estimator and b_1 to the fixed effects estimator, the *Hausman* test may also be used as a test of identifying the problem of endogeneity. Since under the fixed effects model there is a degree of correlation between the individual effects term and the independent variables, the problem of endogeneity arises under the alternative hypothesis.

By summing up, the first estimator (random effects) is consistent under the null hypothesis but inconsistent under the alternative. In contrast, the second estimator (fixed effects) may be consistent under both hypotheses; however it retains the properties of efficiency only under the alternative. This means that in the case of panel data, the fixed effects estimator has good asymmetric properties under both hypotheses, while the random effects estimator is asymmetric only under the null hypothesis. As has been presented by Kunst (2010), the random effects estimator is inconsistent under the alternative hypothesis of choosing the fixed effects model. This emerges from the fact that as the time horizon tends to infinity, the individual fixed effects are not estimated as a separate coefficient. They are viewed as realizations of random variables with mean equal to zero, which proves that the assumption of an unbiased error term does not hold (because the error term mean is different than zero) by leading to inconsistency.

Following the argumentation, Kunst (2010) refers to the problem of choosing between the fixed effects and the random effects approach, based on Mundlak (1978) and Hsiao (2004). In particular, the random effects model is more suitable when the absence of endogeneity is expected. This expectation may be enhanced whenever the individual dimension *N* greatly exceeds the number of the time dimension *T*, under which the effects of the individual entities may be viewed as random. Additionally, Mundlak (1978) suggests that the fixed effects model is just a special case of the random effects model. In particular, the individual effects term is correlated with the explanatory variables, while the random effects model treats this correlation equal to zero. For this very reason and based on the potential persistence of such correlation, the *Hausman* test will provide the necessary evidence of choosing between the fixed effects and the random effects model.

In many cases, the random effects model is chosen whenever there is correlation between the individual effects and the error term of each entity. Under such cases, the fixed effects model fails to provide efficient estimations since it accounts only for the presence of endogeneity and not of serial correlation. However, if the error terms of the entities do not appear to be correlated and there is no presence of endogeneity, then both of those models are equivalent to a simple OLS estimation. This means that when variance across entities is zero, there is no significant difference across the cross-sections and thus, there is no panel effect. Due to the absence of individual effects, an OLS regression can be estimated which can lead to efficient and consistent results.

A diagnostic test which can be used in order to identify whether the residuals among cross-sections appear to be contamporeneous correlated has been provided by Breusch and Pagan (1980) under which they use the LaGrange Multiplier (LM) methodology. The null hypothesis of this test regards the assumption of cross-sectional independence (or the absence of individual heterogeneity) over the alternative of cross-sectional dependence. According to the argumentation of Breusch and Pagan, the LM test for cross independence is subject to bias-adjustment and thus, the proposed estimations appear to satisfy the assumption of consistency. In particular, the LM test is based on the average of the squared pair-wise correlation coefficients of the residuals terms. Its application is feasible on panel data models for which the cross-section dimension (*N*) is relatively small compared to the time dimension (*T*) (Pesaran and Ullah, 2008).

According to Breusch and Pagan (1980), a simple pooled regression is taken into consideration of the following form

$$y_{it} = X'_{it}\beta + u_{it}, \text{ for } i=1,\dots,N \text{ and } t=1,\dots,T \tag{44}$$

where y_{it} is the dependent variable for individual entity i and time t, X'_{it} represents the transpose time variant vector of regressors ($1xk$) and $u_{it} \sim (0, {\sigma_{u_i}}^2)$, where the value of variance is allowed to change between entities. In order to estimate this regression, Breusch and Pagan proposed the LaGrange Mulitplier (LM) methodology for testing the null hypothesis of cross-sectional independence versus the alternative of cross-sectional dependence or otherwise, cross-sectional correlation among the error terms. The test is formulated according to the following expression

$$LM = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{\,2} \tag{45}$$

where $\hat{\rho}_{ij}^{\,2}$ represents the sample estimate of the residuals' pair-wise correlation and is expressed as

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{T} e_{it}e_{jt}}{\sqrt{(\sum_{t=1}^{T} e^{2}_{it})(\sum_{t=1}^{T} e_{jt})}} \tag{46}$$

where $e_{it} = y_{it} - X'_{it}b$ is the *OLS* estimate of the error term u_{it} and b represents the estimations of the vector of coefficients $\beta_{(\mathrm{kx1})}$. However, the assumption under which the number of the cross-section dimension (N) is considered to be relatively small, compared to the time dimension (T), must hold in order for the LM test to be valid. Therefore, under this setting, the null hypothesis of cross-sectional independence is defined as $Cov(u_{it}, u_{jt}) = 0$, for all t and $i \neq j$, where the LM statistic is asymptotically distributed as χ^2 with $N(N-1)/2$ degrees of freedom.

Under this specification of testing for cross-sectional independence and given the fact that the number of the individual entities (sectors) in this study is $N=56$, while the time dimension is $T=33$, the *LM* statistic will not be able to provide valid inferences. Since in micro panel data studies the number of the individual entities exceeds the time dimension, cross-sectional dependence is less likely to arise (Baltagi, 2001). Nevertheless, Breusch and Pagan argued that when the time horizon tends to infinity and given the fact that $\hat{\rho}_{ij}^{\,2}$ for $i=1,\ldots,N-1$ and $j=i+1,\ldots,N$ are asymptotically uncorrelated, then a scaled version of the LM statistic may account for both large N and large T (Pesaran and Ullah, 2008). The scaled version of LM is the following

$$NLM = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{\rho}_{ij}^{2}-1)\text{, where } NLM \sim N(0,1) \tag{47}$$

On the other hand, in cases where the number of the individual entities N significantly exceeds the time dimension T, Pesaran and Ullah (2008) argued that a substantial size of distortions may arise. This happens because under a finite time dimension, the mean of

$T\hat{\rho}_{ij}{}^2 - 1$ will not be correctly pinpointed at zero and given a large number of individual entities *N*, the *LM* statistic is likely to provide incorrect results.

In order to provide a solution for this weakness, Ullah (2004) presented a set of techniques that may address this problem in panel data where *N*>*T* (finite) and result in correct econometric estimations. Under a set of assumptions, the *New LM* statistic that Ullah proposed is

$$NLM^* = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}((T-k)\hat{\rho}_{ij}^2 - \mu_{\mathrm{T}ij}) \qquad (48)$$

where μ_{Tij} corresponds to the mean of $(T-k)\hat{\rho}_{ij}{}^2$ and k is the number of regressors. The *NLM** statistic is zero regardless the size of *N* and *T* under the null hypothesis of non-correlated error terms. This means that any increase in the individual entities *N* will be unlikely to result in any size distortions[92]. Therefore, by taking into account the *New LM* statistic proposed by Breusch and Pagan (1980) and modified by Ullah (2004) will be able to test whether the panel data in each of the undertaken regressions appear to be subject to cross-sectional dependency. If the null hypothesis, under which the error terms among the entities are uncorrelated, is rejected, then the presence of cross-sectional dependence will be considered and thus, the use of the random and fixed effects model.

However, even if there is evidence of cross-sectional dependence, the analysis has to take into account the effects of the correlation *between* the error terms of the individual entities and the correlation *within* each individual entity. The latter issue addresses the problem of endogeneity, which acquires the use of the fixed effects model. For this reason, the *Hausman test* is appropriate in order to test which model is preferable. According to Hausman (1978), under the null hypothesis, it is assumed that the coefficients in the fixed and random effects are consistent and therefore, the random effects model is selected. This happens because the random effects estimator appears to be efficient as well, whereas the fixed effects estimator is only consistent.

On the other hand, if the null hypothesis is rejected, the effect of correlation *within* the cross-sections emerges, by validating the presence of correlation between the individual effects and the explanatory variables of each entity. This effect addresses the problem of

[92] However, as Pesaran and Ullah (2008) argued, there would still be some bias for small samples. In this study, such issue does not arise and thus, the *NLM* statistic is suitable for satisfying the underlying regressions.

endogeneity and as argued above, the best way to treat this problem is to use the fixed effects model. This approach assumes no correlation between the individual effects and the error term, thus focusing on eliminating endogeneity. In addition, the random effects approach assumes the absence of endogeneity and consequently, it is focused on eliminating correlation between the individual effects and the error term of each entity.

The diagnostic tests proposed by Hausman (1978) and Breusch and Pagan (1980) will provide the necessary evidence for the regressions of this study in order to test whether there is cross-sectional dependence. As a result, the best model between the fixed and the random effects will be selected. If those selections are determined, then the following important issues respond to conditions that may help to decide which econometrical method has to be used to obtain the estimates each regression. Such issues address the presence of heteroskedasticity, along with the degree of serial correlation in the error term of an individual entity between time lags. Based on their significance, the most suitable econometrical techniques will be applied under which the resulting estimations will not be subject to inconsistency and inefficiency. In the case of panel data, the study will consider the Likelihood Ratio (*LR*) test for heteroskedasticity, proposed by Neyman and Pearson (1933) and the Wooldridge test for the presence of serial correlation in the error term of each entity, proposed by Wooldridge (2002).

The Likelihood Ratio test, in general, is a statistical test developed by Neyman and Pearson (1933), which is used in order to compare the fit of two estimators. In particular, the null hypothesis is considered to be a special case of the alternative hypothesis and thus, the *LR* test identifies which estimator is best suited in each of the undertaken regressions. In this case, where the *LR* test is used to provide evidence of heteroskedasticity, the null hypothesis assumes the presence of homoscedasticity, while the alternative hypothesis suggests the presence of heteroskedasticity. Under the null hypothesis, the variance of the error term for every t ($t=1,\dots,T$) must be equal and constant over time. This means that H_0: $\sigma^2_1=\dots\sigma^2_T=\sigma^2$, which indicates that the variance of the error term is independent of the time dimension. On the other hand, if the null hypothesis is rejected, then at least one of those variances is different from the others by providing evidence of heteroskedasticity under which $Var(u_i) = \sigma_t{}^2 \neq \sigma^2$. This means that the variance of the error term u_i is not independent over time and thus, it is not constant.

The LR test statistic which accounts for the presence of heteroskedasticity has the following form, according to the Neyman-Pearson Lemma (1933)

$$LR = 2(logL_u - logL_R)=$$

$$= 2[\log(likelihood\ for\ heteroskedasticity) - \log(likelihood\ for\ homoskedasticity)$$

$$-\log(\frac{likelihood\ for\ homoskedasticity}{likelihood\ for\ heteroskedasticity})] \quad (49)$$

where L_u and L_R represent the likelihood for the unrestricted and the restricted model respectively[93]. According to this statistic, the most suitable model will be the one that appears to have the most parameters, based on the probability value derived for each regression separately. This value is compared to the χ^2 distribution under *n* degrees of freedom, where *n* is the difference between the free parameters in the model under the alternative hypothesis and the null hypothesis respectively (Huelsenbeck and Crandall, 1997). In the case of panel data, the *LR* test is used in order to identify the presence of heteroskedasticity in the error terms for each individual entity *i*. It provides the necessary evidence through which the most suitable econometrical method will be selected.

The second important issue that needs to be identified regards the degree of serial correlation in the error terms of the individual entities over the time sample *t*. In particular, the presence of correlation in linear panel data models can lead to biases in the standard errors of the estimated coefficients. As a result, such estimates will be less efficient than they should to (Drukker, 2003). As mentioned before, the presence of contemporaneous correlation in two cases has been discussed: *between* the error terms of each individual entity (cross-section correlation) and *within* each individual entity, where correlation appears between the individual effects term and the explanatory variables. The first case can be identified by the Breusch-Pagan (*LM*) test and be accounted by considering the random effects model. The second case can be identified by the Hausman test, under which the fixed effects model is more appropriable in order to account the presence of endogeneity. An additional case which has not been presented so far refers to the presence of serial correlation within the error term of each individual entity.

[93]For instance, in the fixed effects model, the unrestricted model may correspond to the *FE-3SLS* estimator, due to the presence of both endogeneity and heteroskedasticity, while the restricted model may correspond to the *FE-2SLS* estimator, under which only the presence of endogeneity holds.

The diagnostic test which is going to be taken into consideration in this study for identifying the presence of first-order serial correlation is the *Wooldridge* test, presented by Wooldridge (2002). In particular, there is a number of other tests that can be used for this purpose, like the *Baltagi-Wu* test which is considered to be quite accurate in its estimations (Baltagi and Wu, 1999). However, as Drukker (2003) argues, the Wooldridge test bases its estimation on a set of fewer assumptions, which may render it less powerful but more robust compared to the rest parameterized tests. An advantage over its weaker assumptions concerns the fact that it includes a good size and power properties which enhances the fact of considering it in this analysis.

Wooldridge (2002) assumes a one-way linear model similar to equation (39)

$$y_{it} = \alpha + X'_{it}\beta_1 + Z'_{it}\beta_2 + \mu_i + u_{it}, \text{ for } i=1,\dots,N \text{ and } t=1,\dots,T \quad (50)$$

where y_{it} is the dependent variable for individual i and time t, α denotes the overall constant term in this regression, X'_{it} represents the transpose time variant vector of regressors (*1xk*), Z'_{it} regards the transpose time-invariant vector of regressors (*1xm*), μ_i corresponds to the time invariant individual effects term which also addresses the cross-section effects (random or fixed) and u_{it} is the idiosyncratic error term. In the case where the individual effect μ_i is correlated with the vectors of explanatory variables X'_{it} or Z'_{it}, the vector of coefficients β_1, which represents the time varying covariates, can be estimated consistently by regarding the within-transformed data or the first difference data (Baltagi, 2001; Wooldridge, 2002).

In this case, since the individual effects appear to be correlated with the set of the explanatory variables, the most appropriate model which accounts for the presence of such correlation is the fixed effects model (alternative hypothesis of Hausman test). On the other hand, if the individual effect μ_i is not correlated with vectors X'_{it} and Z'_{it}, then the vectors of coefficients $\beta_1$and β_2 can lead to both consistent and efficient estimates by using the random effects model (null hypothesis of Hausman test). However, under both cases, the idiosyncratic error term within an individual entity is assumed to have zero serial correlation i.e. $E(u_{it}, u_{it+s}) = 0$. If this assumption is not valid, then biased standard errors and less efficient estimators will be generated that over-reject the null hypothesis.

The methodology that has been attempted by Wooldridge regards the use of the residual term resulting from estimating equation (50) in first differences. Therefore, this leads to

$$y_{it} - y_{it-1} = (X'_{it} - X'_{it-1})\beta_1 + (Z'_{it} - Z'_{it-1})\beta_2 + (u_{it} - u_{it-1}) \quad (51)$$

Since the individual effect μ_i differs between entities but remains the same within an individual entity for the whole time period, its difference between time *t* and *t-1* will be zero. Additionally, since there has been assumed that Z'_{it} is a vector of time invariant variables, then the difference of those variables between two time periods will be zero as well. This means that

$$\Delta y_{it} = \Delta X'_{it}\beta_1 + \Delta u_{it} \quad (52)$$

where Δ denotes the first difference operator. Therefore, the procedure followed by Wooldridge regards the estimation of β_1 through (52) and subsequently, those estimations are used in order for residuals $\hat{u}_{it}$ to be obtained.

Drukker (2003) also argues that Wooldridge observed that if the error term of an entity is not serially correlated, then correlation between its first and second order differences will not be zero, but a negative value equal to *-0.5*, i.e. $Corr(\Delta u_{it}, \Delta u_{it-1}) = -0.5$. This indicates that the process estimates the residual terms $\hat{u}_{it}$ from equation (52) by including first order differences and subsequently, it tests whether the correlation coefficient on the lagged residual value is equal to *-0.5* (null hypothesis). Another important characteristic of this test concerns its robustness according to its consideration of a limited number of assumptions (Wooldridge, 2002). For this reason, the Wooldridge test is also robust to conditional heteroskedasticity, which makes it even more preferable than other tests. To conclude with, by employing the Wooldridge test for serial correlation, the null hypothesis assumes that if correlation between Δu_{it} *and* Δu_{it-1} is equal to *-0.5*, there is no presence of first-order serial correlation in the residual term of an individual entity. Otherwise, under the alternative hypothesis, the case of first-order serial correlation between different lags of the residual term is taken into consideration.

B3.2 Time Series/Cross Sectional Data

The diagnostic tests presented above, address the issue of heteroskedasticity, endogeneity and serial correlation within and between the cross-sections, by employing the fixed and random effects model where applicable. However, there are cases under which the estimates of a set of regressions occur according to a time series or a cross-sectional approach, in order to validate the desirable theoretical outcome indicated by such estimations. For this reason, the presence of both heteroskedasticity and serial correlation has to be identified in each of those regressions by using the appropriable diagnostic tests, which differ from the ones presented before.

To begin with, a diagnostic test which is used for the identification of heteroskedasticity in time series and cross-sectional analysis is the *Breusch-Pagan-Godfrey* test, developed by Godfrey (1978a) and Breusch and Pagan (1979). The core methodology which is adopted in order to develop this test concerns the use of the Lagrangian Multiplier (*LM*) test, initially presented by Aitchison and Silvey (1960), also known as Rao's efficient score test (Cramer, 1946; Rao, 1945, 1973). In particular, the Lagrangian Multiplier (*LM*) test accounts for conditional heteroskedastic disturbances in a linear model by employing the Lagrangian Multiplier methodology. The null hypothesis of this test concerns the presence of homoscedasticity, where the variance of the error term for time t remains constant, versus the alternative hypothesis of heteroskedasticity, where the variance of the error term for at least one period t is different.

In particular, as Breusch and Pagan have argued, this test of heteroskedasticity appears to have the same asymptotic properties as the likelihood ratio (*LR*) test[94]. However, the advantage of the former test regards its estimation on a two-step basis by estimating two least squares regressions, thus avoiding any calculations under which the maximum likelihood estimator is obtained. This statistic is formed from the results of maximizing the likelihood ratio subject to the null hypothesis which refers to the presence of homoscedasticity. Its computation is based either on the computation of the LaGrange Multiplier subject to a set of constrains (Aitchison and Silvey, 1960) or on the computation of the first order conditions (Rao, 1973).

In particular, Breusch and Pagan consider a linear regression as in equation (44) under which the error term u_{it} is normal and independently distributed with zero mean and variance $\sigma_t{}^2 = h(z'_t a)$. In particular, $h(.)$ is a function which possesses a first and second order derivatives, α is a ($px1$) vector of unrestricted parameters uncorrelated with z' which is the vector of regressors reflecting the form of heteroskedasticity. Under those assumptions, the null hypothesis of homoscedasticity is expressed as H_0: $\alpha_2 = \ldots = \alpha_\rho = 0$. In this case, it will

[94] The likelihood ration test can also be used to test for the presence of conditional heteroskedasticity in time series and cross-sectional data. It includes the assumption under which the unrestricted model accounts for conditional heteroskedasticity, while the restricted model for homoscedasticity.

hold that ${\sigma_t}^2 = h(a_1) = \sigma^2$ which is a constant term. In the case of heteroskedasticity, the variance of the error term will be ${\sigma_t}^2 = h({z'}_t a)$. The alternative representation is sufficiently general in order to include many of the heteroskedastic forms presented in the literature, such as ${\sigma_t}^2 = \exp({z'}_t \alpha)$ as indicated by Harvey (1976) or ${\sigma_t}^2 = ({z'}_t a)^m$ (Goldfeld and Quandt, 1965; Rutemiller and Bowers, 1968; Glesjer, 1969).

In particular, if there is reason to believe that the variance matrix of the residuals is not independent from the explanatory variables X'_{it}, then an auxiliary regression can be considered under which such variance is linearly dependent to the independent variables:

$$\hat{u}_{it}^2 = \delta_0 + \mathrm{X}'_{it}\,\delta_1 + \psi_{it} \tag{53}$$

This auxiliary regression represents the basis of the Breusch-Pagan-Godfrey test for the presence of conditional heteroskedasticity. Therefore, if the *F-statistic* confirms that the independent variables are not linearly dependent with the variance of the residuals, then the null hypothesis will not be rejected.

However, the Breusch-Pagan-Godfrey test provides evidence for the presence of heteroskedasticity of known form, i.e. ${\sigma_t}^2 = h({z'}_t a)$. If the form of heteroskedasticity is different, then this test will not take it into consideration and thus, it will accept the null hypothesis of homoscedasticity. This will allow the occurrence of incorrect standard errors which will lead to less efficient coefficients. This fact renders the necessity of regarding a different diagnostic test for heteroskedasticity which addresses a general rather than specific forms of heteroskedasticity.

A test of this type has been presented by White (1980) where the null hypothesis considers that the variance of the residual term is constant, against the alternative of a non-constant variance. The only difference from the Breusch-Pagan-Godfrey test is that the alternative hypothesis accounts for heteroskedasticity of unknown form or otherwise, of a general form. In the latter case, where the White test is found to be significant, heteroskedasticity may not be the only cause of this outcome. Another cause which is also taken into consideration concerns the presence of specification errors, because the estimated regression includes cross-product terms. In the case where those terms are omitted, the White test is a test of pure heteroskedasticity of unknown form.

The White test statistic is computed by an auxiliary regression of a similar form of equation (44). For simplicity, it is assumed that the dimension of the transpose independent variables' vector is (*1x2*). Therefore, the regression is of the following form

$$y_{it} = \beta_0 + \beta_{11}x_{1t} + \beta_{12}x_{2t} + u_{it} \tag{54}$$

Based on this equation, the statistic test is computed by regressing the squared residuals on all possible cross products of the regressors. The auxiliary regression is the following

$$u^2_{it} = a_0 + a_1x_{1t} + a_2x_{2t} + a_3x^2_{1t} + a_4x^2_{2t} + a_5x_{1t}x_{2t} + w_{it} \tag{55}$$

Subsequently, in order to test whether the null hypothesis is rejected or not, the value of the *F-statistic*[95] is employed, which reflects a redundant variable test in order to observe the joint significance of the cross-products included in (55). For this reason, the value of R^2 is regarded multiplied by the number of observations *N*, thus providing the statistic of White's test, which is the same as the Lagrangian Multiplier (*LM*)[96]. This means that White's test statistic is asymptotically distributed with the χ^2 distribution with *k* degrees of freedom, where *k* denotes the number of parameters in equation (54) without including the constant term. Based on the aforementioned procedure, White (1980) argued that this test can also be considered as a general model for misspecification, given the fact that the null hypothesis assumes that the error term is both homoscedastic and independent of regressors. Under this case, the linear specification of the testing model is assumed to be correctly defined. Therefore, whenever one of those conditions does not hold, the White test will provide a significant test statistic by rejecting the null hypothesis of constant variance in the error term over the time period.

A different estimator which has been proposed by White (1980) for resulting in estimations which are consistent to heteroskedasticity concerns the computation of *Heteroskedasticity-Consistent (HC) standard errors*. In particular, this estimator allows the fitting of the model which includes a heteroskedastic error term (Huber, 1967; Eicker, 1967). This means that the heteroskedastic consistent estimator can be presented as

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[95] $F = \frac{(SSR_r - SSR_u)/(k+1-h)}{SSR_u/(N-k-1)}$, where SSR_r denotes the restricted model of the residuals of the sum of squares, SSR_u addresses the unrestricted model of the residuals of the sum of squares and *h* represents the term which the restricted model accounts from. Also, the *SSR* is defined by $SSR = \sum_{i=1}^{N}(y_i - x'_i b)^2 = (y - Xb)^T(y - Xb)$.

[96] The *LM* statistic is equation (55) divided by $2\hat{\sigma}^4$, which follows the χ^2 distribution with *k* degrees of freedom.

$$Var_{HCE}(b_{OLS}) = \frac{1}{N}(\frac{1}{N}\sum_{i=1}^{N} X_i X'_i)^{-1}(\frac{1}{N}\sum_{i=1}^{N} X_i X'_i \hat{u}_i^2)\frac{1}{N}\sum_{i=1}^{N} X_i X'_i)^{-1}$$

$$= (X'X)^{-1}(X'Var(\hat{u}_i^2)X)(X'X)^{-1} \quad (56)$$

where $Var(\hat{u}_i{}^2) = \frac{1}{N} diagonal(\hat{u}_1{}^2, \ldots, \hat{u}_N{}^2)$. The limiting distribution which is followed by the *HC* estimator is $\sqrt{N}(b_N - \beta) \rightarrow N(0, \Omega)$[97] which is subject to efficiency. An interesting note for this estimator regards its derivation in terms of Generalized Method of Moments (*GMM*) in order to account the presence of heteroskedasticity in the error term (see section 5.3). This method allows formulations in the weighted variance-covariance matrix of the residual term in order to correct the problems of heteroskedasticity and serial correlation.

To conclude with, the White test can be viewed as a special case of the Breusch-Pagan-Godfrey test. While the latter test addresses only the presence of heteroskedasticity of known form $\sigma_t{}^2 = h(z'_t a)$, the former test identifies the presence of both heteroskedasticity of unknown form and any kind of model misspecification. This means that whenever both tests provide significant results, then the type of heteroskedasticity can be assumed to be of known form. On the other hand, if the White test rejects the null hypothesis of homoscedasticity, this may not be the case for the Breusch-Pagan-Godfrey test. The reason for this outcome lies on the form of heteroskedasticity. If the form is not known, then the latter test will not take it into consideration and thus, it will not reject the null hypothesis. This is the main reason for regarding both of those tests in this study in order to be able to identify the form of heteroskedasticity. As a result, it will be easier to decide which estimation technique will be selected for the acquisition of accurate estimations.

The second issue that may arise, as was argued above, refers to the presence of serial correlation in the error term of each regression. In particular, this type of correlation is observed between the residuals and their own lagged values, a fact that violates the assumption of efficiency. This means that since current residuals may be dependent on their lagged values[98], then an accurate prediction for the dependent variable must be formed which accounts for the presence of serial correlation. The reason for this outcome is that serial

[97] $\Omega = E[(XX')^{-1}]Var(Xu)E[(XX')^{-1}]$. The estimation of the variance matrix Ω results in $\hat{\Omega}_N = NVar_{HCE}(b_{OLS})$.

[98] This case addresses the Autoregressive models of *p* order *AR(p)*, where the error term is dependent on the error terms of the previous *p* time periods *t=2,..,p*. Therefore, by assuming a simple regression similar to (44), the *AR(p)* regression will be of the form $u_{it} = \sum_{j=1}^{p} \rho_j u_{it-j} + w_{it}$.

correlation in the error term results in underestimated standard errors of the coefficients. Additionally, if lagged dependent variables appear on the right hand side of the equation as well, then the *OLS* estimator will be both biased and inefficient (Durbin and Watson, 1950).

One of the two tests which are going to be taken into consideration in this study for identifying the presence of serial correlation in the residual term regards the Durbin-Watson statistic test developed by Durbin and Watson (1950, 1951, 1971). In particular, the Durbin-Watson statistic is a test for identifying the presence of first-order serial correlation in the residual term by measuring the linear relationship between adjacent residuals from a regression model. It regards an *AR(1)* formulation for the residual term of an *OLS* regression under which the null hypothesis assumes that the coefficient of the *t-1* lagged value is equal to zero ($\rho=0$) and thus, the absence of serial correlation. The alternative hypothesis assumes that $\rho \neq 0$ and thus, the presence of first-order serial correlation in the residual term. Therefore, the Durbin-Watson statistic (d) is defined as

$$d = \frac{\sum_{t=2}^{T} \Delta \hat{u}_t^2}{\sum_{t=1}^{T} \hat{u}_t^2} \tag{57}$$

where T is the number of the time dimension. Based on the argumentation of Durbin and Watson, the d statistic is approximately equal to $2(1-\rho)$, where ρ is the coefficient of serial correlation in the residual term. This means that under the null hypothesis, the Durbin-Watson statistic will be at least equal to *2* ($d \geq 2$), while under the alternative hypothesis, its value will be lower than *2*, since $\rho > 0$. In particular, the value of the d statistic fluctuates between *0* and *4*. When it is found to be less than 2, this provides evidence for the presence of positive serial correlation. Additionally, if that value is less than *1*, then this is a sign of a high degree of correlation, given that the value of successive error terms is very close to one another. On the other hand, if d is greater than *2*, then this is evidence of negative serial correlation between successive error terms which indicates that their value is different from one another (Johnston and DiNardo, 1997).

Positive correlation denotes the chance that a positive error of an observation may lead to a positive error for another observation. Similarly, negative correlation regards the chance that a positive error may lead to a negative error for another observation and vice versa. Given the above indications, Durbin and Watson (1971) highlighted the fact that the value of the critical values $d_{L,\alpha}$ and $d_{U,\alpha}$ depend on three factors: the level of significance α, the number of observations N, and the number of the explanatory variables in each regression. Their extraction is formulated by the matrix of the explanatory variables, under the assumption that this matrix is known. Therefore, the distribution of the Durbin-Watson statistic d under the null hypothesis follows the form

$$d \sim \frac{\sum_{i=1}^{N-k} v_i x_i^2}{\sum_{i=1}^{N-k} x_i^2} \tag{58}$$

where k is the number of regressors, x_i are the independent standard normal random variables and v_i are the non-zero eigenvalues of $(I-X(X^TX)^{-1}X^T)A$, where A is the matrix $d = \hat{u}^T A \hat{u}$ that transforms the residuals into the d statistic[99].

To sum up, the presence of serial correlation may not be able to affect the consistency of the estimated coefficients but it restrains the validation of statistical tests. In particular, positive correlation will lead to underestimated standard errors obtained by the *OLS* estimation, meaning that a standard linear regression analysis will cause the computation of small standard errors. Those errors will cause both *F-statistic* and *t-statistic*[100] to be overvalued by resulting in incorrect inferences under which the null hypothesis may falsely be over-rejected.

A reason for this outcome may be the fact that the mean squared error will tend to underestimate the error variance of the sample. Therefore, if the presence of serial correlation is significant, then the most suitable method has to be applied to acquire robust estimations to this form of correlation. One method presented in the literature concerns the *Cohrane-Orcutt transformation* which corrects first-order serial correlation in the residual terms, under the condition that those residuals must follow stationary, first-order autoregressive structure[101].

Nevertheless, despite the important contribution of the Durbin-Watson statistic test for the identification of serial correlation in the residual term, three limitations arise which may restrict the undertaken analysis. The first limitation regards the issue that the d test accounts

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[99] The computational algorithms for finding percentiles of the Durbin-Watson distribution are provided by Farebrother (1980).

[100] The *t-statistic* of an estimator b is defined as $t_b = \frac{b-\beta}{\sigma_b}$, where σ_b represents the standard error of b, which is the estimation of the coefficient β.

[101] For more details, see Cohrane and Orcutt (1949) and Asteriou and Hall (2011).

only for the presence of first-order serial correlation. If higher order serial correlation persists, then this diagnostic test will be unable to provide evidence that suggest this outcome.

The second limitation addresses the fact that the *d* statistic under the null hypothesis depends on the matrix of the explanatory variables. In order to account for this issue, Durbin and Watson set lower and upper bounds $d_{L,\alpha}$ and $d_{U,\alpha}$ respectively for the distribution of statistic *d*, such that a space will exist under which the test will be inconclusive. The last limitation concerns the presence of lagged dependent variables on the right hand side. In this case, the estimations will be biased and subject to inconsistency, due to the presence of endogeneity. In this case, the residual term will be both serially correlated with its lagged values and with the right hand side lagged dependent variables. For those reasons but especially, for the limitation of handling serial correlation of higher-order in the residual term, the *LM* statistical test of Breusch (1978) and Godfrey (1978b) is the second test taken into consideration.

The Breusch-Godfrey (*LM*) statistical test can be used to test a higher than first order serial correlation in the error term of Autoregressive (*AR*) and/or Moving-Average (*MA*)[102] models. It is not affected by the presence of lagged dependent variables on the right hand side of any regression. Those characteristics can render it more preferable to the Durbin-Watson test which only considers first order serial correlation in *AR(1)* non-stochastic errors. In particular, a regression of the form of (54) is regarded by Breusch (1978) and Godfrey (1978b) where the error term follows an *AR(p)* autoregressive form

$$u_{it} = \sum_{j=1}^{p} \rho_j u_{it-j} + w_{it} \tag{59}$$

The linear regression is initially fitted by *OLS* in order to obtain a set of residuals $\hat{u}_{it}$ of the following form

$$\hat{u}_{it} = \beta_0 + \beta_{11} X_{1t} + \beta_{12} X_{2t} + \sum_{j=1}^{p} \rho_j \hat{u}_{it-j} + w_{it} \tag{60}$$

This means that if this auxiliary regression is fitted, then the asymptotic approximation, which can be used to obtain the distribution of the Breusch–Godfrey test statistic is $NR^2 \sim {\chi_p}^2$,

[102] An Autoregressive Moving-Average *ARMA(p)* model is of the form $y_{it} = \beta_0 + \sum_{i=1}^{N} \beta_i X_{it} + \sum_{j=0}^{p} \rho_j u_{it-j}$, where *X* is the matrix of the explanatory variables, *u* corresponds to the *p*-vector of the error term and $\rho_0 = 0$.

where p is the number of the pre-specified time lags in equation (59) and N corresponds to the difference between time observations T and the number of time lags p ($N=T-p$). However, if the presence of correlation between the error term and the explanatory variables is suspected, then the *OLS* fitting in order to obtain $\hat{u}_{it}$ will not provide correct inferences. For this reason, as Wooldridge (1990) suggests, the *Two-Stage Least Squares* formulation will be more accurate but it will also give rise to a number of other complications, such as inefficient standard errors of the coefficients if the error term w_{it} appears to be heteroskedastic.

The null hypothesis of this statistic regards the absence of serial correlation in the residual term, which means that the coefficients of the lagged residuals will be zero (H_0: $\rho_1=\ldots=\rho_p=0$), while the alternative hypothesis reflects the presence of j-order serial correlation (i.e. $j=1,\ldots,p$). Under the alternative case, both *AR(p)* and *MA(p)* processes may be included so that the test may appear to have a greater power against a variety of alternative serially correlated structures (Godfrey, 1987). As in the Durbin-Watson *d* statistical test, the *F-statistic* is regarded as an omitted variable test for the joint significance of the *p-order* lagged residuals. However, since the residual term is not considered as a part of the matrix of the independent variables, the exact finite sample of the *F-statistic* may not be known under the null hypothesis. However, it is still used for comparison purposes.

This procedure shows that the Breusch-Godfrey *LM* statistical test is used for the identification of *p-order* serial correlation in the error term and utilizes the residuals obtained by equation (59). Based on those residual terms, the derivation of a test statistic is formed by considering equation (60) under which the value of the correlation coefficient ρ_j is estimated. Additionally, this test provides a general form of the Durbin-Watson *d* statistic test which is only applicable for testing the presence of first-order serial correlation in *AR(1)* models. The specification of the Breusch-Godfrey *LM* test is not subject to such limitations and therefore, it is considered as a more powerful alternative.