

# **Skilled-Unskilled Wage / Employment Disparity - A CGE Simulation Analysis**

By Dr. Ya Ping Yin  
SEAMS  
University of Hertfordshire Business School  
UK

## Abstract:

From the 1970s to the beginning of the 1990s, a number of OECD countries, particularly the US and the UK, have witnessed a widening disparity in the skilled / unskilled wage differential and / or the unemployment rates. Many factors have been proposed for explaining this disparity, ranging from skill-biased demand shifts to skill-biased technical progress. This paper takes a general equilibrium approach by employing a multi-sector CGE model of Scotland to integrate various factors in a single coherent modelling framework. The modelling framework combines conventional forms of exogenous technical progress in the production process with alternative labour market settings. The paper illustrates that the skill impact of exogenous technical shocks depends on the form of technical progress, the origin of the shock, as well as labour market factors, particularly the wage setting behaviour and asymmetric skill mobility. The CGE simulation results do lend some reserved support to the skill biased technological change argument.

Key words: Skilled/unskilled disparity, exogenous technical progress, multi-sector model, labour market institutions.

JEL classification: J31, O33, O18.

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## 1. Introduction

A number of studies have documented evidence of a collapse in the demand for unskilled workers across the OECD countries from the 1970s to the beginning of the 1990s (see, for example, Murphy and Welch, 1991; Bound and Johnson, 1992; Nickell and Bell, 1995; Manacorda and Petrongolo, 1999. McGregor et. al. (2000) provide evidence of disparity in unemployment rates by occupation across the UK regions). The following general observations have been made in these studies. In one group of countries such as the US and the UK, the rising relative unemployment rates of the unskilled are accompanied by a widening gap between the skilled-unskilled wage differentials<sup>1</sup>. Whilst in another group, mainly continental European countries, the skilled-unskilled disparity is mainly manifested through a general rise in the overall unemployment rate that is primarily accounted for by a substantial rise in the unskilled unemployment rate without an apparent rise in wage inequality.

Such observations have led to a large number of studies that try to explain why such disparities arise. Typical explanations have included skill-biased technological change, increasing international trade, supply and demand mis-match of skill, and labour market institutional factors (Leamer, 1996; Bound and Johnson, 1992; Krugman, 1994; Berman, et. al., 1998; Manacorda and Petrongolo, 1999; Kiley, 1999; Muysken, et. al., 2001). The international trade arguments attributes the disparity to the decline in manufacturing employment across the OECD countries which may have caused a shift in demand from unskilled workers to skilled (and women) workers, as manufacturing tends to have a disproportionately high percentage share of unskilled workers. However, such a shift may not cause a rise in the relative unskilled unemployment rate if the (unskilled) labour market is flexible. Therefore, the labour market institution argument attributes the disparity fundamentally to labour market flexibility or inflexibility. The skill-biased technological change (SBTC) argument attributes the increased relative demand for skilled workers to the skill upgrading (or skill-biased technological improvement) by firms. According to Berman, et. al. (1998), there is strong evidence of pervasive SBTC in the manufacturing sector across the developed countries and they regarded pervasive SBTC as the most important factor in explaining the disparities in skilled / unskilled wage and employment performance.

However, there seems to be a lack of a conceptually consistent framework to integrate the different factors. The present paper does not aspire to provide one, but will consider the main elements of that framework. Conceptually, the rate of employment and the price of a factor of production are jointly determined by the interaction of the demand for and the supply of that factor. On the supply side, one prominent feature of a skill-disaggregated labour market is that the supply of labour by skill types exhibits downward mobility but hardly any upward mobility. In other words, the skilled can do many of the unskilled jobs but it is extremely difficult for the unskilled to enter the skilled job market, at least for some considerable time period. This asymmetry in skill mobility leads to different supply responses from different skill groups. In general, the supply of unskilled workers is expected to be more elastic than the supply of skilled workers. Moreover, it is expected that the divergent supply responses by skilled and

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<sup>1</sup> Although in the US the skilled / unskilled disparity is reflected more clearly in the wage differential than the unemployment rate differential.

unskilled workers are related to the business cycles. Several analysts have pointed out that economic booms tend to benefit disproportionately the unskilled workers from a demand perspective (Reder, 1955; Blank, (2000). From a supply side perspective, economic booms or recessions may be associated with a reduction or an increase in the divergence of the elasticity of supply by skilled and unskilled labour. For example, during an economic boom, it is less likely that skilled workers have to compete with unskilled workers in the unskilled job market. Although favourable labour market conditions may stimulate more active job search from the unemployed and the previously inactive working population, the competition from these groups of workers is much weaker than the competition from the marginalised skilled workers. This is particularly so in cases where there is pervasive skill upgrading in the economy. Therefore, during economic booms, even the unskilled may have some bargaining power in their wage claims and it is expected that the divergence of the elasticity of labour supply between the skilled and the unskilled tends to reduce.

However, it must be noted that over the past few decades the level of educational attainment has increased almost monotonically across the OECD countries. As a result, the relative supply of skilled workers has increased quite substantially over time. Although this relative increase in the supply of skilled workers exerts a pressure on the skilled wage (and hence tends to reduce the skilled-unskilled wage differential), it does not change the central feature of the asymmetry in skill mobility in a skill-disaggregated labour market in any particular period. Therefore, the relative elastic nature of the supply of unskilled workers should not be affected by the changing educational attainment level. Given the elastic supply of unskilled workers, it is not surprising that unskilled workers are more susceptible to demand fluctuations and have less bargaining power in their wage claims than the skilled. Moreover, as the analysis in the previous paragraph indicates, the disparity in skilled / unskilled wage and employment is also expected to be related to the business cycles: the disparity tends to narrow in economic booms and widen in recessions. Therefore, the different elastic or inelastic nature of the supply of unskilled and skilled labour in itself may go some way towards explaining the relatively stagnant nature of the unskilled wage growth and the volatility of unskilled employment (unemployment).

Another asymmetry between skilled and unskilled workers on the supply side is the fact that many unskilled workers are marginal workers, earning hardly more than the reservation wage. Thus, the labour market participation rate among this group of workers is expected to be particularly variable under changing labour market conditions and welfare systems. However, empirical evidence (e.g., in Manacorda and Petrongolo, 1999) seems to rule out divergent labour market participation rates as a factor in explaining the skilled / unskilled disparity.

Turning to the demand side, it is worth noting that the demand for labour is a derived demand (from consumers' demand for products). Therefore, to assess how and why there is a shift in demand from unskilled to skilled workers, it is necessary to examine the composition of the products that an economy produces and the way these products are produced. Since different products have different skill attributes and hence require different combinations of skilled and unskilled labour to produce them, a change in the composition of products will induce a change in relative demand for skilled / unskilled labour. But what causes the product composition to change? One possible answer is the changing consumer taste in favour of skill-intensive products. If this is

the case, then the income elasticity of demand for skill-intensive products should be higher when income is higher. Unfortunately, there seems little empirical research in this area. An alternative explanation of a changing product composition is offered by the international trade argument – it is due to the rationalisation of production on a global scale. To the extent that the production of less skill-intensive products (like many manufactured products) is increasingly being relocated to the developing countries, there is an accompanying reduction in relative demand for unskilled workers in the developed countries.

As regards the way in which the products are produced, even if the composition of products remains unchanged, the composition of demand for skill types can still change if there is a change in the production technology in favour of some particular types of skill. Although the SBTC view has become the dominant explanation of the skilled / unskilled disparity, the empirical evidence that has been produced is not strong enough to really substantiate its dominant position. The empirical evidence mainly comes from the micro (firm) level (e.g., Kaiser, 2001) or a more macro level (e.g., Berman et. al., 1994; Berman et. al., 1998). However, the micro evidence is mainly qualitative and does not provide a measure of the quantitative scale of the shift in demand. The macro evidence is also weak as it relates to the manufacturing sector only, which accounts for a small and still decreasing share of total employment in the developed economies<sup>2</sup>. A convincing evaluation of the main factors requires a more comprehensive coverage of the economic activities and a more coherent framework for integrating the various factors at work.

The present study attempts to combine some of the main factors into a coherent modelling framework, with a rather narrow focus on the impact of technological change on the skilled / unskilled disparity in the context of general equilibrium in the product and labour markets. The next section of the paper examines whether and how technical progress can influence the skill disparity in theory. The section starts by disaggregating the labour market into two skill types – the skilled and the unskilled while maintaining the aggregate product market structure. The paper proceeds to introduce disaggregated product market. Technical change is modelled in the conventional way, i.e., it is treated as an exogenous labour- or capital-saving improvement in the production technology. Both skill-biased and skill-unbiased technical progress is introduced in order to examine their impact on relative demand for skilled labour. The supply-side responses in the labour market are captured through the introduction of alternative wage determination mechanisms. Due to the complexity of analysis, this paper also employs a multi-sector computable general equilibrium model (CGE) of Scotland to simulate the numerical magnitudes of the impacts of technological change on the skilled / unskilled disparities. Section 3 gives a brief introduction to the simulation framework. Section 4 discusses the simulation set-up and results. Section 5 concludes.

It must be made clear that the aim of the present study is rather modest: the main aim is to investigate the mechanisms of how various factors interact and the possible consequences rather than to evaluate the relative importance of each factor.

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<sup>2</sup> In the UK, manufacturing employment only accounts for less than 1/6 of total employment now.

## 2. Theoretical analysis of the impact of technological change on the wage and employment structure

### 2.1. The aggregate case

It is useful to illustrate the possible impact of technical progress on aggregate employment and unemployment to start with. As Blanchard (2000) points out, the impact of an exogenous technical progress on aggregate output and employment is generally ambiguous. Although in a perfectly competitive world, the aggregate supply curve (AS) shifts outward, movements of the aggregate demand curve (AD) depend on how the increase in productivity occurs in the first place. If productivity growth comes from the implementation of major technological breakthroughs, then the AD also shifts outward due to improved consumers' and investors' confidence about the future. In this case, technical progress will lead to an increase in output and employment, and hence a reduction in aggregate unemployment. However, if productivity growth comes from a more efficient use of existing resources (perhaps due to increased international competition), it could lead to the AD shifting inward and thus a fall in output and a rise in unemployment. A very simple model can help to illustrate this case<sup>3</sup>.

Let  $\lambda$  denote an exogenous technical progress (TP),  $E$  the demand for labour in efficiency units,  $L$  the demand for labour in numbers (i.e.,  $L = E/\lambda$ ),  $W$  the wage rate and  $W^e$  the efficiency wage rate (defined to be  $W/\lambda$ ). Then,

$$E = E(W^e) \tag{2.1}$$

Differentiating (2.1) with respect to  $\lambda$ , we obtain,

$$\frac{dL}{d\lambda} = -\frac{E(\epsilon+1)}{\lambda^2} \tag{2.2}$$

where  $\epsilon$  is the elasticity of labour demand. It is obvious that for TP to have a positive impact on employment, it requires  $\epsilon < -1$ , i.e., labour demand must be rather elastic. If, for some reason, labour demand is inelastic, then TP may well increase aggregate unemployment. It must be noted that the elasticity of labour demand is generally endogenous in a general equilibrium context, i.e., it depends on other factors such as the substitution between labour and capital and the product and labour market conditions (e.g., the price elasticity of demand for products). The next section introduces some of the factors as well as skill disaggregation.

### 2.2. Skill disaggregation with aggregate product market and skill “unbiased” technical progress

Let  $V$  denote the aggregate output, which is produced by labour ( $L$ ) and capital ( $K$ ) according to the following CES production function:

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<sup>3</sup> This model follows closely that by McGregor et. al. (2000). However, the present paper corrects an error in the original exposition.

$$V = (aK^{-r} + bL^{-r})^{-1/r} \quad (2.3)$$

where  $r = \frac{1-s}{s}$  and  $\sigma$  denotes the elasticity of substitution between labour and capital.

For illustrative purpose, let TP be of the labour saving (or Harrod neutral) type. For the moment, we introduce TP only in the aggregate production function so that there is no skill bias, i.e., the TP shock will have an equi-proportionate impact on skilled and unskilled workers in the first round. Optimal production decision implies the following derived labour demand function:

$$L = \left( \frac{PbI^{\frac{s-1}{s}}}{P_l} \right) sV \quad (2.4)$$

where P is the product price and  $P_l$  is the aggregate labour price. Taking the natural log of (2.4) and differentiating  $\ln L$  with respect to  $\lambda$ , we obtain:

$$\frac{\partial \ln L}{\partial \lambda} = s \left( \frac{\partial \ln P}{\partial \lambda} - \frac{\partial \ln P_l}{\partial \lambda} \right) + \frac{s-1}{1} + \frac{\partial \ln V}{\partial \lambda} \quad (2.5)$$

It is clear that the sign of (2.5) is generally undetermined. The term in the brackets on the RHS indicates how the price mark-up over wage costs change in response to TP. Even if this term is zero in the long run, how employment is affected depends jointly on how output responds to TP.

To introduce skill disaggregation, let the aggregate demand for labour (L) be a composite of demand for skilled ( $L_s$ ) and unskilled ( $L_u$ ) labour in the following way:

$$L = (gL_s^{-r_1} + dL_u^{-r_1})^{-1/r_1} \quad (2.6)$$

where  $r_1 = \frac{1-s_1}{s_1}$  and  $\sigma_1$  denotes the elasticity of substitution between skilled and unskilled labour. It is again straightforward to derive the demand for skilled and unskilled labour equations:

$$L_s = \left( \frac{Pg}{P_{ls}} \right) s_1 L \quad (2.7)$$

$$L_u = \left( \frac{Pd}{P_{lu}} \right) s_1 L \quad (2.8)$$

Therefore, the relative demand for skilled over unskilled labour can be expressed as:

$$\frac{L_s}{L_u} = \left( \frac{P_{lu}g}{P_{ls}d} \right) s_1 \quad (2.9)$$

Taking the natural log of (2.9) and totally differentiating the log-transformed function, we get,

$$d \ln \left( \frac{L_s}{L_u} \right) = s_1 \left[ d \ln \left( \frac{g}{d} \right) - d \ln \left( \frac{P_{lu}}{P_{ls}} \right) \right] \quad (2.10)$$

The LHS denotes the change in relative demand for skilled over unskilled labour. Following Manacorda and Petrongolo (1999), the term  $d \ln(\frac{g}{d})$  on the RHS can be regarded as a shift in relative demand factors (e.g., an exogenous shift in the production technology in favour of skilled workers). The term  $d \ln(\frac{P_{lu}}{P_{ls}})$  can be regarded as summarising the supply-side responses to the shift in relative demand factors. If the shift in relative demand factors is exactly matched by an offsetting supply-side response, there is no change in the skilled / unskilled disparity. Therefore, if there is a relative shift in demand to skilled labour (an increase in  $\gamma/\delta$ ), (2.10) requires a compensating shift in the relative wage in the opposite direction in favour of the unskilled labour to maintain the employment structure. It is clear that in this framework, following an exogenous shift in relative demand in favour of the skilled, then the skilled / unskilled wage differential and the unskilled / skilled unemployment gap tend to reinforce each other. Moreover, the elasticity of substitution between skilled and unskilled workers ( $\sigma_1$ ) also matters. Given an exogenous shift in demand from unskilled workers to skilled workers, if the supply side adjustment fails to offset the relative demand shift, *ceteris paribus*, the change in relative demand will be higher the higher is the magnitude of  $\sigma_1$ , and *vice versa*. This is not surprising as a high elasticity of substitution between skilled and unskilled workers facilitates the relative demand shift from the unskilled to the skilled. However, a different  $\sigma_1$  will imply different supply constraints of the skilled and unskilled labour and hence different wage adjustments. Therefore, to investigate the impact of  $\sigma_1$  on relative demand changes, we need to examine how the skilled and unskilled wages are determined.

Following Layard, et. al. (1991), the wage function for the skilled takes the double-logarithmic form:

$$\ln P_{ls} = z_s - \theta_s \ln u_s \quad (2.11)$$

where  $\theta_s$  denotes the elasticity of skilled wage with respect to skilled unemployment rate,  $z_s$  wage pressure factors specific to the skilled, and  $u_s$  the skilled unemployment rate. The unskilled wage function takes a similar form. It is straightforward to obtain:

$$\ln\left(\frac{P_{lu}}{P_{ls}}\right) = z_u - z_s + \ln\left(\frac{u_s^{\theta_s}}{u_u^{\theta_u}}\right) \quad (2.12)$$

Thus, (2.10) can be rewritten as:

$$d \ln\left(\frac{L_s}{L_u}\right) = \sigma_1 [d \ln\left(\frac{g}{d}\right) - d(z_u - z_s) - d \ln\left(\frac{u_s^{\theta_s}}{u_u^{\theta_u}}\right)] \quad (2.13)$$

Given a shift in relative demand in favour of the skilled, a high elasticity of substitution between the skilled and the unskilled tends to make both  $d(z_u - z_s)$  and

$d \ln\left(\frac{u_s^{\theta_s}}{u_u^{\theta_u}}\right)$  negative, thus reinforce the demand shift. Therefore, it is concluded that the

skilled / unskilled disparity is positively related to the magnitude of the elasticity of substitution between the two groups of workers.

### 2.3. Skill disaggregation with disaggregated product market and skill “biased” technical progress

Note in the above section that an exogenous skill unbiased TP does not generate any *direct* (i.e., first round) impact on the skilled / unskilled disparity with an aggregate product market, although the ultimate impact depends on how product prices and wages respond to the productivity growth. Before we introduce biased TP, we first examine how unbiased TP interacts with a disaggregated product market to influence the skill disparity. Let  $V_i$  ( $i = 1, 2, \dots, n$ ) denote sectoral outputs and  $L_i$  the sectoral composite demand for labour. Then we can obtain the sectoral demand functions for skilled and unskilled labour as follows:

$$L_{si} = \left( \frac{P_{li} g_i}{P_{lsi}} \right)^{s_1} L_i \quad (2.14)$$

$$L_{ui} = \left( \frac{P_{li} d_i}{P_{lui}} \right)^{s_1} L_i \quad (2.15)$$

Simple algebraic manipulation shows that within sector  $i$ , the skill unbiased TP cannot have any direct impact on the skilled / unskilled disparity. However, the relative demand for skilled (unskilled) workers across different sectors could be affected by the TP shock:

$$\frac{L_{si}}{L_{sj}} = \left( \frac{P_{li}}{P_{lj}} \frac{P_{lsj}}{P_{lsi}} \frac{g_i}{g_j} \right)^{s_1} \left[ \frac{P_i}{P_j} \frac{b_i}{b_j} \left( \frac{I_i}{I_j} \right)^{\frac{s-1}{s}} \frac{P_{lj}}{P_{li}} \right]^s \frac{V_i}{V_j} \quad (2.16)$$

Note in (2.16) that if sectoral productivity growth is unbalanced, then the skilled / unskilled disparity will be affected. Even if TP is balanced across all the sectors (i.e.,  $\lambda_i = \lambda_j$ ), relative demand for skilled labour across sectors could still be affected by TP because  $\lambda$  enters the sectoral production functions ( $V_i$  and  $V_j$ ), unless balanced sectoral productivity growth is associated with balanced sectoral output growth. In a Neo-classical growth model, this is indeed the case and hence no change in the skilled / unskilled disparity could arise in that model. In an imperfectly competitive world, we should expect the skill disparity to be affected by a skill unbiased TP. In this case, TP can only be the triggering off mechanism for any change in the skill disparity. Apart from the imperfectly competitive nature of the product and labour markets, many more factors, including the initial sectoral output and employment shares as well as the initial sectoral distribution of skill types, will contribute to the ultimate impact on skill disparity. It is also expected that TP shocks in different sectors should have different impacts on the skill disparity.

A simple way of introducing a skill biased TP is to allow for unskilled labour saving TP to be present in the sectoral composite labour demand functions. With some algebraic manipulation, the intra-sectoral relative demand for skilled labour over unskilled labour is obtained as follows:



$$\frac{L_{si}}{L_{ui}} = \left( \frac{P_{lui} g_i}{P_{lsi} d_i} \right)^{s_1} I^{1-s_1} \quad (2.17)$$

Thus, the biased TP has a direct impact on the skill disparity. It is straightforward to show that the inter-sectoral demand for skilled (unskilled) labour will also be directly affected by the biased TP. Therefore, compared with a unbiased TP, although the sign of the ultimate impact of a biased TP on skill disparity is still undetermined, the magnitude of the impact is expected to be magnified significantly.

Due to the analytical complexity in combining TP, product market and labour market conditions in a single coherent framework, the study will employ a CGE model of the Scottish economy to simulate the ultimate impact on the skilled / unskilled disparity as a result of skill biased or unbiased TP. The next section briefly discusses the main features of the Scottish CGE model.

### 3. The CGE simulation framework - AMOS<sup>4</sup>

AMOS is a CGE modelling framework parameterised on data from a UK region, Scotland. A very brief description is presented in this section - more detail is available in Harrigan et. al. (1991). AMOS identifies four transactor groups, namely households, corporation and government<sup>5</sup>; three commodities and activities, viz. manufacturing, non-manufacturing traded and sheltered,<sup>6</sup> and two exogenous external transactors (RUK and ROW). Throughout this paper commodity markets are taken to be competitive. We do not explicitly model financial flows, our assumption being that Scotland is a price-taker in competitive UK financial markets.

The AMOS framework allows a high degree of flexibility in the choice of key parameter values, model closures and even aggregate structure. However, a crucial characteristic of the model is that, no matter how it is configured, we impose cost minimisation in production with multi-level production functions, generally of a CES form but with Leontief and Cobb-Douglas being available as special cases. There are four major components of final demand: consumption, investment, government expenditure and exports. Of these, real government expenditure is exogenous. Consumption is a linear homogeneous function of real disposable income. Exports (and imports) are generally determined via an Armington link (Armington, 1969) and are therefore relative-price sensitive. Investment is determined in such a way that the actual capital stock is ultimately adjusted to the desired capital stock, which is compatible with a simple theory of optimal investment behaviour given the assumption of quadratic adjustment costs.

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<sup>4</sup> AMOS is an acronym for a macro-micro model of Scotland.

<sup>5</sup> In AMOS, Scotland is treated as a self-governing economy, in the sense that there is only one consolidated government sector. Central government activity is partitioned to Scotland and combined with local government activity.

<sup>6</sup> Manufacturing comprises sectors 12-89, non-manufacturing traded sectors 1-10, 91-97, 99-102 and 109-111 (mainly banking and financial services, and transport and telecommunication services), sheltered sectors 11, 90 and 98, 103-108 and 112-114 (mainly public services and domestic services) in the 1989 Scottish Input-Output Tables (Scottish Office Industry Department, 1994).

The labour market is disaggregated by skill types using information in the 1990 UK New Earnings Survey<sup>7</sup>. For both skilled and unskilled labour market, we employ two alternative wage determination systems. The first one is a regional bargaining wage curve in which the real consumption wage is directly related to workers' bargaining power, and therefore inversely to the regional unemployment rate (Minford *et al*, 1994). The alternative is a fixed nominal wage system that is compatible with wage bargaining at the national level. Empirical support for the bargained "wage-curve" specification is now widespread, even in a regional context (Blanchflower and Oswald, 1994). The fixed nominal wage system is included for the purpose of illustrating the impact on skill disparity of TP under different labour market settings.

Here we take the bargaining function for each group from the regional econometric work reported by Layard *et al*, (1991) and Nickell and Bell (1995)<sup>8</sup>. The elasticity of skilled (unskilled) wage rate with respect to skilled (unskilled) unemployment rate is taken to be 0.062 (0.054). Where we introduce the Harrod-neutral improvement in technology, labour demand is determined in efficiency units. The number of efficiency units of labour supplied by each worker is increased by the rate of technical improvement. Therefore for any given wage to the worker, the cost of labour to the firm, in efficiency units, is reduced. The bargaining mechanism by which the wage to the worker is determined is not affected by these adjustments.

The main feature that distinguishes the skilled labour from the unskilled labour is that only skilled labour is assumed to be mobile across geographical borders (whilst both types of labour are assumed to be perfectly mobile across industrial sectors)<sup>9</sup>. We take net migration by skilled workers to be positively related to the real wage differential and negatively to the unemployment rate differential between Scottish and RUK skilled workers in accordance with the econometrically estimated equation reported in Layard *et al*. (1991). The migration function is of the form:

$$m = \beta - 0.08(u_s - u_r) + 0.06(w_s - w_r)$$

where:  $m$  is the net in-migration rate (as a proportion of the indigenous population);  $w_r$  and  $u_r$  are the natural logarithms of the real consumption wage and unemployment rates, respectively, in the rest-of-the-UK, and  $\beta$  is a calibrated parameter. Since the paper focuses on the ultimate impact on skill disparity following a shock to TP, the simulations are run over multi periods until the long run equilibrium position (with stable unemployment rates and prices being reached, see McGregor *et al.*, 1996, for a discussion of the long run property of a regional CGE model). In the multi-period simulations the net migration flows in any period are used to update population stocks at the beginning of the next period, in a manner analogous to the updating of the capital stocks. The economy is initially assumed to have zero net migration, and ultimately, net migration flows establish a new population equilibrium where this condition again holds.

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<sup>7</sup> Skilled workers are classified as non-manual workers (both male and female) and unskilled workers as manual workers (again, both gender).

<sup>8</sup> Although the parameters of  $z_s$  and  $z_u$  are calibrated.

<sup>9</sup> This distinction between skilled and unskilled labour is different from the standard treatment that assumes asymmetric skill mobility in the production process, i.e., skilled workers can replace unskilled workers but the substitution cannot run in the opposite direction. The present treatment is perhaps more significant in a regional context than at the national level.

The supply of both types of labour in AMOS is endogenous due to the labour market participation decisions by these workers<sup>10</sup>. For any increase in regional employment over a time period in which population is fixed, 75% comes from the registered unemployed, whilst the remainder is supplied by increases in local labour-market participation. This is the assumption used in official government studies (Alexander and Whyte, 1995). All sectors use a CES production technology with "best guess" elasticities of substitution of 0.3 (Harris, 1989) and Armington trade substitution elasticities of 2.0 (Gibson, 1990). The capital stock adjustment parameter ( $\lambda$ ) is taken to be 0.5 in each sector.<sup>11</sup> The elasticity of substitution parameter is taken from Nickell and Bell (1995) to be 3. Since Manacorda and Petrongolo (1999) argued that Nickell and Bell's estimate is too high and their estimate is unity, a value of 1.01 is also used to check whether there is any difference in the simulation results<sup>12</sup>.

#### 4. Simulation results and discussion

Before we introduce skill biased TP, we examine how unbiased TP interacts with alternative labour market settings to affect the employment and wage structure. By unbiased TP, we mean TP at the top level of production involving aggregate labour and capital inputs. The biased TP in the present context means an exogenous skilled labour-saving TP, i.e., the productivity of skilled workers has increased. It is worth pointing out that the initial skilled / unskilled (real) wage ratio is 1.66 and the initial skilled unemployment rate is just less than 1/3 of the unskilled unemployment rate. In all the simulation results that are presented below, the figures refer to the percentage changes in the gap between unskilled and skilled unemployment rates and the skilled / unskilled wage differential (a negative sign indicates a reduction in the disparity).

##### Simulation 1: Skill unbiased TP with wage bargaining

In the first simulation, we introduce a bargained wage equation for each type of labour. It should be noted that although the bargained wage rate exhibit some level of rigidity in the short run, the wage rates are completely flexible in the long run. Since the results reported are the long run equilibrium results, these are associated with flexible wage adjustment. The simulation results are presented in Table 1.

Table 1. Impact of a 5% across the board unbiased TP on skill disparity

| Type of TP | % change in wage differential | % change in unemployment rate differential |
|------------|-------------------------------|--|
| Harrod     | -0.68                         | -10.51                                     |
| Hicks      | 0.4                           | -17.97                                     |
| Solow      | 0.57                          | -7.09                                      |

<sup>10</sup> No change in the supply of different skill types due to education and training is considered in the present study.

<sup>11</sup> This default value of the adjustment parameters is based on investment equations estimated for the Scottish manufacturing sector. This is, in fact, the only sector in AMOS for which a time series of investment data exists. For other sectors information is available only for the years in which a Scottish I-O table has been constructed.

<sup>12</sup> A CES function excludes the unitary value for the elasticity of substitution.

### Simulation 2: Skill unbiased TP with nominal wage rigidity

In this simulation, we introduce nominal wage rigidity in both types of labour market. Although the reported results are also long run equilibrium results, the long run equilibrium is achieved mainly through quantity rather than (nominal) price adjustment. The simulation results are presented in Table 2.

Table 2. Impact of a 5% across the board unbiased TP on skill disparity

| Type of TP | % change in wage differential | % change in unemployment rate differential |
|------------|-------------------------------|--|
| Harrod     | 0.01                          | 8.73                                       |
| Hicks      | 0.00                          | -31.25                                     |
| Solow      | 0.00                          | -4.89                                      |

From the above two simulations, it is clear that capital-saving TP (that is associated with the Solow and Hicks neutral TP) reduces the disparity in the unemployment rate, particularly when the labour market is inflexible, but tends to increase the wage disparity slightly. A labour-saving TP increases the unemployment rate disparity under nominal rigidity, but reduces it when wages are flexible. A labour-saving TP also tends to reduce the wage disparity with flexible prices.

Clearly a skill unbiased TP, no matter in what form and under two alternative labour market settings, is unlikely to generate the wage and unemployment disparity that is observed in the real world. Below we start to introduce unskilled labour-saving TP. Since the rigid nominal wage system is unlikely to generate the observed wage disparity, we only introduce the bargained wage system. The biased TP is introduced at the bottom level involving substitution between skilled and unskilled labour. The simulation results are reported in Table 3. Note that in the table, “All” refers to a 5% TP across all sectors, “M” a 5% TP in manufacturing, “N” a 5% TP in non-manufacturing traded sector, “S” a 5% TP in the sheltered sector, and “No mig.” a 5% TP across all sectors without any geographic mobility for any type of workers.

Table 3. Impact of a skill 5% biased TP on skill disparity

| Sector  | % change in wage differential | % change in unemployment rate differential |
|---------|-------------------------------|--|
| All     | 0.45                          | 7.57                                       |
| M       | 0.13                          | 2.10                                       |
| N       | 0.06                          | 1.08                                       |
| S       | 0.25                          | 4.21                                       |
| No mig. | 2.08                          | 44.70                                      |

In contrast to unbiased TP, the simulation results of a biased TP seemingly fit empirical evidence in the UK quite well: a rising unemployment differential accompanied by a rising wage differential. Moreover, sectoral specific shocks generate different impacts, with biased TP in the sheltered sector generating the largest increase in disparity and the non-manufacturing traded (NMT) sector the modest increase. Apart from other factors, the initial distribution of skilled and unskilled labour must have contributed to the divergent sectoral impacts. Table 4 presents the initial sectoral distribution of skilled and unskilled labour.

Table 4. Sectoral distribution of skilled and unskilled labour (%)

| Sector | Skilled | Unskilled |
|--------|---------|-----------|
| M      | 8.84    | 35.18     |
| N      | 49.95   | 27.47     |
| S      | 41.21   | 37.35     |
| All    | 100.00  | 100.00    |

It is clear that the sheltered sector has the largest share of unskilled workers and the NMT sector the smallest (largest) share of unskilled (skilled) workers. Since a unskilled labour-saving TP is biased against the unskilled employment, it is no surprise that the sector with the largest concentration of unskilled workers is hit the hardest by the TP shock.

Table 3 also highlights the importance of geographical mobility of labour: without it the disparity in skilled / unskilled unemployment rates and wage rates following a biased TP is even more profound. However, it is worth pointing out that although the percentage increase in disparity seems quite dramatic, the associated increase (or reduction) in percentage point in the unskilled (skilled) unemployment rate is rather limited. Even in the case of no mobility of labour, the unskilled unemployment rate increases from 13% to 14.04% and the skilled unemployment rate reduces from 4% to 3%. Since the modelled economy is a region within a national economy, the assumption of complete immobility of skilled labour is obviously unrealistic. The inclusion of labour mobility will further limit the impact on the percentage point increase (or reduction) in the unskilled (skilled) unemployment rate. Therefore, although a skill biased TP is sufficient to generate the observed disparity in skilled / unskilled disparity in the UK (Scotland), it is difficult to say that it alone can generate the sort of scale in the disparity.

As discussed above, the elasticity of substitution ( $\sigma_1$ ) between the two groups of workers is expected to matter for the simulation results. All the above results are associated with the magnitude of 3 for  $\sigma_1$  as suggested by Nickell and Bell (1995). Below we use a magnitude of 1.01 and re-run the simulation of a 5% TP across the board. It turns out that the impact on the skilled / unskilled disparity is reversed compared with the case as reported in Table 3 above: now the wage differential is reduced by 0.44% and the unemployment rate differential is reduced by 6.83%. Therefore, these simulation results cast further doubt on the SBTC explanation of the skilled / unskilled disparity.

## 5. Concluding remarks

There have been a number of explanations of the increased disparity between unskilled and skilled unemployment rates and / or between skilled and unskilled wage rates. The SBTC explanation has been accepted by many analysts as the dominant explanation, although the empirical evidence is rather limited in lending support for this explanation. Our CGE simulation results do lend some support to the SBTC argument. However, the impact on skill disparity is of such a limited magnitude that it is unlikely to have generated the extent of the disparity as has been observed in the real world on its own. The SBTC explanation will be further weakened if the elasticity of substitution between the skilled and the unskilled is low. Moreover, since 1992, empirical evidence from the UK General Household Survey (not shown here)

seems to show a steady fall in both the unemployment rate gap and the wage differential in the UK until mid-1990s. It is highly unlikely that the SBTC suddenly reversed the direction of impact, unless there is a change (a reduction) in the elasticity of substitution between skilled and unskilled workers. Given the sustained economic growth since 1992 and the associated general improvement in the labour market conditions, the substitution between skilled and unskilled labour may have become more limited. If this is the case, then SBTC is still consistent with the recent fall in the skilled / unskilled disparity in the UK. It is worth mentioning, however, that this consistency cannot be maintained without the required change in the labour market.

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