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TECHNICAL CHANGE AND UNEMPLOYMENT: POLICY RESPONSES AND DISTRIBUTIONAL CONSIDERATIONS

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Abstract

We analyze some macroeconomic implications that follow from the fact that people tend to consume higher-quality goods as their incomes rise. The model involves two sectors: one producing a homogeneous good and the other producing a product with variable levels of quality. Both sectors use skilled and unskilled labour, but higher quality varieties of the differentiated good are more skilled-labour intensive. The skilled-tounskilled wage ratio is fixed at a level sufficiently low that some unskilled workersremain unemployed. We show that uniform (across sectors), Hicks-neutral technological progress must increase the unemployment rate. We then discuss a number of policy responses (tax cuts, direct government employment of the unskilled, employment subsidies to firms for hiring the unskilled, increased generosity of unemployment insurance) under different scenarios concerning how the government finances these initiatives. Political economy consequences are emphasized, as we assess each policy's chance of receiving political support from skilled workers. We conclude that a subsidy for the employment of unskilled workers, financed by a rise in the employer payroll tax rate associated with skilled workers is a viable policy option.

JEL Classification: E60, J18, J31, J38.

Keywords: technical change, vertical product differentiation, unemployment income distribution.

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1. Introduction

One of the well-known facts of the last two decades has been the worsening wage and employment prospects for lower-skilled groups in most OECD countries. In the United States and in the United Kingdom the worsening prospects have taken the form of decreases in the real earnings of lower-skill workers: the real hourly wages of young males with 12 or fewer years of schooling has dropped by more than 20 percent in the last two decades. In continental Europe real wages at the bottom of the skill distribution have risen, but at the cost of a significant increase in unemployment for this group, especially relative to the United States (Krugman (1995), Freeman (1995)) and to the unemployment rate for higher-skill workers. Alogoskoufis et al (1995, p.50) report that whereas at the beginning of the 1980's the ratio of the unemployment rates of unskilled to skilled workers was 1.9 in France and 2.9 in Germany, by the start of the 1990's the corresponding ratios were 3.5, and 3.4 respectively. The main explanation for the different experiences across the Atlantic is institutional: in the United States flexible real wages absorb the downward shifts of the labour demand curve, whereas in continental Europe rigid real wages result in higher unemployment[1].

Most of the research effort during the last decade has focused on identifying the causes of the reduction in the demand for less-skilled workers. The initial response of many commentators was to link this development to increased trade exposure with low-wage countries, both as a source of imports and as hosts for foreign investors. The response of most trade economists has been that trade between the North and the South is still too small to have had a significant effect on Northern labour markets (for an opposite

view, see Wood (1994) and Leamer (1998)). The favoured explanation regarding the causes of these changes is skill-biased technological change which has improved the wage and employment prospects of relatively skilled workers, while simultaneously damaging the wage and employment prospects of less skilled workers (see, for example, Juhn et al (1993), Berman et al (1997), and Machin and Van Reenen (1998)). Indeed, Aghion and Howitt (1998, p. 299) state that "if technological change is to generate an increase in wage inequality, it must be because technological change is biased toward certain skills or specializations, in the sense that it reveals and enhances new differences in abilities among workers across or within educational cohorts." However, Moutos (2000) has demonstrated that technological change need not be biased in order to generate increases in wage inequality. In the context of a two-sector general equilibrium model he showed that even a technological improvement that is not skill-biased can cause an increase in the skill premium. In the present paper we show that if the skill premium is constant (an assumption approximating the situation of many Western European countries), then neutral technological progress can result in an increase in the unemployment rate for the less-skilled.

The intuition behind this and other results (reported below) is most easily appreciated by considering an economy with two goods – luxuries and necessities – and two factors – skilled and unskilled labour. With a Stone-Geary utility function involving a positive required level of consumption for necessities but not luxuries, standard Engel curves are involved. As individuals become richer, they switch demand toward luxuries. With Cobb-Douglas production functions for both goods, with skilled labour the factor

[1] Gregg and Manning (1997) have raised some doubts regarding the importance of labour market institutions in explaining the differences in labour market outcomes across the Atlantic. They argue that

that is used relatively intensively in the production of luxuries, and with labour market institutions that limit a fall in the relative price of unskilled labour, the switch toward luxuries raises unemployment among the unskilled. Neutral technical progress is one development that raises peoples' incomes, so it increases unemployment.

We suspect that most economists would be comfortable with two, but not all three, of the assumptions that underlie the scenario sketched in the previous paragraph. Evidence confirms that the income elasticity of luxuries exceeds that for necessities (see, for example, Deaton and Muellbauer (1980)), and that there are many rigidities in labour markets that limit factor price changes (see, for example, Bean (1994)). However, we think that it would be far easier to defend the proposition that high-quality goods are more skilled-labour intensive than low-quality goods – than the proposition that necessities are less skilled-labour intensive than luxuries[2]. It is more difficult to derive results in this setting, but that is the purpose of the paper. By focusing on the quality dimension below, we do not need to introduce varying income elasticities of demand. Moreover, we do not need to assume that the sector producing necessities is less skilled-labour intensive than the sector producing luxuries. With the focus no longer being on the necessity-luxury distinction, we can simplify by assuming a Cobb-Douglas, not Stone-Geary, utility function. Also, since it is easier to specify varying quality within a Leontief-type production function, we adopt such a specification, instead of the Cobb-Douglas, for one of the two industries. That sector produces a vertically differentiated good, and higher quality varieties of that good are more skilled-labour intensive than lower quality varieties. An increase in real incomes (due to either higher productivity or

differences in education policies have played a far greater role in shaping outcomes.

lower taxes) generates increased demand for higher quality varieties and therefore results in a decrease in the (relative) demand for less-skilled workers. The resulting increase in the unemployment rate for these workers is thus caused not by changes in relative marginal products but by a product demand shift towards higher quality varieties.

In addition to inquiring about the effects of technological change and general tax reductions, we examine whether there exist policy options which can ameliorate the adverse employment effects of these developments. We consider employment subsidies to firms for hiring less-skilled workers, and changes in both unemployment insurance generosity and direct government employment of less-skilled workers. In all cases we examine different ways in which the government adjusts other instruments under its control so as to keep the government budget in balance. (For a similar approach to a related set of questions, see Sorensen (1997).) Only one policy succeeds in reducing the unemployment rate without reducing (significantly) either the incomes of those working or of those that remain unemployed. That policy is a subsidy paid to firms for employing unskilled labour – financed by a payroll tax levied on firms that is proportional to their wage bill paid to skilled workers.[3]

In the remainder of the paper, we present the model (section 2), define the equilibrium relationships (section 3) and then we derive the main policy implications of the analysis (section 4). The final section offers some concluding comments.

[2]In fact, one industry which may be regarded as producing a necessity is the petroleum industry, and this may be the most skill-intensive industry of all (see Leamer and Thornberg (2000)).

2. The Model

We assume a closed economy which produces and consumes two goods (X and Y) with the use of skilled labour (S) and unskilled labour (L). We assume that perfect competition prevails in the market for both goods. We also assume that for any number of reasons (trade unions, government regulations, social conventions) the relative wage between the two groups of workers is kept constant at a level which results in unemployment for unskilled workers. Although this is a very crude characterization of labour markets, we adopt it for reasons of tractability and because it matches with the apparent lack of a trend in the skill premium in most European countries.

2.1 Production

Good X is a homogeneous good produced under constant returns to scale,

$$X = AS_X^{\alpha} L_X^{1-\alpha}, \qquad 0 < \alpha < 1 \tag{1}$$

with parameter A reflecting the state of technological knowledge. The cost minimizing factor demands for skilled (S_x) and unskilled labour (L_x) corresponding to the above production function are

$$S_X = \left(\frac{w(1-v)}{r(1+\tau)}\right)^{1-\alpha} \left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha} X / A \tag{2}$$

$$L_X = \left(\frac{w(1-v)}{r(1+\tau)}\right)^{-\alpha} \left(\frac{\alpha}{1-\alpha}\right)^{-\alpha} X / A \tag{3}$$

[3] This policy has also received support in a small open-economy model involving variability in the relative wage of skilled workers, and an efficiency-wage rationale for unemployment within this group (Scarth (1997)).

where w is the wage of unskilled labour, r is the wage of skilled labour, τ is a (proportional to the skilled wage rate) payroll tax payable by the firm for the employment of skilled workers and v is a (proportional to the wage) subsidy for the employment of unskilled labour. (For ease of exposition, we have set all other employment-related taxes equal to zero). The average cost function corresponding to equation (1) is

$$AC_X = P_X = \left(\frac{w(1-v)}{1-\alpha}\right)^{1-\alpha}\left(\frac{r(1+\tau)}{\alpha}\right)^{1-\alpha} / A\,. \tag{4}$$

The assumption of perfect competition ensures that the price of good X, P_x, is equal to average cost.

Good Y is a vertically differentiated good which can be produced by all firms at various quality levels. We assume that quality is measured by an index Q, and that there is complete information regarding quality. We further assume that average costs depend on quality and that, for any given quality level, average cost is independent of the number of units produced. These assumptions can be captured by the following Leontief-type production function[4]

$$Y_Q = A \cdot \min\left(S_Y / \gamma Q, L_Y / \delta\right). \tag{5}$$

In equation (5), Y_Q denotes the number of units of quality Q produced, A is the same productivity parameter as in equation (1), S_Y stands for the employment of skilled workers, L_Y denotes employment of unskilled workers, and γ and δ are Leontief input-requirement coefficients. This specification of production technology implies that as quality increases, more units of skilled labour are required to produce each unit of the Y

[4] The assumption of fixed-coefficient technology necessitates the existence of another sector in which factor use depends on factor prices. Otherwise the ratio of factor prices would be indeterminate. Flam and Helpman (1987) use a similar functional form for the influence of quality on labour requirements, with only one type of labour.

good. This assumption is consistent with the fact that increases in quality – for a given state of technological capability – involve the employment of a larger number of personnel not only for the production of a higher number of features attached to each good (such as electric windows, air bags and ABS in the case of automobiles) that directly absorb skilled labour, but also to the development and refinement of these features. By contrast the number of units of unskilled labour required to produce a unit of the good is independent of quality and equal to δA^{-1}. This specification is the simplest that can capture the idea that the number of unskilled workers employed (for example, cleaners, security guards, clerks, drivers of merchandise, workers doing simple assembly operations) is to a large extent independent of the quality of the good. In any case, all that is needed for the results of this paper, is that higher quality varieties of the *Y* good require a higher proportion of skilled to unskilled labour than lower quality varieties[5]. This implies that a production function of the type $Y_Q = A\min(S_Y / \gamma Q^{\varepsilon}, L_Y / \delta Q^{\lambda})$ would generate the same results, as long as, $\varepsilon > \lambda$.

Equation (5) implies that the (average cost and) price at which each variety of good *Y* will be offered is

$$P(Q) = (r(1+\tau)\gamma Q + w(1-v)\delta)/A. \qquad (6)$$

We note that the wage subsidy for the employment of unskilled labour is given to both *X* and *Y* producing firms.

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[5] The assumption of zero substitutability between skilled and unskilled labour in this sector is rather extreme. However, when it is matched with our assumption that the elasticity of substitution is equal to unity in the homogeneous good sector, it results in an economy-wide elasticity of substitution between zero and unity, which is consistent with the empirical evidence (Hammermesh (1993)). Moreover, most studies

2.2 Preferences

All households are assumed to have identical preferences, and to be endowed with either one unit of skilled or one unit of unskilled labour, which they supply inelastically. Following Flam and Helpman (1987) we assume that the homogeneous good is divisible, whereas the quality-differentiated product is indivisible and households can consume only one unit of it. Households are assumed to choose the quantity they want to consume of the homogeneous product (C) and the quality level of the differentiated good (Q) by solving the following problem

$$\max\ U = C^{1-\mu}Q^{\mu} \qquad \text{subject to } P_X C + P(Q) = m \tag{7}$$

where $m = r(1\text{-}t)$ in the case of households (consumers) owning one unit of skilled labour, $m = w(1\text{-}t)$ in the case of working households owning one unit of unskilled labour and $m = \phi w(1\text{-}t)$ in the case of unemployed (unskilled) households. In the above definitions of income for the three groups of households, t stands for the proportional tax rate and ϕ (<1) is a policy parameter (the replacement rate) determining the proportion of unskilled labour wages that are given as unemployment benefits to unemployed workers. Note that although the price P_x remains constant no matter how much the individual household consumes of good X, the price "per unit of the quality index" $P(Q)/Q$ which the consumer pays for the other good is not constant. Nevertheless, the household knows the exact correspondence between quality and price. All perfectly competitive firms are assumed to announce to the households a price list linking quality to price as given by equation (6).

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dealing with the issue of increased earnings inequality assume that it is less than unity (see, Wood (1994, p. 132), Cline (1997, p. 163), and Sachs and Shatz (1998, p. 233)).

The budget constraint faced by the household is non-linear in this case, with $P(Q)/Q$ being a decreasing function of Q.[6]

The demand functions for each type of household (skilled, unskilled employed and unskilled unemployed) arising from optimization (7) are

$$Q_S = [r(1-t) - w(1-v)\delta A^{-1}]A\mu/[r(1+\tau)\gamma] \quad (8)$$

$$Q_L = [w(1-t) - w(1-v)\delta A^{-1}]A\mu/[r(1+\tau)\gamma] \quad (9)$$

$$Q_U = [\phi w - w(1-v)\delta A^{-1}]A\mu/[r(1+\tau)\gamma] \quad (10)$$

$$C_S = [r(1-t) - w(1-v)\delta A^{-1}](1-\mu)/P_X \quad (11)$$

$$C_L = [w(1-t) - w(1-v)\delta A^{-1}](1-\mu)/P_X \quad (12)$$

$$C_U = [\phi w - w(1-v)\delta A^{-1}](1-\mu)/P_X \quad (13)$$

Assuming that positive "amounts" of quantity and quality are chosen, we must impose the restrictions that $r(1-t) - w(1-v)\delta A^{-1} > 0$, $w(1-t) - w(1-v)\delta A^{-1} > 0$ and $\phi w(1-t) - w(1-v)\delta A^{-1} > 0$. These conditions hold as long as the initial productivity level enables (even the unskilled) workers to afford the lowest quality at which the differentiated good can be produced.[7]

2.3 Labour Market

The easiest way to generate unemployment in this model is to assume that the wages of the unskilled are kept at a constant fraction of skilled wages:

[6] If the skilled labour required to produce one unit of quality Q is equal to γQ^{ε}, $\varepsilon > 1$, then $P(Q)/Q$ could be an increasing function of Q. We have verified that the qualitative nature of our results remains unaffected by such a change.

[7] The assumption that unskilled workers cannot afford the lowest quality at which the differentiated good can be offered may be more suitable as a description of the situation in many developing countries. Introducing such features into the model may be a worthwhile extension of the present paper.

$$w = \theta r \,. \tag{14}$$

This relative wage rigidity may be thought of as a consequence of wage compression by trade unions, or it may be the result of "fair wage" considerations by firms intent on minimizing the cost per efficiency unit of labour (see, Akerlof and Yellen (1990)). Experimental evidence (Fehr et al. (1993)) and field surveys (Agell and Lundborg (1999)), suggest that behaviour is indeed strongly influenced by notions of fairness. It is thus likely that unskilled workers compare their wages to those of skilled workers and firms abstain from reducing the (relative) wage of the unskilled even when there is an excess supply of them[8].

From equations (3) and (14) we get that

$$L_X = \left(\frac{\theta(1-v)}{1+\tau}\right)^{-\alpha}\left(\frac{\alpha}{1-\alpha}\right)^{-\alpha} X / A \,. \tag{15}$$

Equation (15) makes clear that if θ is kept artificially high, then the demand for unskilled labour in the homogeneous goods sector may be less than the difference between unskilled labour supply and employment in the differentiated goods sector. (Note that employment in the differentiated goods sector would not respond to changes in relative factor prices, even if they occurred.)

In addition to employment in the *X* and *Y* sectors, we introduce the possibility that the government employs unskilled labour. Letting *G* denote government employment of unskilled labour, *u* be the unemployment rate among the unskilled portion of the population, and (as above) *L* be the (fixed) supply of unskilled labour, we define the

[8] An alternative way to model the labour market would be to posit a "wage curve" (Blanchflower and Oswald (1994)) relationship between the relative wage rate and the relative unemployment rate. This change would temper the (unskilled) unemployment rate effects of neutral technological change that are derived below, but the main thrust of our analysis would remain unaltered.

employment of unskilled workers, (1-*u*)*L*, as the sum of employment in the *X* and *Y* sectors (L_X and L_Y) and government employment:

$$(1-u)L = L_X + [\delta(L+S)/A] + G\,. \qquad (16)$$

Note that since all households are assumed to consume just one unit of the vertically differentiated good, the aggregate demand (in terms of physical units) for these goods is equal to $L + S$ (where S is the (fixed) supply of skilled labour), and the aggregate demand for unskilled labour by firms in this sector is equal to $\delta A^{-1}(L+S)$.

2.4 Government

The government is assumed to finance its unemployment benefit payments, government employment expenditure and subsidies to private sector firms for the employment of unskilled workers with a proportional income tax on the incomes of employed workers and a payroll tax on skilled workers (payable by employers). The government budget constraint is thus specified as

$$t((1-u)wL + rS) + \tau rS = vw((1-u)L - G) + wG + \phi wuL\,. \qquad (17)$$

We assume that the wages paid by the government to unskilled workers are equal to those paid by private sector firms. One interpretation could be that the government acts as a leader in the determination of the unskilled wage (possibly through minimum wage legislation which is indexed to the skilled wage). Within this interpretation, it can be assumed that (due to efficiency-wage considerations) firms find it costly to deviate from this norm. In what follows we will first assume that the government keeps its budget balanced by adjusting the payroll tax rate for skilled workers (that is, by changing parameter τ).

3. Equilibrium

One equation defining equilibrium in the market for the homogeneous good X is

$$X = C_S S + C_L(1-u)L + C_U uL\,. \tag{18}$$

With respect to good Y, equations (8), (9) and (10) determine the three "market clearing" varieties (identified by Q_S, Q_L and Q_u) of the good that will be produced in equilibrium. The number of units produced and consumed of each variety will be equal to the number of skilled, employed unskilled and unemployed unskilled individuals, respectively.

The conditions describing equilibrium in the market for skilled labour can then be written as

$$S = S_X + (\gamma Q_S^{\varepsilon} S/A) + (\gamma Q_L^{\varepsilon}(1-u)L/A) + (\gamma Q_U^{\varepsilon} uL/A) \tag{19}$$

where γQ_i^{ε}, $i = S, L, U$, denotes the number of units of labour required to produce the quality level demanded by the three types of households.

The model (equations (2), (3), (4), (6), (8), (9), (10), (11), (12), (13), (14), (16) or (19), (17) and (18)) can be solved to determine Q_S, Q_L, Q_U, C_S, C_L, C_U, X, S_X, L_X, w, r, $P(Q)$, u and one of the government controlled variables (t, v, τ, ϕ, G). Since this is a real model, determining only relative prices, one absolute price must be chosen as the numeraire. We set P_X equal to unity. Since all budget constraints (both private and public) are satisfied, Walras' Law implies that one of equations (16) and (19), which define equilibrium in the labour markets, is redundant. Given our interest in the determination of the unemployment rate of unskilled workers and the after-tax real incomes of skilled, employed and unemployed unskilled workers we collapse the model (through successive substitutions) to two equations determining the unemployment rate

and the residually determined government policy variable. To this purpose, we first use equations (4), (6), (8), (9) and (10) to substitute for Q_S, Q_L and Q_u (respectively) in equation (19). Then we use equations (11), (12), (13), and (18) to substitute for X in equation (2). The value for S_X is then inserted into equation (19) to get

$$S = [(1 - t - \theta\delta(1 - v)A^{-1})S + \theta(1 - t - \delta(1 - v)A^{-1})(1 - u)L + \theta(\phi - \delta(1 - v)A^{-1})uL] \cdot$$
$$B/(1 + \tau) \qquad (20)$$

where $B = \alpha(1 - \mu) + \mu$.

Equation (20) and the government budget constraint (equation (17)) determine the unemployment rate of unskilled workers u, and one of the policy variables.

4. Analysis

4.1 The Effects of Technological Change

We start the analysis by assuming that the government adjusts the employer payroll tax rate for skilled workers (τ) to keep its budget in balance. From equations (17) and (20) we find that

$$du / dA = L_Y / AL > 0, \qquad (21)$$

which states that an increase in A (the index of technology) causes an increase in the unemployment rate of unskilled workers. This outcome occurs because increased productivity results in an increase in real wages (for both skilled and unskilled workers) and this, in turn, induces households to demand more (physical) units of the homogeneous good, and higher quality varieties of the vertically differentiated product[9].

[9] A possible objection to the empirical plausibility of this line of argument may focus on the fact that the demand for services increases faster than income, and the presumption that the production of services makes (relatively) intensive use of unskilled labour. Although this may well be true for certain types of

As is evident from equations (2) and (3), this change in the production level of the homogeneous good cannot affect the relative demand for skilled versus unskilled labour. Nevertheless, the switch to higher quality varieties in the other sector causes an increase in the demand for skilled workers. The resulting increase in the relative demand for skilled labour overall would result in an increase in the relative price of skilled to unskilled labour (a rise in the r/w ratio) if this relative price were not fixed. The fall in the relative price of unskilled labour would induce firms in the homogeneous goods sector to combine the same number of unskilled workers with fewer skilled ones – as skilled workers are released from this sector to produce the higher quality varieties demanded by the consumers. However, with the r/w ratio fixed, as skilled labour is released from the homogeneous good sector in order to satisfy the increased demand for skilled labour in the differentiated goods sector, firms in the homogeneous goods sector (who wish to maintain relative factor use intact), will also release unskilled labour which will not be absorbed by the other sector. The resulting increase in the unemployment rate (and unemployment benefit payments) then necessitates a fiscal adjustment (in this case, in the form of an increase in the employer payroll tax rate for skilled workers).

While the model is simplified, it is tempting to consider its quantitative implications. In recent years, all European economies have witnessed both technological progress and changes in the composition of their labour force. In particular, the ratio of

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services (like personal services), it is not true for other types of services (like business services, such as insurance, finance, accounting, marketing, engineering, or design). In fact, Esping-Andersen (1999, p.109) shows that for Germany, Sweden, and the United States the percentage increase in the employment of professional and technical staff was far larger than the percentage change in the employment of unskilled staff in the service sector. In addition, even if the demand for some services is growing very fast and even if the production of these services uses unskilled labour intensively, Oulton (2001) has argued that many of the fastest growing services - particularly financial and business services, transport and communications, and distributive trades - produce intermediate products (that enter the production relationship for both

skilled labour relative to unskilled has increased (through increased opportunities for education)[10] . Within our setting of a constant aggregate labour force, we capture this shift toward increased skills by considering the effect of an increase in the supply of skilled labour which is equal to the reduction in the supply of unskilled labour: $dS = -dL$. We find the effect on the unemployment rate to be

$$du / dS\big|_{dS=-dL} = (B(1-\theta(1-ut))-1)/\theta BL < 0. \qquad (22)$$

To illustrate the quantitative implications of the model, we assume the following (initial) parameter values: $A = L = S = 1$, $L_Y = 0.4$, $u = 0.1$, $t = 0.3$, $\theta = 0.5$, $B = 0.75$ ($\alpha = \mu = 0.5$ is a set of values which make $B = 0.75$). These assumptions imply that the economy contains an equal number of skilled and unskilled individuals, that 40 percent of the unskilled are employed in the sector producing the homogeneous good, 40 percent are employed in the differentiated goods sector, that the unemployment rate for the country as a whole is 5 percent (10 percent of the unskilled labour force), that the proportion of the unskilled that are employed by the government is 10 percent, and that the unskilled wage rate is half that received by skilled workers.[11]

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luxuries and necessities). It is for this reason that we stress the quality dimension of all goods in this paper.

[10] Note that it is possible to have changes in the composition of the labour force, even if the skill premium (relative wage) is held constant. Gregg and Manning (1997) argue that government education policy (by making rationing less severe) has produced changes in the composition of the labour force in the UK that far exceeded changes attributable to market forces. Another channel through which changes in the composition of the labour force can take place is immigration (see, for example, Schmidt et al. (1994) and Fuest and Thum (2001) who analyze models in which immigrants are unskilled). Within our framework, immigration of unskilled workers will result in an increase in the unemployment rate.

[11] Regarding these parameter values we note that the most important ones regarding the quantitative implications of the model are the relative size of skilled and unskilled workers in the population and the relative wage rate. There does not appear to be an agreed upon value in the literature for either these parameters, perhaps because 'skill' is not a uni-dimensional and measurable characteristic, of which some workers possess more than others, and of which some activities require more than others. If we define skilled workers as those with substantial post-secondary school education, then the evidence suggests that in OECD countries the ratio of skilled workers in the labour force is more than 40 percent, and that the unskilled to skilled wage ratio is close to 0.5 (see, Wood (1994)).

What expressions (21) and (22) reveal is that, if (say over a ten year period) the cumulative productivity increase were 20%, an increase in the share of the labour force that is skilled of 5% would be required to keep the unemployment rate constant. Alternatively, if the change in the composition of the labour force during this period were only 4%, the same productivity increase would result in an increase in the unemployment rate for the unskilled by about 1.6 percentage points. (An alternative way of summarizing this outcome is to note that the economy-wide unemployment rate would increase from 5% to 5.8%.) We find it reassuring that the model generates plausible outcomes of this sort. The reader can readily verify that model-consistent changes in the parameter values do not produce large variations in the quantitative implications presented above. As a result, we proceed to use the model to consider other developments and policy reactions.

4.2 A Balanced-Budget Cut in the Size of Government

The return to higher productivity growth is not the only significant development in recent years. We have also witnessed increased pressure for reductions in the size of government. Many European governments have been scaled back (as a proportion of GDP) in the face of this pressure. We model this response as a balanced-budget cut in government employment of unskilled workers and in the income tax rate. By replacing the payroll tax rate (with the income tax rate) as the variable which adjusts to keep the budget in balance, we find that

$$du / dG = -1 / L < 0 \tag{23}$$

$$dt / dG = [\theta(1 - t - \phi)(1 + \tau)] / [(1 - u)L\theta + S] > 0 \tag{24}$$

These results indicate that a cut in the government's employment of unskilled workers (matched by an income tax cut) generates higher unemployment. If this is a policy designed to help the better-off, then our model supports such an initiative. Using the price of the homogeneous good as the numeraire, we can calculate the change in the after-tax incomes of the different households. From equations (4) and (14) we find that the wages of the skilled and unskilled are not affected. This fact implies that after-tax real wages for both groups of workers (in terms of the numeraire good) rise, while the similar measure for the unemployed remains the same. Further, using equation (6) we can calculate the effects of the policy on real (after-tax) incomes in terms of the differentiated good. Since the price (schedule) of this good is unaffected by this policy, we conclude that all those that remain employed gain whereas those that were already unemployed do not lose. If we leave aside the possible negative effects of reductions in government employment (arising from the associated reduction in the provision of public goods) on household utility, it appears that the median-voter would support (and has indeed supported) this policy.

4.3 Increases in Government Employment

From the above it appears that increases in government employment of unskilled workers is a policy that can reduce unemployment. However, as noted, such a policy would receive very little political support if it were accompanied by income tax increases. For this reason, we now examine whether increases in government employment which are financed by increases in the employer payroll tax rate for skilled workers can prove more palatable to the electorate. We find that

$$du / dG = -1 / BL < 0 \tag{25}$$

$$d\tau / dG = \theta(1 - t - \phi) / S > 0 \tag{26}$$

Result (25) implies that increases in government employment financed by payroll tax increases on the skilled reduce the unemployment rate by more than if they are financed by income tax hikes. This is understandable, since the rise in the payroll tax rate for the skilled makes the relative cost of skilled workers to the firms in the homogeneous good sector higher, so they respond by increasing their employment of unskilled workers. However, as before, this policy is not likely to find many supporters in the electorate. It results in lower (after-tax) real incomes for all households (except for those that shift from being unemployed to being employed). This can be readily verified by using equations (4), (6) and (26) to calculate first the change in absolute wages, and then the change in real wages in terms of both goods.

4.4 Increasing the Generosity of Unemployment Insurance

Given that productivity growth raises unemployment in this model, and given the undesirable effects of the policies just examined – especially on the incomes of those that remain unemployed – it is worth considering an initiative that can make unemployment less costly. We thus consider the effects of an increase in the replacement rate (ϕ) which is financed by a rise in the payroll tax rate on skilled workers. We find that

$$du / d\phi = (B - 1)u / B(1 - v) < 0 \tag{27}$$

$$d\tau / d\phi = u\theta L / S > 0\,. \tag{28}$$

Although result (27) looks surprising (increasing unemployment benefits reduces unemployment), it can be easily explained.[12] It is caused by the fall in the relative price of unskilled labour which the firms face as a result of the rise in the payroll tax rate which firms pay when employing skilled workers. As can readily be verified from equations (4), (6), and (28), this policy results in a decline in the incomes of both skilled and unskilled (employed) workers. It can also be verified that the real income of those that remain unemployed rises since the rise in the replacement rate in the unemployment insurance system more than makes up for the drop in the real wage that individuals earn while working.[13] Nevertheless, since the employed are much more numerous, this policy initiative has the same disadvantage as those considered earlier – it will not achieve political support.

4.5 Employment Subsidies

Among the various policy proposals aiming at reducing the cost of employing less-skilled workers that have appeared in the literature (see, for example, Dreze and Malinvaud (1994), Phelps (1997), Solow (1998), Wood (1994)) we examine the effects of a targeted employment subsidy. We assume that this subsidy for the employment of unskilled workers is financed by a higher payroll tax rate for skilled workers. This ensures that the relative cost faced by firms for hiring unskilled workers falls, and that firms in the homogeneous good sector respond by increasing their employment of

[12] In a more elaborate model of unemployment determination, Atkinson (1999) has also demonstrated that unemployment benefit cuts may have effects opposite to what is commonly supposed.

[13] From the above one may surmise that if the rise in unemployment benefit payments is financed through an increase in the income tax rate, there would be no change in the unemployment rate. This is indeed the case.

unskilled workers. The effects of this policy on the unemployment rate and the payroll tax rate are found to be

$$du/dv = [(B-1)L_Y - L_X]/BL(1-v) < 0 \tag{29}$$

$$d\tau/dv = [(1-t-\phi)L_X + (1-v)L_Y]\theta/S(1-v) > 0 \tag{30}$$

This policy comes closest to being an all-winning one. This is probably because it aims to directly intervene and correct a distortion at source – by lowering the relative price of unskilled labour faced by firms. From equations (4), (6) and (30) we can calculate the effects on the real incomes of all groups – skilled workers, unskilled workers, and the (unskilled) unemployed. It is left for the reader to verify that the expressions are of ambiguous sign – real wages rise in terms of one good and they fall in terms of the other. For this reason we proceed to explicitly calculate welfare changes on the basis of our adopted utility function. To this purpose, we first calculate the indirect utility function corresponding to each group, and then we derive the effects of the subsidy on utility (taking into account that higher subsidies necessitate higher payroll taxes). The resulting percentage change in utility, V, for each group as a result of a subsidy is equal to

$$\begin{aligned}(dV/V)/dv = &-B\theta[(1-t-\phi)L_X + (1-v)L_Y]/[S(1-v)(1+\tau)] \\ &+ [(1-\mu)(1-\alpha)/(1-v)] + \theta L_Y/[(1-t)(L+S) - \theta L_Y(1-v)]\end{aligned} \tag{31}$$

We note that the percentage change in utility is equal for all groups, since relative wages, the replacement ratio, and the income tax rate are constant, and the utility functions are homogeneous. To illustrate, we use the same set of parameter values that was listed in section 4.1. We find that an employment subsidy involving government funds equal to one percent of GDP (which, with the assumed parameter values, requires dv = 0.03) generates an increase in utility (for all groups) of about two-thirds of one percentage

point, and a decrease in the unemployment rate among the unskilled of about two percentage points. (The economy-wide unemployment rate would be reduced by one percentage point). We note that such an initiative (in terms of funds committed) is equal to the amount that many European countries spent in 1987 on active labour market policies (Layard et al (1991, p. 479)). Also, it is worth noting that – as is easily seen from equation (31) – the significance of the effect on the unemployment rate is independent of the chosen parameter values.

Are the beneficial (and – under any set of plausible parameter values – significant) effects on unemployment of this policy always accompanied by non-negative effects on household utility? Equation (31) indicates that the answer is no. Nevertheless, extensive sensitivity testing with a wide-variety of model-consistent parameter values indicates that all plausible calibrations generate either positive (and sometimes significant) effects of subsidies on utility or very small negative ones. For example, reducing the proportion of skilled individuals to one-third of the labour force (L=1, S=0.5) still results in an increase in utility for every group. (The magnitude in this case is about one-sixth of a percentage point, and this follows from dv=0.02 – since this assumption is required with this set of parameter values to retain total spending on subsidies equal to one percent of GDP.) We have considered even lower values (one-fifth) for the share of skilled individuals in the labour force (L=1, S=0.25). This is a rather an extreme parameterization for OECD countries, and one that requires a value of w/r (=θ) of 0.35 to ensure that the rest of the parameter values are model-consistent and reasonable. In this case, the employment subsidy results in a decline in household utility of less than a tenth of a percentage point. The reader can change the parameter values in

other dimensions and verify that any set of plausible parameter values results in either (possibly significant) increases in household utility or very small (less than a tenth of a percentage point) decreases in it. Consequently, subsidies to unskilled labour appear to have significant benefits without any serious costs – since no group has an interest in voting against it. Thus, our analysis supports employment subsidies for the less skilled.

5. Concluding Remarks

One of the paper's conclusions is that neutral technological change – which increases the relative demand for skilled labour by shifting product demand towards higher quality varieties – causes a decline in the employment of unskilled labour if the skilled-to-unskilled wage ratio is sticky. The other conclusions concern how governments might react to this development. Several policies – subsidies for the employment of the unskilled, direct government employment of unskilled individuals, and increases in unemployment insurance (all financed by higher payroll taxes for skilled workers) – succeed in alleviating the adverse employment effects of technological change. But, as the paper has emphasized, political economy considerations – regarding a sharing of the burden of combating unemployment – are important as well. With almost every policy experiment, the tension is between employed (whether skilled or unskilled) and unemployed workers. To summarize this tension with a concrete example, we can assume that minimum wage legislation is responsible for keeping the ratio of unskilled-to-skilled wages constant at a high level. This policy benefits those unskilled workers fortunate enough to remain employed, but it reduces the income of those who are forced into unemployment. Nevertheless, it is usually the case that the unemployed represent a

poorly organized minority with little impact on political decisions. For this reason, it is difficult (politically) to reduce the minimum wage.

In contrast to this, the paper draws attention to a policy that may be helpful for reducing unemployment without encountering political-implementation problems.[14] We have seen that a change in the payroll tax system involving higher payroll tax rates (faced by firms) for skilled workers and lower tax rates (or subsidies) for the unskilled leads to an increase in the relative demand for unskilled labour and a lower unemployment rate. Our analysis shows that this policy will have an imperceptible effect on the incomes of the employed (whether skilled or unskilled), and it may thus be a policy which can achieve political support. Since it is possible that the small effect on the real incomes of those already employed is positive, this policy can be an example of what Alan Blinder (1987) has called "percolate up" – as opposed to "trickle down" economics.

[14] In addition to the policy stressed in the text, the model suggests that subsidies for increased access to higher education (although involving a longer gestation period) which alter relative labour supplies may also be a "win-win" initiative.

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