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MIGRATION, JOBS AND WELFARE: A GENERAL EQUILIBRIUM ANALYSIS

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Abstract. Immigration has been an important element of the economic development of many countries, although in recent years there has been an intensification of doubts about the benefits of further immigration. This paper brings some simple general-equilibrium modelling tools to bear on the question of the employment and welfare effects of immigration. Employment and taxation effects, rather than wage and distributional effects, are found to be crucial in determining the impact of immigration on the welfare of factor-owners in the receiving country. These employment effects depend on the type of immigration and the substitutability or complementarity relationships between immigrant labour and unemployed labour. Certain types of immigration are shown to be Pareto-improving for the receiving country, without any need for lump-sum transfers. Simple numerical simulations illustrate the results.

1. INTRODUCTION

Immigration has been an important element of the economic development of many countries, but recent years have seen an intensification of doubts about the benefits of further immigration. These doubts seem linked, to some extent, to economic factors such as higher unemployment in the receiving countries, the deteriorating position of workers at the bottom of the wage distribution in the receiving countries, changes in the background and skills of migrants, and increased sensitivity to benefit and public-good usage by migrants.

As one would expect for such an important issue, there has been a large amount of empirical work on the effects of immigration. Card (1990), Altonji and Card (1991), La Londe and Topel (1991), Borjas (1994, 1995), and Borjas et al. (1996, 1997) concentrate on the US. Zimmermann (1995) discusses the European experience, while Pope and Withers (1993) consider Australia. The present paper is not an empirical study, and instead focuses on the theoretical frameworks in which overall effects are assessed.

The most common theoretical framework for the empirical studies comes from the classic paper of Berry and Soligo (1969). It was the framework used in the influential recent assessment of the benefits of immigration of Borjas (1995), who concluded that "the family of models summarised in this paper provides the foundation for a positive theory of immigration policy" (p. 18), and also Borjas et al. (1997), who refer to it as the "aggregate factor proportions approach" (p. 39).

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Let us briefly review the Berry and Soligo (1969) analysis, using figure 1. There is a single aggregate commodity with an exogenous price, and exogenous endowments of labour and capital. Technology is constant-returns-to-scale and concave, represented by the downward-sloping schedule of marginal product of labour. Immigration is modelled as an increase in the endowment of labour from N to $N+M$, which reduces the equilibrium wage rate from W^N to W^{N+M} and creates the shaded immigration surplus (i.e. the increase in factor income), equal to the additional area under the marginal-product-of-labour schedule less migrant income. This immigration surplus is greater the flatter the schedule of marginal product of labour, and with reasonable aggregate elasticities of labour the surplus is very small.

The purpose of this paper is to reconsider the question of the economic effects of immigration using general-equilibrium modelling tools. This will allow us to consider composition effects by industry and type of labour, changes in unemployment induced by immigration of different types of labour, as well as benefit and taxation transfer effects. Although it is obviously impossible simultaneously to consider everything that matters in a tractable and understandable model, the framework offered in this paper seems to go further than the existing literature.[1] Despite taking account of the general-

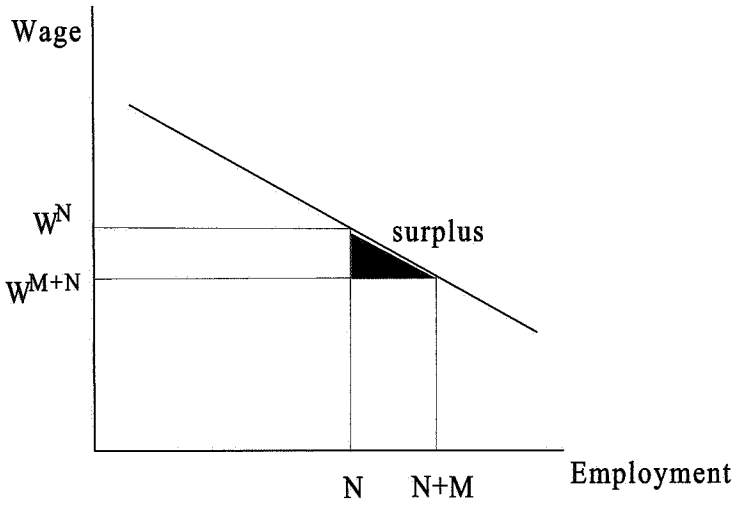

Figure 1. Partial-equilibrium effects

[1] Kuhn and Wooton (1991) also use a general-equilibrium trade approach but do not consider the crucial issue of unemployment. They, though, have the complication of a nontraded good, and many of the welfare results are ambiguous. Friedberg and Hunt (1995) mention that in the standard general-equilibrium trade model immigrations will not affect factor prices, but do not consider unemployment; nor does their very simple model allow consideration of the crucial general-equilibrium susbstitutability or complementarity relationships.

equilibrium interactions and these additional issues, clear-cut results can be derived about the effects of immigration on wages, employment and welfare. It will be shown that the effects of immigration depend crucially on the type of immigration and the general-equilibrium substitutability or complementarity relationships between immigrant labour and unemployed labour in the receiving country.[2]

The results differ substantially from Berry–Soligo type analyses, and offer solution to some puzzles noted by empirical researchers using their framework. One of these puzzles is the consistent failure to find large wage effects of immigration – see especially the studies of Card (1990), La Londe and Topel (1991) and Borjas et al. (1996).[3] The general-equilibrium analysis suggests this could be because the adjustment is being carried in the industrial structure of the economy and employment rather than wages. However, without undertaking a large-scale computable general-equilibrium modelling exercise it is not possible to check this puzzle solution empirically.

2. MAIN FEATURES OF THE ANALYSIS

The purpose of the paper, which is to provide an alternative framework and highlight effects neglected in the existing literature, influences the modelling choices. It will be as simple as possible, especially in relation to issues which have received a lot of attention in the literature.

In assessing the economic effects of immigration, the focus will be on the incomes of native factor-owners in the receiving country, and this will be the welfare measure. Income of native factor-owners is the wage of each factor multiplied by the number of units of each factor employed. Effects on the migrants themselves as well as the countries from which they come are important issues, but not the focus of this paper.[4] It is the current natives who decide about immigration flows through the political process. When measuring the impact on the incomes of natives there will be no need to rely on costless lump-sum transfers or other devices to overcome distributional problems, as the major welfare results turn out to be clear Pareto gains or losses for factor-owners in the receiving country.

[2] There is a large literature on factor mobility in general equilibrium but the questions addressed and thus the analyses are different to this paper. One strand of the literature, beginning with Mundell (1957), recently brought together by Wong (1995), considers the extent to which trade in factors and trade in goods are substitutes. Neary (1995) points out some problems with these models as explanations of simultaneous factor and goods trade. Another strand beginning with Ramaswami (1968) and more recently summarized in Bhagwati and Srinivasan (1983) deals with choices between capital and labour mobility. The conclusions from the latter type of analysis have been recently extended to include unemployment, by Brecher and Choudhri (1987).

[3] These studies, although they consider the effects of immigration on local labour markets over a fairly short time period, are the best evidence we have and are the types of studies most likely to find large effects if they are there. In the longer-run and economy-wide studies, the effects of immigration on wages are difficult to disentangle from other effects.

[4] A distinction between natives and migrants cannot be pushed too far as almost all natives were once themselves migrants.

The models constructed in this paper are based on the standard general-equilibrium model of the production sector of a competitive trading economy.[5] World goods prices will be taken as given. Production technology will be concave and constant-returns-to-scale, and represented by minimum unit-cost functions. The models will have multiple goods and factors, with the factors identified as different types of labour.[6]

Immigration will be represented by an exogenous increase in the economy's endowment of a particular factor, implying that immigrants are identical to the corresponding type of local labour. The issue of imperfect substitutability between immigrants and natives of the same type, addressed by many authors beginning with Grossman (1982), will not be considered here. Other issues such as capital brought in by the migrants, or technology transfer associated with immigration, will not be considered.

Since many of the doubts about immigration are related to unemployment, this will be introduced via a binding wage floor which applies to labour of a particular type, including migrants of that type. This wage floor might represent the level of unemployment or other welfare benefits. It could also be as proxy for some underlying efficiency wage, insider–outsider or union bargaining explanation of an above-market clearing wage. The justification of the wage floor makes no difference to the wage and unemployment impact of immigration results in the paper, although in deriving the welfare results it will be interpreted as a government-set minimum wage.[7]

A difficult modelling issue is how to treat the allocation of jobs between migrants and natives when there is unemployment. One extreme would be that migrants join the end of job queues, so there is no displacement of local workers of the same type who are already employed. At the other extreme it could be assumed that there is complete displacement of employed natives by immigrants of the same type. Migrants may be more desperate for work, and have other difficult-to-observe characteristics which make them attractive to employers, so there would seem to be a case for some displacement of local workers. To capture this, a displacement parameter will be introduced into the model; the value of d will range from zero, representing no displacement, to 1 representing complete displacement of natives by immigrant workers of the same type when there is unemployment.

To capture the effect of taxation transfers between migrants and natives, income taxes at rate t will be levied on all factor income, including that of new

[5] The basic model with full employment is described fully in Woodland (1982, chs 1–3).

[6] Traditionally in these general-equilibrium trade models, one of the factors has been identified as capital, and this identification is possible. However, specifying a fixed endowment of capital makes less sense in the current environment of international mobility of capital.

[7] Welfare results could be derived for other interpretations. If the wage floor were an unemployment benefit, financed say by lump-sum taxes, then the welfare results would be slightly more complicated as there would be an additional transfer between migrants to natives equal to the difference between benefits drawn and lump-sum taxes paid by the two groups. There would also be some redistribution between natives, to the extent that natives who lose their jobs draw unemployment benefits financed by employed natives.

migrants, with the proceeds distributed to native factor-owners. Any taxes paid by migrants distributed back to migrants have no net impact on the welfare of natives and will be ignored.

3. ECONOMIC EFFECTS OF IMMIGRATION: THE SIMPLEST MODEL

The simplest and most popular general-equilibrium model of the production sector has two goods, two factors and a floor which applies to the price of one factor.[8,9] There must be unemployment of the factor subject to the floor. As was shown by Brecher (1974), imposition of a binding wage floor in an initially diversified economy producing both goods makes production of the good which uses the factor subject to the floor relatively intensively unprofitable, firms exit the industry, and the economy becomes completely specialized in the other good.[10]

Equilibrium conditions which fully describe this production sector are given below. The floor $\overline{w}$ applies to factor 2 which is used relatively intensively in industry 2. To simplify the notation the superscript on $\overline{w}$ has been dropped, and it will always refer to the floor on factor 2. Factor 1 might represent skilled labour and factor 2 unskilled labour.

Industry 1 is active and makes zero profits, with the given world price p equal to the minimized value of unit cost $c(\ )$,[11] which depends on factor prices w:

$$p^1 - c^1(w^1, \overline{w}) = 0, \qquad y^1 > 0. \tag{1}$$

Industry 2, which uses factor 2 relatively intensively,[12] becomes unprofitable and produces no output:

$$p^2 - c^2(w^1, \overline{w}) < 0, \qquad y^2 = 0. \tag{2}$$

[8] As is the case with many models of this type, outputs, employment and factor prices can be determined from production conditions alone. There is no need to specify preferences and the consumption sector of the model.

[9] Results for the full-employment versions of the models considered in this paper are given in Woodland (1982, ch. 3). The most important of these to bear in mind for comparison with the results of this paper are that in a two-factor two-good model factor prices are unaffected by small endowment changes; while in the two-factor three-good specific-factors model an increase in the endowment of the mobile factor reduces the price of the mobile factor and increases the prices of both specific factors. An increase in the endowment of a specific factor reduces the price of both specific factors and increases the price of the mobile factor.

[10] To understand the result, think first about the industry which uses the factor subject to the floor least intensively. In order to maintain zero profits in that industry, the price of the other factor must fall. However, because the other industry uses the factor subject to the floor more intensively, this fall will be insufficient to allow firms in the industry that uses the factor subject to the floor relatively intensively to make zero profits. It is possible to escape the necessity of specialization by allowing feedback effects on terms of trade from the imposition of the wage floor. The robustness and reasonableness of the specialization result is considered in more detail in Oslington (1997). While the specialization outcome does helpfully emphasize that factor market distortions can wipe out industries, the fact that we are left with just one industry means the model does not capture well the linkages between industries that are the essence of the general-equilibrium approach.

[11] The unit cost function is $c(w^1, \overline{w}) = \min(w^1 x^1 + \overline{w} x^2)$ s.t. $f(x^1, x^2) \geqslant 1$, where f is the production function.

[12] Formally, $c_1^1/c_2^1 > c_1^2/c_2^2$.

Factor 1 is fully employed. The usage of factor 1 to produce a unit good 1 is the derivative of the unit-cost function with respect to the factor price $c_1^1(w)$ by Shephard's lemma. The total usage of the factor, which is this unit factor usage multiplied by the output of the active industry, fully absorbs the endowment v:

$$c_1^1(w^1, \overline{w})y^1 - v^1 = 0, \qquad w^1 > 0. \tag{3}$$

Factor 2 which is subject to the floor is less than fully employed:

$$c_2^1(w^1, \overline{w})y^1 - v^2 < 0, \qquad w^2 = \overline{w}. \tag{4}$$

Consider the effects of immigration on this economy. Irrespective of immigration, the price of factor 2 always remains fixed by the floor, while the price of factor 1 is determined by the zero-profit condition (1) for the active industry, independently of factor endowments. Thus immigration, represented by an increase in either of the factor endowments, has no effect on factor prices.

An important but much misunderstood point is that this insensitivity of factor prices to small changes in factor endowments is not the same thing as the controversial factor-price equalization theorem. The equalization of factor prices across countries is a stronger proposition that additionally requires technology to be identical across countries and each country to produce the same set of goods. Thus the observation that factor prices are not in fact equalized internationally does not undermine the factor-price insensitivity result.

Migration does, however, affect unemployment. If immigration involves the unemployed factor 2, the extent of the change in unemployment of native workers, denoted U, will depend on the value of the displacement parameter d: $\partial U/\partial v^2 = d$.

On the other hand, if the immigration is of the fully employed factor 1, the migrants cause the active industry 1 to expand in (3), allowing additional units of the unemployed native factor 2 to be profitably absorbed by the active industry 1, reducing unemployment, so that:

$$\partial U/\partial v^1 = -(\partial y^1/\partial v^1)c_2^1(w^1, \overline{w}) = -[1/c_1^1(w^1, \overline{w})]c_2^1(w^1, \overline{w}) < 0.^{13}$$

As discussed, welfare is the income of native factor-owners, so welfare results can be obtained by combining the effects of immigration on factor prices and unemployment, and any tax transfers.[14] It has been shown that factor prices are unaffected by immigration of factor 2, so this type of immigration affects welfare only through native employment loss, which depends on the extent of

[13] Throughout the paper these expressions are obtained by totally differentiating the equilibrium conditions and substituting. In signing the expressions, note that the $c_i^j(\,)$ terms are positive as a result of the assumptions about production technology.

[14] Adding a standard consumption sector with identical homothetic preferences (described for example in Woodland, 1982, ch. 6) would mean the income results in the paper would translate into similar net export responses. The factor-income welfare results would then translate into open-economy indirect utility results.

displacement. At the margin the loss is valued at the factor price floor, so the welfare result is

$$\partial \text{welfare}/\partial v^2 = -(\partial U/\partial v^2)\overline{w} = -d\overline{w} < 0.$$

By contrast, immigration of fully employed factor 1 is unambiguously welfare-improving because factor prices do not change, employment of the unemployed domestic factor 2 grows (valued at the factor price floor), and there is also the taxation transfer from immigrants to domestic factor owners:

$$\partial \text{welfare}/\partial v^1 = -(\mathrm{d}U/\mathrm{d}v^1)\overline{w} + tw^1 = [1/c_1^1(w^1, \overline{w})]c_2^1(w^1, \overline{w})\overline{w} + tw^1 > 0.$$

This welfare improvement is a particularly strong result because no group of factor owners loses – there is no need to rely on costless lump sum income transfers or some other device to neutralize distributional effects of immigration.

4. ECONOMIC EFFECTS OF IMMIGRATION: A MORE COMPLEX MODEL

The two-factor two-good model considered in the previous section has the advantage of simplicity but it cannot deal adequately with the issue of complementarity and substitutability between migrant and different types of native labour. A widely used model which allows this to be dealt with, and avoids the specialization problem,[15] is the two-good three-factor specific-factors model of Jones (1971). It will be assumed that factors 1 and 2 are specific to their respective industries, factor 3 is mobile between the industries,[16] and the floor will apply to one of the specific factors.

In this model the mobile factor is a complement of the unemployed factor and the other specific factor is a substitute for the unemployed factor. This contrasts with the two-factor two-good model where the factors must be general-equilibrium complements. Note that the definition of substitutes or complements in general equilibrium is not the same as in a single-good production function with three factors, as in Hicks (1970) for instance. In general equilibrium the three factors need not enter into the same production or cost function. Modifying the standard definition of q complements for our general-equilibrium setting, factors i and j will be defined as substitutes, increases in the endowment of factor i reduce usage of factor j, and complements otherwise. Substitute factors are rivals for the remaining factor, and complements the reverse. Ruffin (1981) refers to enemies and friends rather than substitutes and complements, and this is a helpful way of understanding the relationships.

[15] In the two-good three-factor model specialization is avoided because, although the floor causes the price of one other factor to be bid down, there is now another factor whose price can adjust so that factor prices can be consistent with zero profits in both industries.

[16] Ruffin (1981) shows that a three-factor two-good model without the specific-factors restriction must have extreme factors which correspond to the specific factors. A three-factor two-good model without the specific-factors restriction thus gives similar results to those presented in the present paper.

In the analysis the floor $\overline{w}^2$ applies to specific factor 2 which might represent unskilled labour, with the other specific factor representing specialized skilled labour, and the mobile factor representing moderately skilled labour which can be used in many industries.[17] Equilibrium conditions are given below:

Industries 1 and 2 are active and make zero profits:

$$p^1 - c^1(w^1, w^3) = 0, \qquad y^1 > 0 \tag{5}$$

$$p^2 - c^2(\overline{w}, w^3) = 0, \qquad y^2 > 0 \tag{6}$$

Factors 1 and 3 are fully employed:

$$c_1^1(w^1, w^3)y^1 - v^1 = 0, \qquad w^1 > 0 \tag{7}$$

$$c_3^1(w^1, w^3)y^1 + c_3^2(\overline{w}, w^3)y^2 - v^3 = 0, \qquad w^3 > 0 \tag{8}$$

Factor 2 is subject to the floor and less than fully employed:

$$c_2^2(\overline{w}, w^3)y^2 - v^2 < 0, \qquad w^2 = \overline{w}. \tag{9}$$

Just as in the simpler two-factor two-good model, prices of factors not subject to the floor can be determined from the zero-profit conditions (5) and (6), without any reference to endowments, so immigration again has no effect on factor prices.

Immigration of factors subject to unemployment adds to native unemployment to the extent that immigrants displace native workers, just as in the two-factor two-good model:

$$\partial U/\partial v^2 = d.$$

The effects of immigration of fully employed factors are more complex than in the two-factor two-good model, and unemployment can move in opposite directions depending on which factor migrates. Immigration of the mobile factor 3 will be allocated between industries 1 and 2 according to (8), and any factor 3 allocated to industry 2 will increase the output of that industry and through (9) reduce domestic unemployment:

$$\partial U/\partial v^3 = -(\partial y^2/\partial v^3)c_2^2(w^3, \overline{w}) = -c_2^2(w^3, \overline{w})/c_3^2(w^1, \overline{w}) < 0.$$

The opposite result occurs for the other fully employed factor. Immigration of factor 1 will expand industry 1 in (7) and pull the mobile factor away from industry 2 in (8), reducing its output and increasing unemployment in (9) so that:

$$\begin{aligned}\partial U/\partial v^1 &= -(\partial y^2/\partial v^1)c_2^2(w^1, \overline{w}) \\ &= [c_3^1(w^1, \overline{w})c_2^2(w^1, \overline{w})]/[c_3^2(w^1, \overline{w})c_1^1(w^1, \overline{w})] > 0.\end{aligned}$$

[17] A specific-factors model with unemployment of the mobile factor has also been considered. In this variant migration has no effect on factor prices, and immigration of either specific factor reduces unemployment and improves welfare. Since these results are broadly similar to the two-factor two-good model, they are not presented here.

These opposite results reflect the fact that factor 1 is a general-equilibrium substitute for the unemployed factor 2, while factor 3 is a general equilibrium complement for the unemployed factor 2.

Welfare results can again be easily derived from the employment responses because factor prices do not change. Immigration of an unemployed factor affects welfare only through the change in native unemployment:

$$\partial \text{welfare} \partial v^2 = -\mathrm{d}\overline{w} < 0.$$

Immigration of factor 3 will increase welfare through employment and taxation effects:

$$\partial \text{welfare}/\partial v^3 = -(\partial U/\partial v^3)\overline{w} + tw^3 = [c_2^2(w^3, \overline{w})/c_3^2(w^1, \overline{w})]\overline{w} + tw^3 > 0.$$

Immigration of factor 1 will have an ambiguous effect on domestic welfare, with the sign depending on the relative strength of the negative employment and positive taxation effects:

$$\begin{aligned}\partial \text{welfare}/\partial v^1 &= -(\partial U/\partial v^1)\overline{w} + tw^1 \\ &= -[c_3^1(w^1, \overline{w})/c_2^2(w^1, \overline{w})]/[c_3^2(w^1, \overline{w})c_1^1(w^1, \overline{w})]\overline{w} + tw^1 = ?\end{aligned}$$

Results from the models may be summarized by the following propositions.

PROPOSITION 1. (immigration and factor prices). *Immigration has no effect on factor prices in the receiving country.*

PROPOSITION 2. (immigration and unemployment). *Immigration of factors subject to unemployment will reduce employment of natives to the extent that the migrants displace natives of the same type. The effects of immigration of fully employed factors will depend on the general-equilibrium relationship between immigrants and unemployed natives – if they are complements unemployment will fall, if they are substitutes unemployment will rise.*

PROPOSITION 3. (immigration and welfare). *Immigration of factors subject to unemployment will reduce welfare of natives by the value of the product of natives displaced. Immigration of fully employed factors will improve welfare if the migrants and unemployed factors are complements and have an ambiguous effect if they are substitutes (reducing welfare if the magnitude of employment loss exceeds the taxation revenue gain).*

5. NUMERICAL ILLUSTRATIONS

To illustrate the model and obtain some idea of the magnitudes of the effects, a rough calibration will be carried out using Cobb–Douglas functional forms and parameter values from Krugman's (1995) model of a representative OECD country. Both the two-good two-factor model and a two-good three-factor model will be considered.

Notation will be the same as in earlier sections. Recall that factor prices are w^1, w^2 and w^3, endowments are v^1, v^2 and v^3, outputs are y^1 and y^2, and the wage floor on factor 2 is $\overline{w}$, t represents the tax rate, and U unemployment. The superscripts denoting good and factor numbers will precede the powers in the Cobb–Douglas functions.

A. *Two-factor two-good model*

Krugman's cost functions for the goods are $c^1() = w^{1\,2/3}w^{2\,1/3}$ and $c^2() = w^{1\,1/3}w^{2\,2/3}$. He sets both world goods prices equal to 1, and endowments are $v^1 = 40$ and $v^2 = 60$. At a full-employment equilibrium, factor prices are $w^1 = w^2 = 1$, outputs $y^1 = 20$, $y^2 = 80$ and welfare 100.

Now assume that there is a wage floor 10 percent above the full-employment equilibrium price of the second factor so that $\overline{w} = 1.1$, and that the tax rate is 30 percent so that $t = 0.3$. Estimates of the displacement parameter are not available, and it will be set at 1. Equilibrium conditions (1)–(4) are then:

$$1 - w^{1\,2/3}\overline{w}^{1/3} = 0, \qquad y^1 > 0 \tag{10}$$

$$1 - w^{1\,1/3}\overline{w}^{2/3} < 0, \qquad y^2 = 0 \tag{11}$$

$$(2/3)w^{1\,-1/3}\overline{w}^{1/3}y^1 = v^1, \qquad w^1 > 0 \tag{12}$$

$$(1/3)w^{1\,2/3}\overline{w}^{-2/3}y^1 < v^2, \qquad w^2 = \overline{w}. \tag{13}$$

Solving (10), $w^1 = \overline{w}^{-1/2} = 0.95$; and then from (12), $y^1 = (3/2)\overline{w}^{-1/2}v^1 = 57$, so at goods prices of 1 welfare is also 57. Unemployment can then be calculated from (13) and $U = v^2 - (1/2)\overline{w}^{-3/2}v^1 = 60 - 17 = 43$. Note the dramatic changes in outputs compared with full employment, and extremely high rate of unemployment, which suggest that this model where the minimum wage implies complete specialization is not particularly realistic.

Responses of unemployment and welfare to immigration can be calculated:[18]

$$\partial U/\partial v^2 = 1$$

$$\partial \text{welfare} \partial v^2 = -\overline{w} = -1.1$$

$$\partial U/\partial v^1 = (1/2)\overline{w}^{-3/2} = -0.43$$

$$\partial \text{welfare}/\partial v^1 = (1/2)\overline{w}^{-1/2} + tw^{-1/2} = 0.48 + 0.28 = 0.76.$$

B. *Three-factor two-good model*

For this model, for which Krugman (1995) does not present results, the cost functions might be $c^1() = w^{1\,2/3}w^{3\,1/3}$ and $c^2() = w^{2\,2/3}w^{3\,1/3}$, with endowments $v^1 = 20$, $v^2 = 60$ and $v^3 = 40$. Other parameters will be the same as the previous two-factor two-good example. Under full employment, factor prices are $w^1 = w^2 = w^3 = 1$, outputs $y^1 = 30$ $y^2 = 90$ and welfare is 120.

[18] The welfare elasticities to changes in the workforce calculated at initial values are equal to the reported responses, because the values of welfare and the workforce are the same.

With unemployment, equations (5)–(9) become

$$1 - w^{1\,2/3}w^{3\,1/3} = 0, \qquad y^1 > 0 \tag{14}$$

$$1 - \overline{w}^{2/3}w^{3\,1/3} = 0, \qquad y^2 > 0 \tag{15}$$

$$(2/3)w^{1\,-1/3}w^{3\,1/3}y^1 - v^1, \qquad w^1 > 0 \tag{16}$$

$$(2/3)\overline{w}^{-1/3}w^{3\,1/3}y^2 < v^2, \qquad w^2 = \overline{w} \tag{17}$$

$$(1/3)w^{1\,2/3}w^{3\,-2/3}y^1 + (1/3)\overline{w}^{2/3}w^{3\,-2/3}y^2 = v^3 \qquad w^3 > 0. \tag{18}$$

Solving (14) and (15) yields $w^3 = \overline{w}^{-2} = 0.83$ and $w^1 = \overline{w} = 1.1$. Then, from (16), $y^1 = (3/2)\overline{w}v^1 = 33$, and from (18), $y^2 = 3v^3\overline{w}^{-2} - (3/2)\overline{w}v^1 = 66$, so welfare is 99. Unemployment can be calculated from (17): $U = v^2 - 2v^3\overline{w}^{-3} + v^1 = 20$. These values seem more realistic than those for the two-factor two-good model.

Responses of unemployment and welfare to immigration are:

$$\partial U/\partial v^2 = 1$$

$$\partial\text{welfare}\partial v^2 = -\overline{w} = -1.1$$

$$\partial U/\partial v^3 = -2\overline{w}^{-3} = -1.5$$

$$\partial\text{welfare}/\partial v^3 = 2\overline{w}^{-2} + t\overline{w}^{-2} = 1.7 + 0.2 = 1.9$$

$$\partial U/\partial v^1 = 1$$

$$\partial\text{welfare}/\partial v^1 = -\overline{w} + t\overline{w} = -1.1 + 0.33 = -0.77.$$

Note that $\partial\text{welfare}/\partial v^1$ could not be signed theoretically, but with the parameter values chosen the negative employment effect dominates the positive taxation effect, giving a negative result.

C. *Discussion*

Obviously, not too much reliance should be placed on these values, even in the more realistic specific-factors case, because the parameters in the Krugman model are only guesstimates and the Cobb–Douglas form is quite restrictive. Nevertheless, the following points emerge from the numerical illustrations:

- The suggestion in the theoretical part of the paper that the traditional two-good two-factor model is problematic is reinforced by the absurdly high 43 percent rate of unemployment with the minimum wage.
- The magnitude of the employment effects is many times larger than the unemployment benefit and taxation effects, suggesting a resolution of the one ambiguous theoretical result.
- The estimates of the effects of immigration with the three-factor two-good model differ markedly from the results of Borjas (1995, p. 7), for a Berry–Soligo model. He uses a labour demand elasticity of 0.3 to calibrate the model and finds that a 10 percent increase in the labour force through

immigration increases gross domestic product by less than 0.1 percent. Unemployment effects are zero in his full-employment model. On the other hand, with the general-equilibrium model the employment and welfare effects of immigration are quite large, whether they be positive effects for immigration of the complementary factor or negative effects for the substitute factor.

As well as suggesting orders of magnitudes for the effects, these numerical illustrations indicate how empirical researchers might estimate the general-equilibrium effects of immigration under conditions of unemployment.

6. CONCLUSIONS

Overall, the results of this paper suggest that the crucial economic issue is the effect of immigration on employment, and to a lesser extent benefit expenditures and taxation receipts. The employment effects depend on the type of immigration and the general-equilibrium substitutability and complementarity relationships between immigrant and unemployed labour. This conclusion contrasts with the focus of most of the empirical labour literature on wage effects.

Why might these results and the emphasis on adjustments in the structure of the economy and employment be more believable than those in the existing literature? Firstly, the greater prominence in the popular immigration debates of employment issues than wage issues is at odds with the Berry–Soligo analysis but consistent with the results of this paper. Secondly, the focus on wage effects following Berry and Soligo sits uneasily with the lack of empirical evidence for wage effects of immigration noted in the introduction (Card, 1990; Altonji and Card, 1991, pp. 220–5; La Londe and Topel, 1991 pp. 178–83, 190–1; Borjas et al., 1996). The lack of wage effects is consistent with the general-equilibrium theoretical results of this paper. Thirdly, there is some evidence of immigration leading to expansion of industries which use the immigrants and contraction of other industries (Card, 1990, p. 256; Altonji and Card, 1991, pp. 210–16). Fourthly, the general-equilibrium results are consistent with the modest unemployment changes identified in empirical studies (Pope and Withers, 1993; La Londe and Topel, pp. 184, 190–1). The reason is that most countries' immigration intakes have been a mixture of unemployment skilled migrants that the general-equilibrium model suggests will increase unemployment, and unskilled migrants that will reduce unemployment, which would net out to leave the small overall unemployment effect that empirical researchers have found.

Of course the model in this paper has been sharply constructed to emphasize the employment effects rather than the wage effects. Variants of the model where there are feedback effects of the immigration on relative traded goods prices will give a wage effect. Adding another flexible price factor to the model or making one of the goods nontraded will mean that wages respond to some extent to immigration. Another possibility is to endogenize the wage floor, for

instance making it the outcome of some bargaining process between workers and firms which is affected by the level of unemployment. Any wage effects generated in these variants, though, will be much smaller than the wage effects in a Berry–Soligo model because industrial structure and employment are bearing some of the burden of adjustment.

An interesting policy implication of the sharply constructed model with no wage effects is that it is possible to conduct migration policy which gives unambiguous Pareto gains without the need for lump-sum transfers or similar devices. In other words, policies are available which give gains without losses for any domestic factor-owners. This type of policy would need to be informed by an understanding of the general-equilibrium relationships between different types of immigration and employment, and would promote immigration of factors which are complements with the unemployed, leading to higher domestic employment and welfare gains for all natives.

This discussion of the economic effects of immigration, of course, neglects other important aspects of appropriate immigration policy. Environmental impacts of higher population have to be considered. As well as promoting our economic interests we might support immigration to promote a humane and diverse society, or give refugees and others a fair go.

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