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ABSTRACT

Determinants of Attitudes Towards Immigration: A Trade-Theoretic Approach*

This paper uses a three-factor (capital, low- and high-skill labour), two-household (low- and high-skill individuals), two-sector trade model to analyse the determinants of voter attitudes towards immigration under direct democracy and identify factors that would be coherent with both the observed increase in the skilled-unskilled wage differential and the stiffening attitudes towards low-skill capital-poor immigration. If the import-competing sector is intensive in the use of low-skill labour, and capital is the middle factor, an improvement in the terms of trade or neutral technical progress in the exporting sector leads nationals to oppose immigration of capital-poor low-skill households. An increase in income inequality is also likely to stiffen attitudes towards this type of capital-poor, low-skill immigration prevalent in Europe until recently.

JEL Classification: D72, F22, J61
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NON-TECHNICAL SUMMARY

The deteriorating conditions in the OECD labour markets have affected the political debate on immigration. On national political scenes throughout Europe, resistance towards immigration has risen sharply. This has been reflected in a quasi-universal shift in migration requirements favouring immigrants with capital and/or skill ownership through a tightening of immigration quotas. (A recent EU survey reports that over half the respondents in Germany, France, Italy and the United Kingdom feel there are too many immigrants in their countries.) A large empirical literature has sought to establish the reasons for the deterioration in OECD labour markets. While trade economists have emphasized the role of factor endowments and rising pressures from the South resulting from increased globalization, labour economists have emphasized that biased technical progress against unskilled labour has contributed towards explaining rising unemployment and/or rising wage gaps between skilled and unskilled workers in recipient countries. This paper explores the potential links between these phenomena.

We study attitudes towards immigration in a model where attitudes are determined entirely by economic self-interest in a direct-democracy framework. We use the simplest two-sector Heckscher-Ohlin model, one sector (intensive in the use of low-skill labour) representing the import-competing sector, and the other (usually high-skill labour intensive) sector representing the export-competing sector. To accommodate labour economists' views that wages are not entirely determined in product markets, we use a three-factor model with low-skill labour, high-skill labour and capital. To link model-results to the debate on the evolution of the wage gap, we use a two-household variant in which high-skill and low-skill households own varying degrees of capital. This extension also allows us to study the effects of changes in the distribution of income on household attitudes towards immigration.

This three factors – two goods ('3x2') model is a useful vehicle to explore the links between globalization, the deterioration in labour markets in recipient countries and the stiffening in attitudes towards immigration, as it maintains the small-country assumption so dear to trade economists, while it accommodates the positions of labour economists, who view wages as being determined endogenously, in the sense that wages are not tied to world prices. Direct-democracy seems a suitable political-economy approach, insofar as everyone has a 'position' on immigration that is readily expressed in votes in favour of politicians' views on immigration (even though income

changes are not the only determinants of voters' attitudes). The objective is to provide a taxonomy, which helps to identify the conditions under which national attitude towards immigration would be compatible with these observed changes. We believe that a taxonomic approach in this widely understood framework helps establish the nexus between increasing openness to trade, changes in the labour market and resulting pressures for changes in immigration policies. Following are the main results.

Start first with the case where capital ownership is evenly distributed within households. In this case, as immigration has no impact on the aggregate income of residents (immigration is a zero-sum game in this model), households always adopt an opposite attitude towards immigration (unless they are both indifferent). Hence national immigration policy reflects the position of the majority group, which is driven by the usual friend-enemy relationships between factor endowment and factor prices. (The middle factor is a 'friend' or a q-complement with each extreme factor in the sense that an increase in its endowment increases the return to each extreme factor, while extreme factors are q-substitutes or 'enemies', in the sense that an increase in the endowment of any extreme factors lowers the return to the other extreme factor.) Depending on assumptions about factor intensities, two different patterns arise:

Case I: Capital is the 'middle' factor. Then its influence on both type of wages is positive (capital and labour are friends), so it is *a priori* unclear if a national household is 'capital-poor' (e.g. the wage effect is dominant in his income change) or 'capital-rich' (the capital remuneration effect dominates). As the same ambiguity applies to capital-endowed immigrants, this leads to a 'capital-concerned' national attitude towards immigration (where a capital-poor household always oppose a capital-poor immigrant, irrespectively of the skill degree). Apart from the composition of the population, the key factor in determining immigration policy are the differences in factor intensities, reflected by a 'similarity index' between the middle factor and one of the extreme factors.

Case II: Capital is an 'extreme' factor. Then its influence on the wage of the other extreme factor (in our case low-skill labour) is negative, which eliminates all the ambiguities of the previous case. National attitude towards immigration is now mainly 'skill-concerned' (where a low-skill household always opposes a low-skill immigrant, irrespectively of capital ownership). In this case, the role of the 'similarity index' vanishes.

We examine next the effects of factor accumulation, disembodied technical change and increased openness (proxied by an improvement in the terms-of-trade) on attitudes towards immigration. Results are generally ambiguous, depending on the substitutability/complementarity relationship between factors. With additional assumptions on technology (e.g. a CES technology and identical capital share in total costs in both sectors), however, increased openness would be compatible, in Case I and under plausible conditions, both with a wider wage gap (between high- and low-skill labour) and a stiffening of attitude towards capital-poor immigrants. If this result is in accordance with widely held perceptions, the effects of an increase in high-skill labour endowment or technical progress of the labour-saving type are more difficult to reconcile with widely held views, as they lead to opposite results.

Consider next the case of an uneven distribution of capital within households, thereby relaxing the systematic opposition between households. With skewness in capital ownership, it is possible that a majority of households in each household category will be capital-poor. Then an increase in the disparity of intra-household capital ownership leads to a stiffening of attitudes towards low-skill capital-poor immigrants. Hence, the observed increase in income inequality in recipient countries is consistent with a stiffening of national attitude towards capital-poor immigrants.

1. Introduction

Incentives for international migration have largely been studied as responses to factor-reward differences with factors of production moving internationally to maximise income. The standard Heckscher-Ohlin model predicts that, on efficiency grounds, countries should be as open to the indirect inflow of factor services embodied in goods as to the direct flows of capital and labour. Yet, the globalisation of the world economy has revealed an asymmetry in policies as countries have become concurrently more open to flows of goods and capital and less open to direct flows of labour. Moreover, for countries receiving immigrants, restrictions have become more severe towards unskilled labour. At the same time there has been a widening disparity between the incomes of skilled and unskilled workers. This is in accordance with the Stolper-Samuelson predictions of increased globalisation, suggesting that there is still some usefulness for the standard trade theoretic framework when studying international factor migration and that there may be causal links between changes in the external environment, the deterioration in the labour markets of many recipient countries, and the stiffening of attitudes towards immigration.

To be sure, to understand attitudes towards the movement of people, one must go beyond the standard economic framework where factors of production are apersonal entities. Broadening the framework to take into account the attributes of individuals as in models of locational choice (e.g. Hillman (1994)) or cultural preferences (e.g. Schiff (1997)) help better understand attitudes towards immigration. But it is hard to dismiss the view that, like others, immigration policies are usefully analysed in a political-economy setting in which they are endogenously explained by economic and political self-interest and the institutional mechanisms of collective choice[1]. We study attitudes towards immigration in a model where

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[1] A widely used approach relies on the interest group model which states that the politically active groups will be those where the benefits from regulation policy (in our case immigration) are concentrated. For instance, Freeman (1995) argues that benefits from immigration are concentrated among producers (who enjoy lower wages and face a higher demand) whereas the costs are diffused among the working population group (which earns lower wages). Hence, organised interests get more

attitudes are determined entirely by economic self-interest in a direct-democracy framework à la Mayer (1984), the simplest institutional mechanism of collective choice.

Our objective is to explore the links between deteriorating labour market conditions in recipient countries in the context of economies becoming increasingly more open to trade and the changing attitudes towards immigration. We use the simplest two-good Heckscher-Ohlin model. However, to accommodate labour economists' views that wages are not entirely determined in product markets, we use a three-factor version of the model with low-skill labour, high-skill labour, and capital. And to link model-results to the debate on the evolution of the wage gap, we consider two-households (high-skill and low-skill households that own varying degrees of capital). This extension also allows us to study the effects of changes in the distribution of income on household attitudes towards immigration[2].

It should be pointed out at the outset that this trade-theoretic approach has limitations. To begin with, the straightjacket imposed by this core model will only capture some of the pertinent changes in product and labour markets in recipient countries[3]. Neither will the exclusive focus on economic self-interest be sufficient to understand the changes in attitudes

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attention from political authorities than the general public does, and immigration policies appear more liberal than those that would be wished by the majority of the population. Others also recognise the role of new immigrants as a pressure group (see e.g. Buckley (1996), and Goldin (1994)). For a critical survey of the political-economy literature on immigration, see Hillman and Weiss (1997).

[2] Davies and Wooton (1992) also use a 3x2 model to study the effects of endowment changes on the factoral distribution of income. They do not, however, map factor income into household income. The alternative would have been to rely on the specific-factor model. However, even in this case, the analysis would have produced ambiguous results.

[3] Benhabib's (1996) one-sector one-factor direct-democracy model shares the zero-sum game property of our model and the opposed attitudes of households. He shows that, under majority voting, an immigration policy that increases (lowers) the economy-wide average wealth ownership (or capital-labour ratio) will be defeated if the median voter's wealth is above (below) a critical capital ownership level. He also derives an expression for the immigration policy that would defeat any other policy in a pairwise contest under majority voting.

towards immigration. We hope, however, that a taxonomic approach in a widely understood framework will be helpful in establishing the nexus between increasing openness to trade, changes in the labour market, and resulting pressures for changes in immigration policies.

Section 2 presents the building blocks of the model: household factor ownership patterns and factor intensity conditions. Section 3 develops a simple graphical analysis (see figure 1) that allows to determine household attitudes towards immigration in terms of two parameters: a "similarity" index measuring differences in factor intensities and the household composition in the population. Section 4 carries out standard comparative statics exercises that establish how factor accumulation, terms of trade changes, and disembodied technical progress affect households attitudes towards immigration. Section 5 attempts to interpret model-predicted results about changes in attitudes towards immigration in terms of broad stylised facts on the evolution of product and factor markets in receiving countries. Section 6 concludes.

2. The model

The "3x2" model used here was first introduced by Batra and Casas (1976) and further developed by Jones and Easton (1983) in a different context. As in these papers, we assume that the economy is small so that prices are fixed in international markets, and we take a long run view by assuming that all factors are mobile across sectors. Two goods are produced, X_1 and X_2, with constant return to scale production functions using three factors, low-skill labour, L, high-skill labour, H, and capital, K. Besides having the advantage that immigration has an effect on factor incomes even if the economy remains diversified (as we also assume), the model also allows us to trace the effects of (exogenous) changes in product prices, factor accumulation and technical progress on attitudes towards immigration via changes in factor rewards and household incomes. A one-household version of this model has been used by Kuhn and Wooton (1991) and Davies and Wooton (1992) to study the effects of immigration on wages and income inequality. We discuss first assumptions about households, then turn to technology and factor endowments.

2.1. Households

Because recent observed changes in immigration policies tend to ease and emphasise qualifications and/or capital ownership, it is useful to separate household income from factor income: hence we assume two types of households, each owning either one unit of low-skill labour (L) or one unit of high-skill labour (H) and a positive amount of capital (K)[4]. Households have identical and homothetic preferences. Household income depends on factor prices w_K, w_L, and w_H. Thus, the incomes of low and high-skill households are $y_l=w_L+w_K K_l$ and $y_h=w_H+w_K K_h$, respectively (where l=1,....L and h=1,...,H). It is assumed that immigrants spend their income in the receiving country and do not vote.

Suppose a direct democracy in which people vote on immigration policy. Then, a voter will favour entry of new immigrants if it increases his utility. Define the indirect utility of voter v as $U_v=U_v(p,y_v)$, where p is the relative domestic price of good 1 expressed in terms of good 2, the numéraire, and v=l,h. Then, in the general case where immigrants, M, may bring in capital, the condition for household v to favour immigration is that

$$dU_v = \frac{\partial U_v}{\partial p}\left(\frac{\partial p}{\partial M}dM + \frac{\partial p}{\partial K}dK\right) + \frac{\partial U_v}{\partial y_v}\left(\frac{\partial y_v}{\partial M}dM + \frac{\partial y_v}{\partial K}dK\right) \geq 0. \qquad [1]$$

Since goods' prices are fixed, $\partial p/\partial M = \partial p/\partial K = 0$, the condition for a voter to support the arrival of new immigrants reduce to

$$\begin{aligned} dy_v &= \frac{\partial y_v}{\partial M}dM + \frac{\partial y_v}{\partial K}dK = dM\left[\frac{\partial y_v}{\partial M} + \frac{\partial y_v}{\partial K}\frac{dK}{dM}\right] \\ &= dM\left[\left(\frac{\partial w_v}{\partial M} + \frac{\partial w_v}{\partial K}\frac{dK}{dM}\right) + \left(\frac{\partial w_K}{\partial M} + \frac{\partial w_K}{\partial K}\frac{dK}{dM}\right)K_v\right] \geq 0. \end{aligned} \qquad [2]$$

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[4] In Benhabib (1996), conflicting attitudes derive from different patterns of capital ownership. By not mapping factor-income into household-income, Davies and Wooton (1992) concentrate on the effects of immigration on the functional distribution of income.

where $\frac{dK}{dM} > 0$ indicates the capital ownership of an immigrant M (M=L,H).

Expression [2] shows that a voter's attitude towards immigration depends on factor price changes weighted by household factor endowments. In this expression, the first term in parentheses on the right-hand side gives the effect of immigration on labour income, the second the effect of immigration on capital income. As is well-known from Jones (1965), Ruffin (1981) and Jones and Easton (1983), the effects of factor-endowment changes on factor rewards only depend on factor-intensity assumptions.

2.2. Factor endowments and factor prices

To complete the model, we must specify factor extremity conditions. Presumably, countries that receive immigrants are net importers of low-skill labour intensive products, and exporters of either capital or skilled-labour intensive products. Thus, if we assume that X_1 is the import-competing sector, we need only consider the following two factor-intensity cases:

Factor extremity conditions:

Case (I): capital is the "middle-factor"

$$\frac{a_{L1}}{a_{L2}} > \frac{a_{K1}}{a_{K2}} > \frac{a_{H1}}{a_{H2}} \qquad [3a]$$

Case (II): high-skill labour is the "middle-factor"

$$\frac{a_{L1}}{a_{L2}} > \frac{a_{H1}}{a_{H2}} > \frac{a_{K1}}{a_{K2}} \qquad [3b]$$

where a_{ij} is the amount of factor *i* used in a unit of good *j* (with i=L,H,K and j=1,2). Arguably, most host countries can be classified in these two categories, though which category is a matter of debate[5]. As it turns out (see below), the most interesting case in terms of the variety of results is case I.

We know from Ruffin (1981) that in the 3x2 model the two extreme factors are "enemies" (i.e., an increase in the endowment of one of the extreme factors reduces the reward of the other, while increasing the reward of the middle factor), whereas the middle factor is everybody's "friend" (i.e., an increase in the endowment of the middle factor rises the extreme factor prices). Hence, high-skill and low-skill labour are enemies in case I, whereas they are friends in case II. Table 1 summarises factor price effects of factor endowments changes under the two cases of factor extremity conditions. It indicates the change in factor rewards when endowment growth affects only one factor. The pattern of signs indicates clearly that the middle and extreme factors are q-complements while extreme factors are q-substitutes.

Table 1: Ruffin's factor extremity conditions and marginal changes in factor prices[1)]

Case I ↓ →	dw_L	dw_K	dw_H	
dL	-	+	-	dL
dK	+	-	+	dH
dH	-	+	-	dK
	dw_L	dw_H	dw_K	← ↑ **Case II**

[1)] A negative (positive) sign in a cell indicates a decrease (increase) in the corresponding factor income (e.g. dw_H/dL is negative in case I but positive in case II).

[5] For example, Bowen, Leamer and Sveikauskas (1987) find that both the US and most European countries are net exporters of high-skill labour services. But so are they of capital services though barely so in the case of the US. On the other hand, Davies and Wooton (1992) argue that the broad evidence suggests that the US belongs to case I.

To deal with the effect of capital-endowed immigrants, we need to extend Ruffin's analysis to allow for generalised endowment changes. Using a hat (^) to denote a relative change, the equations linking product price and factor endowment changes to factor rewards are:

$$\theta_{L1}\hat{w}_L + \theta_{K1}\hat{w}_K + \theta_{H1}\hat{w}_H = \hat{p}_1 \qquad [4]$$

$$\theta_{L2}\hat{w}_L + \theta_{K2}\hat{w}_K + \theta_{H2}\hat{w}_H = \hat{p}_2 \qquad [5]$$

$$\xi_L\hat{w}_L + \xi_K\hat{w}_K + \xi_H\hat{w}_H = \hat{V} \qquad [6]$$

where p_j is the price of commodity j, θ_{ij} is the share of factor i in sector j's costs, ξ_i is the (general equilibrium) economy-wide elasticity of the use of the middle factor with respect to w_i and $\hat{V}$ is the relative change in the net supply of the middle factor resulting from endowment variations (see equation [8] below). Note that equation [6] results from the manipulation of the three-equations five-unknowns system describing the full-employment condition for each factor. In [6], output changes ($\hat{X}_1, \hat{X}_2$) have been implicitly solved from the extreme factor markets and substituted in the middle factor expression[6].

The Appendix shows that, at constant commodity prices, for any change in factor endowments, the relative change in the reward of factor i, $\hat{w}_i$, is given by :

$$\hat{w}_i = -\frac{1}{\tilde{\Delta}}\frac{\theta^m}{\theta^i}\alpha_i\hat{V} \qquad [7]$$

where $\tilde{\Delta}$ is a negative term defined in the Appendix, reflecting factor substitutability, while θ^i (θ^m) is the share of factor i (of the middle factor) in national income.

[6] The right hand side of [6] can be interpreted as the factor endowment-driven change in the net supply of the middle factor (keeping factor prices at their initial level and allowing output changes such that extreme factor markets are cleared), while the left-hand side represents the necessary adjustment of the demand for the middle factor through factor rewards' changes.

Denote by e^+, e^- the extreme factors and by λ_i^+ (λ_i^-) the share of factor i used by the sector that is relatively intensive in extreme factor e^+ (e^-). Then, if $\hat{V}_i$ is the relative change of the endowment of factor i, $\hat{V}$ is given by:

$$\hat{V} = -\sum_{i \in (e^+, m, e^-)} \alpha_i \hat{V}_i = \hat{V}_m - (\alpha_{e^+} \hat{V}_{e^+} + \alpha_{e^-} \hat{V}_{e^-}) \qquad [8]$$

where

$$\alpha_{e^+} = \frac{\lambda_m^+ - \lambda_{e^-}^+}{\lambda_{e^+}^+ - \lambda_{e^-}^+}, \qquad \alpha_{e^-} = \frac{\lambda_m^- - \lambda_{e^+}^-}{\lambda_{e^-}^- - \lambda_{e^+}^-}, \qquad \alpha_m = -1 \qquad [9]$$

This notation brings out that $|\alpha_i|$ can be interpreted as an index of similarity between factor i and the middle factor. As $\lambda_i^+ = 1 - \lambda_i^-$, it is easily shown that $\alpha_{e^+} = 1 - \alpha_{e^-}$. Thus, from [8], $\hat{V}$ can be interpreted as the difference between the middle factor's growth rate and the weighted average of the growth rate of extreme factors. If this difference is positive (negative), factor growth will lead to an excess supply (demand) of the middle factor at constant factor prices, leading to a decrease (increase) of the middle factor's reward and an increase (decrease) of the reward of extreme factors. Finally, $\hat{V} = 0$ defines the set of factor growth rates that have no effect on factor prices.

3. Attitudes towards immigration

In the absence of voting costs, households will favour (oppose) immigration if their income increases (decreases) following immigrants' arrival. We consider permanent immigration and assume either that there were no immigrants previously or that previous immigrants are assimilated and vote. Also, assume that households within each group have identical endowments of capital[7]. Then, in this type of model, a one-shot factor immigration

[7] In reality, households groups are heterogeneous. In section 5, we explore, by simulation, the implications of allowing for an uneven distribution of capital within each household group (intra-

leaves the income of residents unchanged[8]. With capital evenly distributed within each household category, this implies that, as in Benhabib (1996), high-skill and low-skill households will always adopt an opposite attitude towards immigration. The following paragraphs develop intuitively how factor intensity conditions determine household attitudes following a marginal immigration.

Consider first a Ruffin-type case, with an inflow of low-skill immigrants with no capital ownership. Then, if capital is the middle factor (case I), low-skill and high-skill households are enemies. Does this imply that low-skill households (high-skill) will always oppose (favour) immigration? Not necessarily, since, to take a counter-intuitive case, it could be that low-skill households' income increases because of the increase of their capital income. Hence, in case I, there is a critical capital-ownership level that will determine a household's attitude towards immigration. The same reasoning would apply (but would lead to different critical capital-ownership levels) for an inflow of high-skill immigrants with no capital ownership, since high and low-skill labour are still enemies (in terms of equation [8], $\hat{V} < 0$).

Consider now the same type of low-skill immigration when high-skill labour is the middle factor (case II). As capital and low-skill labour are now enemies, low-skill households loose on both counts and necessarily oppose immigration. What about high-skill households, whose capital (labour) income falls (rises)? One would think that the attitude would depend again on a critical capital-ownership level. However, given that immigration is a zero-sum game for residents, the gain in high-skill wage income is equal to the combined loss in capital and low-skill wage income. With capital evenly distributed within each category, this necessarily leaves high-skill households with a gain. Contrarily to case I, for an inflow of high-skill immigrants with no capital ownership, the friend/enemy relationship with immigrants would be

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group disparity in capital ownership). Till then, we assume either a uniform distribution of capital within and across household groups, or an inter-group disparity in household capital ownership (see equation [12]).

[8] National income is the sum of factor payments, $Y=w_L L+w_H H+w_K K$. By the envelope theorem, the marginal impact of a one-shot immigration on national income is $\partial Y/\partial M=w_M$ (M=L,H), which means that total income of the incumbent factors remains unchanged.

reversed ($\hat{V}$ changes sign in [8]), leading to opposite households' attitudes.

Going beyond Ruffin-type immigration, what happens if immigrants also own capital? Even though this case is more complicated, the same mechanisms are at work. In case I, as long as the capital brought by immigrants is below a critical level, $\hat{V}$ remains negative, leading to the same attitudes. And if the capital ownership of immigrants exceeds that critical level, attitudes are reversed because $\hat{V}$ changes sign, which implies, by [7], that the pattern of factor rewards' changes reverses. In case II, if immigrants are low-skilled, the capital they bring in simply reinforces the effects on resident households' income noted above ($\hat{V}<0$). But if immigrants are high-skill there is now again a critical capital-ownership level of immigrants above which the previous results would be reversed.

The above can be synthesised by rewriting equation [2] in a slightly different way and by defining household capital ownership levels in relation to the critical levels identified above. For $dw_K \neq 0$, noting that $dy_v = dw_v + dw_K K_v = dw_K \left[\frac{dw_v}{dw_K} + K_v\right]$, and using [7] leads to:

$$dy_v = \left[-\frac{1}{\bar{\Delta}}\frac{\theta^m}{\theta^K}\alpha_K\right]\left[\hat{V}\right]\left[\frac{\alpha_v}{\alpha_K}\frac{K}{V} + K_v\right] \qquad [10]$$

which reflects that the attitude of household v would change if there are critical capital-ownership levels for which expression [10] changes sign.

Definition: Critical capital-ownership levels:

1) A national household v (v=l,h) is *capital-poor (capital-rich)* if its capital ownership, K_v, is less (greater) than the critical household ownership level, $K_v^c(J), J = I, II$.

2) An immigrant household u (u=l,h) is *capital-poor (capital-rich)* if its capital ownership, ${}^M_u K$, is less (greater) than the critical immigrant capital ownership level, ${}^M_u K_v^c(J), J = I, II$.

Critical capital-ownership level values (see table A1 in the Appendix) depend on national factor endowments and differences in factor intensities reflected by α_i (the similarity index). For households, using [7], these critical levels are given by:

$$K_v^c = -\frac{dw_v}{dw_K} = -\frac{\alpha_v}{\alpha_K}\frac{K}{V} \qquad [11]$$

which is positive if the comparison involves the middle factor (as $\alpha_m = -1$). In case I, since $K_v^c(I) = \alpha_v \frac{K}{V}$, the similarity index between v and K, α_v, also reflects the share of total capital that must be allocated to household v to leave it just indifferent to immigration.

Define now τ, the index of inter-group disparity of the distribution of capital:

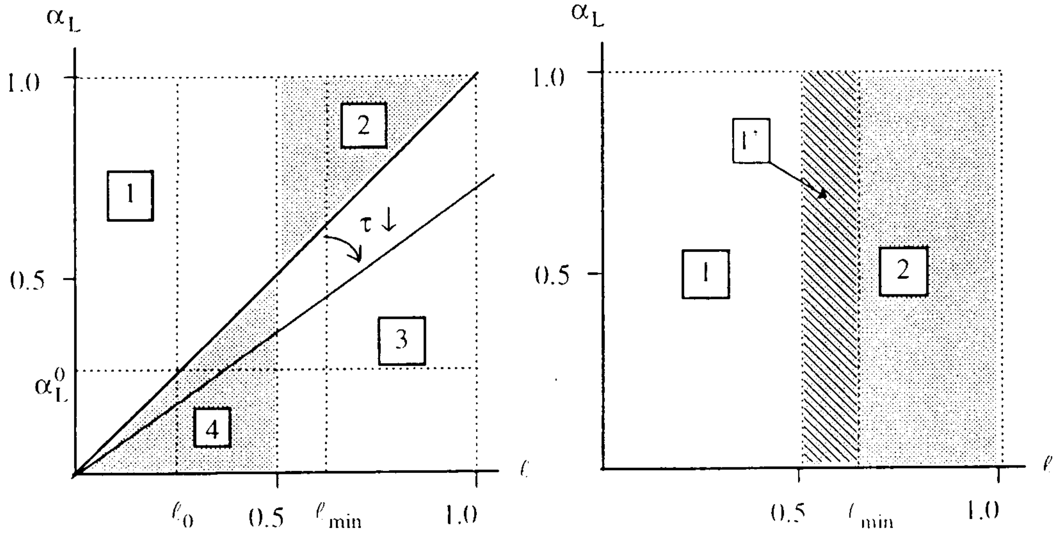
$$\tau \equiv \left(\frac{K_L}{L}\right) \Big/ \left(\frac{K}{L+H}\right) \qquad [12]$$

Remembering that $K = K_L + K_H$, this index takes the value of 1 when there is no inter-household disparity in the distribution of capital and 0 when all capital ownership goes to the high-skill household group. Finally, let $\ell \equiv L/(L+H)$ be the share of low-skill households in total population.

Then, the effective share of total capital owned by household v, $s_v \equiv K_v/K$, is given by the following expressions:

$$s_L = \tau\ell, \qquad s_H = 1 - \tau\ell \qquad [13]$$

Figure 1: determinants of national attitude towards immigration



1(a) - case I
(capital is the middle factor)

1(b) - case II
(high-skill labour is the middle factor)

ℓ: share of low-skill households in total population

α_L: similarity index between low-skill labour and the middle factor (or also, in case I: share of total capital that should accrue to low-skill households to make them indifferent to immigration)

ℓ_{min}: minimum share for voting low-skill households to become the majority (ℓ_{min} =0.5 if all low-skill households vote)

see text for interpretation of shaded areas.

Clearly, as $\alpha_L = 1 - \alpha_H$ and $s_L = 1 - s_H$, $\alpha_L < (>) s_L \Leftrightarrow \alpha_H > (<) s_H$. This confirms that in case I, when L households are capital-rich (capital-poor), H households are necessarily capital-poor (capital-rich). In case II, the only potential candidates for critical capital ownership would be high-skill households, $K_H^c(II) = (1/\alpha_K)(K/H)$. However, with capital evenly distributed within H households, indifference would only be reached if the share of total capital accruing to H households would exceed 100% ($1/\alpha_K$). Thus, as noted above, there is no relevant critical capital ownership for households in case II.

National attitude towards immigration are depicted graphically in figure 1, on the basis of ℓ and α_L values. In case I (figure 1(a)), as seen above, indifference for all households is reached along the $\alpha_L = \tau \ell$ line, which coincides with the diagonal when $\tau=1$ (recall that indifference requires $K_v^c = \alpha_v(K/V) = K_V = s_v(K/V)$, which implies $\alpha_v = s_v$). For all points above (below) this line, low-skill households are capital-poor (capital-rich), the reverse being true for high-skill households. Thus, if immigrants are capital-poor, all points above the indifference line correspond to cases where low(high)-skill households oppose (favour) immigration, while positions are reversed below the indifference line. As national attitude will match the attitude of the majority group, in the clear areas 1 and 3 (the shaded areas 2 and 4), the economy favours (opposes) capital-poor immigration. If immigrants were capital-rich, all positions would be reversed. Finally, an increase in inter-group capital distribution disparity (a lower τ) would be associated with a widening of the range of (ℓ, α_L) values where low(high)-skill households are capital-poor (capital-rich), which is represented by a rotation of the indifference line towards the right leading to new shaded areas.

It is thus clear that the role of the similarity index in determining attitudes towards immigration depends on the distribution of capital ownership. In the extreme case where low-skill households own no capital ($\tau=0$), the attitude towards immigration will only depend on the share of low-skill households in total population (this case is considered in figure 1(b)). The degenerated case of the 2x2 model can also be illustrated in figure 1. If high-skill (low-skill) labour and capital are used with the same intensities in both sectors, $\alpha_L=0$ ($\alpha_L=1$) in both figures. Then households are indifferent to immigration as marginal changes in endowments have no impact on factor rewards.

Return to the general case. For example, in figure 1(a), suppose that the share of low-skill labour is $\ell_0 < 0.5$ and that the similarity index takes the value $\alpha_L^0 = \ell_0$. Suppose that immigrants are capital-poor in the sense defined above. In this case, poor households are a minority, but since both groups are indifferent to immigration, this is a borderline situation. Suppose now that $\alpha > \alpha_L^0$. Then, high-skill households will favour immigration (area 1), and since they are the majority, this implies that the political process, as modelled here, would be favourable to immigration of capital-poor immigrants. Conversely, if $\alpha < \alpha_L^0$, high-skill households (who are the majority) would oppose immigration and this would reflect the national attitude towards immigration. Finally, suppose that $\alpha = \alpha_L^0$, but that there is inter-group disparity in capital ownership ($\tau < 1$). Then, high-skill households that own more capital would be in favour of immigration (the intersection of the two dashed lines would now be in a clear area) and the economy would be favourable to immigration.

In general, the value taken by the similarity index is crucial in determining national attitudes towards immigration[9]. It is therefore useful to rewrite [9] in the following form that brings out the role of factor shares in determining the value of the index. If θ_i^+ (θ_i^-) is the share of factor i in total costs of the sector that is relatively intensive in extreme factor e^+ (e^-) and θ^i is the share of factor i in national income, then:

$$\alpha_{e^+} = \frac{\theta^{e^+}}{\theta^m}\left(\frac{\theta_m^+\theta_{e^-}^- - \theta_{e^-}^+\theta_m^-}{\theta_{e^+}^+\theta_{e^-}^- - \theta_{e^-}^+\theta_{e^+}^-}\right), \qquad \alpha_{e^-} = \frac{\theta^{e^-}}{\theta^m}\left(\frac{\theta_m^-\theta_{e^+}^+ - \theta_{e^+}^-\theta_m^+}{\theta_{e^+}^+\theta_{e^-}^- - \theta_{e^-}^+\theta_{e^+}^-}\right) \qquad [9']$$

To fix likely orders of magnitude, suppose that the middle factor is used with the same

[9] The role of the similarity index is however attenuated once it is assumed that capital ownership is not evenly distributed within households (see section 5).

intensity by both sectors, $\theta_m^+ = \theta_m^-$ (an assumption made in section 4 on comparative statics). Then, as shown in equation [A6'] in the Appendix, the similarity index is given by:

$$\alpha_{e^+} = \frac{\theta^{e^+}}{\theta^{e^+} + \theta^{e^-}}, \qquad \alpha_{e^-} = \frac{\theta^{e^-}}{\theta^{e^+} + \theta^{e^-}} \qquad [9'']$$

In this special case, the similarity index is equal to the share of the extreme factor in total income accruing to extreme factors.

Turn now to case II represented in figure 1(b). As there is no relevant critical-capital ownership for households, low(high)-skill households will systematically oppose (favour) low-skill immigration irrespective of their capital ownership. Thus, in figure 1(b), the clear area 1 (the dashed area 2) corresponds to a national acceptation (opposition) to low-skill immigrants. The same is true for capital-rich high-skill immigration, whereas the interpretation would reverse if high-skill immigrants were capital-poor.

Results so far can be summarised in the following propositions:

When capital ownership is evenly distributed within each group of households:

1. *low-skill and high-skill households always have opposite attitudes towards immigration.*
2. *when capital is the middle factor, national attitude towards immigration is mainly "capital concerned", as households' attitudes are independent of the type of immigrants (but for the critical capital-ownership level of immigrants).*
3. *when high-skill labour is the middle factor, national attitude towards immigration is mainly "skill-concerned", as households' attitudes are independent of their capital ownership (although they do depend on the capital-ownership of high-skill immigrants).*

Finally, the assumption that all immigrants are assimilated and vote can easily be relaxed. For example, assume that only a proportion γ of resident low-skill households vote ($0 \leq \gamma \leq 1$). Then, remembering that $\ell \equiv L / (L + H)$, the condition for voting low-skill households to become the majority is $\ell > \ell_{min} = (\gamma + 1)^{-1}$ $(0.5 \leq \ell_{min} \leq 1)$. In terms of figure 1, this means that the vertical line beyond which there is a reversal of attitude towards immigration is shifted to the right, leading to new shaded areas which are more akin to the attitude of high-skill households[10].

4. Comparative statics

How do changes in the economic environment affect the attitude towards immigration? Three exogenous changes are considered. First is growth through factor accumulation. In this case, critical-capital ownership levels for national households (see equation [11]) will be affected both directly, through factor endowment changes, and indirectly, through changes in the similarity index. This indirect effect is induced by variations in factor rewards (equation [7]), which derive from the comparative statics expressions [4] to [6].

Second, we take up changes in relative prices. It is widely perceived that reduction in tariffs and other barriers to trade (such as the cost of doing business) have been important components of globalisation that could have affected attitudes towards immigration. Here we proxy the effects of globalisation by an exogenous rise in the relative price of the exporting sector (X_2)[11].

Third is the impact of technical progress. It is believed that technical progress has contributed, partially at least, to the increasing wage gap between workers of different skills.

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[10] For example, figure 1(b) can be interpreted as reflecting the Gulf countries, with a strong proportion of low-skill individuals who are not assimilated as nationals. Then, $\ell_{min} > 0.5$ and the shaded area 2 is reduced by the dashed zone 1'. Thus, a national attitude favourable to low-skill immigrants could remain compatible with a direct democracy process even though low-skill households are the majority of the population.

[11] To be rigorous, one should take into account the redistributive effects of a reduction in trade barriers (e.g.: poor's get the resulting tariff revenue). This is ignored here.

We deal with disembodied technical progress, either neutral or low-skill-labour saving.

The relevant comparative statics expressions are equations [4] to [6] with $\hat{p}_1 = 0$, $\hat{p}_2 > 0$, $\hat{V} = 0$ in the case of relative price changes and $\hat{p}_1 = -v_1$, $\hat{p}_2 = -v_2$, $\hat{V} = -\eta$ in the case of technical progress (where $v_j = \sum_i \theta_{ij} \hat{a}_{ij}^{ex}$, $\eta = \eta_m - \left(\alpha_{e^+} \eta_{e^+} + \alpha_{e^-} \eta_{e^-}\right)$, $\eta_i = \lambda_{i1} \hat{a}_{i1}^{ex} + \lambda_{i2} \hat{a}_{i2}^{ex}$ and $\hat{a}_{ij}^{ex}$ denotes the exogenous component of the rate of change of a_{ij}). From the above, it is clear that neutral technical progress in sector 2 would be equivalent to an increase in the price of that sector. Hence, after dealing with the effects of a reduction of protection, we only treat across the board low-skill labour-saving technical progress in the following section.

As there is no relevant critical-capital ownership for households in case II, we concentrate the comparative statics analysis on case I, in the situation where immigrants are capital-poor (other cases are left to the reader). To save space, we only summarise results, with derivations relegated to the Appendix.

4.1 Growth in factor endowments

To get qualitative results, we make two simplifying assumptions. First, we consider cases where only one factor's endowment changes at a time, namely a capital increase or an increase in the endowment of high-skill labour. Second, we neutralise for the direct effect of endowment changes. Thus, in the case of capital growth, we assume that it is spread evenly across households. In the case of labour growth, we assume that the initial capital endowment of the group is spread evenly across individuals. Then, at constant factor prices, the critical level of capital ownership would change proportionately to the individual ownership of capital, which neutralises the direct effect of endowment changes. Variations in the attitude towards immigration are thus only driven by the indirect effect, through changes in the similarity index α_L.

It turns out that, in the general case, the sign of $\hat{\alpha}_L$ is ambiguous, depending on factor intensities and substitutability/complementarity between factors (see equations [A10] in the Appendix). To resolve this ambiguity, we take the "symmetric" case mentioned above (i.e. $\theta_m^+ = \theta_m^-$) and consider a one-level CES functional form for technology. Then, simple conditions can be derived under which an increase in factor endowment leads to changes in the similarity index and hence to changes in the attitudes towards immigration. These added restrictions also allow us to sign the effects of the other shocks on the value of the similarity index.

In the case of capital accumulation (as shown by equation [A16] in the Appendix), α_L will fall if the elasticity of substitution is higher in sector 2, a plausible condition as this sector is the exporting one[12]. As α_L falls, the critical-capital ownership level of high(low)-skill households increases (decreases), which means that this household category becomes more opposed (favourable) to immigration. To interpret this result, return to figure 1(a) and suppose that initially $\tau = 1$, $\alpha = \alpha_L^0$, $\ell = \ell_0$, which leads to indifference towards immigration, high-skill households being the majority. The increase in capital will shift the economy's point downwards, in a shaded area meaning opposition to (capital-poor) immigration, which reflects the new position of the majority group.

The impact of an increase in high-skill labour endowment is apparently more complex. On the one hand, it implies a decrease in ℓ which, starting from the same initial indifference point, would lead to a favourable national attitude towards (capital-poor) immigration. But on the other hand, it also leads to a change in α_L, which could run against the previous effect. However, as shown in the Appendix, in the "realistic" case where the elasticity of substitution is higher in the exporting sector, although α_L may eventually fall, it will never reverse the first effect. In sum, starting from indifference, an increase in high-skill labour endowment is likely to favour (capital-poor) immigration.

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[12] Under the symmetry assumption, this results also means that an increase in the middle factor's endowment leads to a relative increase of the share of the extreme factor used in the sector with the highest elasticity of substitution.

4.2 Increase in the relative price of the exporting sector

In the general case, an increase in the relative price of the exporting sector has an ambiguous impact on factor returns. However, if factors are substitutes, then as shown by Jones and Easton (1983), one obtains Stolper-Samuelson effects on the extreme factor returns, while the real return accruing to the middle factor depends on factor intensities and substitutability. In any case, to find out the effect on attitudes towards immigration, we need again to identify the effect of the shock on the value of the similarity index α_L.

With CES production functions (as shown in the Appendix, equation [A21]), whatever the values of the elasticities of substitution, α_L unambiguously decreases following the increase in the relative price of the exporting sector (or a neutral technical progress in the same sector)[13]. Therefore, starting from the usual initial indifference point in figure 1(a), this means that an increase in the relative price of the exporting sector (i.e. a reduction of protection) would generate an opposition to (capital-poor) immigration.

4.3 Low-skill labour-saving technical progress

Finally, the effect of across-the-board labour-saving technical progress on factor prices is generally ambiguous (see equations [A22] in the Appendix). If factors are substitutes, although the change in the low-skill labour wage rate remains ambiguous, the wage rate of high-skill individuals falls while the return to capital increases. In the simple symmetric case of a CES production technology, if the elasticity of substitution is higher in the exporting sector, α_L increases unambiguously (see equation [A25]). Thus, starting from the usual indifference point in figure 1(a), across the board low-skill labour-saving technical progress leads the economy to favour (capital-poor) immigration.

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[13] Although this result does not depend on the symmetry assumption, it means under symmetric conditions that an increase in the price of sector 2 increases the relative share of the extreme factor used intensively in that sector.

Results of the comparative statics can be summarised in the following propositions:

<u>Case I</u>: capital is the middle factor. Suppose that: high-skill individuals are the majority; there is neither inter-group nor intra-group disparity in capital distribution; the capital factor share in total cost is the same in both sectors; technology is of the CES type with a higher elasticity of substitution in the exporting sector. Then, starting from an initial indifference, the national attitude towards (capital-poor) immigration will become:

1) favourable in case of an increase in high-skill labour or a low-skill labour-saving technical progress in both sectors.
2) opposed in case of an increase in the capital stock or an improvement in the terms of trade (which is equivalent to a neutral technical progress in the exporting sector).

These results would be reversed if either low-skill individuals were the majority or immigrants were capital-rich.

<u>Case II</u>: high-skill labour is the middle factor. As there is no relevant critical-capital ownership level for national households, neither of these shocks would affect the position of each household category (but an increase in high-skill labour would reverse national attitude towards immigration if high-skill individuals become the majority).

5. Discussion

Consider the following often-cited stylised facts pertinent for the evolution of the labour market in recipient countries: (i) a decrease in the relative price of import-competing activities as a result of the globalisation that has reduced protection; (ii) an increase in the skill-unskilled wage gap; (iii) an increase in income (and capital) inequality; and (iv) technical progress, perhaps of the labour-saving variety.[14]

[14] Some have proposed (e.g. Wood(1994)) that globalisation has induced "defensive" labour-saving technical progress in the labour-intensive import-competing sectors.

Take again the symmetric case with capital the middle factor (case I). Then the import-competing (exporting) sector is intensive in low(high)-skill labour. Besides being plausible, case I brings out more sharply the conflict between skilled and unskilled labour while giving room for capital ownership minima among immigrants.

According to the results in section 4, via Stolper-Samuelson effects, globalisation is consistent with the observed increase in the wage gap. So is neutral technical progress in the exporting sector. However, across-the-board low-skill labour-saving technical progress would lead to a reduction of the wage gap along the lines shown by Findlay and Grubert (1959) in the 2x2 case. In the symmetric case, endowment changes would leave the wage gap unchanged. In short, the dominant effect is the Stolper-Samuelson one. Now, if Stolper-Samuelson effects are dominant, as shown above, this would lead to a stiffening in attitudes towards capital-poor immigration. However, even in this simple symmetric case, once one allows for an increase in the share of high-skill households in total population (which has no effect on the wage gap in this symmetric case), the attitude towards immigration is ambiguous since the effect of high-skill labour growth is favourable towards capital-poor immigration.

Assume now that capital ownership is not necessarily evenly distributed within households but follows a Beta distribution. The probability density function for the capital ownership of household v is given by:

$$f(K_v) = \frac{\Gamma(\beta_v + \gamma_v)}{\Gamma(\beta_v)\Gamma(\gamma_v)} \left(\frac{K_v}{c_v}\right)^{\beta_v - 1} \left(1 - \frac{K_v}{c_v}\right)^{\gamma_v - 1} \left(\frac{1}{c_v}\right) \qquad [14]$$

where K_v belongs to the interval $[0, c_v]$, $c_v > 0$ and Γ is the gamma function. For each household group, the upper bound value c_v is obtained from the mean: $E(K_v) = c_v \dfrac{\beta_v}{(\beta_v + \gamma_v)} = \dfrac{K_v}{V}$, V=H,L. This distribution is symmetric (skewed to the left) if $\beta_v = \gamma_v$ ($\beta_v < \gamma_v$).

For simplicity, suppose that parameters describing the distribution of capital within each household group are the same for both groups (i.e. $\beta_l = \beta_h$, $\gamma_l = \gamma_h$)[15]. Start with the case where the distribution is symmetric ($\beta = \gamma$) and there is no inter-group disparity in the distribution of capital ($\tau=1$). In this case, we get exactly the same results as in the case of no intra-group disparity of capital ownership. This is because the number of people in each household group having the attitude of the other group's majority is the same (hence, figure 2(a) is identical to figure 1(a)). Introduce now inter-group disparity in capital distribution ($\tau<1$), maintaining the same symmetrical distribution for each household group (figure 2(b)). Then, one is approximating the case where low-skill households have no capital, which has been discussed in section 3 (case II). Indeed, figure 2(b) approximates figure 1(b)[16].

Introduce now skewness in the distribution of capital (with no inter-group disparity). Again suppose identical standard forms for each group (figure 2(c)). Then, along the diagonal, although the mean voter would be indifferent to immigration, the median voter has lower capital in both groups, leading to a majority opposed to capital-poor immigration. As figure 2(c) confirms, to reverse this unfavourable attitude towards immigration, one must either alter the composition of the population or the value of the similarity index. Finally, figure 2(d) combines inter-group disparity and within-group skewness by combining the parameters used in figures 2(b) and 2(c).

Capital ownership distribution being highly skewed (see Wolff, 1996)), figures 2(c) or 2(d) are probably better guides of the roles of households composition and factor intensity differences in determining attitudes towards immigration. Also, taking a probabilistic approach to reflect ignorance about the economy's parameter values, note that, starting from

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[15] This implies identical standard forms for both groups (the standard form for the Beta is obtained through the change of variable that restricts the domain to the interval [0,1]).

[16] For values of α_L approximating zero, the critical capital ownership level of high(low)-skill households is very high(low). But as high-skill households receive a higher proportion of total capital, a sufficient number of them go along with low-skill households to create a majority favourable to capital-poor immigration.

figure 2(a), where the shaded area is 1/4, an increase in inter-group and/or intra-group disparity increases the importance of the shaded area, which approximately could reach 5/8, reflecting a higher probability of opposition to capital-poor immigration[17]. After all, widening income disparities would appear to be coherent with the generalised move towards introducing capital requirements in immigration.

Before concluding this discussion note that case II provides interesting results when low-skill labour (instead of high-skill labour) is the middle factor. Then, if low-skill households are the majority, the country will systematically favour high-skill immigrants (whatever their capital ownership) and capital-rich low-skill immigrants. This could be representative of the case where immigrants become progressively assimilated in the country (in the sense of voting or having a say on immigration policy).

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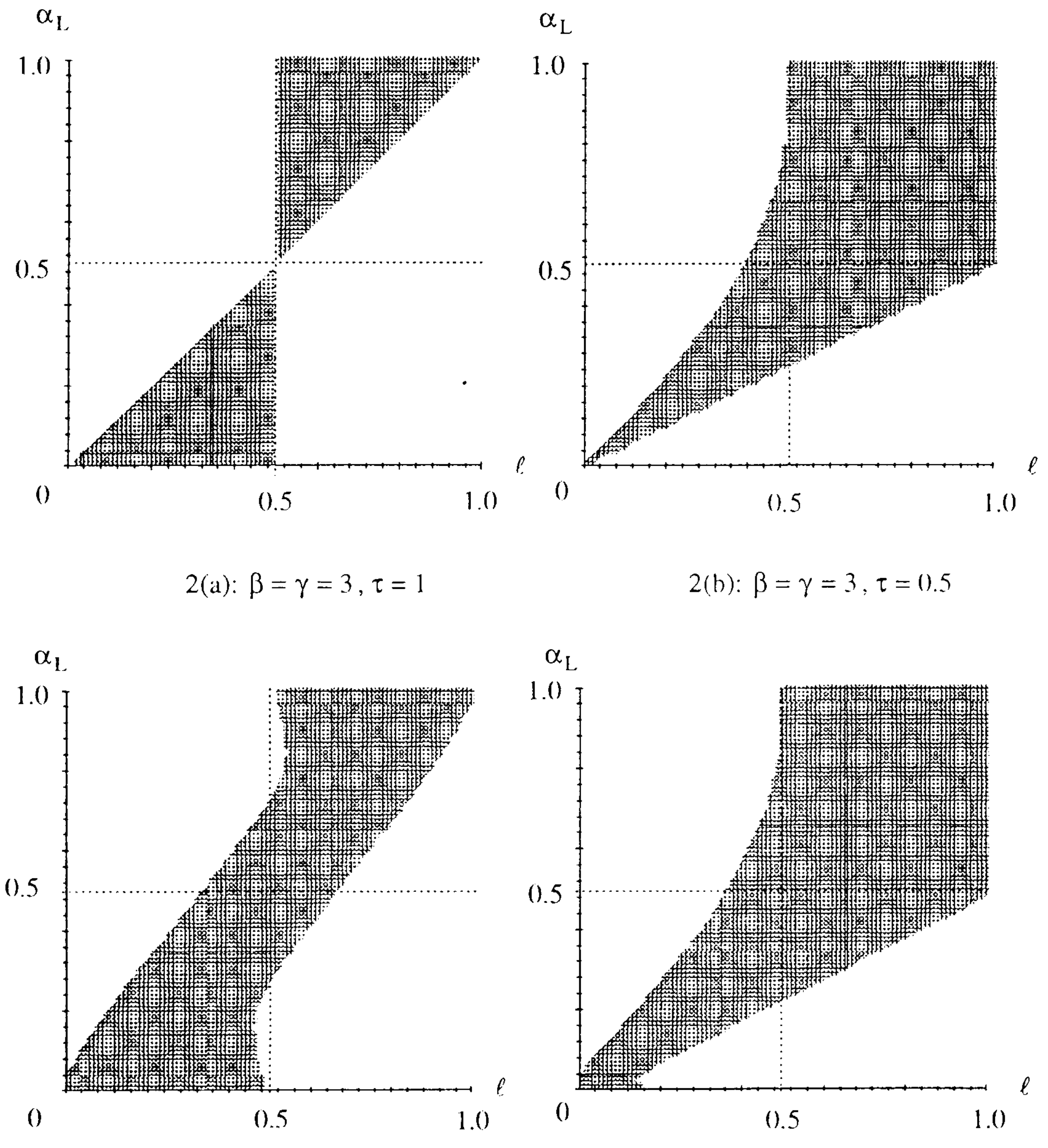
[17] Of course different values would be obtained with other functional forms to represent the distribution of capital. We have used the Beta since it makes it easy to reproduce the base case of no intra-group capital ownership disparity.

Figure 2: Capital ownership distribution and attitudes towards immigration

(Case I: capital is the middle factor)



2(a): $\beta = \gamma = 3$, $\tau = 1$

2(b): $\beta = \gamma = 3$, $\tau = 0.5$

2(c): $\beta = 3, \gamma = 6$, $\tau = 1$

2(d): $\beta = 3, \gamma = 6$, $\tau = 0.5$

6. Conclusions

This paper has developed a simple trade-theoretic model to investigate the links between a changing economic environment for a price-taking trading economy, and households' attitudes towards immigration. In spite of the complexity of the 3 factor 2 household model, we were able to show that so long as household capital-ownership disparities are inter-group, then attitudes towards immigration are determined by two parameters: an index of factor-use similarity (whose values can be approximated by readily available data on factor shares in export and import-competing sectors) and the household composition of the population.

At the same time, the model's strength (i.e. that it is rooted in well-received theory) is also the source of its shortcomings, which are worth reminding. First, as the comparative statics analysis revealed, the model allows too wide a range of patterns, so that depending on assumptions about factor intensities and substitutability , almost any attitude can be made compatible with the model. At the same time, as noted in the introduction, the straightjacket of the model does not allow factor flows to have a net impact on the aggregate income of residents, and it fails to cover certain stylised facts.

For example, recent immigration policy in a number of OECD countries tends to favour simultaneously either capital-rich low-skill immigrants and high-skill immigrants. This appears incompatible with the dichotomy implied by the 3x2 approach between capital-concerned countries (case I) and skill-concerned countries (case II), unless low-skill households are assumed to be the majority and low-skill labour is supposed to be the middle factor. Also, it is generally recognised that immigration brings out a number of externalities due to social and/or cultural differences. This is simply ruled out by the model: the sole impact of immigration are wage effects, which, through the zero-sum game property for residents, are conditioning the main results. Finally, an important dimension of globalisation is the decline of the jobs "sheltered" from international competition. This is probably affecting attitudes towards immigration, an effect that could only be captured in this framework if it were extended to include a non-traded sheltered sector.

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Appendix to:

"Determinants of attitudes towards immigration: a trade-theoretic approach"

(not submitted for publication)

This appendix develops the comparative statics of the 3x2 model and derives the results presented in the main text.

1. The 3x2 model

This section outlines the main characteristics of the 3x2 model based on Jones and Easton (1983) (the general case is treated by Jones and Scheinkman (1977)). Consider a small open economy producing two goods (j=1,2) with three factors (i=1,2,3). Assuming perfect competition and diversification, general equilibrium is characterised by the usual zero-profit and full employment conditions:

$$\sum_{i=1}^{3} a_{ij} w_i = p_j \qquad [A1]$$

$$\sum_{j=1}^{2} a_{ij} x_j = V_i \qquad [A2]$$

where w_i is the wage rate of factor i, p_j the price of good j, a_{ij} the quantity of factor i by unit output of good j, x_j the output of sector j and V_i the endowment of factor i.

In order to characterise factor intensities, the following definitions are needed: the share of factor i remuneration in total income, $\theta^i \equiv \frac{w_i V_i}{Y}$, the share of good j in total income, $\theta_j \equiv \frac{p_j x_j}{Y}$, the employment share of sector j in factor i, $\lambda_{ij} \equiv \frac{a_{ij} x_j}{V_i}$, and the redistributive share of factor i in sector j, $\theta_{ij} \equiv \frac{a_{ij} w_i}{p_j}$. Clearly, $\sum_i \theta^i = \sum_j \theta_j = 1$, $\sum_j \lambda_{ij} = \sum_i \theta_{ij} = 1$, and

$\theta_{ij} = \lambda_{ij} \frac{\theta^i}{\theta_j}$.

It is assumed that factor 3 is the "middle factor" in the sense that, for any level of factor prices, the following "factor extremity conditions" à la Ruffin (1981) hold:

$$\frac{a_{11}}{a_{12}} > \frac{a_{31}}{a_{32}} > \frac{a_{21}}{a_{22}} \Leftrightarrow \lambda_{11} > \lambda_{31} > \lambda_{21} \Leftrightarrow \frac{\theta_{11}}{\theta_{12}} > \frac{\theta_{31}}{\theta_{32}} > \frac{\theta_{21}}{\theta_{22}} \qquad [A3]$$

Using a hat (^) to denote relative change, total differentiation of equations [A1] and [A2] leads to the following reduced form for factor prices variations (see Jones and Easton, equation [20]):

$$\theta_{11}\hat{w}_1 + \theta_{21}\hat{w}_2 + \theta_{31}\hat{w}_3 = \hat{p}_1 \qquad [A4a]$$

$$\theta_{12}\hat{w}_1 + \theta_{22}\hat{w}_2 + \theta_{32}\hat{w}_3 = \hat{p}_2 \qquad [A4b]$$

$$\xi_1\hat{w}_1 + \xi_2\hat{w}_2 + \xi_3\hat{w}_3 = \hat{V} \qquad [A4c]$$

where ξ_k is the (general equilibrium) economy-wide elasticity of the use of factor 3 with respect to w_k and $\hat{V}$ is the relative change in the net supply of factor 3 resulting from endowment variations keeping factor prices at their initial level and allowing output changes such that extreme factor markets are cleared. It can be shown that

$$\xi_k \equiv \sigma_3^k - \left(\alpha_1\sigma_1^k + \alpha_2\sigma_2^k\right) \qquad [A5a]$$

$$\hat{V} \equiv \hat{V}_3 - (\alpha_1\hat{V}_1 + \alpha_2\hat{V}_2) \qquad [A5b]$$

where σ_i^k is the economy-wide elasticity of the use of factor i with respect to w_k, under the assumption that each industry's output is kept constant, and $\alpha_1(\alpha_2)$ denotes the index of similarity between factors 1(2) and 3,

$$\alpha_1 \equiv \frac{\lambda_{31} - \lambda_{21}}{\lambda_{11} - \lambda_{21}} = \frac{\theta^1}{\theta^3} \frac{(\theta_{31}\theta_{22} - \theta_{21}\theta_{32})}{(\theta_{11}\theta_{22} - \theta_{21}\theta_{12})} \quad \text{[A6a]}$$

$$\alpha_2 \equiv \frac{\lambda_{11} - \lambda_{31}}{\lambda_{11} - \lambda_{21}} = \frac{\theta^2}{\theta^3} \frac{(\theta_{11}\theta_{32} - \theta_{31}\theta_{12})}{(\theta_{11}\theta_{22} - \theta_{21}\theta_{12})} \quad \text{[A6b]}$$

with $0 < \alpha_1 < 1, 0 < \alpha_2 < 1$ and $\alpha_1 + \alpha_2 = 1$.

Useful simplifications arise in the "symmètric" case, e.g. when the redistributive factor share of the middle factor is identical in both sectors ($\theta_{31} = \theta_{32}$). As the full employment condition of the middle factor can be written $\theta_{31}\theta_1 + \theta_{32}\theta_2 = \theta^3$, and as $\theta_1 + \theta_2 = 1$, this implies that $\theta_{31} = \theta_{32} = \theta^3$. Furthermore, as $\sum_i \theta_{ij} = 1$, this leads to $\theta_{11} - \theta_{12} = \theta_{22} - \theta_{21} = \delta$, which implies, from [A6], that $\alpha_1 / \theta^1 = \alpha_2 / \theta^2$. Finally, as $\alpha_1 + \alpha_2 = 1$, one obtains:

$$\alpha_1 = \frac{\theta^1}{\theta^1 + \theta^2} \quad \text{[A6'a]}$$

$$\alpha_2 = \frac{\theta^2}{\theta^1 + \theta^2} \quad \text{[A6'b]}$$

From [A4], using Cramer's rule, the relative changes in factor prices are given by:

$$\hat{w}_1 = \frac{1}{\Delta}\{[\theta_{22}\xi_3 - \theta_{32}\xi_2]\hat{p}_1 - [\theta_{21}\xi_3 - \theta_{31}\xi_2]\hat{p}_2 + [\theta_{21}\theta_{32} - \theta_{22}\theta_{31}]\hat{V}\} \quad \text{[A7a]}$$

$$\hat{w}_2 = \frac{1}{\Delta}\{-[\theta_{12}\xi_3 - \theta_{32}\xi_1]\hat{p}_1 + [\theta_{11}\xi_3 - \theta_{31}\xi_1]\hat{p}_2 - [\theta_{11}\theta_{32} - \theta_{12}\theta_{31}]\hat{V}\} \quad \text{[A7b]}$$

$$\hat{w}_3 = \frac{1}{\Delta}\left\{[\theta_{12}\xi_2 - \theta_{22}\xi_1]\hat{p}_1 - [\theta_{11}\xi_2 - \theta_{21}\xi_1]\hat{p}_2 + [\theta_{11}\theta_{22} - \theta_{12}\theta_{21}]\hat{V}\right\} \quad [A7c]$$

where $\Delta \equiv \theta^3[\theta_{11}\theta_{22} - \theta_{12}\theta_{21}]\left[\frac{\xi_3}{\theta^3} - (\alpha_1\frac{\xi_1}{\theta^1} + \alpha_2\frac{\xi_2}{\theta^2})\right]$, which is always negative (see Jones and Scheinkman, 1977).

From [A6a], the relative change in the similarity index is given by:

$$\hat{\alpha}_1 = \frac{[\lambda_{31}\hat{a}_{31} - (\alpha_1\lambda_{11}\hat{a}_{11} + \alpha_2\lambda_{21}\hat{a}_{21})] - [\lambda_{31}\hat{V}_3 - (\alpha_1\lambda_{11}\hat{V}_1 + \alpha_2\lambda_{21}\hat{V}_2)]}{\lambda_{31} - \lambda_{21}} \quad [A8]$$

Define e_i^k, the sector 1 component of σ_i^k, by $e_i^k \equiv \lambda_{i1}\frac{\partial a_{i1}}{\partial w_k}\frac{w_k}{a_{i1}} = \lambda_{i1}\frac{\hat{a}_{i1}}{\hat{w}_k}$, and φ_k, the sector 1 component of ξ_k, by $\varphi_k \equiv e_3^k - (\alpha_1 e_1^k + \alpha_2 e_2^k)$. As a_{ij} is homogenous of degree zero in factor prices, $\sum_k e_i^k = 0$, $\sum_k \varphi_k = 0$, $\sum_k \sigma_i^k = 0$ and $\sum_k \xi_k = 0$. Thus, [A8] can be rewritten:

$$\hat{\alpha}_1 = \frac{[\varphi_1\hat{w}_1 + \varphi_2\hat{w}_2 + \varphi_3\hat{w}_3] - [\lambda_{31}\hat{V}_3 - (\alpha_1\lambda_{11}\hat{V}_1 + \alpha_2\lambda_{21}\hat{V}_2)]}{\lambda_{31} - \lambda_{21}} \quad [A9]$$

where the first bracket in the numerator represents sector 1 component of the relative change in the demand for factor 3 (resulting from factor prices variations) and the second is sector 1 component of the relative change of the net supply of factor 3 (due to endowment variations at initial factor prices). Although both quantities must be equal in the aggregate (which is the interpretation of equation [A4c]), it is not necessarily the case at the sector level, which means that the sign of $\hat{\alpha}_1$ is ambiguous. Finally, $\hat{\alpha}_2 = -(\alpha_1 / \alpha_2)\hat{\alpha}_1$ as, by definition, $\alpha_1 + \alpha_2 = 1$.

2. Endowment changes

Using equations [A6] and [A7], when commodity prices remain constant, the rates of change of factor prices are given by the following expressions:

$$\hat{w}_1 = -\frac{1}{\tilde{\Delta}}\hat{V}\alpha_1\frac{\theta^3}{\theta^1} \qquad [A10a]$$

$$\hat{w}_2 = -\frac{1}{\tilde{\Delta}}\hat{V}\alpha_2\frac{\theta^3}{\theta^2} \qquad [A10b]$$

$$\hat{w}_3 = \frac{1}{\tilde{\Delta}}\hat{V} \qquad [A10c]$$

where $\tilde{\Delta} = \Delta / [\theta_{11}\theta_{22} - \theta_{12}\theta_{21}] = \xi_3 - (\alpha_1\xi_1\frac{\theta^3}{\theta^1} + \alpha_2\xi_2\frac{\theta^3}{\theta^2}) < 0$.

From [A10], simple expressions can be obtained for the ratios of absolute changes in factor prices:

$$\frac{dw_1}{dw_2} = \frac{\alpha_1}{\alpha_2}\frac{V_2}{V_1} \qquad [A10a']$$

$$\frac{dw_1}{dw_3} = -\alpha_1\frac{V_3}{V_1} \qquad [A10b']$$

$$\frac{dw_2}{dw_3} = -\alpha_2\frac{V_3}{V_2} \qquad [A10c']$$

Note that these ratios do not depend on endowment changes, nor on factor substitutability, but do depend on initial factor endowments. Indeed, different initial endowments affect these ratios both directly, through the V_j/V_k terms, and indirectly, through possible changes in α_1 (and therefore α_2).

Using [A10], the relative change in the similarity index (equation [A9]) becomes:

$$\hat{\alpha}_1 = \frac{\hat{V}}{\lambda_{31} - \lambda_{21}} \left[\frac{\frac{\varphi_3}{\theta^3} - \left(\alpha_1 \frac{\varphi_1}{\theta^1} + \alpha_2 \frac{\varphi_2}{\theta^2}\right)}{\frac{\xi_3}{\theta^3} - \left(\alpha_1 \frac{\xi_1}{\theta^1} + \alpha_2 \frac{\xi_2}{\theta^2}\right)} - \frac{\lambda_{31}\hat{V}_3 - (\alpha_1\lambda_{11}\hat{V}_1 + \alpha_2\lambda_{21}\hat{V}_2)}{\hat{V}_3 - (\alpha_1\hat{V}_1 + \alpha_2\hat{V}_2)} \right] \quad [A11]$$

For the sake of clarity in the comparative statics analysis, we consider cases where only one factor's endowment changes at a time. A general analysis of the sign of $\hat{\alpha}_1$ would include a discussion of both substitutability (φ_k, ξ_k) and factor intensity (α_1, α_2) parameters. To simplify, we consider the symmetric case, where $\alpha_1 / \theta^1 = \alpha_2 / \theta^2$ (i.e., $\theta_{31} = \theta_{32}$). Hence, knowing that $\sum_k \varphi_k = 0$ and $\sum_k \xi_k = 0$, it follows that the first term between brackets in [A11] simplifies to φ_3 / ξ_3, which leads to:

$$\text{sign}(\hat{\alpha}_1) = \begin{cases} \text{sign}\left[\hat{V}_1(\lambda_{11} - \frac{\varphi_3}{\xi_3})\right] \\ \text{sign}\left[\hat{V}_2(\lambda_{21} - \frac{\varphi_3}{\xi_3})\right] \\ \text{sign}\left[\hat{V}_3(\frac{\varphi_3}{\xi_3} - \lambda_{31})\right] \end{cases} \quad [A12]$$

3. CES case

Let define a CES production function for both sectors such as:

$$x_j = \left[\sum_{i=1}^{3} c_j^i (V_j^i)^{\rho_j}\right]^{1/\rho_j} \quad [A13]$$

where c_j^i is the distribution parameter of factor i (i=L,H,K) in sector j (j=1,2) and ρ_j is the elasticity parameter. Note that $\rho_j = (\sigma_j-1)/\sigma_j$, where σ_j stands for the elasticity of substitution in sector j. Cost minimisation yields $V_i^j = \left(\frac{w_i}{c_i^j}\right)^{-\sigma_j}\left[\sum_{i=1}^{3}(w_i)^{1-\sigma_j}\left(c_i^j\right)^{\sigma_j}\right]^{\frac{\sigma_j}{1-\sigma_j}} x_j$. Using the zero profit condition, this expression simplifies to:

$$V_i^j = \left(\frac{w_i}{c_i^j}\right)^{-\sigma_j}\left(p_j\right)^{\sigma_j} x_j. \qquad [A14]$$

It follows, after some transformations, that $\xi_1 = -\alpha_1\sigma_1^1 = \alpha_1\left[\lambda_{11}\sigma_1 + (1-\lambda_{11})\sigma_2\right]$, $\xi_2 = -\alpha_2\sigma_2^2 = \alpha_2\left[\lambda_{21}\sigma_1 + (1-\lambda_{21})\sigma_2\right]$, and $\xi_3 = \sigma_3^3 = -\left[\lambda_{31}\sigma_1 + (1-\lambda_{31})\sigma_2\right]$, while $\varphi_1 = -\alpha_1 e_1^1 = \alpha_1\sigma_1\lambda_{11}$, $\varphi_2 = -\alpha_2 e_2^2 = \alpha_2\sigma_1\lambda_{21}$ and $\varphi_3 = e_3^3 = -\sigma_1\lambda_{31}$. This implies that $\varphi_3 / \xi_3 = \sigma_1\lambda_{31} / \left(\sigma_1\lambda_{31} + \sigma_2\lambda_{32}\right)$ and leads to the following expression for $\hat{\alpha}_1$ in the symmetric case:

$$\hat{\alpha}_1 = \frac{\hat{V}}{\lambda_{31} - \lambda_{21}}\left[\frac{\lambda_{31}\sigma_1}{\overline{\sigma}} - \frac{\lambda_{31}\hat{V}_3 - (\alpha_1\lambda_{11}\hat{V}_1 + \alpha_2\lambda_{21}\hat{V}_2)}{\hat{V}_3 - (\alpha_1\hat{V}_1 + \alpha_2\hat{V}_2)}\right] \qquad [A15]$$

where $\overline{\sigma} = \lambda_{31}\sigma_1 + \lambda_{32}\sigma_2$. Hence, in the symmetric case with a CES production function, and after some transformations, condition [A12] can be expressed in terms of elasticities of substitution only:

$$\text{sign}(\hat{\alpha}_1) = \begin{cases} \text{sign}\left[\hat{V}_1\left(\frac{\lambda_{11}}{\lambda_{31}}\frac{\lambda_{32}}{\lambda_{12}} - \frac{\sigma_1}{\sigma_2}\right)\right] \\ \text{sign}\left[\hat{V}_2\left(\frac{\lambda_{21}}{\lambda_{31}}\frac{\lambda_{32}}{\lambda_{22}} - \frac{\sigma_1}{\sigma_2}\right)\right] \\ \text{sign}\left[\hat{V}_3\left(\frac{\sigma_1}{\sigma_2} - 1\right)\right] \end{cases} \qquad [A16]$$

where, from [A3] and using the relationship $\lambda_{i1} = 1 - \lambda_{i2}$, it is clear that $\frac{\lambda_{11}}{\lambda_{31}}\frac{\lambda_{32}}{\lambda_{12}} > 1$ while

$0 < \frac{\lambda_{21}}{\lambda_{31}}\frac{\lambda_{32}}{\lambda_{22}} < 1$.

As a special case, consider $\hat{V}_2 > 0, \hat{V}_1 = \hat{V}_3 = 0$, and define $\ell \equiv V_1 / (V_1 + V_2)$. Then

$\hat{\alpha}_1 = -[\alpha_2 / (\lambda_{31} - \lambda_{21})][(\lambda_{31}\sigma_1 - \lambda_{21}\bar{\sigma}) / \bar{\sigma}]\hat{V}_2$ and $\hat{\ell} = -(1-\ell)\hat{V}_2$. Thus, starting from

$\alpha_1 = \ell$, it is easily shown that $|\hat{\alpha}_1| > |\hat{\ell}| \Leftrightarrow \sigma_2 < \sigma_1$

4. Technical progress

Let $\hat{a}_{ij} = \hat{a}_{ij}^{ex} + \hat{a}_{ij}^{en}$, where $\hat{a}_{ij}^{ex}$ ($\hat{a}_{ij}^{en}$) denotes the exogenous (endogenous) rate of change of a_{ij}. With technical progress, total differentiation of equations [A1] and [A2] leads to the following reduced form, similar to [A4],

$$\theta_{11}\hat{w}_1 + \theta_{21}\hat{w}_2 + \theta_{31}\hat{w}_3 = -v_1 \qquad [A17a]$$

$$\theta_{12}\hat{w}_1 + \theta_{22}\hat{w}_2 + \theta_{32}\hat{w}_3 = -v_2 \qquad [A17b]$$

$$\xi_1\hat{w}_1 + \xi_2\hat{w}_2 + \xi_3\hat{w}_3 = -\eta \qquad [A17c]$$

where $v_j = \sum_i \theta_{ij}\hat{a}_{ij}^{ex}$ and $\eta = \eta_3 - (\alpha_1\eta_1 + \alpha_2\eta_2)$, with $\eta_i = \lambda_{i1}\hat{a}_{i1}^{ex} + \lambda_{i2}\hat{a}_{i2}^{ex}$.

Note that equations [A17] are very similar to equations [A4]. They also lead to equations [A7] for factor prices changes, but with $\hat{p}_j$ replaced by $-v_j$ and $\hat{V}$ replaced by $-\eta$.

From [A6a], the relative change in the similarity index is now given by:

$$\hat{\alpha}_1 = \frac{\left[\lambda_{31}\hat{a}_{31}^{en} - (\alpha_1\lambda_{11}\hat{a}_{11}^{en} + \alpha_2\lambda_{21}\hat{a}_{21}^{en})\right] + \left[\lambda_{31}\hat{a}_{31}^{ex} - (\alpha_1\lambda_{11}\hat{a}_{11}^{ex} + \alpha_2\lambda_{21}\hat{a}_{21}^{ex})\right]}{\lambda_{31} - \lambda_{21}} \quad [A8']$$

where the first term between brackets depends on the elasticities of substitution/ complementarity between factors defined above (see equations [A8] and [A9]). Thus, following the same procedure as before, [A8'] can be rewritten:

$$\hat{\alpha}_1 = \frac{\left[\varphi_1\hat{w}_1 + \varphi_2\hat{w}_2 + \varphi_3\hat{w}_3\right] + \left[\lambda_{31}\hat{a}_{31}^{ex} - (\alpha_1\lambda_{11}\hat{a}_{11}^{ex} + \alpha_2\lambda_{21}\hat{a}_{21}^{ex}))\right]}{\lambda_{31} - \lambda_{21}} \quad [A9']$$

4.1. Neutral technical progress in sector 2

Assume that $\hat{a}_{i2}^{ex} = \kappa < 0$, whereas $\hat{a}_{i1}^{ex} = 0$. This implies that $v_1 = 0$, $v_2 = \kappa$ and $\eta = 0$ (thus equivalent to an increase in the price of commodity 2). Using equations [A7] leads to the following relative changes in factor prices due to a neutral technical progress in sector 2:

$$\hat{w}_1 = \frac{1}{\Delta}\kappa(\theta_{21}\xi_3 - \theta_{31}\xi_2) \quad [A18a]$$

$$\hat{w}_2 = -\frac{1}{\Delta}\kappa(\theta_{11}\xi_3 - \theta_{31}\xi_1) \quad [A18b]$$

$$\hat{w}_3 = \frac{1}{\Delta}\kappa(\theta_{11}\xi_2 - \theta_{21}\xi_1) \quad [A18c]$$

Note that in the case where factors are pure substitute (which means that $\xi_3 < 0$, ξ_1 and $\xi_2 > 0$), then $\hat{w}_1 < 0$ and $\hat{w}_2 > 0$, while the sign of $\hat{w}_3$ remains ambiguous.

Using [A18], the expression for the evolution of α_1, [A9'], becomes:

$$\hat{\alpha}_1 = \frac{(\hat{w}_2 - \hat{w}_1)\varphi_2 + (\hat{w}_3 - \hat{w}_1)\varphi_3}{\lambda_{31} - \lambda_{21}} = \frac{1}{\Delta}\frac{\kappa}{\lambda_{31} - \lambda_{21}}(\xi_2\varphi_3 - \xi_3\varphi_2) \qquad [A19]$$

which leads to the condition: .

$$\hat{\alpha}_1 > 0 \Leftrightarrow \xi_2\varphi_3 > \xi_3\varphi_2 \qquad [A20]$$

Using a CES production function as defined by equation [A13], the evolution of α_1 can be characterised unambiguously:

$$\hat{\alpha}_1 = -\alpha_2\sigma_1\sigma_2\frac{\kappa}{\Delta} < 0. \qquad [A21]$$

4.2. Low-skill labour-saving technical progress in both sectors

Assume that $\hat{a}_{1j}^{ex} = \kappa < 0$, whereas $\hat{a}_{2j}^{ex} = \hat{a}_{3j}^{ex} = 0$. This implies that $v_1 = \theta_{11}\kappa$, $v_2 = \theta_{12}\kappa$ and $\eta = -\alpha_1\kappa$. Solving [A17] leads to the following relative changes in factor prices:

$$\hat{w}_1 = \frac{1}{\bar{\Delta}}\kappa\left(-\xi_3 + \xi_2\alpha_2\frac{\theta^3}{\theta^2} - \alpha_1\alpha_1\frac{\theta^3}{\theta^1}\right) \qquad [A22a]$$

$$\hat{w}_2 = -\frac{1}{\bar{\Delta}}\kappa\alpha_2\frac{\theta^3}{\theta^2}(\xi_1 + \alpha_1) \qquad [A22b]$$

$$\hat{w}_3 = \frac{1}{\tilde{\Delta}}\kappa(\xi_1 + \alpha_1) \quad [A22c]$$

where $\tilde{\Delta} = \xi_3 - (\alpha_1\xi_1\frac{\theta^3}{\theta^1} + \alpha_2\xi_2\frac{\theta^3}{\theta^2}) < 0.$

Under the assumption that factors are pure substitute, $\hat{w}_2 < 0$ and $\hat{w}_3 > 0$, while the sign of $\hat{w}_1$ remains ambiguous. If, in addition, it is assumed that $\theta_{31} = \theta_{32}$, then $\hat{w}_2 - \hat{w}_1 = \kappa < 0$, while $\hat{\alpha}_1$ is given by (using [A9'] and [A22]):

$$\hat{\alpha}_1 = \frac{\kappa}{\lambda_{31} - \lambda_{21}}\left[\frac{(\varphi_1\xi_2 - \varphi_2\xi_1) + \alpha_1\varphi_3}{\xi_3} - \alpha_1\lambda_{11}\right] \quad [A23]$$

whose sign remains ambiguous.

Finally, in the CES case, [A23] becomes:

$$\hat{\alpha}_1 = \alpha_2\kappa\left[\frac{\sigma_1}{\bar{\sigma}}\frac{\lambda_{31}}{\lambda_{11} - \lambda_{31}} - \left(\frac{\sigma_1\sigma_2}{\bar{\sigma}} + \frac{\lambda_{11}}{\lambda_{11} - \lambda_{31}}\right)\right] \quad [A24]$$

where $\bar{\sigma} = \lambda_{31}\sigma_1 + \lambda_{32}\sigma_2$. It can be shown that:

$$\hat{\alpha}_1 > 0 \Leftrightarrow \sigma_2 > \frac{\lambda_{31}\lambda_{12}\sigma_1}{(\lambda_{11} - \lambda_{31})\sigma_1 + \lambda_{11}\lambda_{32}} \quad [A25]$$

A sufficient (although not necessary) condition for [A25] to hold is simply $\sigma_2 > \sigma_1$.

Table A1: Critical capital-ownership level values

<table>
<tr><td></td><td colspan="2">Households critical level of capital $K^c_v(J), J = I, II$</td><td colspan="2">Immigrants critical level of capital ${}^{M}_{u}K^c_v(J), J = I, II$</td></tr>
<tr><td></td><td>Low-skill immigrants</td><td>High-skill immigrants</td><td>Low-skill immigrants</td><td>High-skill immigrants</td></tr>
<tr><td colspan="5">Case I: Capital is the middle factor</td></tr>
<tr><td>Low-skill households</td><td colspan="2">$K^c_l(I) = \alpha_L \frac{K}{L}$</td><td rowspan="2">${}^{M}_{l}K^c_v(I) = \alpha_L \frac{K}{L}$</td><td rowspan="2">${}^{M}_{h}K^c_v(I) = (1-\alpha_L)\frac{K}{H}$</td></tr>
<tr><td>High-skill households</td><td colspan="2">$K^c_h(I) = (1-\alpha_L)\frac{K}{H}$</td></tr>
<tr><td colspan="5">Case II: High-skill labour is the middle factor</td></tr>
<tr><td>Low-skill households</td><td colspan="2">none</td><td rowspan="2">none</td><td rowspan="2">${}^{M}_{h}K^c_v(II) = \frac{1}{(1-\alpha_L)}\frac{K}{H}$</td></tr>
<tr><td>High-skill households</td><td colspan="2">$K^c_h(II) = \frac{1}{(1-\alpha_L)}\frac{K}{H}$ (1)</td></tr>
</table>

(1) only pertinent if capital is not evenly distirbuted within high-skill households.