International Labor Mobility and the Demand for Imports

ULRICH KOHLI*

1. INTRODUCTION

Does immigration cause a reduction in the wages of domestic workers? This question has long been a source of concern for economists and policy makers alike, and it has become particularly relevant at a time when regional trade agreements are likely to increase international labor mobility and/or the ability of industry to locate in low wage countries. In Switzerland, where guestworkers have at times made up well over a quarter of the work force, this question has moved to the forefront of the debate about the economic impact of European integration since labor mobility is an important element of the design of the European Single Market.

One line of research that economists have found particularly useful to address this and related questions is what has become known as the production-theory approach to immigration. This approach, pioneered by GROSSMAN (1982), treats foreign labor services as an input to the technology. One can thus determine whether immigrant and native workers are substitutes or complements in production, and it makes it possible to assess the income-distribution effects of international labor mobility. This approach has been applied to the Swiss case by BUTARE and FAVARGER (1992), and by BÜRGENMEIER, BUTARE, and FAVARGER (1992).

It is striking that none of the studies based on the production-theory framework has modeled immigration – which is obviously an international phenomenon – within an open-economy setting. That is, no allowance has been made for possible links between international factor movements and foreign trade. Yet, this question has been debated quite extensively in the theoretical trade literature. Many questions, as yet unanswered in the empirical literature, thus arise. Does immigration reduce or enhance a country’s foreign trade? Who benefits most from international movements of labor in an open-economy context? How does a change in the terms of trade affect the distribution of income in the presence of international labor mobility? The main objective of this paper

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1. See GREENWOOD and McDOWELL (1986) for a recent survey of the economic impact of immigration.
2. According to some authors, foreign trade and international factor mobility act as a substitute for each other; see MUNDELL (1957). According to others, the two phenomena are complements; see MARKUSEN (1983), for instance. Thus the question remains largely an empirical matter.

is to start addressing some of these questions. For this purpose, we will expand the GNP function approach to import determination to also take into account the demand for foreign labor services.³

Another feature of the production-theory approach to immigration is that it has involved a fair degree of confusion. Some of the empirical evidence is in terms of Allen-Uzawa elasticities of substitution, and some of it is in terms of Hicksian elasticities of complementarity. Analysts have often failed to fully appreciate this distinction when comparing results drawn from different studies. Yet comparison of Allen-Uzawa elasticities of substitution and Hicksian elasticities of complementarity is not a simple matter since the passage from one set of elasticities to the other is not trivial, and it is not always well understood. One objective of this study is to clarify this point by reporting both Hicksian elasticities of complementarity and Allen-Uzawa elasticities of substitution between resident and nonresident workers. However, we will argue that yet another set of elasticities, those derived from the GNP function setting precisely, is best suited to analyze the impact of immigration in an open economy context; this will make it possible to assess the impact of changes in domestic factor endowments and in traded good and service prices on immigration, imports, production, and the distribution of income.

Still another problem which has plagued the production-theory approach to immigration, and indeed much of the econometric work dealing with flexible functional forms, is that the estimates frequently violate the required regularity conditions. For example, a little known fact about Grossman's (1982) widely cited study is that her results are derived from a Translog production function which is not well behaved since it fails to be concave. Yet, curvature conditions are implied by economic theory and they must be met for the estimates to be meaningful. For this reason, we will select a functional form that makes it possible to impose curvature conditions globally if needed.

The remainder of this paper is set out as follows. Section 2 briefly reviews alternative descriptions of the aggregate technology, and it presents the GNP function approach to immigration and the demand for imports. Section 3 discusses the empirical implementation of the model. Sections 4 and 5 present our empirical results while Section 6 concludes.

2. THE GNP FUNCTION APPROACH TO MODELING THE DEMAND FOR IMPORTS AND FOREIGN LABOR SERVICES

The production-theory approach to immigration treats immigrants as an input to the technology. Similarly, the production-theory approach to import determination views imports as intermediate goods. We will therefore assume that aggregate output is obtained with the use of four inputs: imports, resident labor, nonresident labor, and

³ The GNP function approach to modeling imports has been developed by Kohli (1978, 1991); see Kohli (1992) for recent estimates for Switzerland.
Let the aggregate technology be represented by the following linearly homogeneous, concave, increasing production function:

\[ Q_Y = f(q_M, q_N, q_L, q_K; t), \quad (1) \]

where the \( q \)'s represent quantities; the labels \( Y, M, N, L \) and \( K \) stand for gross output, imports, nonresident labor, resident labor, and capital respectively; \( t \) is a time index.\(^5\)

The substitution and complementarity relationships implied by the technology can be assessed with the help of Hicksian elasticities of complementarity which can easily be derived from the production function:

\[ \psi_{jk} = f_{jk}/(f_j f_k), \quad j, k \in \{M, N, L, K\}, \quad (2) \]

where \( f_j = \partial f(\cdot)/\partial q_j, f_{jk} = \partial^2 f(\cdot)/\partial q_j \partial q_k \), and \( f = f(\cdot) \) for short. \( \psi_{jk} \) is positive if inputs \( j \) and \( k \) are \( q \)-complements in the Hicksian sense, and it is negative if the two inputs are \( q \)-substitutes. These elasticities are relevant if one wishes to assess the impact of an increase in the quantity of one input on its price, and on the prices of all other inputs. Thus, if \( \psi_{LN} \) is negative, one can assert that an increase in immigration will, other things equal, lead to a reduction in the wage rate of resident workers.

The Hicksian elasticities of complementarity given by (2) are defined for given input quantities, and they are not to be confused with Allen-Uzawa elasticities of substitution, \( \sigma_{jk} \), defined for given input prices; \( \sigma_{jk} \) is positive if inputs \( j \) and \( k \) are substitutes in the Allen-Uzawa sense, and it is negative if they are complements. We define \( \Sigma = [\sigma_{jk}] \) as the Allen-Uzawa substitution matrix and \( \Psi = [\psi_{jk}] \) as the Hicksian complementarity matrix. As shown by KOHLI (1991), the link between \( \Sigma \) and \( \Psi \) is given by:

\[ \Sigma^* = S^{-1} \Psi^* \Sigma S^{-1} \quad (3) \]

where:

\[ \Psi^* = \begin{bmatrix} \Psi u' \\ u' 0 \end{bmatrix}, \quad \Sigma^* = \begin{bmatrix} \Sigma u' \\ u' 0 \end{bmatrix} ; \]

4. For simplicity, we assume that exports are perfect substitutes for output intended for domestic use; that is, gross output is either absorbed domestically or exported to the rest of the world. For an alternative treatment, albeit without international labor mobility, see KOHLI (1991).

5. It is noteworthy that studies focusing on the role of immigrant workers have left out intermediate goods of foreign origin. If we rule out Leontief and Hicks aggregation, this approach is only legitimate if the production function is weakly separable between imports and other inputs. Yet to the best of our knowledge, this hypothesis has never been tested.
\( S^- \) is a 5x5 diagonal matrix with the four cost shares and a one as elements, and \( u \) is a 4-dimensional unit vector. Thus the passage of Hicksian elasticities of complementarity to Allen-Uzawa elasticities of substitution involves the inversion of a bordered matrix. Note that as soon as the number of inputs exceeds two, one cannot infer anything about the sign of \( \psi_{jk} \) from the sign of \( \sigma_{jk} \) alone. Thus, two inputs could be Hicksian q-complements, and yet they could equally well be Allen-Uzawa substitutes or complements.

While both the Hicksian and the Allen-Uzawa elasticities are relevant in some circumstances, one can argue that in an open economy context, yet another framework is necessary. Indeed, it is reasonable to assume that the endowments of domestic factors are given. At the same time, considering Switzerland as a small open economy, we can treat the prices of output, imports, and nonresident labor services as exogenous as well. This militates in favor of the representation of the aggregate technology by the following GNP function:

\[
\pi(p_M, p_N, p_Y; q_L, q_K; t) = \max_{q_Y, q_M, q_N} \{ p_Y q_Y - p_M q_M - p_N q_N: q_Y = f(q_M, q_N, q_L, q_K; t) \},
\]

where \( p_Y \) is the price of gross output. \( \pi(\cdot) \) is well defined for positive prices and nonnegative factor endowments. Given the assumptions made on \( f(\cdot) \), \( \pi(\cdot) \) is linearly homogeneous and convex in prices; nondecreasing in the price of output and nonincreasing in the prices of variable inputs; and increasing, linearly homogeneous and concave in fixed input quantities.\(^6\)

The representation of the technology by a GNP function makes it easy to derive the GNP maximizing supply of output, demand for imports, and demand for nonresident labor. Indeed, it follows from Hotelling's Lemma that:

\[
q_i(p_M, p_N, p_Y; q_L, q_K; t) = \pm \frac{\partial \pi(\cdot)}{\partial p_i} \quad i \in \{ M, N, Y \}.
\]

The homogeneity properties of \( \pi(\cdot) \) imply that the output supply (variable input demand) functions are linearly homogeneous in domestic factor endowments, as well as homogeneous of degree zero in output and variable input prices; furthermore, the convexity of \( \pi(\cdot) \) with respect to output and variable input prices indicates that all output supply (and variable input demand) functions are necessarily nondecreasing in their own prices.

The marginal product conditions imply that the differentiation of \( \pi(\cdot) \) with respect to factor endowments yields the competitive factor rental prices:

\[
p_j(p_M, p_N, p_Y; q_L, q_K; t) = \frac{\partial \pi(\cdot)}{\partial q_{ij}} \quad j \in \{ L, K \}.
\]

\(^6\) See Diewert (1974).
The homogeneity of \( \pi() \) implies that the two fixed input inverse demand functions (6) are linearly homogeneous in the prices of output and variable inputs, and homogeneous of degree zero in domestic factor endowments. Furthermore, it follows from the concavity of \( \pi() \) with respect to factor endowments that they are nonincreasing in their own quantities.

In the GNP function framework, the substitution possibilities allowed for by the technology can be described by the following set of price and quantity elasticities:

\[
\begin{pmatrix}
\hat{M} \\
\hat{N} \\
\hat{Y} \\
\hat{L} \\
\hat{K}
\end{pmatrix} = \begin{bmatrix}
\epsilon_{MM} & \epsilon_{MN} & \epsilon_{MY} & \epsilon_{ML} & \epsilon_{MK} \\
\epsilon_{NM} & \epsilon_{NN} & \epsilon_{NY} & \epsilon_{NL} & \epsilon_{NK} \\
\epsilon_{YM} & \epsilon_{YN} & \epsilon_{YY} & \epsilon_{YL} & \epsilon_{YK} \\
\epsilon_{LM} & \epsilon_{LN} & \epsilon_{LY} & \epsilon_{LL} & \epsilon_{LK} \\
\epsilon_{KM} & \epsilon_{KN} & \epsilon_{KY} & \epsilon_{KL} & \epsilon_{KK}
\end{bmatrix} \begin{pmatrix}
\hat{P}_M \\
\hat{P}_N \\
\hat{P}_Y \\
\hat{Q}_L \\
\hat{Q}_K
\end{pmatrix},
\]

(7)

where the hats (\(^\hat{\cdot}\)) denote relative changes. These elasticities are defined for given prices of imports, foreign labor services, and gross output, and for given domestic factor endowments. The elasticities in the northwest corner of (7) are the price elasticities of output supply and variable input demand. The elasticities in the southwest corner indicate the impact of changes in the prices of output and variable inputs on domestic factor rental prices. The elasticities in the northeast corner of (7) capture the effect of changes in domestic factor endowments on the supply of output and on the demand for variable inputs. In the southeast corner, finally, we find the quantity elasticities of the inverse demands for the domestic factors. All these elasticities can be obtained from estimates of \( \pi() \); indeed, making use of (5)-(6), it can be seen that:

\[
\epsilon_{mn} = (\pi_{mn}/\pi_m)z_n,
\]

(8)

where \( \pi_{mn} = \partial^2 \pi() / (\partial z_m \partial z_n) \) and \( \pi_m = \partial \pi() / \partial z_m; z_m \) and \( z_n \) \( \in \{p_M, p_N, p_Y, q_L, q_K\} \).

The signs of \( \epsilon_{LN} \) and \( \epsilon_{KN} \) are particularly important in determining the impact of increased immigration on domestic factor payments; thus, if \( \epsilon_{LN} > 0 \), a reduction in \( p_N \), which leads to an increase in the demand for foreign labor, will tend to reduce the rental price of resident labor. The sign of \( \epsilon_{MN} \), on the other hand, will indicate the impact of changes in the wage rate paid to nonresident workers on the demand for imports. If \( \epsilon_{MN} > 0 \), immigration will tend to act as a substitute for foreign trade.

Upon specification of a functional form, GNP function (4) can be estimated. However, assuming optimization, it is statistically more efficient to estimate instead the system of supply and demand functions (5)-(6). The estimates can then be used to recover (4), and to calculate estimates of (7) with the help of (8). These can then be used to calculate
estimates of $\Psi$ and $\Sigma$. It is important then that the estimated GNP function satisfy all the required regularity conditions, i.e. homogeneity, symmetry, adding-up, and the curvature conditions. While adding-up usually follows from the construction of the data, and while linear homogeneity and symmetry can easily be imposed, this is not necessarily true for the curvature conditions unless one is particularly careful when selecting a functional form.

3. EMPIRICAL IMPLEMENTATION

3.1 Functional Form

For our empirical work, we will use the Symmetric Normalized Quadratic variable profit function recently introduced by Kohli (1993). It is as follows:

$$\pi = \frac{1}{2} \left( \Sigma \beta_j q_j \right) \Sigma a_{ih} p_i p_h / (\Sigma \alpha_i p_i) + \frac{1}{2} \left( \Sigma \alpha_i p_i \right) \Sigma b_{jk} q_j q_k / (\Sigma \beta_j q_j) + \frac{1}{2} \left( \Sigma \alpha_i p_i \right) \left( \Sigma c_{ij} p_i q_j + (\Sigma \beta_j q_j) \right) f_t t + \frac{1}{2} \left( \Sigma \alpha_i p_i \right) \left( \Sigma \beta_j q_j \right) f_{tt} t^2 ,$$

where $A = [a_{ih}]$, $B = [b_{jk}]$, and $C = [c_{ij}]$ are unknown matrices of dimensions $3 \times 3$, $2 \times 2$ and $3 \times 2$, respectively; $d = [d_i]$ and $e = [e_j]$ are unknown 3- and 2-dimensional vectors, respectively; $f_t$ and $f_{tt}$ are unknown scalars; $\alpha = [\alpha_i]$, and $\beta = [\beta_j]$ are nonnegative 3- and 2-dimensional vectors of predetermined parameters. Furthermore, we require $a_{ih} = a_{hi}$, $b_{jk} = b_{kj}$, $\Sigma a_{ih} = 0$, $\Sigma b_{jk} = 0$, $\Sigma d_i = 0$, $\Sigma e_j = 0$, $\Sigma \alpha_i = 1$, $\Sigma \beta_j = 1$; $\Sigma \alpha_i p_i$ and $\Sigma \beta_j q_j$ can be interpreted as fixed-weight price and quantity indexes, respectively; in what follows, we will assume that they have the Laspeyres form.

Function (9) is a straightforward extension of the family of functional forms proposed by Diewert and Wales (1987). It is necessarily linearly homogeneous in prices and quantities, and we have shown elsewhere that it is a fully flexible functional form. Furthermore, a necessary and sufficient condition for global convexity in output prices is that $A$ be positive semidefinite, and a necessary and sufficient condition for global concavity in fixed input quantities is that $B$ be negative semidefinite. If necessary, these conditions can be imposed.

7. Except for the treatment of technological change, this is the same functional form as the one used in Kohli (1992) to estimate a 2x4 GNP function for Switzerland.
As indicated by (5)-(6), the output supply and inverse input demand functions are obtained by differentiation of (9):

\[
q_i = \left(\sum \beta_j q_j\right) \Sigma \alpha_{ih} p_h / (\Sigma \alpha_i p_i) - \frac{1}{2} \alpha_i \left(\sum \beta_j q_j\right) \Sigma \Sigma a_{ih} p_i p_h / (\Sigma \alpha_i p_i)^2 + \\
\frac{1}{2} \alpha_i \Sigma \Sigma b_{jk} q_j q_k / (\Sigma \beta_j q_j)^2 + \Sigma c_{ij} q_j + d_i \left(\sum \beta_j q_j\right) t + \\
\alpha_i \left(\Sigma e_{ij} q_j\right) t + \frac{1}{2} \alpha_i \left(\sum \beta_j q_j\right) f_t t + \frac{1}{2} \alpha_i \left(\sum \beta_j q_j\right) f_t t^2
\]

\[
w_j = \frac{1}{2} \beta_j \Sigma \Sigma a_{ih} p_i p_h / (\Sigma \alpha_i p_i) + \left(\Sigma \alpha_i p_i\right) \Sigma b_{jk} q_j q_k / (\Sigma \beta_j q_j) - \\
\frac{1}{2} \beta_j \left(\Sigma \alpha_i p_i\right) \Sigma \Sigma b_{jk} q_j q_k / (\Sigma \beta_j q_j)^2 + \Sigma c_{ij} p_i + \beta_j \left(\Sigma d_i p_i\right) t + \\
\left(\Sigma e_{ij} p_i\right) t + \beta_j \left(\sum \alpha_i p_i\right) f_t t + \frac{1}{2} \left(\Sigma \alpha_i p_i\right) \beta_j f_t t^2
\]

\[i, h \in \{M, N, Y\} \text{ and } j, k \in \{L, K\}.\]

3.2 Data

The GNP function is estimated for Switzerland with annual data covering the period 1950-1986. We require price and quantity series for all five inputs and outputs. The output, import, capital and total employment data are derived from the National Income and Product Accounts; the disaggregation of employment between resident and nonresident labor is based on FAVARGER (1992). The resident worker category comprises natives as well as foreign workers who are Swiss residents. Nonresident workers are holders of either a seasonal permit, an annual permit, or a transborder permit. All fixed input series and all output prices are normalized to unity for 1980. Fixed input prices and variable input and output quantities are expressed in million 1980 Swiss francs; \(t\) is defined as a time trend with unit annual increments and normalized to zero for 1980; \(\Sigma \alpha_i p_i\) and \(\Sigma \beta_j q_j\) are defined, respectively, as direct Laspeyres price and quantity indexes, with 1980 absolute-value weights.

3.3 Stochastic Specification and Estimation Technique

We assume that the demand and supply functions (10)-(11) are exact, except for errors in optimization. We specify a vector of additive disturbances which we assume to be identically distributed, serially independent, normal random vectors with mean vector zero. The model is estimated by nonlinear least squares using SHAZAM, version 7.0 (WHITE, 1978). We have 190 observations (five equations times 38 annual observations) to estimate 15 unknown parameters.
Table 1
Parameter Estimates
(asymptotic-t values in parentheses)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_{11}$</td>
<td>-162.64</td>
<td>-4.35</td>
</tr>
<tr>
<td>$\tau_{22}$</td>
<td>140.79</td>
<td>2.04</td>
</tr>
<tr>
<td>$\alpha_{14}$</td>
<td>-40012</td>
<td>-20.25</td>
</tr>
<tr>
<td>$\alpha_{24}$</td>
<td>23817</td>
<td>9.09</td>
</tr>
<tr>
<td>$\alpha_{34}$</td>
<td>108690</td>
<td>34.60</td>
</tr>
<tr>
<td>$d_{1t}$</td>
<td>-2286.0</td>
<td>-9.78</td>
</tr>
<tr>
<td>$e_{4t}$</td>
<td>185.05</td>
<td>2.45</td>
</tr>
<tr>
<td>$f_{tt}$</td>
<td>-82.375</td>
<td>-6.27</td>
</tr>
<tr>
<td>LL</td>
<td>-1633.47</td>
<td></td>
</tr>
</tbody>
</table>

Note: these estimates were obtained subject to global convexity imposed.

4. EMPIRICAL RESULTS

Estimates of (10)-(11) are reported in Table 1. Global concavity in fixed input quantities was satisfied at the outset, but global convexity in prices had to be imposed; this was done using the procedure of WILEY, SCHMIDT, and BRAMBLE (1973) as described by DIEWERT and WALES (1987). Asymptotic t-values are shown in parentheses. The parameter estimates in Table 1 can be used to calculate Hicksian elasticities of complementarity ($\psi_{jk}$) and Allen-Uzawa elasticities of substitution ($\sigma_{jk}$); their 1986 values are reported in Tables 2 and 3, respectively. It is apparent that imports are a Hicksian q-complement for the three other inputs, as well as an Allen-Uzawa complement for resident labor. Both types of labor and capital are Hicksian q-substitutes for each other, while nonresident labor and capital are complements in the Allen-Uzawa sense. Thus, for given input quantities, an increase in immigration would tend to reduce the return to

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9. We began our empirical work by addressing the question of import separability. Weak separability of imports is necessary for the existence of a value added function that excludes the input of foreign products. We examined this issue by estimating a four input Translog production function, and then testing for linear separability and nonlinear local separability. Both hypotheses are rejected at the 95% confidence level (the test statistics were 13.69 and 7.89 for critical $\chi^2$-values of 7.81 and 5.99, respectively). We therefore conclude that the standard practice of leaving out imports from the description of the technology is inappropriate and may lead to biased results.

10. $A = [a_{jk}]$ is therefore replaced by $TT'$ where $T = [\tau_{jk}]$ is an upper triangular matrix.
domestic labor and capital, and increase the marginal product of imports. For given input prices, on the other hand, an increase in the price of nonresident labor services would favor the demand for domestic labor and imports, and it would reduce the demand for capital services.

Table 2

Hicksian Elasticities of Complementarity
(1986 estimates)

<table>
<thead>
<tr>
<th></th>
<th>k=M</th>
<th>k=N</th>
<th>k=L</th>
<th>k=K</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_{Mk}$</td>
<td>-28.529</td>
<td>11.205</td>
<td>14.207</td>
<td>9.554</td>
</tr>
<tr>
<td>$\psi_{Nk}$</td>
<td>-7.461</td>
<td></td>
<td>-6.573</td>
<td>-1.029</td>
</tr>
<tr>
<td>$\psi_{Lk}$</td>
<td></td>
<td></td>
<td>-7.712</td>
<td>-3.196</td>
</tr>
<tr>
<td>$\psi_{Kk}$</td>
<td></td>
<td></td>
<td></td>
<td>-7.082</td>
</tr>
</tbody>
</table>

Table 3

Allen-Uzawa Elasticities of Substitution
(1986 estimates)

<table>
<thead>
<tr>
<th></th>
<th>k=M</th>
<th>k=N</th>
<th>k=L</th>
<th>k=K</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_{Mk}$</td>
<td>-0.265</td>
<td>5.683</td>
<td>-0.583</td>
<td>0.561</td>
</tr>
<tr>
<td>$\sigma_{Nk}$</td>
<td>-457.495</td>
<td></td>
<td>45.950</td>
<td>-19.898</td>
</tr>
<tr>
<td>$\sigma_{Lk}$</td>
<td></td>
<td></td>
<td>-5.214</td>
<td>3.306</td>
</tr>
<tr>
<td>$\sigma_{Kk}$</td>
<td></td>
<td></td>
<td></td>
<td>-4.146</td>
</tr>
</tbody>
</table>

We next move to the GNP function setting, and we compute the price and quantity elasticities contained in (7). These are shown for selected years in Table 4. Of considerable interest are the own price elasticities of the demand for imports ($\varepsilon_{MM}$) and of the demand for nonresident labor ($\varepsilon_{NN}$): in absolute value, $\varepsilon_{MM}$ falls substantially over time, from about -2.7 in 1950 to -0.3 in 1986; $\varepsilon_{NN}$ increases, from about -1.1 in 1950 to -8.3
Table 4

Price and Quantity Elasticities for Selected Years

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Price elasticities of output supply: ( \epsilon_{ih} = \partial \ln</td>
<td>y_i</td>
<td>/\partial \ln p_h )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \epsilon_{MM} )</td>
<td>-2.686</td>
<td>-1.190</td>
<td>-0.619</td>
<td>-0.385</td>
<td>-0.278</td>
</tr>
<tr>
<td>( \epsilon_{MN} )</td>
<td>-0.705</td>
<td>-0.541</td>
<td>-0.523</td>
<td>-0.431</td>
<td>-0.418</td>
</tr>
<tr>
<td>( \epsilon_{MY} )</td>
<td>3.391</td>
<td>1.732</td>
<td>1.142</td>
<td>0.816</td>
<td>0.696</td>
</tr>
<tr>
<td>( \epsilon_{NM} )</td>
<td>-2.918</td>
<td>-2.461</td>
<td>-1.760</td>
<td>-2.741</td>
<td>-3.241</td>
</tr>
<tr>
<td>( \epsilon_{NN} )</td>
<td>-1.051</td>
<td>-1.593</td>
<td>-2.287</td>
<td>-4.904</td>
<td>-8.252</td>
</tr>
<tr>
<td>( \epsilon_{NY} )</td>
<td>3.969</td>
<td>4.054</td>
<td>4.047</td>
<td>7.645</td>
<td>11.492</td>
</tr>
<tr>
<td>( \epsilon_{YM} )</td>
<td>-0.803</td>
<td>-0.484</td>
<td>-0.326</td>
<td>-0.257</td>
<td>-0.214</td>
</tr>
<tr>
<td>( \epsilon_{YN} )</td>
<td>-0.227</td>
<td>-0.249</td>
<td>-0.343</td>
<td>-0.379</td>
<td>-0.455</td>
</tr>
<tr>
<td>( \epsilon_{YY} )</td>
<td>1.030</td>
<td>0.733</td>
<td>0.670</td>
<td>0.635</td>
<td>0.669</td>
</tr>
<tr>
<td>Quantity elasticities of inverse input demand: ( \epsilon_{jk} = \partial \ln w_j/\partial \ln x_k )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \epsilon_{LL} )</td>
<td>-0.049</td>
<td>-0.111</td>
<td>-0.175</td>
<td>-0.142</td>
<td>-0.140</td>
</tr>
<tr>
<td>( \epsilon_{LK} )</td>
<td>0.049</td>
<td>0.111</td>
<td>0.175</td>
<td>0.142</td>
<td>0.140</td>
</tr>
<tr>
<td>( \epsilon_{KL} )</td>
<td>0.103</td>
<td>0.189</td>
<td>0.293</td>
<td>0.285</td>
<td>0.302</td>
</tr>
<tr>
<td>( \epsilon_{KK} )</td>
<td>-0.103</td>
<td>-0.189</td>
<td>-0.293</td>
<td>-0.285</td>
<td>-0.302</td>
</tr>
<tr>
<td>Quantity elasticities of output supply: ( \epsilon_{ij} = \partial \ln</td>
<td>y_i</td>
<td>/\partial \ln x_j )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \epsilon_{ML} )</td>
<td>0.856</td>
<td>0.727</td>
<td>0.555</td>
<td>0.582</td>
<td>0.538</td>
</tr>
<tr>
<td>( \epsilon_{MK} )</td>
<td>0.144</td>
<td>0.273</td>
<td>0.445</td>
<td>0.418</td>
<td>0.462</td>
</tr>
<tr>
<td>( \epsilon_{NL} )</td>
<td>0.155</td>
<td>-0.456</td>
<td>-0.922</td>
<td>-2.205</td>
<td>-3.656</td>
</tr>
<tr>
<td>( \epsilon_{NK} )</td>
<td>0.845</td>
<td>1.456</td>
<td>1.922</td>
<td>3.205</td>
<td>4.656</td>
</tr>
<tr>
<td>( \epsilon_{YL} )</td>
<td>0.691</td>
<td>0.591</td>
<td>0.475</td>
<td>0.498</td>
<td>0.467</td>
</tr>
<tr>
<td>( \epsilon_{YK} )</td>
<td>0.309</td>
<td>0.409</td>
<td>0.525</td>
<td>0.502</td>
<td>0.533</td>
</tr>
<tr>
<td>Price elasticities of inverse input demand: ( \epsilon_{ji} = \partial \ln w_j/\partial \ln p_i )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \epsilon_{LM} )</td>
<td>-0.423</td>
<td>-0.489</td>
<td>-0.402</td>
<td>-0.433</td>
<td>-0.370</td>
</tr>
<tr>
<td>( \epsilon_{LN} )</td>
<td>-0.019</td>
<td>0.067</td>
<td>0.198</td>
<td>0.258</td>
<td>0.325</td>
</tr>
<tr>
<td>( \epsilon_{LY} )</td>
<td>1.441</td>
<td>1.421</td>
<td>1.203</td>
<td>1.175</td>
<td>1.046</td>
</tr>
<tr>
<td>( \epsilon_{KM} )</td>
<td>-0.150</td>
<td>-0.313</td>
<td>-0.540</td>
<td>-0.624</td>
<td>-0.684</td>
</tr>
<tr>
<td>( \epsilon_{KN} )</td>
<td>-0.213</td>
<td>-0.367</td>
<td>-0.694</td>
<td>-0.752</td>
<td>-0.890</td>
</tr>
<tr>
<td>( \epsilon_{KY} )</td>
<td>1.364</td>
<td>1.681</td>
<td>2.234</td>
<td>2.376</td>
<td>2.575</td>
</tr>
</tbody>
</table>
in 1986. It thus appears that the demand for labor services has become extremely elastic in recent years, while the reverse is true for the demand for imports.  \(^{11}\)

The first part of Table 4 also indicates the signs of cross price effects affecting output, imports and the demand for foreign labor. It is apparent that an increase in the price of imports reduces the demand for nonresident labor, and consequently an increase in \(p_N\) reduces the demand for imports. Not surprisingly, increases in the prices of imports and of nonresident labor reduce the supply of gross output, while an increase in \(p_Y\), which lifts gross output, pulls along the demand for imports and the demand for nonresident labor.

The second part of Table 4 shows the effects of variations in factor endowments on factor rental prices, for given output, import and nonresident labor prices. As expected, an increase in the endowment of either factor leads to a reduction in its rental price, but only weakly so.

The elasticities in the third part of the table indicate the effects of changes in factor endowments on the supply of output and the demand for the variable inputs, for given output and variable-input prices. An increase in the endowment of labor stimulates the supply of gross output and the demand for imports, but, judging from recent estimates, it has a strong negative impact on the demand for foreign labor services. An increase in the endowment of capital also leads to increases in the supply of gross output and in the demand for imports. Moreover, it stimulates the demand for nonresident labor.

The fourth part of Table 4 shows the effects of output (and variable input) price changes on fixed input prices, for given factor endowments. These elasticities are the mirror images of the quantity elasticities reported in the third part of the table. It is therefore not surprising to find that an increase in the price of gross output increases the returns of capital and domestic labor, that an increase in import prices hurts domestic labor and even more so capital, and that a reduction in \(p_N\), which would stimulate the demand for foreign labor, hurts resident workers, but actually benefits capital owners.

### 5. CONTROLED IMMIGRATION

Some readers might object to the treatment of nonresident labor services as a variable input. Indeed, annual permits and seasonal permits are not issued without restrictions, so that one may want to examine the polar case where nonresident labor services are treated as a fixed input. This suggests representing the technology by a variable profit function defined for given resident and nonresident employment, a given stock of capital, and given output and import prices. This framework would yield a set of price and quantity elasticities defined as follows:

---

11. This last result confirms KOHLI's (1992) findings.
\[ \phi_{mn} = \frac{\partial \ln [h_m(p_M, p_Y; q_N, q_L, q_K; t)]}{\partial \ln (z_n)}, \] 

(12)

where \( h_m \in \{q_M, q_Y, p_N, p_L, p_K\} \) and \( z_n \in \{p_M, p_Y, q_N, q_L, q_K\} \). Fortunately, even if we wish to obtain elasticity estimates consistent with this setting, there is no need to give up the GNP function estimates framework. Indeed, we can easily solve (7) for \( \hat{q}_M, \hat{q}_Y, \hat{p}_N, \hat{p}_L \) and \( \hat{p}_K \) as functions of \( \hat{p}_M, \hat{p}_Y, \hat{q}_N, \hat{q}_L \) and \( \hat{q}_K \). We report in Table 5 1986 estimates of the \( \phi_{mn} \)'s obtained in this fashion. We observe that a 10-percent increase in immigration would reduce the income of resident workers by approximately 0.4 percent; the income of nonresident workers, on the other hand, would fall by about 1.2 percent. The beneficiaries would be capital owners whose return would increase by about 1.1 percent. The demand for imports and the supply of output would both be increased by approximately one half of one percent. Thus, increased immigration tends to alter income distribution in favor of capital and at the expense of labor, but this effect is rather weak.

Furthermore, it is again apparent that, as far as Switzerland is concerned, international labor mobility tends to enhance foreign trade. It is also apparent from the estimates in Table 5 that a worsening in the terms of trade hurts all factors of production, not least domestic labor. In fact, the effect is more severe than when the input of nonresident labor is allowed to adjust. We had found earlier (see the estimates of \( \epsilon_{NM} \) in Table 4), that a deterioration in the terms of trade strongly reduces the demand for nonresident labor. Holding nonresident employment constant, the burden of the adjustment falls on resident workers.

### Table 5

**Price and Quantity Elasticities**

**Fixed Nonresident Employment**

(1986 Estimates)

\[
\phi_{mn} = \frac{\partial \ln [h_m(p_M, p_Y; q_N, q_L, q_K; t)]}{\partial \ln (z_n)}
\]

\( h_m \in \{q_M, q_Y, p_N, p_L, p_K\}, \quad z_n \in \{p_M, p_Y, q_N, q_L, q_K\} \)

<table>
<thead>
<tr>
<th>( z_n=p_M )</th>
<th>( z_n=p_Y )</th>
<th>( z_n=q_N )</th>
<th>( z_n=q_L )</th>
<th>( z_n=q_K )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi_{Mn} )</td>
<td>-0.114</td>
<td>0.114</td>
<td>0.051</td>
<td>0.723</td>
</tr>
<tr>
<td>( \phi_{Yn} )</td>
<td>-0.035</td>
<td>0.035</td>
<td>0.055</td>
<td>0.668</td>
</tr>
<tr>
<td>( \phi_{Nn} )</td>
<td>-0.393</td>
<td>1.393</td>
<td>-0.121</td>
<td>-0.443</td>
</tr>
<tr>
<td>( \phi_{Ln} )</td>
<td>-0.498</td>
<td>1.498</td>
<td>-0.039</td>
<td>-0.284</td>
</tr>
<tr>
<td>( \phi_{Kn} )</td>
<td>-0.335</td>
<td>1.335</td>
<td>0.108</td>
<td>0.697</td>
</tr>
</tbody>
</table>

6. CONCLUSIONS

The main purpose of this paper was to integrate the production-theory approach to modeling immigration and the GNP function approach to modeling the demand for imports. Not only does this make it possible to examine the link between labor mobility and the demand for imports, an issue largely ignored in the empirical literature, but by treating domestic factor endowments and the prices of traded goods and services as given, the GNP function approach seems best suited to describe the substitution possibilities between domestic and foreign inputs. Furthermore, particular attention was devoted to the question of curvature conditions since this problem has plagued the production theory approach in the past.

Among our main empirical results, we have found that increased immigration will lower the income of domestic workers, but only weakly so. Capital owners are the beneficiaries of immigration; it is therefore not surprising that the call for increased access to foreign labor markets generally emanates from business leaders. Foreign trade appears as a complement for international labor movements in the sense that, for given domestic factor endowments, an increase in immigration also leads to more imports.
REFERENCES


SUMMARY

This paper examines the contribution of nonresident workers to Swiss production possibilities in an open-economy setting. The analysis is based on the GNP function approach to modeling the demand for imports and it treats foreign labor services and imports as two of several inputs to the technology. The model not only allows for the detection of substitution and complementarity relationships between foreign labor and domestic factors of production, but it also makes it possible to analyze the link between international labor mobility and the demand for imports.

RESUME

Cette étude examine l’impact de la main d’œuvre étrangère sur les possibilités de production suisses dans le contexte d’une économie ouverte. L’analyse se base sur l’approche de la fonction de PNB et elle traite la main d’œuvre non-résidente et les importations comme deux parmi plusieurs inputs de la technologie. Le modèle non seulement permet d’identifier les relations de complémentarité et de substitution entre la main d’œuvre étrangère et les facteurs de production nationaux, mais il rend également possible l’analyse du lien entre la mobilité internationale de la main d’œuvre et le commerce extérieur.