

SPECIALIZATION, THE INTERMEDIATE NATURE OF TRADED PRODUCTS AND THE MYTH OF IMPORT DRIVEN WAGE INEQUALITY IN THE UNITED STATES

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Abstract. Using a model that recognises the prevalent cross-country specialization in production and the intermediate nature of all traded products, I investigate the effect of observed trends in the prices of ordinary intermediate and semi-final imports on the expanding wage differential between skilled and unskilled labour in the USA. Contrary to widely accepted stylised facts, my results suggest that decreases in import prices increase both wage rates, while compressing their differential. Sources of wage dispersion are, however, found in skill-biased economy-wide dynamic processes of capital accumulation and technical change.

1. INTRODUCTION

The role of imports in the dramatic expansion of relative wage inequality between skilled and unskilled labour in the USA that was observed during the 1970s and 1980s has attracted considerable interest in the literature.^{1,2} For the most part, relevant research relies on two key assumptions of orthodox trade theory: (i) fully diversified production; and (ii) the finality of traded commodities. As a result, the dynamics typically considered by relevant studies, such as Sachs and Shatz (1994), Wood (1998) and many others, are fairly elemental; a greater volume of imports implies a lower quantity of ‘corresponding’ (import competing) domestic output, hence lower demand for domestic labour. To the extent that displacement of labour demand affects the markets for skilled and unskilled labour disproportionately, wage inequality may result directly from an increase in imports.

Causal relationships of this nature are, of course, important. However, the nexus between imports and wages is considerably more complex when assumptions (i) and (ii) fail to hold. For example, in the presence of any degree of global division of labour consistent with incomplete diversification in production, an increase in the volume of imports that do not compete with domestic output may have no general equilibrium implications on wage inequality (Yang and Zhang, 2003). Furthermore, even in the presence of complete diversification, when imports are used as intermediate inputs in domestic production they are

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¹ See Figure 1.

² Surveys can be found in Richardson (1995), Burtless (1995), Slaughter (2000).

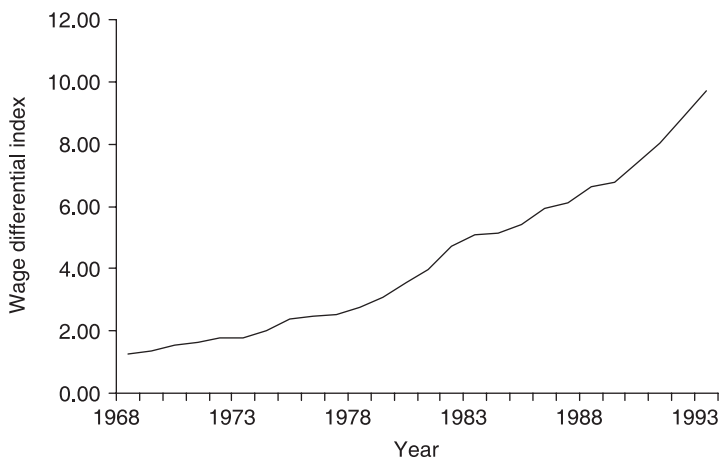


Figure 1. Wage dispersion between skilled and unskilled labour

not necessarily bound to generate an overall negative effect on the demand for domestic labour. To the extent that such imports complement labour in domestic production, they may even stimulate its demand.³

Of course, it is not clear whether accounting for deviations from assumptions (i) and (ii) stacks the deck in favour of, or against, the argument that imports have a significant impact on wage inequality. It is however clear that assumptions (i) and (ii) fail unequivocally when confronted with data. In connection with (i), Schott (2003) has recently showed that traditional product categorizations hide fundamental cross-country specific product differences. He further demonstrated that when these differences are considered, cross-country specialization in largely exclusive subsets of goods is significant. Assumption (ii) is subject to equally acute criticism. As noted by Burgess (1974; 1976), Kohli (1978; 1991; 1993; 1994), Rousslang and To (1993), Appelbaum and Kohli (1997), Tombazos (1998), and many others, *all* imports, including those of so-called 'final' goods, are subject to extensive domestic 'downstream handling'⁴ before reaching the consumer. This is reflected in the well known observation that a significant portion of the 'shelf price' of *all* imports reflects value added domestically⁵ and requires that all traded goods are treated as intermediate products in empirical research.

An analytical framework that investigates the role of imports in domestic production, and which relinquishes assumptions (i) and (ii), was originally

³ See Tombazos (1999b; 2003a) for a relevant discussion.

⁴ This may involve a host of domestic channels including assembly, finishing, transportation, insurance, storage, repackaging, marketing and retailing.

⁵ According to Rousslang and To (1993, p. 214), domestic value-added increases the final price of US imports by a greater margin than the combined effect of import tariffs and international transportation costs in the case of about half of all import categories, and for the overall average of all sectors examined by these authors.

proposed by Burgess (1974; 1976), and further developed by Kohli (1991). A derivative of this framework was introduced to the trade and wage inequality debate by Tombazos (1999a), and was subsequently used in a number of relevant applications by Falk and Koebel (2002), Tombazos (2003a), Hijzen *et al.* (2005) and others. This approach requires the specification of a model that treats imports as an input in the domestic economy. In an econometric setting, aggregate economy-wide production may be represented by its variable profit function dual, and subsequently formalised using a flexible functional form. Economy wide (direct or inverse) demand functions for domestic factors (including labour) and imports can then be derived, and subsequently estimated in a simultaneous equation setting. Finally, the ensuing elasticities are employed to infer the net impact of imports on domestic labour markets.⁶

One of the most policy relevant applications of such a model entails disaggregation of imports in traditional intermediate and traditional final goods (henceforth ordinary intermediate and semi-final goods, respectively). While *all* such imports⁷ are subject to downstream handling, Tombazos (1998; 1999b) identifies certain regularities that relate the 'extent' of such handling (i.e., the level of 'intermediateness') of any given category of imports with associated net effects on aggregate labour demand. Crudely speaking, this author finds that imports of semi-final goods typically lead to net substitutions with aggregate domestic labour, while imports of ordinary intermediate products generally complement aggregate labour demand. Extending this research in efforts to investigate the role of downstream handling in the prevailing wage inequality between skilled and unskilled labour would generate results of considerable policy relevance. Yet, this is an issue that has not been explored in the literature.

The only previous efforts to disaggregate imports by kind in a model of the US economy that accounts for the intermediate nature of imports were undertaken by Harrigan and Balaban (1999) and Harrigan (2000). These contributions relate to issues examined in this paper, but do not shed light on the 'downstream handling' – 'wage inequality' nexus. There are two reasons for this. First, Harrigan and Balaban (1999) as well as Harrigan (2000) do not distinguish imports on the basis of their level of 'intermediateness'. Second, both studies represent aggregate US production using a Translogarithmic Variable Profit Function with curvature conditions externally enforced. Curvature conditions are, of course, necessitated by economic theory and must hold for a variable profit function to be meaningful (Kohli, 1991). However, enforcing these conditions in the case of the Translog is inappropriate because it purges the flexibility of this functional form (see Diewert and Wales, 1987, p. 48). The implications are significant as the resulting model relinquishes its potential to correctly identify complementary relationships between imports and domestic labour. Yet, such possible complementarities underlie the very reason for adopting a framework of analysis that accounts for the intermediate nature of traded products.

⁶ It should be noted that while this approach treats imports as inputs in domestic production, it also captures the full effects of imports that derive from displacing demand for domestic final output.

⁷ Including 'semi-final' goods.

In this paper I investigate the role of imports disaggregated by kind on the prevailing wage inequality in the US. I employ a model that is specifically designed to relate key import categories' level of 'intermediateness' with wage inequality and which, unlike previous studies, can correctly account for both the negative as well as the positive effects that imports have the potential to exert on domestic demand for labour.

The remainder of this paper is organized as follows. The model is discussed in Section 2, and the econometric implementation in Section 3. The results are presented in Section 4, and concluding remarks are reserved for Section 5.

2. THE MODEL

Given the objectives outlined in the previous section, the model employed in this study disaggregates labour in skilled (S) and unskilled (U) categories and imports in ordinary intermediate (I) and semi-final (F) goods. To capture the intermediate nature of all traded products, both categories of imports are treated symmetrically as inputs in domestic production together with capital and labour.

Following Krugman (1995, p. 355) and Kohli (1991, p. 76, 170, 198), the prices of capital (K), skilled labour (S), and unskilled labour (U), together with the quantities of ordinary intermediate imports (I), semi-final imports (F),⁸ and aggregate output (Y) are treated as variable. In this context, production technology is represented using the symmetric normalised quadratic (SNQ) variable profit function developed by Kohli (1993). This functional form allows the required non-uniform statistical treatment of inputs, and is given by

$$\pi = \frac{1}{2}(\mathbf{g}'\mathbf{x})\mathbf{p}'\mathbf{A}\mathbf{p}/(\mathbf{v}'\mathbf{p}) + \frac{1}{2}(\mathbf{v}'\mathbf{p})\mathbf{x}'\mathbf{B}\mathbf{x}/(\mathbf{g}'\mathbf{x}) + \mathbf{p}'\mathbf{C}\mathbf{x} + \mathbf{p}'\mathbf{D}\mathbf{x}t + \frac{1}{2}(\mathbf{v}'\mathbf{p})(\mathbf{g}'\mathbf{x})\xi t^2 \quad (1)$$

where $\mathbf{x} = (x_U, x_S, x_K)'$ and $\mathbf{p} = (p_Y, p_D, p_I)'$ collect the quantities of fixed inputs and the prices of 'outputs', respectively; $\mathbf{A} \equiv [a_{ih}]$, $\mathbf{B} \equiv [b_{jk}]$ and $\mathbf{C} \equiv [c_{ij}]$ denote unknown symmetric parameter matrices of dimensions 3×3 ; $\mathbf{D} \equiv [d_{ij}]$, represents an unknown parameter matrix of dimensions 3×3 ; $\mathbf{g} \equiv [g_j]$; and $\mathbf{v} \equiv [v_i]$ represent vectors of preselected parameters of order 3, $\forall i, h \in (Y, F, I)$ and $j, k \in (U, S, K)$; ξ denotes an unknown scalar parameter; $\sum_h^{(Y,F,I)} a_{ih} = 0 \forall i \in (Y, F, I)$; $\sum_k^{(U,S,K)} b_{jk} = 0 \forall j \in (U, S, K)$; $\sum_i^{(Y,F,I)} v_i = 1$ and $\sum_j^{(U,S,K)} g_j = 1$. Equation (1) is a fully flexible functional form and it is neither necessarily concave in fixed input quantities, nor necessarily convex in the prices of the variable quantities.

Using the Gorman-Diewert adaptation of Hotelling's⁹ lemma, in the context of the *variable* profit function, differentiation of $\pi(\cdot)$ with respect to input prices yields the supply of output and the demand for variable inputs (i.e., imports) given by

⁸ My disaggregation of imports in ordinary intermediate and semi-final categories roughly follows Aw and Roberts (1985) and Tombazos (1998). More detailed disaggregations of imports were initially attempted, but abandoned as they did not allow the econometric implementation to converge.

⁹ See Diewert (1974, p. 137).

$$y = (g'x)Ap/(v'p) - \frac{1}{2}v(g'x)p'Ap/(v'p)^2 + \frac{1}{2}vx'Bx/(g'x) + Cx + Dxt + \frac{1}{2}v(g'x)\xi t^2 \tag{2}$$

where $y = (y_Y | y_D, y_I)'$ collects the quantities of ‘outputs’.¹⁰

If, under competitive conditions, producers also optimise with respect to fixed inputs,¹¹ the inverse fixed input demand functions for capital and the two types of labour can be derived from the ‘marginal product’ conditions and are given by

$$w = \frac{1}{2}gp'Ap/(v'p) + (v'p)Bx/(g'x) - \frac{1}{2}g(v'p)x'Bx/(g'x)^2 + C'p + D'pt + \frac{1}{2}(v'p)g'\xi t^2 \tag{3}$$

where $w = (w_U, w_S, w_K)'$ represents the prices of the fixed inputs.

Substitution possibilities between inputs and outputs can be explored by estimating the elasticity matrix given by

$$E = \begin{bmatrix} [\{\text{diag}(\nabla_p \pi(\cdot))\}^{-1} \cdot (\nabla_{pp}^2 \pi(\cdot)) \cdot (\text{diag}(p))] & [\{\text{diag}(\nabla_p \pi(\cdot))\}^{-1} \cdot (\nabla_{px}^2 \pi(\cdot)) \cdot (\text{diag}(x))] \\ [\{\text{diag}(\nabla_x \pi(\cdot))\}^{-1} \cdot (\nabla_{xp}^2 \pi(\cdot)) \cdot (\text{diag}(p))] & [\{\text{diag}(\nabla_x \pi(\cdot))\}^{-1} \cdot (\nabla_{xx}^2 \pi(\cdot)) \cdot (\text{diag}(x))] \end{bmatrix} \tag{4}$$

where, given $m, n \in (p, x)$, $\nabla_m \pi(\cdot)$ represents the gradient of $\pi(\cdot)$ with respect to m and $\nabla_{mn}^2 \pi(\cdot)$ denotes the sub-hessian of $\pi(\cdot)$ with respect to m and n . Similarly, the impact of technical change, made possible by the passage of time, on the prices of the fixed inputs can be captured by the time semi-elasticity

$$E_{xt} = [\text{diag}(\nabla_x \pi(\cdot))]^{-1} \cdot (\nabla_{xt}^2 \pi(\cdot)) \tag{5}$$

3. DATA AND ESTIMATION

The model employed in this paper requires data on prices and quantities for skilled and unskilled labour, capital, intermediate and semi-final imports and aggregate output. The raw data that was used to construct the required variables was obtained from the *National Income and Product Accounts of the United States* (NIPA), the *Survey of Current Business*, and the *Occupations by Industry Subject Reports* of the 1970 *Census of Population*.

To generate price and quantity indexes corresponding to economy-wide output, capital, skilled labour and unskilled labour, in accordance with the requirements of the model discussed in the previous section, I followed the approach used by Tombazos (2003a). In the context of this approach, construction of economy-wide output entails a Tornqvist aggregation of all categories of income listed in the NIPA. These include 14 categories of private consumption, nine categories of private investment, six categories of consumption by the state and federal governments, six categories of investment by the state and federal governments, three categories of exports (including services) and the changes in durable and

¹⁰ Note that variable inputs, such as imports, are treated as negative outputs in the model.

¹¹ See Diewert (1974, p. 140) for a relevant discussion.

non-durable business inventories. Given that my model treats imports as an input of domestic production, nominal capital expenditure for any given year corresponds to the nominal value of economy-wide output net of the wage bill and expenditures on imports. To determine the implicit rental rate of capital for each year, I divided nominal capital expenditures by capital stock that I define as the sum of the net stock of fixed non-residential equipment and structures and the net stock of residential capital.

Economy-wide data on employment and wages for skilled and unskilled labour is not currently available for the USA. To produce representative indexes I relied on the definition for skilled labour nominated by Ray (1981) who classifies skilled occupations to include professionals and managers as well as sales, clerical and precision production labour. Using this definition, and the occupational breakdown across industries that appears in the *Occupations by Industry Subject Reports* of the 1970 *Census of Population*, I calculated the percentage of skilled workers over total employment in each of the 54 industries identified in the NIPA. I then proceeded to classify industries as either high-skill intensive or low-skill intensive. An industry is considered to be high-skill intensive if it employs a higher percentage of skilled labour than the average of all industries under examination (which approximates the economy's skilled-labour intensity). Otherwise, an industry is classified as low-skill intensive. Representative wages and employment levels for the clusters of high-skill intensive and low-skill intensive industries were derived using Tornqvist aggregations. These employment and wage figures are used as proxies for the representative economy-wide employment and wage rate of 'skilled' and 'unskilled' labour, respectively.

Disaggregation of imports in intermediate and semi-final groupings was guided by the NIPA's *end-use* classification of imports that corresponds to the following categories: foods, feeds, and beverages (I_1); durable industrial supplies and materials (I_2); non-durable industrial supplies and materials (I_3); petroleum and products (I_4); capital goods except autos (I_5); autos and parts (I_6); durable consumer goods (F_1); non-durable consumer goods (F_2); and other consumer goods (F_3). Following Tombazos (1998), I classify categories I_1, I_2, \dots, I_6 as *intermediate imports* and categories F_1, F_2 , and F_3 as *semi-final imports*. With the exception of incorporating category I_6 in intermediate imports, which is necessitated by the significant similarities between this category and category I_5 , my disaggregation is otherwise identical to the one suggested by Aw and Roberts (1985). The data used covers the period 1968–1994.¹²

The econometric model consists of six equations: the aggregate output supply function; the two variable input demand functions pertaining to ordinary intermediate and semi-final imports; and the three inverse demand functions of capital and the two types of labour. Simultaneous estimation of these equations was performed using an autocorrelation-adjusted non-linear three stage least

¹² I avoid using recent international trade data which has not benefited from a sufficient accumulation of revisions. See Tombazos (2003b) for a relevant discussion.

Table 1. Eigenvalues of matrices **A** and **B** of estimated symmetric normalized quadratic variable profit function

<i>Eigenvalues (Cholesky Values)</i>	
<i>Matrix A</i>	<i>Matrix B</i>
0.0590, 0.0176, 0.0000 (0.0585, 0.0173, 0.0000)	-0.6695, 0.0055, 0.0000 (-0.6694, 0.0000, 0.0000)

Notes: Convexity requires matrix **A** to be positive semidefinite, and concavity requires matrix **B** to be negative semidefinite. Eigenvalues of curvature-corrected models in parentheses.

squares (AN3SLS) method¹³ that accounts for statistically relevant endogenous dimensions of import prices that may arise because of the size of the US economy.

Following a preliminary estimation of the model the curvature conditions were checked.¹⁴ Table 1 reports the relevant eigenvalues. As can be seen from this table, while convexity was satisfied in the first round of estimations, concavity was not. This necessitated global enforcement of this condition, and the subsequent re-estimation of the model.¹⁵ The method used relies on the approach originally proposed by Wiley *et al.* (1973).

In their well known contribution, Wiley *et al.* (1973) prove that a sufficient condition for a matrix **Q** to be negative semidefinite is that it can be expressed as $\mathbf{Q} = -\mathbf{Z} \cdot \mathbf{Z}$ where $\mathbf{Z} \equiv [z_{jk}]$ is a lower triangular matrix. Building upon the work of these authors, Diewert and Wales (1987) showed that this condition is also necessary.

We define

$$\mathbf{z} = \begin{bmatrix} z_{1,1} & 0 & L & 0 \\ z_{2,1} & z_{2,2} & L & 0 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & L & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ z_{J,1} & z_{J,2} & L & z_{J,J} \end{bmatrix}. \tag{6}$$

Hence, the negative product of this lower triangular matrix with its transpose gives

¹³ The instrumental variables employed are: excise taxes, sales taxes, and personal savings as percentages of personal disposable income; the budget deficit, net foreign investment, and the government wage bill as percentages of GDP; the discount rate; the producer price indices of Canada, Japan, the United Kingdom and Germany; the population of the US, Canada, Japan, Germany and the United Kingdom; the time trend and the time trend squared; and a constant.

¹⁴ Convexity with respect to output and variable input prices requires the estimated parameter matrix $\mathbf{A} \equiv [a_{jk}]$ to be positive semidefinite, and concavity with respect to the quantities of the fixed factors requires the coefficient matrix $\mathbf{B} \equiv [b_{jk}]$ to be negative semidefinite.

¹⁵ It should be noted that, unlike the case of the Translog, external imposition of curvature does not compromise the flexibility of the SNQ functional form.

$$\mathbf{Q} = \begin{bmatrix} -z_{1,1}^2 & -z_{1,1} \cdot z_{2,1} & L & -z_{1,1} \cdot z_{J,1} \\ -z_{1,1} \cdot z_{2,1} & -z_{2,1}^2 \cdot z_{2,2}^2 & L & -z_{2,1} \cdot z_{J,1} - z_{2,2} \cdot z_{J,2} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & L & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ -z_{1,1} \cdot z_{J,1} & -z_{2,1} \cdot z_{J,1} - z_{2,2} \cdot z_{J,2} & L & -z_{J,1}^2 - z_{J,2}^2 - L - z_{J,J}^2 \end{bmatrix}. \quad (7)$$

As previously noted, a sufficient condition for the variable profit function to be concave, with respect to the quantities of the fixed factors, is that the estimated parameter matrix $\mathbf{B} \equiv [b_{jk}]$ is negative semidefinite. Hence, imposition of concavity requires the reparametrization of the model equations by replacing each element of matrix \mathbf{B} with its corresponding expression in \mathbf{Q} . However, given the constraint of linear homogeneity in the fixed input quantities \mathbf{x} which requires $\sum_k b_{j,k} = 0$, matrix \mathbf{B} is not of full rank. Hence, in the context of the proposed reparametrization, this constraint must also be imposed on equation (7).¹⁶ Using the procedure outlined above, concavity was imposed globally before re-estimating the model. The eigenvalues of the final edition of the model are given in parentheses in the second row of Table 1.

4. EMPIRICAL RESULTS

The resulting parameter estimates of the final edition of the model are reported in Table 2 together with the associated *t*-statistics, degrees of freedom (DOF) and Berndt's generalized \tilde{R}^2 (1991, p. 468). The overall fit of the model as reflected by the \tilde{R}^2 is quite good, and monotonicity is satisfied for all observations with the exception of the first observation in the case of intermediate imports.

Table 3 reports selected annual and average elasticities derived from the parameter estimates of Table 1 using equations (4) and (5). The first part of Table 2 reports what Appelbaum and Kohli (1997, p. 627) refer to as the 'Stolper-Samuelson' elasticities. As can be noted, sign reversals are common. However, the average elasticities given by $\varepsilon_{U,F}$, $\varepsilon_{U,B}$, $\varepsilon_{S,F}$ and $\varepsilon_{S,B}$ are all negative with values given by -0.093 , -0.112 , -0.052 , and -0.064 , respectively. This result suggests that the downward trend in the relative price of imports observed in recent years, discussed by Feenstra and Hanson (1999), has stimulated wages. While this result is consistent with the findings of Appelbaum and Kohli (1997) as well as Tombazos (1998; 1999b) who account for both the downstream-production as well as the output-substitution effects of imports, it contradicts the findings of mainstream studies in the area of wage dispersion, such as Borjas and Ramey (1994) and Wood (1998), that only consider the latter. Still, this observation alone does not preclude some congruity between my results and those of studies that only consider the output-substitution quality of imports – at least to the extent that the results of those studies suggest that a decrease

¹⁶ See Tombazos (2003a) for a discussion of linear homogeneity in fixed input quantities in the context of curvature enforcing reparametrizations.

Table 2. Estimated symmetric normalized quadratic variable profit function parameters

$a_{Y,Y}$	0.31066×10^{-1} (0.561)	$c_{I,S}$	0.91344×10^{-1} (1.107)
$a_{Y,F}$	-0.26298×10^{-1} (-0.461)	$c_{I,K}$	-0.12844^{***} (-1.697)
$a_{F,F}$	0.33123×10^{-1} (0.458)	$d_{Y,U}$	0.17182 (0.885)
$z_{1,1}$	0.10932×10^{-1} (0.005)	$d_{Y,S}$	0.11645 (0.710)
$z_{2,1}$	0.56631 (0.005)	$d_{Y,K}$	0.39909* (2.798)
$z_{2,2}$	-0.87744×10^{-1} (0.000)	$d_{F,U}$	0.31962 (1.342)
$c_{Y,U}$	1.0492* (6.397)	$d_{F,S}$	0.31941 (1.533)
$c_{Y,S}$	0.88090* (6.378)	$d_{F,K}$	-0.34426^{**} (-2.006)
$c_{Y,K}$	0.75751* (5.772)	$d_{I,U}$	-0.39780^{**} (-2.932)
$c_{F,U}$	-0.32238^{***} (-1.791)	$d_{I,S}$	-0.26798^{**} (-2.267)
$c_{F,S}$	-0.25873 (-1.635)	$d_{I,K}$	0.17322 (1.576)
$c_{F,K}$	0.27054** (2.058)	ξ	-0.87850×10^{-1} (-0.413)
$c_{I,U}$	0.17727*** (1.920)		
DOF	131		
\bar{R}^2	0.9998137		

Notes: *t*-statistics in parentheses. *, ** and *** denote significance at the 1%, 5% and 10% level with a two-tailed test, respectively. The data used corresponds to 1968–1994 with the first observation lost because of the autocorrelation correction discussed in the estimation section. Given that all equations estimated simultaneously incorporate the same right-hand side variables, the degrees of freedom (DOF) of the model are given by the number of observations (26) multiplied by the number of equations (6) minus the number of estimated coefficients (25). Hence there are 131 degrees of freedom.

Table 3. Selected annual and average elasticities of the symmetric normalized quadratic variable profit function

Elasticity	Year				Average	
	1970	1980	1985	1994		
Price elasticities of inverse factor demands (Stolper-Samuelson Elasticities) $\epsilon_{ji} = \partial \ln w_j / \partial \ln p_i$						
$\epsilon_{U,Y}$	1.259	1.256	1.210	1.180	1.202*	(18.695)
$\epsilon_{U,F}$	-0.291	-0.137	-0.033	0.092	$-0.093^{***\dagger}$	(-1.708)
$\epsilon_{U,I}$	0.091	-0.116	-0.187	-0.275	$-0.112^{*\dagger}$	(-3.479)
$\epsilon_{S,Y}$	1.043	1.100	1.051	0.983	1.024*	(18.491)
$\epsilon_{S,F}$	-0.250	-0.095	0.003	0.130	-0.052^\dagger	(-0.934)
$\epsilon_{S,I}$	0.059	-0.066	-0.117	-0.172	$-0.064^{***\dagger}$	(-2.304)
$\epsilon_{K,Y}$	0.815	1.105	1.093	1.171	1.028*	(17.745)
Quantity elasticities of inverse factor demands $\epsilon_{jk} = \partial \ln w_j / \partial \ln x_k$						
$\epsilon_{U,K}$	0.044	0.071	0.061	0.059	0.062	(0.775)
$\epsilon_{S,K}$	0.429	0.610	0.491	0.425	0.494*	(4.561)
Time semi-elasticities of inverse factor demands $\epsilon_{jt} = \partial \ln w_j / \partial t$						
$\epsilon_{U,t}$	0.231	-0.028	0.026	0.109	0.083*** [†]	(1.836)
$\epsilon_{S,t}$	0.255	0.102	0.106	0.153	0.157*	(4.476)
$\epsilon_{K,t}$	0.201	0.254	0.244	0.163	0.205*	(3.789)

Notes: *t*-statistics in parentheses. Superscripts *, ** and *** denote significance at the 1%, 5% and 10% level with a two-tailed test, respectively. Superscript [†] Indicates sign reversals.

in import prices augments wage dispersion. Given the qualitative nature of my results, such a decrease in the price of imports may contribute to the trend in wage dispersion if it generates a disproportional increase in the demand for skilled labour. However, such a relationship does not find support in the evidence. At

least in the post-1980 period,¹⁷ the *relative* magnitudes of corresponding Stolper-Samuelson elasticities across the two types of labour examined by my model are consistently characterised by inequalities $\varepsilon_{U,F} < \varepsilon_{S,F}$ and $\varepsilon_{U,I} < \varepsilon_{S,I}$. Hence, contrary again to the results of mainstream studies, such as Feenstra and Hanson (1999), trade liberalization schemes which decrease the relative price of ordinary intermediate or semi-final imports, such as uniform tariff reductions, are found to compress, rather than augment, the prevailing wage inequality.

The asymmetric impact of changes in the prices of intermediate and semi-final imports on the wages of skilled and unskilled labour partly confirms relevant a priori expectations. As I noted in an earlier paper, ‘... other things equal, imports with a high intermediate (final) content are more likely to exhibit complementarity (substitutability) with domestic labour’ (Tombazos (1999b, p. 355)]. In the context of the model employed in this paper, this statement would be consistent, other things equal, with corresponding import-price, wage-rate Stolper-Samuelson elasticities that are smaller in the case of ordinary intermediate as compared to semi-final imports. At least in the post-1985 period the expected pattern emerges in the results. A comprehensive interpretation of the pre-1985 results is beyond the scope of this paper. However, it should be noted that these results reflect, among other factors, the nature of the synergy of negative and positive labour demand effects that ensue from output substitution and downstream production processes, respectively, as well as differences in the skill intensity of domestic industries competing with intermediate and semi-final imports. In short, ‘other things’ are not always equal.

Bhagwati and Dehejia (1994) have argued that, rather than trade, the observed trend in wage dispersion is likely to be driven by the economy-wide impact of potentially skill-biased dynamic processes of technical change and capital accumulation (pp. 52–55; 69–71). The impact of technical change on wages, made possible by the passage of time, is captured in my model by the time semi-elasticities $\varepsilon_{U,t}$ and $\varepsilon_{S,t}$ which are both statistically significant at the 1% level with averages of 0.083 and 0.157 respectively. As can be noted, $\varepsilon_{S,t} > \varepsilon_{U,t}$ for all observations. This suggests that technological advancements are more (less) likely to complement (substitute) demand for skilled rather than unskilled labour. Given that $\varepsilon_{S,t}$ is, on average, about twice as large as $\varepsilon_{U,t}$, and given that the two elasticities assume fairly large values,¹⁸ technical change is likely to be an important contributor to the prevailing trend in wage dispersion. This result is also consistent with the findings of studies that investigate this issue at the micro-level such as Berman *et al.* (1994). Examination of the capital-labour elasticities suggests that capital accumulation strongly reinforces the role of

¹⁷ It should be noted that, as pointed out by Bhagwati and Dehejia (1994, p. 37), 1980 marks the beginning of the era in which the wage differential increased most noticeably.

¹⁸ To place these figures in perspective, it should be noted that the time variable, t , that appears in the model was originally assigned values 1, 2, ..., 27 for years 1968, 1969, ..., 1994, respectively. However, to promote convergence, and together with all prices and instruments, t was normalised to the value of 1 for 1987 which necessitated dividing the original value of t corresponding to each year in the data by the number 20. Hence, the normalised edition of t corresponds to 0.05 for 1968, 0.1 for 1969, 0.15 for 1970, and so on. In this light, the average value of, say, $\varepsilon_{S,t}$ that corresponds to 0.157 implies that the passing of each year increases the wage rate of skilled workers by an average of 0.79% [= (0.157/20) × 100].

technical change in wage dispersion with $\varepsilon_{S,K}$ assuming an average value of 0.494 that is more than seven times larger than the corresponding value of 0.062 for $\varepsilon_{S,K}$, both of which are statistically significant at the 1% level.

5. CONCLUDING REMARKS

Widely accepted stylized facts blame the negative trend in import prices, observed in recent decades, for the expanding wage differential between skilled and unskilled labour. My results contradict such assessments. They instead suggest that systematic decreases in the relative prices of all imports, ordinary intermediate and semi-final imports alike, stimulate both wage rates, while compressing rather than expanding their differential. Important sources of wage dispersion are, however, found in skill-biased economy-wide dynamic processes of capital accumulation and technical change. Hence, my results provide support to Bhagwati and Dehejia's (1994, p. 69) view that, rather than imports, it might very well be the aggregate production function that represents unskilled labour's 'ultimate threat'.

REFERENCES

- Appelbaum, E. and U. Kohli (1997) 'Import Price Uncertainty and the Distribution of Income', *Review of Economics and Statistics* 79, 620–30.
- Aw, B. Y. and M. J. Roberts (1985) 'The Role of Imports from the Newly-Industrializing Countries in U.S. Production', *Review of Economics and Statistics* 67, 108–17.
- Berman, E., J. Bound and Z. Griliches (1994) 'Changes in the Demand for Skilled Labor within U.S. Manufacturing: Evidence from the Annual Survey of Manufactures', *Quarterly Journal of Economics* 109, 367–97.
- Berndt, E. R. (1991) *The Practice of Econometrics: Classic and Contemporary*. Reading, MA: Addison-Wesley.
- Bhagwati, J. and V. Dehejia (1994) 'Freer Trade and Wages of the Unskilled – Is Marx Striking Again?' in J. Bhagwati and M. H. Koster (eds), *Trade and Wages: Leveling Wages Down?* Washington, DC: American Enterprise Institute, 36–71.
- Borjas, G. J. and V. A. Ramey (1994) 'Time-Series Evidence on the Sources of Trends in Wage Inequality', *American Economic Review* 84, 10–16.
- Burgess, D. F. (1974) 'Production Theory and the Derived Demand for Imports', *Journal of International Economics* 4, 103–18.
- Burgess, D. F. (1976) 'Tariffs and Income Distribution: Some Empirical Evidence for the United States', *Journal of Political Economy* 84, 17–43.
- Burtless, G. (1995) 'International Trade and the Rise in Earnings Inequality', *Journal of Economic Literature* 33, 800–16.
- Diewert, W. E. (1974) 'Applications of Duality Theory', in M. D. Intriligator and D. A. Kendrick (eds), *Frontiers of Quantitative Economics*. Amsterdam: North-Holland, 106–206.
- Diewert, W. E. and T. J. Wales (1987) 'Flexible Functional Forms and Global Curvature Conditions', *Econometrica* 55, 43–68.
- Falk, M. and B. M. Koebel (2002) 'Outsourcing, Imports and Labour Demand', *Scandinavian Journal of Economics* 104, 567–86.
- Feenstra, R. C. and G. H. Hanson (1999) 'The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979–90', *Quarterly Journal of Economics* 114, 907–40.
- Harrigan, J. (2000) 'International Trade and American Wages in General Equilibrium, 1967–95', in R. C. Feenstra (ed.), *The Impact of International Trade on Wages*. Chicago, Ill: University of Chicago Press, 171–93.
- Harrigan, J. and R. A. Balaban (1999) 'U.S. Wages in General Equilibrium: The Effects of Prices, Technology, and Factor Supplies, 1963–91', *NBER Working Paper 6981*, National Bureau of Economic Research, 1–41.

- Hijzen, A., H. Gorg and R. C. Hine (2005 – forthcoming) 'International Outsourcing and the Skill Structure of Labour Demand in the United Kingdom', *Economic Journal* 115, 860–78.
- Kohli, U. R. (1978) 'A Gross National Product Function and the Derived Demand for Imports and Supply of Exports', *Canadian Journal of Economics* 11, 167–82.
- Kohli, U. R. (1991) *Technology, Duality, and Foreign Trade: the GNP Function Approach to Modeling Imports and Exports*. Ann Arbor, MI: University of Michigan Press.
- Kohli, U. R. (1993) 'A Symmetric Normalized Quadratic GNP Function and the U.S. Demand for Imports and Supply of Exports', *International Economic Review* 34, 243–55.
- Kohli, U. R. (1994) 'Canadian Imports and Exports by Origin and Destination: a Semi-Flexible Approach', *Canadian Journal of Economics* 27, 580–603.
- Krugman, P. R. (1995) 'Growing World Trade: Causes and Consequences', *Brookings Papers on Economic Activity* 1, 327–62.
- Ray, E. J. (1981) 'The Determinants of Tariff and Non-Tariff Trade Restrictions in the United States', *Journal of Political Economy* 89, 105–21.
- Richardson, J. D. (1995) 'Income Inequality and Trade: How to Think, What to Conclude', *Journal of Economic Perspectives* 9, 33–55.
- Rousslang, D. J. and T. To (1993) 'Domestic Trade and Transportation Costs as Barriers to International Trade', *Canadian Journal of Economics* 26, 208–21.
- Sachs, J. D. and H. J. Shatz (1994) 'Trade and Jobs in U.S. Manufacturing', *Brookings Papers on Economic Activity* 1, 1–69.
- Schott, P. K. (2003) 'One Size Fits All? Heckscher-Ohlin Specialization in Global Production', *American Economic Review* 93, 686–708.
- Slaughter, M. J. (2000) 'What Are the Results of Product-Price Studies and What Can We Learn from Their Differences?' in R. C. Feenstra (ed.), *The Impact of International Trade on Wages*. Chicago, Ill: University of Chicago Press, 129–65.
- Tombazos, C. G. (1998) 'U.S. Production Technology and the Effects of Imports on the Demand for Primary Factors', *Review of Economics and Statistics* 80, 480–3.
- Tombazos, C. G. (1999a) 'The Role of Imports in Expanding the Demand Gap between Skilled and Unskilled Labour in the U.S.', *Applied Economics* 31, 509–17.
- Tombazos, C. G. (1999b) 'The Impact of Imports on the Demand for Labour in Australia', *Economics Letters* 62, 351–6.
- Tombazos, C. G. (2003a) 'A Production Theory Approach to the Imports and Wage Inequality Nexus', *Economic Inquiry* 41, 42–61.
- Tombazos, C. G. (2003b) 'New Light on the "Impressionistic View" of the Balancing Item in Australia's Balance of Payments Accounts', *Applied Economics* 35, 1369–78.
- United States Department of Commerce, B.o.E.A. (various annual issues) *The National Income and Product Accounts of the United States – Statistical Tables*. Washington DC: US Government Printing Office.
- United States Department of Commerce, B.o.E.A. (various monthly issues) *Survey of Current Business*. Washington DC: US Government Printing Office.
- United States Department of Commerce, B.o.t.C. (1973) *Census of Population 1970, Subject Reports: Occupations by Industry*. Washington DC: US Government Printing Office.
- Wiley, D. E., W. H. Schmidt and W. J. Bramble (1973) 'Studies of a Class of Covariance Structure Models', *Journal of the American Statistical Association* 68, 317–23.
- Wood, A. (1998) 'Globalisation and the Rise in Labour Market Inequalities', *Economic Journal* 108, 1463–82.
- Yang, X. and D. Zhang (2003) 'Economic Development, International Trade, and Income Distribution', *Journal of Economics* 78, 163. 190.