THE CHOICE OF STRUCTURAL MODEL IN TRADE-WAGES DECOMPOSITIONS*

Lisandro Abrego
University of Warwick

John Whalley
Universities of Warwick and Western Ontario
and NBER

March 1999

ABSTRACT

This paper explores the use of structural models as an alternative to reduced form methods when decomposing observed joint trade and technology driven wage changes into components attributable to each source. Conventional mobile factors Heckscher-Ohlin models reveal problems of specialisation unless price changes accompanying trade shocks are small, and also produce wide ranges for the decomposition for parameterisations consistent with the joint change. A differentiated goods model which generalises Heckscher-Ohlin removes problems of specialisation and concentrates the range of decompositions more narrowly, but introduces larger demand side responses to trade shocks which greatly reduce the effect of trade. The conclusion offered is that the choice of structural model matters for decomposing observed wage changes into trade and technology components, and that reduced-form methods which do not discriminate between alternative structural models may not

---

* This paper forms part of a project on Globalisation and Social Exclusion supported by the Targeted Socio Economic Research programme of the European Union. We are grateful to Bob Anderton, Paul Brenton, Matthias Luecke, and Ken Wallis for helpful comments on an earlier draft.

be that informative for such decompositions.

1. INTRODUCTION

This paper addresses the ongoing debate on the principal sources of increased wage dispersion in the form of an elevated premium paid to skilled labour in OECD countries in recent years. Many papers have been written on the subject, and most focus on increased trade and skill biased technological change as the two principal causes.[1] Lawrence and Slaughter (1993), Krugman and Lawrence (1993), Leamer (1996), Baldwin and Cain (1997) and others conclude that the role of trade is small; Wood (1994) points to a dominant role for trade. Conclusions in this literature rest largely on reduced form regressions. Some, such as Murphy and Welch (1991), Borjas, Freeman, and Katz (1991) estimate the factor content of trade and use these estimates via exogenous (literature based) labour demand elasticities to infer the wage change attributable to trade. They then compare this to observed wage changes. Others, such as Leamer (1996) and Baldwin and Cain (1997) use estimating equations derived from explicit general equilibrium models.

Our purpose here is to explore the use of structural models as an alternative to reduced form methods when decomposing observed joint trade and technology driven wage changes into the components attributable to each source. We first use a conventional Heckscher-Ohlin trade model with two factor inputs (skilled and non-skilled labour) and two outputs (skilled labour intensive, and non-skilled labour intensive outputs), where the economy in question is a taker of goods prices on world markets.[2] Skilled and unskilled labour are mobile between sectors, but are internationally immobile. In this model, trade shocks are modelled as world price changes, and technology shocks

[1] Immigration enters as a third factor in some literature.

[2] The structure that we use here is actually a variant of the Heckscher-Ohlin model—it contains two goods, two factors and homogeneous products but there is only one (small) country and

as changes in production function share parameters. We calibrate such a model both to UK data for 1990, and to the relative wage change observed for the joint technology/trade shocks over the period 1980-1995. We then explore the use of the model for decomposition experiments by first removing technology only, and then subsequently removing trade, and computing equilibria for each case. These allow for an assessment of the separate role of trade and technology in observed changes in wage inequality over the period.

Results using simple Heckscher-Ohlin as the structural model for decomposition suggest that this model is unlikely to be suitable for analysis of actual country experiences. First, the model can only be solved for relatively small shocks since with the CES functional forms used in the model (or indeed any convenient functional form), the production frontier is close to linear and so specialisation accompanies even small changes.[3] Second, there are significant degrees of ambiguity associated with the decompositions for the small changes that the model is able to be solved for. These indicate that there is a range of parameterisations for the model which are consistent with the same reduced form data, but these parameterisations yield divergent decompositions of the same joint change. Estimated reduced forms do not allow for discrimination between these alternative parameterisations for use in decomposition.

We then consider an alternative differentiated goods model of which the Heckscher-Ohlin model is a special case. In this imported goods and non-exportable domestic products are imperfect substitutes in demand, and as the substitution elasticity between domestic products and imports

---

our base case pattern of trade is pre-determined .

3 Fixed-factor variants of the same model can be used to remove specialisation, but these have the property that price shocks are largely borne by the fixed factors, rather than the mobile skilled and unskilled labour types.

approaches infinity the model reverts to the more classical Heckscher-Ohlin form. For finite substitution elasticities, this model weakens, and typically removes the specialisation properties of simple Heckscher-Ohlin models, allowing actual joint technology and wage changes to be decomposed into constituent parts. It also incorporates endogenous domestic price determination in response to world price changes within imperfect pass through of world price changes onto prices of domestically produced goods (in simple Heckscher-Ohlin models all external shocks fully impact domestic goods prices). It also allows for direct model calibration to import demand elasticity estimates, something that in simple Heckscher-Ohlin is considerably more difficult.

Analysing decompositions of the same UK data with this model reveals strikingly different results relative to simple Heckscher-Ohlin—specialisation problems recede, and the range of decomposition results for given joint changes is substantially narrowed, in part because trade shocks can now be absorbed on the import demand side of the model without full transmission to domestic producer prices. The increase in inequality attributed to trade changes can change sign depending upon whether the demand side substitution elasticity between domestic and foreign goods is greater or less than one. These demand side effects thus play a key role in trade-wages decompositions.

We interpret our results as showing how alternative structural models with different properties can be built for decompositional analysis, each consistent with the same joint shock, but with sharply different results. Using a simple Heckscher-Ohlin model, close to what is found in some of the trade and wages literature, only small changes can be analysed and these, in turn, offer a wide range of decompositions from alternative data consistent parameterisations. With a product differentiation model, large changes can be analysed and across alternative parameterisations decomposition results are relatively robust, but with demand side effects entering the model the contribution of trade to inequality is much reduced. We suggest that exploration of alternative structural models rather than reduced forms may be the way forward to more satisfactorily sort out trade and technology effects on wage dispersion.

II THE TRADE AND WAGE INEQUALITY DEBATE

Recent literature on trade and wages focuses on understanding the quantitative significance of trade in explaining the sharp increase in OECD wage inequality which has occurred during the 1980s. This issue is important because of the associated pressures for protection which arise if trade is deemed to be the main source of increased inequality. This increase in inequality has been documented for a number of OECD countries, most notably the US and the United Kingdom (e.g., Davis, 1992; Kosters, 1994). The pattern has been observed across different types of workers according to their skills (low vs. high skill), education level (college vs. non-college graduates), and experience. Even among "observably similar workers" wage inequality has increased (e.g. Davis, 1992). There has also been some documentation of a rise in unemployment in European countries without major increases in wage inequality (Kosters, 1994)—as well as of a decline in wage inequality in some key developing countries (Korea, Venezuela, Colombia and Brazil) (Davis, 1992). A large literature has evolved on the explanation of increased wage inequality, especially for the US case.[4]

Two major factors have been identified as responsible for this phenomenon: increased trade with developing countries and technological change biased against unskilled labour. The great majority of research has concluded that unskilled-biased technological change, rather than increased trade, is the main source of the surge in wage inequality in the1980s.[5]

[4]See, for instance, the surveys by Burtless (1994); and Brenton (1998). Also see Deardorff and Hakura (1994).

[5]Exceptions to this conclusion include Borjas, Freeman and Katz (1991); Wood (1994); and Feenstra and Hanson (1996). The latter identify outsourcing as a significant cause.

This literature uses a variety of econometric models.[6] Early papers focused on how trade changes labour demand via the factor content of trade (e.g. Borjas, Freeman, and Katz (1991), Murphy and Welch (1991), and Katz and Murphy (1992)). They typically ran regressions which link labour demand (by type of labour) and trade flows, and then used actual trade flows to infer the changes in labour demand they imply. They then combined these labour demand changes with wage elasticity of labour demand estimates culled from the literature to infer what portion of actual wage changes are due to trade changes. This work generally came to the conclusion that the portion of actual wage change attributable to trade is small.

These estimates, based on factor content of trade calculations, were later criticised by Wood (1994) who argued that trade is a considerably more important factor than these analyses show. He argued that for many products, especially those from developing countries, there is no comparable domestic product, and so factor substitution effects attributed to trade using conventional elasticities are understated. He also argues that technological response to trade will occur in expectation of future trade surges, and so some of what is attributed to technology in factor content analyses should in reality be attributed to trade.

Later papers in the area (Lawrence and Slaughter, 1993; Baldwin and Cain, 1997; and Leamer, 1996) take a different approach and work with estimating equations derived from explicit general equilibrium models of a Heckscher-Ohlin type. Lawrence and Slaughter, for instance, relate changes in relative skilled and unskilled wage rates to changes in prices of skilled and unskilled labour intensive products. Highlighting key measurement issues, they suggest that for the US the changes

---

[6]Francois and Nelson (1998) are seemingly the other authors who use an applied general equilibrium model to look at the effects of trade and technology on wage inequality. They set out

in product prices appear to be opposite from that needed to generate increased wage inequality (i.e. unskilled intensive product prices rise rather than fall). Their conclusion is that trade is relatively unimportant, and that unskilled-biased technical change is the main source of increased wage inequality.

Finally, more recent work regresses measures of factor shares on measures of outsourcing (Feenstra and Hanson, 1996; Anderton and Brenton, 1998) concluding that trade may be more important than in earlier analyses. Anderton and Brenton (1998), in particular, find that trade is more important when trade only with developing countries rather than with all countries is used as an explanatory variable.

Our point of departure is to note that virtually all of these analyses use reduced-form data in their estimations, with little or no work explicitly employing structural models[7] even though structural models are needed to make a meaningful decomposition of an observed relative wage change into a portion due to trade and a portion due to (skill-biased) technological change. Because the model parameters which are consistent with given reduced-form data are not unique, different parameterisations can generate a different decomposition between trade and technological change as sources of an observed combined change in inequality. As a result, limited inference can be drawn as to the relative importance of trade and technology from the analysis of reduced-form model results alone, some attention to structural models may be required.

---

a modelling approach, rather than analyze decompositions in detail.

[7]An exception is Leamer (1996), where a structural form is estimated. More recently, Francois and Nelson (1998) have also set out an applied general equilibrium model to use to analyze the effects of trade and technology on wage inequality.

III A HECKSCHER-OHLIN INEQUALITY DECOMPOSITION FOR THE UK

We first explore decompositions of combined wage and technology shocks using some numerical simulations from a simple and theory-consistent Heckscher-Ohlin general equilibrium model calibrated to UK data. We use 1990 data on production, consumption, factor use, and trade, aggregated into a two commodity unskilled labour intensive and skilled labour intensive product and industry classification to calibrate the model, and use data on trade shocks and wage changes covering the period 1976-1990 and 1980-1995, respectively. Technology shocks are inferred from the wage outcome over the period and the data on trade shocks. We describe this data in more detail in an appendix.

We use a two-good (importable/exportable), two factor (skilled/unskilled labour) Heckscher-Ohlin model to incorporate both trade shocks and changes in skilled-biased technological change. Alternative choices of parameter values for the functional forms used in the model imply that this structural model form can be parameterised in different ways, each of which gives the same wage inequality change for a combined trade and technology shock. There are in fact many such parameterisations, while each potentially gives different decompositional results.

We are able to show substantial ambiguity in the resulting decompositions for this model across different parameterisations. In the simple Heckscher-Ohlin case, specialisation also occurs even for only small goods price changes since the production frontier in such models is close to linear for convenient functional forms (see Johnson (1966)). While the ambiguity for the small size decompositions that we can perform can be reduced either by restricting key elasticity parameters—such as production substitution elasticities between skilled and unskilled labour—to a narrow range of values, appealing to literature estimates (Hamermesh, 1993) or by moving to increasingly constrained calibration in which we require more than calibration to only the combined wage change over the period, we suggest nonetheless that the simple Heckcsher-Ohlin model is a poor performer for decompositional analysis.

Production

In our simple Heckscher-Ohlin model, we consider a small open price taking economy that produces two goods, M and *E* (importable and intensive in unskilled labour, and exportable and intensive in skilled labour, respectively), both of which are traded at fixed world prices. The production of each good requires the use of two factors: skilled labour, *S*, and unskilled labour, *U*. Each good is produced using a constant returns to scale CES technology, with constant elasticity of substitution between *S* and *U*.

$$Y_i = \gamma_i \left[\beta_i U_i^{-\rho_i} + (1-\beta_i) S_i^{-\rho_i} \right]^{-\frac{1}{\rho_i}}, \qquad i = M, E \tag{1}$$

where Y_i represents output, γ_i denotes units of measurement, β_i is a share parameter, and ρ_i determines the elasticity of substitution, η_i, between U_i and S_i, with $\eta_i = \frac{1}{1+\rho_i}$.

Labour Market

We take the endowment of unskilled and skilled labour to be fixed (there is no labour-leisure choice), and to equal $\bar{U}$ and $\bar{S}$ respectively. Full employment of each type of labour is assumed. We also assume competitive labour markets so that each type of labour is paid its marginal value product, i.e,

$$W_U = \gamma_i \beta_i U_i \; P_i Y_i^{1-\rho_i} \qquad (i = M, E) \tag{2}$$

$$W_S = \gamma (1-\beta_i) S_i P_i Y_i^{1-\rho_i} \qquad (i = M, E) \tag{3}$$

where W_U and W_S denote unskilled and skilled wage rates respectively, and P_i is the (fixed) world price of good *i*.

Trade

Imports and domestically produced goods are homogeneous, as is also the case with exports (i.e. trade is of Heckscher-Ohlin form). This homogeneity assumption implies that trade flows in any good are only one-way, i.e. one of the goods is exported and the other imported.

In equilibrium trade balance will hold, i.e.,

$$\sum_{i=M,E} P_i T_i = 0 \tag{4}$$

where the T_i denote the net trade of the country in the two goods, *M* and *E*. If good *i* is exported, domestic production less consumption is positive; if good *i* is imported, this difference is negative.

Equilibrium and Market Clearing Conditions

Given the small open economy assumption, equilibrium in this model is given by unskilled and skilled wage rates, such that the two domestic labour markets clear, i.e.

$$\sum_i U_i = \overline{U}, \qquad i = M, E \tag{5}$$

$$\sum_i S_i = \overline{S}, \qquad i = M, E \tag{6}$$

Consumption of each good *i* is given by the difference between production and trade, i.e.

$$C_i = Y_i - T_i, \qquad i = M, E \tag{7}$$

where C_i denotes consumption of good *i*.

Production of each good, in turn, is given by using equations (2), (3), (5) and (6) and solving for Y_i along with W_U and W_S as part of the equilibrium.

Decomposing the Effects of Trade and Technology on Wage Inequality

We can use the Heckscher-Ohlin model presented above to investigate the decomposition of a total wage rate effect from a joint trade-technology shock into a separate trade related and technology components. To do this, we consider trade shocks to be represented by world price shocks which generate more trade. We take such shocks to be given by falls in the relative price of unskilled intensive to skilled intensive products. Our data for the UK indicate a relative price fall of 7.9% for unskilled-intensive products over the period 1976-1990.[8] Given the data on wage change over the sample period, we determine the technology shock by residual as that needed to yield the observed wage change as a model solution in the presence of the combined trade and technology shock. We then treat technology shocks as changes in the share parameters applying to skilled and unskilled labour in sector production functions. We focus on technological change which is factor specific, assuming in our analysis that such changes occur only for unskilled labour.

Specialisation and Simple Heckscher-Ohlin

The Heckscher-Ohlin model immediately proves unsatisfactory for the task of decomposing UK data on wage inequality into separate trade and technology components because of the near

---

8 This estimate is based on information from Neven and Wyplosz (1996), as set out in the appendix.

linearity of the production frontier alluded to above, and the associated problems of specialisation. We can, however, solve the model for smaller trade and technology changes than those observed, and such solutions also indicate ambiguity in decomposition for such changes. We have simulated the effects of a joint 1% fall in the world price of the unskilled-intensive good relative to the skilled intensive good, and a 1% technological change adverse to unskilled labour to provide some sense of model behaviour under such changes. We represent this latter change by a 1% reduction in the share parameter on unskilled labour in the production of both goods, so as to represent pervasive unskilled-biased technological change, which, as we indicate earlier, the bulk of the literature finds to be responsible for the surge in wage inequality during the 1980s (e.g. Berman, Bound and Griliches,1994; Baldwin and Cain, 1997).

Results

In table 1 we report two alternative model parameterisations, determined such that, given the combined trade and technology shocks, both generate the same change in relative wages (-6.67% in Table 2), but with different decomposition results for the portion due to trade and to technological change. There are, in fact, many such parameterisations that can be determined, and Table 1 presents merely two that we have been able to find using a GAMS (Generalized Algebraic Modelling System) code which endogenously determines model parameterisations consistent with the combined change we specify.

Table 1 presents details of these two model parameterisations. They differ substantially in share parameters and production side elasticities. In both parameterisations the importable good utilises unskilled labour intensively—which we, for now, take as a stylised fact for the UK and other

OECD economies. We vary production parameters only—the elasticities of substitution and labour shares, leaving demand parameters—the substitution elasticity and goods shares—unaltered since this is a small open economy model.

Table 2 presents decomposition results for each of the two model parameterisations. These are obtained by first only allowing technology to change, and then only the trade change to occur, and computing a new equilibrium in each case. The resulting wage change is then compared to that from the joint change (shown in Table 2). Although the overall change in wage inequality is the same for both parameterisations, the relative importance of trade and technology in each case is different. For parameterisation *A*, the technology shock is dominant, whereas for parameterisation *B* the opposite occurs. Were we to regress, say, factor price changes from the joint shock on goods price changes (the trade shock) and some measure of the technology change, such a regression does not allow differentiation to be made between competing parameterisations of the structural model, all of which are consistent with reduced form data, but each of which gives a different decomposition.

In passing we also comment on a further feature of Heckcsher-Ohlin—large wage changes occur from only relatively small product price changes. This reflects the same feature alluded to earlier, that with a production frontier close to linear, a small change in output prices from a trade shock (1% here) moves the economy a substantial distance along the frontier with a large change in output composition and hence a large relative wage change. In our UK simulations, the result of this is that changes in goods prices that constitute only a small fraction of the actual change over the period we consider here generate wage effects stronger than those observed. Thus, using Heckcsher-Ohlin models to analyse decomposition for economies in which significant output price and relative wage changes have simultaneously occurred is a further problem for such models.

Table 1
Two Parameterisations of a UK Trade Model
Each Giving the Same Joint (Trade and Technology)
Wage Changes

Share parameters	Good *M*	Good *E*	Good *M*	Good *E*
Production				
Unskilled labour	0.86	0.29	0.81	0.45
Skilled labour	0.14	0.71	0.19	0.56
Consumption	0.52	0.48	0.52	0.48
Elasticities of substitution				
Production	0.4	0.6	0.5	2.50
Consumption	1.25		1.25	

Table 2
Decomposition Results on the Relative Importance of Trade and Technology
for a Total Wage Change of -6.67% (implied by a 1% trade and a 1% technology shock)

	A	**B**
%Change in W_U/W_S for joint trade and technology change	-6.67	-6.67
Fraction of change in W_U/W_S due to technology	0.58	0.43
Fraction of change in W_U/W_S due to trade	0.42	0.57

IV TRADE AND TECHNOLOGY DECOMPOSITIONS IN A DIFFERENTIATED GOODS MODEL

As we note above, the most commonly used structure in which to conduct analyses of the contribution of trade and technology to wage inequality is a two-factor (high/low skilled labour), two-good (high skilled intensive, low skilled intensive) Heckscher-Ohlin trade model. In this structure, the key parameters affecting the decomposition of the total wage effect into component parts are production side parameters— shares and elasticities. The results in the preceding section suggest that this model may be inappropriate for the conduct of such analyses. This is because such models typically have close to linear production frontiers, and so for a small shock complete specialisation can occur, and also wide variations in decompositions occur across parameterisations.

In this section we examine an alternative structural model with differentiated goods, similar to the one set out in de Melo and Robinson (1989), and recently discussed in Bhattarai, Ghosh and Whalley (1999). In this model, imports and domestically produced goods are imperfect rather than perfect substitutes. Imports are not produced domestically, and one of the domestically produced goods is not traded. The model remains a two produced goods, two factor model with two traded goods, but embodies three goods in aggregate when the consumption side is included.[9] Imports and exports are traded at fixed world prices. The domestic good—which is an imperfect substitute for imports—and the exportable are the two produced goods. Each uses skilled and unskilled labour. Imports and the (non-exportable) domestic good enter consumption. This structure removes the

---

9 In de Melo and Robinson's model, three goods are also considered—two of which are domestically produced—but only two of them (the imported and the domestic good) enter preferences.

problems with specialisation associated with the simple Heckscher-Ohlin model when performing trade-technology decompositions since imports are not produced domestically. This differentiated goods model generalises the Heckscher-Ohlin model, since as the elasticity of substitution in demands between domestically produced goods and imports approaches infinity, it asymptotically approaches Heckscher-Ohlin.

Model results using the same UK data as above show both that large change decompositions can now be made and that demand side parameters are critical for the results of such decompositions. When the substitution elasticity in preferences between domestic products and imports is one, terms of trade shocks can be fully accommodated on the demand side by an offsetting quantity adjustment in the imported goods not domestically produced. No impacts on wage rates of skilled and unskilled workers occurs since all the adjustment is now in consumption of the non-produced traded good. The sign of the wage rate impact also changes as this elasticity goes above or below one. These are radically different properties to those found for simple Heckscher-Ohlin models, indicating how critical the choice of structural model is for wage-technology decompositions.

Model

Denoting imports by *M*, exports by *E*, and domestic goods by *D*, preferences are defined over *M*, *D* and E, with *D* and *E* being the produced goods. Using the same two factor inputs *U* and *S*, high and low skilled labour, production occurs for only two of the three goods, *D* and *E*. Effectively the same two-by-two structure is preserved, but differentiated goods are imported and domestically produced. Unlike in the Heckcsher-Ohlin model above, preferences now enter the picture and a product price is endogenously determined, even in the small country case.

Thus, preferences are denoted by

$$U(M^D, E^D) \tag{8}$$

where M^D is the composite of imports, M, and the domestic import substitute, D^D, i.e.

$$M^D = h(M, D^D)$$

and technology by

$$D^S = D(U^D, S^D) \tag{9}$$

$$E = E(U^E, S^E), \tag{10}$$

where U^D, S^D, U^E, and S^E denote inputs of high and low skilled labour used in domestic good and export production; D^S is production of the imperfect substitute domestic good, and D^D is demand for the same good. E^D is demand for the exportable good.

The economy is a taker of prices for exports and imports, $\overline{P}_E, \overline{P}_M$, but now the price for the domestic good P_D is endogenously determined. The per unit cost functions in the production of *E* and *D*, consistent with zero profits, are

$$P_D = g_D(W^U, W^S) \tag{11}$$

$$\overline{P}_E = g_E(W^U, W^S) \tag{12}$$

where W^U and W^S are the wage rates of high and low skilled labour, and g_D and g_E are per unit costs functions.

Full employment conditions for factors yield

$$f^U_D \cdot D^D + f^U_E . E = \overline{U} \tag{13}$$

$$f^S_D \cdot D^D + f^S_E . E = \overline{S} \tag{14}$$

where $f^U_D, f^U_E, f^S_D, f^S_E$ are per unit cost minimising factor demands for U and S in the production of D and E.

The representative household in this economy maximise the utility function (8) subject to the budget constraint

$$P_D D^P + \overline{P}_M M + \overline{P}_E E^D = W^U \overline{U} + W^S \overline{S} \tag{15}$$

In equilibrium, the price of the domestically produced good P^*_D, will be determined such that market clearing occurs in D, i.e.

$$D^D = D^S \tag{16}$$

No market clearing is required in either E or M. Walras Law, which holds for demand functions generated from utility maximisation subject to a budget constraint, also implies that trade balance will hold, i.e., in equilibrium

$$\overline{P}_M M = \overline{P}_E E \tag{17}$$

In this model, relative to the simple Heckscher-Ohlin model discussed earlier, one additional endogenous variable, P^{D^*}, enters the model. Additional parameters enter the model in terms of preferences over D^D and M. Thus, in the case where the elasticity of substitution in preferences between D^D and M is unity, changes in world prices of imports can be fully accommodated by changes in import volumes. In this case, trade shocks have no impact on domestic production patterns, and hence no impact on the relative wages of skilled and unskilled labour. In trade and technology decompositions, the role of trade in affecting the relative wages of the skilled and unskilled will be zero in such a case. In addition, we note that empirical studies of import demand elasticities (Stern *et al.* (1976); Reinert (1992); and Shiells and Reinert (1993)) consistently produce estimates in the neighbourhood of one; and in a CES function the own price demand elasticity approaches the negative of the substitution elasticity as the relevant share parameter approaches zero.

Results

With specialisation problems removed in the model, we are able to consider the full change in relative wages and goods prices for our decomposition exercise for the UK economy. The number we use for the change in the relative price of the unskilled-intensive good is –7.9% (based on Neven and Wyplosz (1996)), and for the fall in wages of the unskilled relative to

[10] In the absence of estimates of technological change fully consistent with the units of measurement used in the production functions in our model, we determine the size of technological change residually, given the observed relative wage and product price changes. As in the previous section, we assume that technological change is biased against unskilled labour.

Table 5 reports results for a decomposition experiment of this data conducted for this model

10 Both estimates are for the UK, and are discussed in more detail in the appendix.

with a substitution elasticity in preferences of unity. In this case, independently of the parameterisation used for the model, the fraction of the change in W_U / W_S due to trade is zero because trade shocks are fully accommodated on the demand side of the model. In Table 6 we report ranges of decomposition results for parameterisations where the elasticity of substitution in preferences departs from unity. We consider elasticity values above and below unity, and roughly consistent with literature estimates of import demand elasticities. In all cases, the contribution of trade to wage inequality is small, but changes sign as the elasticity of substitution in consumption moves below one.

From this, we conclude that the choice of structural model makes a significant difference to the conclusions of any trade-technology decomposition experiment analysing recent changes in wage inequality for OECD countries. For the simple Heckscher-Ohlin case widely discussed in the literature, only small shocks can be analysed because of specialisation problems, and along with these restrictions wide ranges for decompositions are obtained for model parameterisations consistent with the observed combined wage change. Using a differentiated goods model, large changes can be analysed since specialisation is not a problem but much (or most) of the trade shock is absorbed on the demand side, sharply raising the contribution of technology.

Table 5
Trade-Technology Decomposition in Differentiated Goods Model where the Substitution Elasticity in Preferences Equals One

1. Parameterisations

	Parameterisation A		*Parameterisation B*	
Share Parameters	Good *D*	Good *E*	Good *D*	Good *E*
Production				
Unskilled labour	0.41	0.21	0.55	0.30
Skilled labour	0.59	0.79	0.45	0.70
Consumption	0.56	0.28	0.56	0.28
Elasticities				
Production	1.25	1.25	2.0	2.0
Consumption	1.0		1.0	

1. Decomposition Results on the Relative Importance of Trade and Technology for a Total Wage Change

	A	**B**
% change in w_U / w_S in UK data for joint technology and trade change	15.0	15.0
Fraction of change in w_U / w_S due to technology	1.0	1.0
Fraction of change in w_U / w_S due to trade	0.0	0.0

Table 6
Range of Technology-Trade Decompositions over Alternative Values for the Elasticity of Substitution in Preferences (   )

	= 0.5-1.0	= 1.0-2.0
Range for fraction of change in W_U / W_S due to technology	1.02-1.00	1.00-0.96
Range for fraction of change in W_U / W_S due to trade	-0.02-0.0	0.0-0.04

VI SUMMARY AND CONCLUSIONS

This paper uses general equilibrium numerical simulation techniques to explore the significance of the choice of structural model when assessing the contribution of trade and technological change to the increased wage inequality documented for a number of OECD countries for the 1980s, most notably the US and the UK. Using a simple Heckscher-Ohlin model, we first show how both problems of specialisation can occur for large trade shocks and different model parameterisations are consistent with a given change in wage inequality from trade and technology shocks which yield different decompositions of the combined change into trade and technology components. We also use a differentiated goods model with imports and domestically produced goods as imperfect rather than perfect substitutes, since this removes the problem of specialisation. This model, however, also introduces demand side considerations through substitution in preferences between domestic goods and imports.

Our results with the second model indicate an ability to examine large rather than only small trade shocks in decomposition experiments, but also much reduced variation in results across parameterisations. This is because now, depending on the value of the elasticity of substitution in consumption, the demand side of the model can absorb a large portion of trade shocks (indeed all of the trade shock when this elasticity is one).

For these results we suggest that it is important to explicitly explore the properties of particular structural models in decompositions, rather than only appealing to them as theoretically consistent models for reduced form analyses. The choice of structural model, perhaps not surprisingly, seems to matter for such decompositions.

REFERENCES

Anderton, B. and P. Brenton (1998) "The Dollar, Trade, Technology and Wage Inequality in the

Baldwin, R.E. and G.G. Cain (1997) "Shifts in US Relative Wages: The Role of Trade, Technology *NBER Working Paper* No. 5934.

Bhattarai, K., M. Gosh and J. Whalley (1999) "On Some Properties of a Trade Closure Widely Used in Numerical Modelling. *Economics Letters* 62:13-21.

Brenton, P.A. (1998) "Rising Trade and Falling Wages: A Review of the Theory and the Empirics," in Brenton, P.A., and Pelkmans, J. (ed.), *Globalization and European Workers*. London: MacMillan, forthcoming.

Berman, E., J. Bound and Z. Griliches (1994) "Changes in the Demand for Skilled Labour within US Manufacturing: Evidence from Annual Survey of Manufactures," *Quarterly Journal of Economics* 109: 367-98.

Borjas, G., R. Freeman and L. Katz (1991) "On the Labour Market Effects of Immigration and Trade," in Borjas, G. and R. Freeman (eds.), *Immigration and the Work Force*. Chicago: The University of Chicago Press.

Deardorff, A. and D.S. Hakura (1994) "Trade and Wages: What are the Questions," in Bhagwati, J. and M. Kosters (eds.), *Trade and Wages: Levelling Wages Down?*. Washington: AEI Press.

Davis, S. (1992) "Cross-Country Patterns of Changes in Relative Wages," *NBER Macroeconomics Annual*: 239-91.

De Melo, J. and S. Robinson (1989) "Product Differentiation and the Treatment of Foreign Trade in Computable General Equilibrium Models of Small Economies." *Journal of International Economics* 27: 47-67.

Feenstra, R. and Hanson, C. (1996) "Globalization, Outsourcing and Wage Inequality," *American Economic Review*, May, 240-45.

Francois, F. and D. Nelson (1998) "Trade, Technology and Wages: General Equilibrium Mechanics," *Economic Journal* 108: 1483-1499.

Hamermesh, D.S. (1993) *Labour Demand*. Princeton: Princeton University Press.

Haskel, J. (1996) “Declining Wages for Unskilled Workers.” *CEPR Discussion Paper* No. 1490.

Johnson, H.G. (1966) “Factor Market Distortions and the Shape of the Transformation Frontier.” *Econometrica* 34: 686-98.

Katz, L. and K. Murphy (1992) “Changes in Relative Wages, 1963-1987: Supply and Demand Factors,” *Quarterly Journal of Economics* 107: 35-78.

Kosters, M. (1994) “An Overview of Changing Wage Patterns in the Labour Market,” in Bhagwati, J. and M. Kosters, *op. cit*.

Krugman, P. and R. Lawrence (1993) “Trade, Jobs and Wages,” *NBER Working Paper* No. 4478.

Lawrence, R. and M. Slaughter (1993) “International Trade and American Wages: Giant Sucking *Brookings Papers of Economic Activity* 161:226.

Leamer, E. (1996) “In Search of Stolper-Samuelson Effects on U.S. Wages,” *NBER Working Paper* 5427.

Murphy, K. and F. Welch (1991), “The Role of International Trade in Wage Differentials,” in Koster, M. (ed.), *Workers and Their Wages: Changing Patterns in the United States*: Washington: AEI Press.

Neven, D. and C. Wyplosz (1996) “Relative Prices, Trade and Restructuring in European Industry.” *CEPR Discussion Paper* No. 1451.

Reinert, K. (1992) “Armington Elasticities for United States Manufacturing Sectors.” *Journal of Policy Modelling* 14: 631-39.

Shiells, C. and K. Reinert (1993) “Armington Models and Terms of Trade Effects: Some Econometric Evidence for North America.” *Canadian Journal of Economics* 26: 299-316.

Stern, R. M. *et al*. (1976) “Price Elasticities in International Trade: An Annotated Bibliography.” London: Macmillan.

Wood, A. (1994) *North-South Trade, Employment and Inequality*, Oxford: Clarendon Press.

APPENDIX

UK DATA USED IN TRADE AND TECHNOLOGY DECOMPOSITIONS

This appendix describes the UK data used for the parameterisation of both the Heckscher-Ohlin and differentiated goods model. We have calibrated both models to a 1990 data set on UK production, trade, and factor use as well as data on relative wage and product price changes over the 1980s in the case of the differentiated goods model. Production and trade data come from the UK input-output matrix for 1990. The data on trade are adjusted for model consistency. Wage and employment data by sector and skill category have been obtained from *Labour Market Trends* and the *New Earnings Survey* for 1990. All these data are aggregated into the two-good, skilled and unskilled intensive classification.

The data on relative price changes for goods are taken from Neven and Wyplosz (1996). They disaggregate import price changes for manufacturing both by sector (which they also disaggregate according to different factor skill intensities) and origin of imports (between developed and developing countries), and cover the period 1976-90. This information, together with information on the composition of UK imports by origin for 1990, gives a decline in the relative import price of the unskilled-labour intensive good of 7.9%. The data on the decline of relative earnings by UK unskilled workers (15% over the period 1980-95) that we use for the decomposition exercise in our differentiated goods model comes from Haskel (1996).

The definition of 'unskilled' and 'skilled' workers we utilise corresponds to manual and non-manual workers—as defined in UK official statistics. The production sectors included in our unskilled-intensive sector are those that for the 1990 input-output table level of disaggregation were net importers of goods or services, plus non-traded sectors (public administration, utilities and construction). Our skilled-intensive sector is then made up of the remaining sectors. This aggregation produces a ratio of unskilled to skilled labour of 0.64 for the unskilled-intensive sector, and 0.18 for the skilled-intensive sector, in our 1990 base year. The domestic and export good sectors of our differentiated goods model correspond to the unskilled-intensive and skilled-intensive sectors, respectively, as defined above