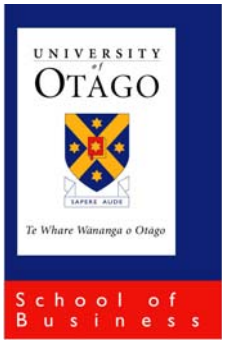

ISSN 0111-1760

University of Otago
Economics Discussion Papers
No. 0606

October 2006

Trade and Rising Wage Inequality: What can we learn from a Decade of Computable General Equilibrium Analysis?

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Abstract

This paper surveys computable general equilibrium (CGE) contributions to trade-wage debate. We conclude that this literature provides an avalanche of support for the view that trade has had only a minor influence on wage inequality through Heckscher-Ohlin channels. Moreover, some studies show that trade may be associated with declining wage inequality and/or reveal that North-North trade is responsible for a greater proportion of the increase in Northern wage inequality than North-South trade. The impact of trade-induced technical change, however, has received little attention in the CGE literature.

JEL classification: C68, F16

Keywords: computable general equilibrium modeling, trade and wages

1. Introduction

Increased North-South, or developed-developing, trade and rising skilled-unskilled relative wages (or skill premiums) in the North are linked via two propositions widely used by trade economists – the Heckscher-Ohlin (H-O) and Stolper-Samuelson (S-S) theorems. Specifically, if the global economy is H-O and skilled and unskilled labour the factors of production, the skill-abundant North will export the skill-intensive good and the unskilled-abundant South the unskilled-intensive commodity. If, as has occurred in recent decades, there is an increase in the relative economic size of the South and/or trade frictions are reduced, the relative price of skill-intensive products will rise in the North. This price movement, in accordance with the S-S theorem, will increase the skilled wage and decrease the unskilled wage.

It is, therefore, quite natural that the H-O and S-S theorems are used as the starting point for most empirical analyses of the connection between trade and wages. Three strands of empirical research have emerged: (a) product price studies, (b) factor content of trade analyses, and (c) computable general equilibrium (CGE) investigations. The first two approaches draw of H-O and S-S properties. Specifically, product price studies utilise simple general equilibrium relationships between changes in relative product prices and changes in relative factor prices that must hold under the zero profit condition of perfectly competitive models, and factor content of trade studies make use of the property that trade in goods is a substitute for trade in factors in the H-O model.

CGE studies, on the other hand, build a theoretically consistent general equilibrium model, introduce shocks representative of trade changes, and compute a set of relative

prices so that all markets are in equilibrium. CGE modellers typically introduce several modifications to the H-O model so that their models are able to explain real-world phenomena, such as intra-industry trade. Crucially, however, these modifications compromise the clarity of the S-S theorem. Because of this ambiguity and the predictions of H-O and S-S have been instrumental in the trade-wage debate, CGE modelling serves an import role in settling the argument. Indeed, Francois and Nelson (1998, p. 1483) note, "when the issue at hand is the link between international trade and relative wages there is simply no substitute for general equilibrium analysis."

Following more than a decade of CGE analysis of the link between trade and wages, this study takes stock of the current body of knowledge, outlines key findings in the literature, provides an analytical framework to evaluate the drivers of important results, and suggests how future research might proceed. We do this in three further sections. Section 2 surveys the CGE literature. Section 3 evaluates the main findings in the literature. The final section concludes.

3. CGE studies of trade and wage inequality

CGE investigations of the link between trade and wages differ with respect to dimensionality, market structure, and calibration. To make headway, we organise the literature into three categories: pioneering, illustrative and empirical studies. As their name suggests, pioneering studies were the first CGE studies to contribute to the trade-wage debate and did so using models closely related to the H-O framework. Illustrative studies typically provide insights as to how departures from the H-O model influence the link between trade and wages, identify a small number of sectors,

and/or are largely parameterised by guesstimates. Empirical studies, on the other hand, are calibrated using real-world data and usually employ a finer level of aggregation than their illustrative counterparts. CGE studies contributing to the trade-wage debate are synthesised in Table 1.

Pioneering studies

Krugman (1995) undertakes the simplest CGE analysis of the link between trade and wage inequality. The author's model represents the OECD as a "standard" H-O economy (two goods, two factors, perfect competition etc) and uses an offer curve, which dictates that the OECD has substantial market power, to represent newly industrialised economies (NIEs). Krugman (1995, p. 358) asks his model the following question, "how large a change in relative wages in the OECD might be associated with the emergence of NIE trade actually seen?" The results reveal that increased OECD-NIE trade raised the relative wage of skilled labour in the OECD by less than three percent. As the value of OECD imports from NIEs is only around two percent of OECD GDP, Krugman attributes the small change in relative wages to a small trade volume effect.

Lawrence and Evans (1996) contribute to the debate using a framework similar to Krugman's except that three sectors (high-skilled and basic manufacturing, and non-tradables) are identified and world prices are exogenous. The model is parameterised so as to represent the US economy in 1990 and Lawrence and Evans analyses the future impact of trade on wages by adjusting world prices so that US production of basic manufacturing is replaced by imports. The shock requires a five-fold increase in US imports of basic manufacturing and causes the skill premium to increase by 7.5%.

This is a relatively small increase given the extreme nature of the shock and can be attributed to the small decline (1.8%) in the price of basic manufacturing required to eliminate domestic production of basic manufacturing and the small share (7%) of this commodity in US output. Lawrence and Evans (1996, p. 18) conclude, "if the impact of very large shifts in trade in the future is likely to be relatively small, it suggests that the much smaller growth in trade with developing countries over the past 15 years is unlikely to have had [a] major impact on labour markets."

Illustrative studies

Cline (1997) contributes to the debate by constructing what he calls the trade and income distribution equilibrium (TIDE) model. The TIDE model is perfectly competitive and identifies three factors (skilled and unskilled labour, and capital), five sectors (three traded and two-non-traded) and 13 regions. Cline focuses on wage inequality in the US. An important feature of the TIDE model is that constraints are placed on trade flows for each commodity in each region so that imports do not exceed half of domestic consumption and exports do not exceed half of domestic production. This specification stops regions from specialising in a subset of goods and is an alternative to assuming that domestic and imported products are imperfect substitutes as in the Armington approach. Additionally, production functions differ across regions with respect to technical efficiency. Cline calibrates the TIDE model using a mixture of empirically-grounded and postulated estimates so as to benchmark the model to 1993.

Cline assesses the impact of trade on wages by comparing the results from a number of backward-looking simulations to a baseline backcast, which is computed by

simulating actual changes in factor endowments, transport costs and trade barriers. Due to the significant increase in the relative supply of skilled labour, the skill premium falls by 47% between 1973 and 1993 in the baseline. Cline assesses the impact of increased trade by freezing transport costs and protection at their 1973 levels. The results indicate that the skill premium would have been 10% lower in 1993 than in the baseline if trade frictions had not been reduced. In another counterfactual, Cline eliminates transport costs and tariffs from 1973 onwards. The simulation indicates that the removal of trade barriers would have increased the US skill premium by around 20% in 1973 but by only 6.25% in 1993 relative the respective baselines. The smaller impact of the counterfactual in later years reflects falling transport costs and tariffs in the baseline. From this, Cline concludes that the world has moved a long way towards free trade over the last three decades and any further decreases in transport costs and protection may have only moderate effects.

In another experiment, Cline moves the TIDE model as close as possible to the H-O model. The counterfactual removes non-tradable sectors, gets rid of the constraints on trade flows, and sets tariffs and transport costs equal to zero. In this simulation, the US wage ratio doubles and there is a trend towards global factor price equalisation, but US unskilled wages are still many times greater than those in developing countries.[1] Consequently, Cline concludes that the existence of non-tradable sectors and consumers' preferences for domestically produced goods over imports are natural barriers against large changes in factor prices due to trade.

[1] Factor price equalisation does not occur because all regions do not continue to produce all commodities and differences in technologies across regions are maintained.

Cline also assesses the likely impact of trade on wages in the future. He does this by creating a 2013 baseline (which incorporates estimates of changes in factor endowments, technical efficiency parameters, transport costs and trade distortions) and considering several forward-looking scenarios. In one future scenario, Cline freezes transport costs and protection at 1993 levels. The US skill premium falls by 5% relative to the 2013 baseline in this experiment. Drawing on results from his forward- and backward-looking scenarios Cline (1997, p. 238) concludes, "the results of the TIDE model simulations suggest that trade… [has] had a significant impact over the past decade in the observed rise of skilled wages relative to unskilled wages. In contrast, for the future the model suggests a much more benign outlook."

Although the TIDE model is a productive workhouse for evaluating the channels through which trade influences relative wages, Cline's conclusion regarding the historical impact of trade is a little misleading. This is because Cline ignores the large difference between the observed increase in wage inequality and the change in wage inequality simulated in the TIDE model. Specifically, results from Cline's backward-looking analysis suggest that reduced transport costs and trade barriers increased the US skill premium by around 5% and factor supply changes reduced the premium by 47% between 1973 and 1993. Combined with Cline's assertion that the US skill premium increased by about 20% over this period, these figures indicate that trade accounted for only 7.4% of the total (factor) demand-induced increase in the skill premium. The influence of trade, therefore, seems small relative to that of other factors.

Abrego and Whalley (2000 & 2003) consider a small-country H-O model with a skilled-unskilled dichotomy, and a heterogeneous good variant of the model where imports and domestically produced importables are imperfect substitutes as in the so-called Armington assumption. The model is calibrated to UK data for 1990 and the authors' shock the model by imposing the observed increase in the world relative price of the skill-intensive commodity. Like Lawrence and Evans (1996), Abrego and Whalley (2000) find that the trade shock eliminates domestic production of the unskilled-intensive commodity when goods are homogenous. For a relative price change that does not induce specialisation (a price change smaller than that observed) the authors report that trade accounted for around 50% of the observed increase in wage inequality. This finding, however, is somewhat erroneous as the authors do not consider the large increase in the relative supply of skilled labour. The proportion of increased wage inequality attributable to trade is, therefore, likely to be much less than 50%. When imports and the domestic good are imperfect substitutes, Abrego and Whalley illustrate that there may be little or no transmission of international price shocks to relative wages and that simulated changes in relative wages can change sign depending on whether the demand-side substitution elasticity between domestic and foreign goods is greater or less than one.

Tokarick (2005) focuses on the role of non-traded goods. The author's model identifies three sectors (exportables, importables, and non-tradables) and three factors (skilled labour, unskilled labour, and capital). World prices for tradable goods are exogenous and the problem of specialisation is avoided by assuming that capital is sector specific. Tokarick calibrates his model to US data for 1982 and conducts simulations under two alternative assumptions concerning non-tradables. Specifically,

in one set of simulations adjustment of the non-traded sector is permitted and in another it is not.

Tokarick shocks the model by implementing observed changes in trade variables (the trade deficit, import tariffs, and the terms of trade) between 1982 and 1996. A small increase in the skill premium (0.2%) is simulated in both variants of the model. Decomposition analysis, however, reveals that the movement in relative wages associated with each component of the trade shock changes sign for some components when the assumption regarding the adjustment of non-tradables is altered. For example, tariff cuts are associated with a decrease in wage inequality when the non-traded sector is able to adjust and an increase in the skill premium when it is not. This is because there is a decline in the price of (skill-intensive) non-tradables when non-tradables adjustment is allowed, whereas, by design, there is no change in the price of non-tradables in the alternative scenario.

Tokarick also considers what would happen if the 1996 US economy had no opportunity to trade. When the non-traded sector is allowed to adjust, autarky results in output of exportables contracting, production of importables and non-tradables increasing, and a rise in the price of non-tradables. These changes are associated with a 2.2% rise in the skill premium. Conversely, wage inequality falls by 6.0% when there is no adjustment in the market for non-traded goods as the only sectoral adjustments are a decrease in the production of exportables and an increase in importables output, which results in a decline in the relative price of exportables. Tokarick (2005, p. 858) concludes, “changes in trade related variables has a negligible

effect on relative wages" and, through interactions between the non-traded sector and the rest of the economy, expanding trade may have reduced wage inequality.

De Santis (2001 & 2003) produces evidence that the influences of trade and technology on wages are not independent. The author models a small open economy that employs skilled and unskilled labour to produce two goods, unskilled-intensive manufactures and skill-intensive services. De Santis refers to the unskilled-intensive commodity as a capital good as it is used as an intermediate input in both sectors. Services also employ a set of differentiated foreign capital goods, which are imperfect substitutes for the domestic variety. Manufactures are produced by a Cobb-Douglas production function whereas there is relative complementarity between skilled labour and capital goods (the elasticity of substitution between skilled labour and capital is lower than that between unskilled labour and capital) in services. De Santis (2001) also models imperfect inter-sectoral labour mobility by stipulating that aggregate quantities of skilled and unskilled labour are assigned to different sectors according to separate constant elasticity of transformation (CET) functions. To facilitate the analyses of two different technology shocks, two variants of the model are created. In the base model, the number of foreign capital goods, which are produced by monopolistic firms, is endogenous. The number of foreign capital goods is fixed in the alternative specification.

De Santis benchmarks his model to UK data for the late 1970s and attempts to explain an 18% increase in the UK skill premium between 1979 and 1992 using two alternative technology shocks. In the variant where the number of capital goods is variable, a reduction in trade costs results in an increase in wage inequality as it

fosters the development of new capital goods by foreign firms, which increases the marginal product of skilled labour relative to that for unskilled labour due to the capital-skill complemenatrity assumption. De Santis' trade shock, therefore, involves an endogenous reduction in trade costs so that the model reproduces the observed change in UK wage inequality. In the author's second shock, the number of foreign capital goods is fixed and De Santis simulates the observed increase in wage inequality by introducing endogenous skilled labour-augmenting technical change in both sectors. De Santis refers to the first shock as trade-induced, sector-bias technical change, and the second as skill-bias technical change. Both variants of the model are able to explain the expansion in services and the contraction of manufacturing in the UK but De Santis favours the variant of the model with trade- induced technical change as it can also explain the large increase in UK imports of capital goods.

Empirical models

Thierfelder and Robinson (2002) analysis draws on a 15 sector (12 in manufacturing), six factor (professional, technical support, semi-skilled, and low-skilled labour; land; and capital) model calibrated to the 1982 US economy. A "double Armington" assumption is employed (for each good) in that imported and domestic varieties are imperfect substitutes, and there is imperfect substitution in production between exported and domestic varieties. Two shocks considered by Thierfelder and Robinson include a 50% reduction in the world price of imports and a $200 billion increase in the trade balance. Combined, these shocks generate a 1.25% increase in the professional-low-skill relative wage. When labour is immobile, however, a 17.3% increase in wage inequality is observed. Thierfelder and Robinson (2002, p. 24) conclude, "trade is responsible for very little of the wage gap", but "in the short term,

when it is difficult for unskilled workers to move out of manufacturing sectors, trade shocks can have a strong impact on the wage ratio." (p. 23)

Cortes and Jean (1999) analyse the impact of the expansion of developing countries on European wages by doubling the size of emerging economies. The authors' model identifies three regions (the EU, emerging economies, and Rest of World), three factors (skilled labour, unskilled labour, and capital), and 13 sectors (agriculture, services and 11 manufacturing sectors). Output is produced by a Leontief nest of intermediate inputs and a composite of primary factors. The primary factor nest is such that there is capital-skill complementarity. There is imperfect competition in manufacturing and perfect competition in other sectors. On the consumption side, European and Rest of World goods are imperfect substitutes for emerging country goods and manufactures within each composite region are differentiated using a CES function as in the Dixit-Stiglitz approach.

The authors' shock results in the share of emerging country imports in European final demand (import penetration) rising from 1.6% to 3.0% in manufacturing. As might be expected, increases in import penetration are greatest in manufacturing sectors with low fixed costs producing lowly differentiated products (e.g., textiles and clothing) and smallest in sectors producing highly differentiated goods that have high fixed costs (e.g., chemical products). These adjustments, and associated changes in production, result in European wage inequality increasing by 0.8%. From this Cortes and Jean (1999, p. 117) deduce, "the increased international integration of emerging countries in the world economy does not appear to be the main source of problems in the European labour market."

Jean and Bontout (2000) employ a single country CGE model to analyse the causes of growing wage inequality in France between 1970-92. Three primary factors (skilled labour, unskilled labour, and capital) and nine sectors are identified. There is perfect competition in services, which are non-traded, and Cournot competition elsewhere. The authors' chosen production structure is the same as in Cortes and Jean (1999). Consumption is modelled using a series of CES nests. Imports from the North and South are differentiated using an Armington aggregation and a Dixit-Stiglitz approach is used to differentiate French varieties from each other.[2]

Jean and Bontout's trade shock involves changing relative import prices and Armington share coefficients and results in an increase in the skill premium of 1%. In another simulation, the authors assume that increased import penetration increases productivity and sectoral skilled-unskilled employment ratios. Although the skill premium increase by 5.5% in this simulation, the authors conclude that, in the presence of significant downward pressure on wage inequality resulting from factor supply changes, trade did not have a significant effect on relative wages.

Tyers and Yang's (1997) consider the effects of trade liberalisation, and the rapid development of several developing countries using a modified version of the standard GTAP model (Hertel, 1998) and release 3 of the GTAP database (McDougall, Elbehri, and Truong, 1998). The authors' aggregation of the database identifies North America, the EU, Australasia (which are collectively known as Older Industrialised Countries or OIEs), Japan, Rapidly Developing Economies (RDEs: China, Indonesia,

[2] The authors' empirical framework is unable to model the large increase in unemployment over the sample period. Instead, Jean and Bontout assume that there was full employment in 1970 and account for the observed increase in structural unemployment by calculating an underlying full employment equilibrium by adjusting relative wages.

Hong Kong, Malaysia, Singapore, Republic of Korea, Taiwan, and Thailand), and Rest of the World. Five factors of production (skilled labour, unskilled labour, farm labour, land, and capital) and 32 sectors are also recognised. Tyers and Yang's chosen model is a perfectly competitive representation of the global economy that captures both bilateral trade flows amongst regions and inter-sectoral linkages within regions. Imports are differentiated by country of origin as in the Armington assumption. A non-standard feature of the model concerns the allocation of labour to different uses. Specifically, (aggregate) labour is allocated to either the farm or urban labour market, and urban labour is distributed between the skilled and unskilled labour markets in a two-level CET nest.

Like Cline (1997), Tyers and Yang conduct both backward and forward-looking analyses. The authors look back to examine the effects of the emergence (increased trade openness and dramatic expansion) of RDEs, and forward to evaluate the impact of a continuation of recent trends. The authors' backward-looking simulation focus on the period 1970-92 and evaluates the impact of observed changes in the world economy by removing the dramatic growth and increased openness of RDEs. This is accomplished by shocking factor endowments and making tariffs endogenous so as to control for the level of RDE imports of each commodity. The results reveal that trade increased skilled-unskilled wage inequality by 0.2%, 0.3%, and 0.9% in North America, the EU, and Australasia respectively. Changes in ratios of skilled to farm wages are more interesting. As RDEs are land-scare, the shock lowers wage inequality between skilled and farm labour by around 9% in North America and Australasia and by about 6% in the EU.

Tyres and Yang generate a 2010 baseline and simulate two counterfactuals in their forward-looking analysis. In the first, tariff and export subsidy equivalents of trade distortions in agriculture and food processing are reduced by half and all other trade barriers are abolished. The simulation results in a contraction of unskilled-intensive manufacturing sectors in OIEs and increases skilled-unskilled wage inequality by between one and three percent relative to the 2010 baseline. There is also a decrease in urban-rural wage inequality in North America and Australasia. In the authors' second forward looking counterfactual, in addition to the above trade reforms, voluntary export restraints are placed on RDE exports to OIEs so that domestic absorption of RDE imports in each product category is maintained at 1992 levels. The shock results in declines in skilled-to-unskilled wage ratios in OIEs of less than one percent. The authors close by noting that trade has only resulted in a small increase in the dispersion of skilled and unskilled wages and future changes in trade policy will not have a large impact on relative wages.

Other studies built on the GTAP framework include Winchester, Greenaway and Reed (2006), and Winchester (2006). Winchester, Greenaway and Reed's contribution embodies a new labour classification. The classification observes wage and educational attainment data for 77 occupations in the UK and uses cluster analysis to determine both the composition and number of labour groups. Four labour types – highly skilled, skilled, semi-skilled, and unskilled – are generated. Cost share for these labour types are mapped onto the UK component of Version 6 of the GTAP database, which corresponds to the global economy in 2001. The authors' aggregation of the database identifies four regions (the UK, Other Developed, RDEs, and Rest of World), and five factors of production (four labour types and capital). Two alternative sectoral aggregations are employed; one identifies five sectors and the other 19.

The authors' trade shock removes changes in UK sectoral imports relative to GDP between 1980 and 2001 by introducing a set of endogenous export taxes in other regions. The results show an increase in wage inequality between any pair of labour types but simulated changes in relative wages are small. For example, the largest movement in relative wages, which occurs for the highly skilled to-unskilled wage, is 1.5%. The authors conclude that trade is not the main driver of increased wage inequality in the UK.

Winchester (2006) focuses on New Zealand. The author begins by highlighting several observation indicating that the impact of trade on wages in New Zealand should be greater than the impact of trade on US or UK wages (such as, relative to GDP, New Zealand imports more from RDEs than either the US or the UK). Winchester extends the New Zealand component of the GTAP database by including data for four labour types with different qualifications (degree, vocational, high school, and no qualification). The author's trade shock removes changes in New Zealand exports and imports relative to GDP between 1980 and 2001 by controlling import tariffs and export taxes in other regions. The results reveal that, as New Zealand has a comparative advantage in agriculture-based products and these commodities make intensive use of unskilled labour, trade has caused a reduction in New Zealand wage inequality. The largest relative wage decline concerns the ratio of degree to no qualification wages, which falls by 4.02%.

The investigation reveals that increased imports generated a small increase in New Zealand wage inequality. Decomposition of the impact of imports by commodity and region uncovers that imports from other developed nations and RDEs increased the degree-no qualification relative wage by 0.83% and 0.51% respectively. These results

not only suggest that trade cannot be responsible for increased wage inequality, but also that most of the downward pressure on unskilled wages due to imports results from trade with other developed nations.

Winchester also investigates the short-run impact of trade on wages. The author does this by restricting the mobility of no qualification labour employed in unskilled-intensive manufacturing, which he labels vulnerable labour. When vulnerable labour is immobile, import changes increase the degree-vulnerable relative wage by 13.6%. This indicates that imports may have had a relatively large detrimental effect on a small subset of the population in the short-run. However, as a small degree of labour mobility softens the blow to unskilled labour considerably and vulnerable labour accounts for a small proportion of total no qualification labour, imports could not have driven the observed increase in New Zealand wage inequality.

3. Lessons from a decade of CGE analysis

The overwhelming conclusion from more than a decade of CGE analysis is that the impact of trade on wages via H-O channels has been small relative to role played by other factors. An approximation of the rise in wage inequality in the US and the UK is that the skilled-to-unskilled wage ratio in both countries increased from 1.5 to 1.8 during the final decades of the twentieth century. The CGE literature indicates that this ratio would have been around 0.9 in both nations at the end of the century if factor supply changes had occurred in isolation (Cline, 1997; Winchester and Greenaway, 2006). These numbers suggest that demand side influences resulted in the skilled relative wage rising by 0.9 (or 60% of the 1980 skilled-unskilled wage ratio) over a 20 year period. Studies surveyed in this chapter indicate that trade increased the skilled-unskilled wage by at most 5% (or 0.075), which implies that the force of

other factors was at least 12 times greater than that of trade. Moreover, several studies (Tyers and Yang, 1997; Tokarick 2005; and Winchester, 2006) indicate that increased trade may be associated with declining wage inequality.

To examine why the results from empirical modelling are at odds with S-S predictions, we consider a small H-O economy where imports (M) are differentiated from domestically produced importables (D) in an Armington fashion but exportables (E) are not differentiated on global markets. Following Thierfelder and Robinson (1996), the proportional change in the skilled wage ($\hat{w}_S$) minus the corresponding change in the unskilled wage ($\hat{w}_L$) can be expressed as:

$$\hat{w}_S - \hat{w}_L = \frac{1}{(\theta_{SE} - \theta_{SD})} \frac{(\sigma_A - 1)}{(\sigma_A + \Omega)} (\hat{p}^E - \hat{p}^M) \qquad (1)$$

where θ_{SE} and θ_{SD} are, respectively, the cost shares of skilled labour in E and D and are less than one, σ_A is the elasticity of substitution between M and D, $\hat{p}^E$ and $\hat{p}^M$ are proportional changes in the world prices of E and M respectively, and Ω is the elasticity of transformation in production between E and M and is positive.[3]

This framework nests the standard H-O model, which is obtained by setting σ_A equal to infinity. In this case (1) reduces to:

$$\hat{w}_S - \hat{w}_L = \frac{1}{(\theta_{SE} - \theta_{SD})} (\hat{p}^E - \hat{p}^M) \qquad (2)$$

[3] See Robinson and Thierfelder (1996) for the arguments of Ω.

If E uses skilled labour relatively intensively ($\theta_{SE} > \theta_{SD}$) and there is an increase in the relative price of E it is possible to derive the following relationship between product and factor prices:

$$\hat{w}_S > \hat{p}^E > \hat{p}^M > \hat{w}_L \qquad (3)$$

This is the well-know magnification effect and demonstrates the S-S theorem.

If M and D are not perfect substitutes, the relationship between factor and product prices depends crucially on the value of the Armington elasticity. When $1 < \sigma_A < \infty$ M and D are imperfect substitutes and, because the decline in the relative price of M has a smaller impact on the price of D, world prices apply less influence on factor prices than in the H-O case. Changes in international prices have no impact on domestic product or factor prices when σ_A is unity as the Armington nest is Cobb-Douglas so a change in the price of M is offset by a demand change of equal proportion. If $\sigma_A < 1$ M and D are gross complements and the S-S effect is reversed; that is, an increase in the relative price of E is associated with falling wage inequality. Therefore, as also demonstrated by Abrego and Whalley (2002 & 2003), Robinson and Thierfelder (1996), and Thierfelder and Robinson (2002), the magnification effect is less likely to hold as the Armington elasticity increases and the impact of trade on wages is weakened considerably when the homogenous-goods assumption is relaxed.[4]

Dimensionality and specialisation are other reasons why the transmitted effect of product price changes is less than that predicted by the S-S theorem. With respect to

[4] Other restrictions on the substitutability between imports and domestic production, such as Dixit-Stiglitz product differentiation and the restrictions in Cline's (1997) model, also reduce the impact of changes in foreign prices on the domestic economy.

dimensionality, Ethier (1984) reveals that the S-S theorem is replaced by the much weaker S-S correlation when there are more than two commodities.[5] Turning to specialisation, as noted by Lawrence and Evans (1996), once there is complete specialisation, the S-S theorem no longer holds and further trade will have a limited impact. If a country no longer produces the importable good wages are determined in the domestic and exportable sectors. These results suggest that, although qualitative support for the S-S theorem is provided by many CGE analyses, as in, for example, Winchester, Greenaway and Reed (2006), real-world modifications to the H-O model (e.g., product differentiation) moderate changes in international prices.

Before closing we investigate regional sources of relative wage changes due to trade in developed nations by extending the decomposition analysis in Winchester (2006). Our modelling framework is identical to the author's except that we employ a skill-unskilled dichotomy and modify the region of focuses. Specifically, in addition to focusing on New Zealand, we undertake simulations were the UK is the focus region and other developed regions are included in a composite region and also when the US is the region of interest. The results are reported in Table 2 and reveal that, as New Zealand is more open than the UK or the US, movements in New Zealand relative wages are larger than those in the other nations of interest. As might also be expected, the impact of increased (skill-intensive) exports reinforces the effect of imports on the skilled-unskilled wage ratio in the UK and US. For example, changes in US imports over the 1980-2001 period increased the relative wage of skilled labour by 0.19% and the combined impact of rising imports and exports pushed up this wage by 0.60%.

[5] The S-S correlation indicates, "there is a tendency for changes in relative commodity prices to be accompanied by increases in the rewards of factors employed most intensively by those goods whose prices have relatively risen the most and employed least intensively by those goods whose prices have fallen the most."(Ethier, 1984, p.164).

Nevertheless, simulated changes in wage inequality are small. Another anticipated result is that changes in unskilled-intensive manufacturing imports generate large increases in wage inequality relative to the total amount of wage inequality provoked by changes in import volumes. The most striking results, which are located in the final row of the table, reveal that over half of the import-induced increase in wage inequality in all three regions results from increased trade with other developed nations. These findings provide further support that trade has not significantly influenced wage inequality in the North through H-O channels.

A substantial caveat regarding our conclusions should be noted. Specifically, our discussion does not eliminate the possibility that trade from low-wage economics has influenced the wage distribution in developed nations via mechanisms other than H-O and S-S forces. Wood (1994) argues that increased competition form low-wage countries may induce producers of importables in developed nations to adopt new, unskilled labour-saving technologies. As noted early, Jean and Bontout (2000) illustrate that although the impact of trade on wages is larger when imports (partially) drive skill-biased technical change the usual conclusion is not overturned. This result does not, however, rule out the possibility that the threat of import competition may induce a larger shift in skill-biased technical change.

In general, skill-biased technical change has been poorly captured by CGE modellers. Typically, the impact of skill-biased technical change is determined residually, as the proportion of the increase in relative wages unexplained by trade, and production function parameters or other variables are adjusted so that the model simulates the desired change in relative wages (Cline, 1997; Tyers and Yang, 2000; Abrego and Whalley, 2000 & 2003; De Santis, 2002 & 2003). One exception is Winchester and

Greenaway (2006), who estimate changes in three capital assets and show that changes in the skill premium can be explained by the fall in the effective price of high-tech equipment when capital equipment complements skilled labour. The authors' framework is, however, silent on the source of the decline in the price of high-tech equipment and, therefore, cannot determine what proportion of the price decline results from trade pressures. Conversely, De Santis (2002 & 2003) provides a useful illustration of the channels through which the interaction of trade and technology can influence relative wages but the author employs a highly-aggregated model and determines technical change residually. In particular, De Santis notes that the fall in transport costs required for his model to generate the observed increase in UK wage inequality is plausible, but a much larger decrease in transports costs would have been required if he considered the increase in the relative supply of skilled labour. Determining the role of trade-induced technical change is an area requiring further research.

4. Conclusions

This paper has surveyed CGE contributions to the trade-wage debate. Despite the strong link between trade and wages in a simple and well-know general equilibrium model, this literature provides an avalanche of support for the consensus in the wider literature that the impact of trade has been minor. The reason for this conflict is that there is a softening of the link between product and factor prices when the H-O framework is moulded into a more accurate representation of the real world. Moreover, some studies show that trade may be associated with falling wage inequality and/or reveal that North-North trade is responsible for a greater proportion of the increase in Northern wage inequality than North-South trade. A caveat concerning this conclusion, however, is that that CGE analyses have little to say about

how trade influences wages via non-H-O channels. In particular, the role of trade-induced technical change has not been examined in detail.

Table 1: Trade-wage CGE studies

Study	Modelling Framework*	Key experiments(s)	Change in skilled-unskilled relative wage due to trade
Krugman (1995)	1-2-2, perfect competition, the OECD is able to influence world prices	Determines the change in relative wages associated with the observed increase in OECD-NIE trade	< 3%
Lawrence and Evans (1996)	1-3-2, perfect competition, non-traded sector, exogenous world prices	Changes world relative prices so that US basic manufacturing is replaced by imports	Small
Cline (1997)	13-5-3, perfect competition, restrictions on sectoral imports and exports	Forward- and backward-looking experiments examining changes in transports costs and trade barriers	5%
Abrego and Whalley (2000 & 2003)	1-2-2, perfect competition, Armington assumption, exogenous world prices	Simulates observed changes in world prices for alternative Armington elasticities	Small
Tokarick (2005)	1-3-3, perfect competition, sector specific capital, exogenous world prices	Simulates observed changes in the US trade deficit, import tariffs and the terms of trade	Negligible
De Santis (2002 & 2003)	1-2-2, perfect competition, differentiated capital goods which complement skilled labour, reduced trade costs stimulate the introduction of new foreign capital goods	Reduces trade costs so that the model replicates the observed change in the UK skilled-unskilled relative wage	N.A.
Thierfelder and Robinson (2002)	1-12-6, perfect competition, Armington product differentiation	50% reduction in the world price of imports and a $200 billion increase in the US trade balance	1%
Cortes and Jean (1999)	3-13-3, imperfect competition in manufacturing, perfect competition elsewhere, Armington and Dixit-Stiglitz product differentiation	Doubles the size of emerging economies	1%

Continued

Table 1: Trade-wage CGE studies (continued)

Study	Modelling Framework*	Key experiments(s)	Change in skilled-unskilled relative wage due to trade
Jean and Bontout (2000)	1-9-3, perfect competition in services, imperfect competition elsewhere, Armington and Dixit-Stiglitz product differentiation	Simulates changes in French imports with and without trade-induced technical change	1% or 6%
Tyers and Yang (1997)	6-37-5, perfect competition, Armington product differentiation, GTAP framework with imperfect labour mobility	Forward- and backward-looking experiments examining changes in trade frictions and rapid RDE growth	< 1%
Winchester, Greenaway and Reed (2006)	4-19-5, perfect competition, Armington product differentiation, GTAP framework	Removes changes in UK sectoral imports relative to GDP	1%
Winchester (2006)	4-7-7, perfect competition, Armington product differentiation, GTAP framework	Removes changes in New Zealand sectoral imports and exports relative to GDP	-3%

Note: * Dimensionality is represented regions-sectors-factors

Table 2: Changes in the skilled-unskilled relative wage, 1980-2001, %

Due to change in:	New Zealand	UK	US
Imports and Exports	-2.93	1.08	0.60
Imports	0.88	0.66	0.19
Unskilled-manufacturing imports	0.53	0.71	0.41
Imports from developed nations	0.48	0.36	0.11

Source: Model simulations described in the text.

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