

Another Search for the Smoking Gun: An Empirical Investigation of the Link Between Trade and Wages in a Small Open Economy

First Draft: March 2006

This Draft: March 2006

Niven Winchester
Department of Economics
University of Otago
P.O. Box 56
Dunedin
New Zealand

Email: nwinchester@business.otago.ac.nz

Tel: + 61 3 479 8648

Fax: + 61 3 479 8174

Preliminary draft – please do not cite

The link between increased North-South trade and the deteriorating relative position of unskilled workers in developed nations has been the subject of a large number of empirical studies in recent decades. We contribute to this literature by conducting the first computable general equilibrium (CGE) evaluation of the association between the two events in New Zealand - a small, open economy that experienced a significant change in trade policy in the early 1980s. We find that increased imports since 1980 caused only a marginal increase in wage inequality in New Zealand and, overall, increased trade (both imports and exports) decreased wage inequality in this nation. We interpret these results as convincing evidence that trade is not responsible for increases in wage inequality in developed nations.

JEL classification: F16, J24, J31

Keywords: trade and wages; skill classification; human capital.

1. Introduction

Most governments attempt to manage economic systems so as to deliver a higher standard of living to each successive generation and to see the fruits of growth distributed in a manner that is seen to be “fair”. Many commentators would argue that several developed economies have not succeeded in achieving this in recent decades: relative to the fraction of the population that is skilled, unskilled workers were better off in 1980 than at the beginning of the twenty-first century.

One explanation for the increase in wage inequality between skilled and unskilled workers in skilled-labour abundant developed nations is increased imports, which are produced using large quantities of unskilled labour, from unskilled-labour abundant developing nations. Proponents of this argument claim that unskilled labour embodied in imports reduced the relative demand for unskilled labour in developed countries and placed downward pressure on the relative wage of the unskilled. Two well-known trade theorems – the Heckscher-Ohlin (H-O) and Stolper-Samuelson (S-S) theorems – support this view.

Although trade and wages are closely tied in the H-O model, however, the strength of S-S theorem is reduced when some of the restrictive assumptions of the H-O model are relaxed. As a result, the link between increased North-South trade and the deteriorating relative position of unskilled workers in developed nations has been the subject of a large number of empirical studies. The consensus in this literature – see Greenaway and Nelson (2000, 2001) for reviews – is that increased trade has not been a major contributor to increased wage inequality in developed nations.¹

¹ Notable authors who reach an alternative conclusion include Wood (1994, 1998) and Leamer (1998).

We contribute to the trade and wages literature by undertaking the first computable general equilibrium (CGE) study of link between trade and wages in New Zealand.² Although the increase in wage inequality in New Zealand has not been as marked as in the US and the UK,³ New Zealand is an interesting country to investigate as it is a small, relatively open economy that experienced a significant change in trade policy in the early 1980s. Our study maps several different labour classifications, which are built on educational and occupational data, onto the New Zealand component of the GTAP database. We find that increased imports since 1980 caused only a marginal increase in New Zealand wage inequality and approximately two-thirds of the rise in the skill premium (the increase in wage paid to skilled labour divided by the wage received by unskilled labour) due to increased imports can be attributed to increased domestic sales of commodities from other developed nations. Moreover, as New Zealand's comparative advantage lies in agricultural related products and these commodities make intensive use of unskilled labour, when observed changes in both imports and exports are simulated we find that increased trade over the 1980-2001 period placed downward pressure on the skill premium in New Zealand. We interpret these results as convincing evidence that trade is not responsible for increased wage inequality in developed nations.

This paper has three further sections. Section 2 outlines the salient features of our model and data and describes features of the data likely to have a large influence on

² To our knowledge there are only two other New Zealand-focused studies: Deardorff and Lattimore (1999) and Lattimore et al. (2002).

³ According to the OECD Employment Outlook (July 1996, Table 3.1) changes in the skill premium, as measured by the wage paid to ninth decile male workers divided the wage of fifth decile male workers, between 1984 and 1994 in New Zealand, the US and the UK were 7.83%, 9.68% and 8.77% respectively.

our results. Section 3 details the form and outcomes of our modeling exercises. Section 4 concludes.

2. Trade and wages in an economy-wide context

Three divisions of empirical research have emerged in the trade and wages literature: (a) product price studies, (b) factor content of trade studies, and (c) CGE analyses. Procedures (a) and (b) utilise properties present in the H-O model. Specifically, product price studies exploit the relationship between product and factor prices in zero profit conditions. Following Slaughter (1998), product price studies can be classified as either consistency checks or mandated wage studies. Consistency checks test whether or not changes in product prices have been in the right direction to drive an increase in wage inequality (Lawrence and Slaughter, 1993; Sachs and Shatz, 1994; Neven and Wyplosz, 1996; Haskel and Slaughter, 2001). Mandated wage analyses estimate changes in factor prices required to maintain binding zero profit conditions in all industries in the presence of observed changes in product prices and technology (Leamer, 1998; Baldwin and Cain, 2000; Haskel and Slaughter, 2001). Factor content of trade studies make use of the property that trade in goods is a substitute for trade in factors by estimating changes in effective domestic supplies of skilled and unskilled labour due to trade (Wood, 1994, 1998; Deardorff and Lattimore, 1999).

Researchers who adopt the third approach set up a modified H-O model and solve this model numerically (Krugman, 1995; Lawrence and Evans, 1996; Cline, 1997; Tyers and Yang, 1997, 2000; Cortes and Jean, 1999; Nahuis, 1999; Abrego and Whalley, 2000; Jean and Bontout, 2000; De Santis 2002, 2003; Winchester, Greenaway and

Reed, 2006; Winchester and Greenaway, 2006). We choose to conduct a CGE analysis as we wish to preserve the fundamental characteristics of the H-O model whilst also using a model complex enough to capture several important features of actual economies, such as intra-industry trade. Another advantage associated with CGE modelling is that this approach models interdependencies and feedback effects, which can be difficult to capture using other techniques, explicitly.⁴

Our CGE framework is based on the GTAPinGAMS model, which is a static, global model that captures both bilateral trade flows amongst regions and inter-sectoral linkages within regions. The GTAPinGAMS framework is set out in detail by Rutherford and Paltsev (2000). Features of the model concerning production, trade and closure which are important for our analysis are outlined below. Starting with trade, imports are differentiated from domestic commodities and by region of origin according to the Armington assumption (Armington 1969). That is, for each good, imports from different regions are gathered in a constant elasticity of substitution (CES) nest to create an import composite. The import composite is combined in a further CES nest with the domestically produced variety to generate a composite that is purchased by domestic consumers, firms and government. The specification of the Armington assumption is important as it affects the degree to which domestic product prices are affected by changes in international prices. In the H-O model, domestic goods and imported varieties are perfect substitutes. When the Armington assumption is employed (and the elasticities in the Armington specification are less than infinity) domestic and imported varieties are imperfect substitutes and the proportional change

⁴ In this connection, 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.”

in the domestic price of a particular variety due to a change in the world price of that variety is less than the proportional change in the corresponding world price.⁵ Consequently, the effect of increased trade on wages is muted when the Armington assumption is introduced.

Turning to production in GTAPinGAMS, output in each sector is governed by a Leontief nest of an intermediate input composite and a primary factor composite. The intermediate input composite is derived from a further Leontief aggregation of intermediate inputs of different products, which are themselves composites of domestically produced and imported varieties. The value added composite is created by a Cobb-Douglas aggregation of primary factors. As constant returns to scale production functions are employed in our chosen model, prices and factor rewards adjust so as to maintain zero profits (as in the H-O framework). The nature of the valued added nest can also have a large influence on the results. Specifically, the greater the substitutability between factors of production, the smaller the variation of changes in factor returns due to trade liberalisation. Guided by Johnson (1997), we modify the value added nest in GTAPinGAMS by combining different types of labour using a CES aggregator with an elasticity parameter equal to 1.5, and amalgamating the labour composite with other primary factors using a Cobb-Douglas aggregator.

With respect to closure, factor prices are endogenous so there is full employment, and factors are perfectly mobile across sectors (but immobile internationally). Also, savings is investment driven so the real exchange rate adjusts to maintain a constant current account deficit in each region. As a result of our chosen factor market closure,

⁵ As noted by Abrego and Whalley (2000), domestic and imported varieties can also be unrelated commodities or complements if the relevant Armington parameters are equal to unity or less than one respectively. We do not discuss these cases as estimates of Armington elasticities are typically much larger than one (see Hertel et al., 2004).

our analysis ignores adjustment costs due to increased trade so our results have a long-run focus. A benefit of our macroeconomic closure is that it prevents short-run fluctuations in the trade balance from distorting our results (Deardorff and Hakura, 1994).

Our model is calibrated using Version 6 of the Global Trade Analysis (GTAP) database (Dimaranan and McDougall 2005). The database provides a representation of the global economy in 2001 and identifies 87 regions, 57 sectors and five factors of production (skilled and unskilled labour, capital, land, and resources). To suit our needs, we aggregate the GTAP database into four regions (New Zealand, Other Developed, Rapidly Developing Asia, and Rest of World) and seven sectors (agriculture, minerals, food manufacturing, mineral-based manufacturing, unskilled labour-intensive manufacturing, skilled-labour intensive manufacturing, and services). The compositions of sectors and regions identified in our model in terms of components recognised by GTAP are highlighted in Table 1.⁶

Turning to factor aggregation, we augment the New Zealand component of the database to incorporate two alternative skill classifications. We do this because the procedure used to identify skilled and unskilled labour in the GTAP database draws heavily on occupational classifications (see Liu et al., 1998), which can result in some workers being misclassified (Hall, 1993 and Leamer, 1998). Our skill classifications are based on educational attainment and draw on data from the 2001 Census of Population and Dwellings and the 2001 New Zealand Income Survey. In one classification we identify more educated (individuals with a university degree or a

⁶ We choose to work with a relatively highly aggregated version of the database for presentational convenience as our model produces similar results when a more detailed sectoral breakdown is employed.

vocational or school qualification) and less educated workers (individuals with no qualifications). Guided by Winchester, Greenaway and Reed (2006), who develop a skill classification using cluster analysis to determine both the appropriate composition and number of labour types, we identify four labour categories – university qualification, vocational qualification, school qualification, and no qualification – in our second classification.⁷ Consequently, we conduct simulations using three alternative labour classifications for New Zealand: (a) GTAP’s skill classification, which identifies skilled and unskilled labour using an occupation-based method, (b) a skill classifications that recognises skilled and unskilled labour based on educational attainment (as described above), and (c) a skill classification that identifies four labour types (as described above) by observing qualifications. Skill classification (a) is used in all regions other than New Zealand in all simulations, and capital, land and resources are identified in all regions throughout our modelling exercises.

Before implementing our simulation exercises, we eyeball the data to draw some qualitative conclusions about the possible impact of trade on wage inequality. Labour cost shares when four types of labour are identified are displayed in Table 2. These data reveal that, with the exception of skilled manufacturing, there is not a large difference in labour cost shares across non-services, which use workers with no qualifications intensively relatively to other sectors. Services, which has the highest degree qualification labour cost share and the lowest no qualification labour cost share, is the most skill-intensive sector. Additionally, although skilled services is more skill intensive than other manufacturing sectors, it is less skill intensive than

⁷ Details of our labour classification and how we map these data onto the GTAP database are given in the appendix.

services.

Table 3 displays New Zealand sectoral import, export and labour costs shares. These data indicate that New Zealand imports are predominately made up of unskilled and skilled manufacturing, and that exports of food manufacturing, which account for more than one-third of New Zealand's total exports, is New Zealand's most significant export commodity. With respect to labour cost shares, the majority (nearly 70%) of all labour payments originate from services, and agriculture and food manufacturing combined account for a considerable proportion (just over 15%) of total payments to labour.

New Zealand trade shares by commodity and region are presented in Table 4. The last row in each segment presents regional trade shares (e.g., imports from Other Developed make up 63.3% of total New Zealand imports), and other cells display regional trade shares for each commodity (e.g., agriculture imports from Other Developed account for 63.5% of total New Zealand imports of this commodity). From a trade and wages perspective, several interesting features are exposed by these data. In relation to New Zealand's imports, although imports are dominated by goods sourced from Other Developed in every product category except mining, it is interesting to note that imports from Rapidly Developing Asia account for more than a quarter of overall New Zealand imports, and the contribution of imports from Rapidly Developing Asia towards New Zealand's two most significant import commodities (37.0% for unskilled manufacturing and 31.3% for skilled manufacturing) is much higher than the overall incidence of imports from this region (26.5%), especially for unskilled manufacturing. Turning to New Zealand's exports,

the data reveal that the proportion of agriculture exports shipped to Rapidly Developing Asia (52.2%) accounts for a significantly larger proportion of total exports of this commodity than the share of total New Zealand exports to this region (33.4%).

Taken together, the data in Tables 2-4 suggest that it is possible that increased imports from Rapidly Developing Asia hurt unskilled labour in New Zealand in recent decades but, as New Zealand exports are concentrated in unskilled-intensive commodities, growth of New Zealand exports over the same period may (at least partially) have produced an offsetting effect. Also, the data indicate that the large number of workers employed in services may restrict the impact of non-services trade on relative wages.

3. Simulation exercises

We estimate the impact of increased imports on relative wages in New Zealand by imposing 1980 values of New Zealand sectoral imports relative to GDP on the 2001 database.⁸ Influenced by Tyers and Yang (1997) and Winchester, Greenaway and Reed (2006), we do this by introducing a set of endogenous taxes on exports to New Zealand from other regions. We choose to control imports by altering tax instruments in countries other than New Zealand as changing trade policy instruments in New Zealand may have undesirable revenue effects. Changes in imports occurring between 1980 and 2001 are reported in Table 5. Unless stated otherwise, the shock imposed in our simulation exercises removes these changes from the 2001 database.

⁸ As disaggregated data concerning trade in services are scarce we are restricted to evaluating the impact of changes in non-services imports.

Simulated changes in New Zealand real wages for various skill classifications following our trade shock are reported in Table 6. In all labour classifications we observe increases in real wages for all labour types. When two labour types are identified, the estimated increase in skill premium is 0.82% when labour types are identified by observing occupational data and 0.71% when a labour classification based on educational attainment is used. Given that the proportion of unskilled workers in the workforce more than doubled between 1980 and 2001 (Lattimore et al, 2002) and the increase in the skill premium outlined in Section 1, these observations indicate that only a tiny fraction of the increase in New Zealand wage inequality over the 1980-2001 period can be attributed to increased imports.

Turning to the results when there are four labour types, there is a positive relationship between skill level and proportional changes in real wages and the largest simulated increases in wage inequality (the wage paid to individuals with university degrees divided by the wage received by workers with no qualifications) is 1.43%. The increase in the relative wage of skilled labour when there is four labour types (where the skilled wage is calculated as the employment weighted average of the degree, vocational and school wage and the wage for workers with no qualifications represents the unskilled wage) is 1.24%. These results reveal that estimates of the increase in wage inequality induced by trade are larger when four labour types are identified but not large enough to overturn our conclusions regarding the link between imports and wage inequality.

To appreciate what is driving our results, we report simulated changes in New Zealand commodity prices, outputs and trade when two labour types are identified

using occupational data in Table 7.⁹ Given the exogenous changes in import volumes, the direction of output changes are not surprising: production declines in sectors where imports have increased (and vice versa) and there is a positive association between the absolute value of proportional changes in imports and output (i.e., a large increase in imports generates a large decrease in production and a small decrease in imports results in a small increase in production). Overall, there is a negative relationship between changes in prices and imports, which is expected. On exception, however, relates to changes in prices and imports for food manufacturing. Presumably the price of food manufacturing increases despite a large increase in imports of this commodity because agriculture, which has experienced a relatively large price increase, is used intensively in food manufacturing. Evidence of S-S forces is that unskilled manufacturing experiences the largest price decline and this commodity and skilled manufacturing, which both use unskilled labour more intensively than services, experience large price reductions relative to the price of services.

Taken together, the results in Tables 6 and 7 suggest that imports have influenced wage inequality in New Zealand via S-S channels. However, although our modelling exercises are able to replicate observed changes in wage inequality at a qualitative level, simulated changes in wage ratios are very modest. Accordingly, our findings concur with the majority view point that trade has not had a large influence of wage inequality.

To assess the contribution of import changes by commodity and region, we report results from decomposition analyses in Tables 8 and 9. Table 8 displays movements

⁹ By design, reported changes in import volumes in Table 7 are the same as those in Table 5.

in the skilled-to-unskilled relative wage when a skill classification built on occupational data is used.¹⁰ Results presented in the last row of Table 8 represent changes in the skill premium when observed changes in New Zealand imports from each region (for all commodities) are simulated (e.g., the estimated increase in the skill premium due solely to increased imports from Other Developed is 0.559%). The last column of each table reports proportional changes in relative wages when exogenous changes in imports are simulated independently (across all regions) for each commodity (e.g., the estimated increase in the skill premium when only changes in agriculture imports are considered is -0.041%). Other cells present simulated changes in the skilled-to-unskilled relative wage when imports of each commodity from each region are considered independently (e.g., the estimated increase in the skill premium due to increased imports of agriculture from Other Developed is 0.003%).¹¹ The cell in the bottom right-hand corner of Table 8 displays the proportional change in the skill premium when imports of all commodities from all regions are considered and is the same the corresponding change reported in Table 6.¹² The direction of changes in relative wages in the decomposition analysis have intuitive appeal. For example, the large proportional increase in imports of food manufacturing, which makes intensive use of unskilled labour, results in a relatively large increase in the skill premium. Another expected observation is that the simulated increase in the skilled-to-unskilled wage ratio due imports of unskilled

¹⁰ Changes in the skill premium when two labour types are identified using educational data are similar to those reported in Table 8.

¹¹ When evaluating the contribution of imports from a single region, due to relatively high substitution possibilities, we hold imports of the commodity of interest from other regions constant when considering a single commodity and imports of all commodities from other regions constant when assessing the impact of total imports from a region.

¹² Reported changes in the final columns and the final rows of Tables 8 and 9 are not equal to the respective column and row sums as we do not attempt to apportion interaction terms.

manufacturing (0.50%) is larger than corresponding changes due imports of other commodities

For the purpose of evaluating the contribution of North-South trade to increased wage inequality in New Zealand, two observations are of notable interest. First, the increase in the skill premium due to increased imports of unskilled manufacturing from Other Developed (0.32%) is nearly three times larger than the increase in this variable resulting from imports from Rapidly Developing Asia (0.12%). Moreover, the impact of imports (of all commodities) from Other Developed on the skill premium (0.56%) accounts for more than two-thirds of the increase in the skill premium due to imports from all regions (0.82%). Second, increased imports of skilled manufacturing have increased the skill premium (by about one-third of the amount resulting from increased imports of unskilled manufacturing). Presumably this is because, when compared to services, skilled manufacturing makes relative intensive use of unskilled labour.

Table 9, which is interpreted analogously to Table 8, reports changes in the wage of workers with a degree qualification relative to the wage paid to workers with no qualification.¹³ The data reveal that conclusions resulting from our decomposition analysis when there are only two labour types are unchanged when a more detailed skill classification is used; that is, although imports of unskilled manufacturing have a large impact on wage inequality relative to imports of other commodities, imports from Other Developed account for a significant majority of the rise in wage inequality due to increased imports.

¹³ Changes in the university degree-no qualification relative wages in Table 9 are representative of movements in other measures of wage inequality when four types of labour identified.

In addition to causing an increase in New Zealand imports in recent decades, rapid growth in other regions and reduced trade frictions have also strengthened the demand for New Zealand exports. So far we have only considered the impact of increased exports via induced changes in exports required to maintain a fixed trade balance. Consequently, we assess the overall impact of changes in trade volumes (both imports and exports) on New Zealand wage inequality in a further exercise. In a similar fashion to how imports are controlled, we simulate observed changes in New Zealand exports using a set of endogenous import tariffs in other regions. The results, reported in Table 10, reveal that, taken as whole, trade has exerted downward pressure on wage inequality in New Zealand. The main driver of this result is a significant increase in New Zealand exports of (unskilled-labour intensive) food manufacturing, which is at least four times larger than the absolute increase in exports of other commodities (not reported). Consequently, as New Zealand's comparative advantage lies in agricultural-related products and this sector makes relative intensive use of unskilled labour, increased trade has decreased wage inequality in New Zealand.¹⁴ This finding offers strong support for the argument that trade has not caused wage inequality to rise in developed nations.

Several limitations to our study should be noted before closing. First, our analysis does not disclose what forces increased wage inequality. Instead, like other studies (McDougall and Tyers, 1994; Cline, 1997; Tyers and Yang, 2000; Abrego and Whalley, 2000; De Santis, 2003), in the absence of a strong link between trade and wages we presume that skill-biased technical change was the culprit. Second, we do

¹⁴ Deardorff and Lattimore (1999) and Lattimore et al. (2002) also make this observation.

not consider the indirect effect trade may have on relative wages via trade-induced technical change or outsourcing.

4. Conclusions

This paper has implemented the first CGE analysis of the link between increased trade volumes and rising wage inequality in New Zealand - a small, relatively open economy that experienced a significant change in trade policy in the early 1980s. The modelling exercises analysed the impact of increased trade volumes on the distribution of wages in New Zealand using three different skill classifications, which were built on educational and occupational data. Although the results indicated that increased imports have affected New Zealand wages via S-S channels, it was found that imports have resulted in an insignificant increase in wage inequality in New Zealand and most of this increase can be attributed to increased imports from skilled-labour abundant nations. Most significantly, as New Zealand's comparative advantage lies in agricultural related products and these commodities make intensive use of unskilled labour, when changes in both imports and exports are considered, it was found that increased trade has decreased wage inequality in New Zealand. In other words, due to the structure of the New Zealand economy, the direction of changes in relative wages resulting from increased trade is different to that in most developed nations. As both the relative wage paid to skill labour and the relative supply of skilled labour have risen in New Zealand, the US, and the UK (and other developed nations) in recent decades, these findings provide compelling evidence that a factor other than trade – such as skilled biased technical change – was responsible for the deteriorating position of unskilled workers in developed countries.

References

- Abrego, L., and Whalley, J. (2000). The Choice of Structural Model in Trade-Wages Decompositions. *Review of International Economics*, 8 (3): 462-77.
- ABS, (1993). Australian and New Zealand Standard Industrial Classification [online]. Canberra: Australian Bureau of Statistics. Available at <URL:<http://www.abs.gov.au/Ausstats/abs@.nsf/0/87A389CBA2E998F0CA25697E0018FAF4?Open>. [Accessed 27 October 2005].
- Armington, P.S. (1969). A Theory of Demand for Products Distinguished by Place of Production. *IMF Staff Papers*, 16: 159-76.
- Baldwin, R.E. and Cain, G.G. (2000). Shifts in US Relative Wages: The Role of Trade, Technology and Factor Endowments. *Review of Economics and Statistics*, 82 (4): 580-95.
- Cortes, O. and Jean, S. (1999). Does Competition from Emerging Countries Threaten Unskilled Labour in Europe? An Applied General Equilibrium Approach. In P. Brenton and L. Pelkmann (eds.), *Global Trade and European Workers*, London: Macmillan, 1999: 96-122.
- De Santis, R.A. (2002). Wage Inequality Between and Within Broups: Trade-Induced or Skill-Bias Technical Change? Alternative AGE Models for the UK. *Economic Modelling*, 19: 725-746.
- De Santis R.A. (2003). Wage Inequality in the United Kingdom: Trade or/and Technology. *The World Economy*, 26: 893-910.
- Deardorff, A.V., and Hakura, D. (1994). Trade and Wages: What are the Questions? In: J. Bhagwati and M.H. Koster, eds, *Trade and wages: levelling wages down?* Washington, DC: American Enterprise Institute, 1994, pp.1-35.

- Deardorff, A., and Lattimore, R. (1999). Trade and Factor Market Effects of New Zealand's Reforms. *New Zealand Economic Papers*, 33(2), 71-91.
- Dimaranan, B.V. and McDougall, R.A. (2005). *Global Trade, Assistance, and Production: the GTAP 6 Data Base*, Centre for Global Trade Analysis, Purdue University.
- Greenaway, D., Nelson, D. (2000). Globalization and Labour Market Adjustment," *Oxford Review of Economic Policy* 16(3): 1-11.
- Greenaway, D., Nelson, D. (2001). *Globalization and Labour Markets*. Cheltenham: Edward Elgar.
- Haskel, J.E., and Slaughter, M.J. (2001). Trade, Technology and U.K. Wage Inequality. *Economic Journal*, 111 (468): 163-87.
- Hall, R.E. (1993). Comment. *Brookings Papers on Economic Activity*, 2: 211-14.
- Hertel, T., D. Hummels, M. Ivanic, and R. Keeney, 2004. How Confident can we be in CGE-Based Assessments of Free Trade Agreements? NBER Working Paper 10477.
- Johnson, G.E. (1997). Changes in Earnings Inequality: The Role of Demand Shifts. *Journal of Economic Perspectives*, 11 (2): 41-54.
- Krugman, P. (1995). Growing World Trade: Causes and Consequences. *Brookings Papers*, 1: 327-377.
- Lattimore, R., Hawke, G., Duncan, I., and Ballingall, J. (2002). The Changing Demand for Qualified Labour in New Zealand. NZ Trade Consortium working paper no. 23, New Zealand Institute of Economic Research.

- Lawrence, R.Z., and Evans, C.L. (1996). Trade and Wages: Insights from the Crystal Ball. National Bureau of Economic Research Working Paper 5633.
- Leamer, E.E. (1998). In Search of Stolper-Samuelson Effects on US Wages. In S. Collins, ed. *Imports, Exports and the American Worker*. Washington D.C.: Brookings Institution Press, 1997: 141-214.
- Liu, J. et al. (1998). Disaggregating Labour Payments by Skill Level. In R.A. McDougall, A. Elbehri, and T.P. Truong, (eds.), *Global Trade Assistance and Protection: the GTAP 4 Data Base*. Center for Global Trade Analysis: Purdue University, 1998: Chapter 18.
- Mastoris, I. and Travis, J. (1998). Regional Input Output Tables: Australia. In: R.A. McDougall, A Elbehri, and T.P. Truong eds. *Global Trade Assistance and Protection: The GTAP 4 Data Base*. Purdue University, Center for Global Trade Analysis: Chapter 14.2.
- McDougall, R., and Tyers, R. (1994) Developing Country Expansion and Labour-Saving Technical Change: Factor Market Effects and Policy Reactions. *American Journal of Agricultural Economics* 76(5): 1111–1119.
- Nahuis, R., 1999. Global Integration and Wages in a General Equilibrium World Model: Contributions of WorldScan. In: P. Brenton and L. Pelkman, eds. *Global trade and European workers*. London: Macmillan, 1999, pp. 123-46.
- Neven, D., and Wyplosz, C. (1996). Relative Prices, Trade and Restructuring in European Industry. Centre for Economic Policy Research, Discussion Paper 1451.
- Organisation for Economic Cooperation and Development, (1996). OECD *Employment Outlook*, July.

- Rutherford, T.F., and Paltsev, S.V. (2000). GTAPinGAMS and GTAP-EG: Global Datasets for Economic Research and Illustrative Models. University of Colorado.
- Sachs, J.D. and Shatz, H.J. (1994). Trade and Jobs in US Manufacturing, *Brookings Papers on Economic Activity*, 1: 1-84.
- Slaughter, M.J. (1998). International Trade and Labour Market Outcomes: Results, Questions and Policy Options, *Economic Journal*, Vol. 108: 1452-63.
- Statistics New Zealand. (2001) *Census of Population and Dwelling, 2001*. Wellington
- Statistics New Zealand. (2001) *New Zealand Income Survey, June 2001*. Wellington.
- Tyers, R. and Yang, Y. (1997). Trade with Asia and Skill Upgrading: Effects on Factor Markets in the Older Industrial Countries. *Weltwirtschaftliches Archiv*, 133: 383-418.
- Winchester, N. and Greenaway D. (2006). Rising Wage Inequality and Capital-Skill Complementarity. *Journal of Policy Modelling*, forthcoming.
- Winchester, N., Greenaway, D. and Reed, G. V. (2006). A CGE Analysis of Trade and Wage Inequality in the UK. *Review of World Economics/ Weltwirtschaftliches Archiv*, Vol.142 (forthcoming)
- Wood, A. (1994). *North-South Trade, Employment and Inequality*. Oxford: Clarendon Press.
- Wood, A. (1998). Globalisation and the Rise in Labour Market Inequalities. *Economic Journal*, 108: 1463-1482.

Table 1: Regional and commodity aggregations

Regions	Commodities
<ol style="list-style-type: none"> 1. New Zealand 2. Other Developed Australia, Canada, EU15 (Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden), Japan United States, 3. Rapidly Developing Asia China, Hong Kong, Taiwan, Korea (Rep.), Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam 4. Rest of World (ROW) All other regions 	<ol style="list-style-type: none"> 1. Agriculture Vegetables, fruits and nuts; bovine cattle, sheep and goats, horses; animal products not elsewhere classified (nec); raw milk; wool; forestry; paddy rice; wheat; cereal grains; oil seeds; sugar cane, sugar beet; plant-based fibres; crops nec; fishing 2. Minerals Coal, oil, gas, mineral nec 3. Food manufacturing Bovine meat products, meat products nec, dairy products; vegetable oils and fats, processed rice, sugar, food products nec, beverages and tobacco products 4. Mineral manufacturing Petroleum, coal products; chemical, rubber, plastic products, mineral products nec 5. Unskilled manufacturing Textiles, wearing apparel, leather products, wood products, Motor vehicles and parts, transport equipment nec, manufactures nec 6. Skilled manufacturing Paper products, publishing; ferrous metals; metal nec; metal products electronic equipment; machinery and equipment nec 7. Services Electricity; gas manufacture, distribution; water; construction; trade; transport nec; water transport; air transport; communication; financial services nec; insurance; business services nec; recreational and other services; public administration, defence, education, health; dwellings

Table 2: New Zealand labour cost shares by qualification

	No qualification	School qualification	Vocational qualification	Degree qualification
Agriculture	0.226	0.370	0.250	0.154
Minerals	0.267	0.294	0.271	0.169
Food manufacturing	0.236	0.362	0.240	0.162
Mineral manufacturing	0.214	0.345	0.253	0.188
Unskilled manufacturing	0.216	0.365	0.271	0.149
Skilled manufacturing	0.175	0.352	0.292	0.181
Services	0.146	0.338	0.271	0.245

Source: Employment data are taken from the 2001 Census of Population and Dwellings and wage data are sourced from the 2001 New Zealand Income Survey.

Table 3: New Zealand sectoral exports, imports and labour cost shares

	Imports	Exports	Labour cost
Agriculture	0.018	0.122	0.091
Minerals	0.034	0.008	0.004
Food manufacturing	0.058	0.340	0.060
Mineral manufacturing	0.158	0.089	0.033
Unskilled manufacturing	0.239	0.109	0.060
Skilled manufacturing	0.291	0.146	0.065
Services	0.203	0.186	0.687
Total	1.000	1.000	1.000

Source: GTAP 6 database (Dimaranan and McDougall, 2006).

Table 4: New Zealand trade shares, 2001

	Other developed	RDA	Rest of world
<i>Imports</i>			
Agriculture	0.635	0.129	0.237
Minerals	0.133	0.108	0.759
Food manufacturing	0.770	0.163	0.067
Mineral manufacturing	0.654	0.240	0.106
Unskilled manufacturing	0.575	0.370	0.055
Skilled manufacturing	0.658	0.313	0.029
Services	0.693	0.159	0.148
Total	0.633	0.265	0.102
<i>Exports</i>			
Agriculture	0.392	0.522	0.087
Minerals	0.254	0.570	0.176
Food manufacturing	0.457	0.343	0.200
Mineral manufacturing	0.563	0.333	0.104
Unskilled manufacturing	0.618	0.300	0.081
Skilled manufacturing	0.530	0.381	0.089
Services	0.677	0.167	0.156
Total	0.526	0.334	0.140

Note: The final row in each segment lists regional trade shares and other cells display regional trade shares for each commodity.

Source: GTAP 6 database (Dimaranan and McDougall, 2006).

Table 5: Exogenous changes in New Zealand imports relative to GDP, 1980-2001, %

	Other develop.	RDA	Rest of world	Total
Agriculture	4.45	-75.66	-42.10	-31.79
Minerals	81.09	-54.08	-5.17	-14.41
Food manufacturing	199.95	316.20	594.19	224.86
Mineral manufacturing	24.20	-34.53	-54.73	-8.56
Unskilled manufacturing	60.95	89.27	385.93	76.12
Skilled manufacturing	38.17	116.40	392.20	59.04
Total	46.50	34.75	-6.13	36.02

Source: GTAP 6 database (Dimaranan and McDougall, 2006).

Table 6: Changes in New Zealand wages due to import changes, 1980-2001, %

Skill classification based on:	Occupations	Qualifications
<i>When there are two labour types</i>		
W_{skilled}	4.440	3.997
$W_{\text{unskilled}}$	3.575	3.248
$W_{\text{skilled}}/W_{\text{unskilled}}$	0.823	0.709
<i>When there are four labour types</i>		
W_{degree}		4.734
$W_{\text{vocational}}$		3.745
W_{school}		3.723
$W_{\text{no qualification}}$		3.237
$W_{\text{degree}}/W_{\text{vocational}}$		0.947
$W_{\text{degree}}/W_{\text{school}}$		0.965
$W_{\text{degree}}/W_{\text{no qualification}}$		1.434

Note: The skill classification based on occupational data is taken from the GTAP database (Dimaranan and McDougall, 2006) and the labour groupings derived from data on qualifications are described in the text.

Source: Model simulations described in the text.

Table 7: Changes in New Zealand prices, outputs and trade, 1980-2001, %

	Price	Output	Imports	Exports
Agriculture	3.186	0.699	-31.79	3.256
Minerals	5.034	10.572	-14.41	-11.597
Food manufacturing	2.392	-1.444	224.86	7.345
Mineral manufacturing	3.724	2.816	-8.56	1.234
Unskilled manufacturing	-0.973	-13.657	76.12	36.341
Skilled manufacturing	-0.630	-12.165	59.04	41.316
Services	2.372	2.058	-1.303	6.000

Source: Model simulations described in the text.

Table 8: Decomposition of changes in the skilled-to-unskilled relative wage due to imports when labour types are identified using occupational data, 1980-2001, %

	Other Develop.	RDA	ROW	All regions
Agriculture	0.003	-0.029	-0.015	-0.041
Minerals	0.004	-0.016	-0.003	-0.014
Food manufacturing	0.134	0.027	0.015	0.188
Mineral manufacturing	-0.022	0.011	0.012	0.008
Unskilled manufacturing	0.317	0.116	0.048	0.496
Skilled manufacturing	0.108	0.066	0.012	0.159
All sectors	0.559	0.180	0.071	0.823

Source: Model simulations described in the text.

Table 9: Decomposition of changes in the degree-to-no qualification relative wage due to imports, 1980-2001, %

	Other Develop.	RDA	ROW	All regions
Agriculture	0.000	0.003	0.002	0.004
Minerals	0.003	-0.012	-0.002	-0.011
Food manufacturing	0.193	0.038	0.021	0.271
Mineral manufacturing	0.010	-0.010	-0.009	-0.007
Unskilled manufacturing	0.657	0.232	0.096	1.039
Skilled manufacturing	0.072	0.480	0.010	0.088
All sectors	0.963	0.309	0.121	1.434

Source: Model simulations described in the text.

Table 10: Changes in New Zealand wages due to changes in imports and exports, 1980-2001, %

Skill classification based on:	Occupations	Qualifications
<i>When there are two labour types</i>		
W_{skilled}	2.457	3.615
$W_{\text{unskilled}}$	4.860	6.150
$W_{\text{skilled}}/W_{\text{unskilled}}$	-2.286	-2.383
<i>When there are four labour types</i>		
W_{degree}		2.460
$W_{\text{vocational}}$		3.679
W_{school}		4.294
$W_{\text{no qualification}}$		6.177
$W_{\text{degree}}/W_{\text{vocational}}$		-1.172
$W_{\text{degree}}/W_{\text{school}}$		-1.754
$W_{\text{degree}}/W_{\text{no qualification}}$		-3.493

Note: The skill classification based on occupational data is taken from the GTAP database (Dimaranan and McDougall, 2006) and the labour groupings derived from data on qualifications are described in the text.

Source: Model simulations described in the text.

Appendix: Skill classification and augmentation of the GTAP database

Our skill classification draws on two data sources: (a) we collect data on employment by 1996 Australia New Zealand Standard Industry Classification (ANZIC96) four-digit industry and highest qualification attained from the 2001 New Zealand Census of Population and Dwellings; and (b) we source data on average hourly earning by highest qualification attained, and data on average hours worked by ANZIC96 two-digit industries from the 2001 New Zealand Income Survey. We use this data to calculate labour cost shares by qualification for each ANZIC four-digit industry.¹⁵ For GTAP sectors not related to agriculture or food manufacturing (sectors 14-18 and 27-57) these data are mapped onto the New Zealand component of the GTAP database using an ANZSIC-International Standard Industrial Classification (ISIC) industries taken from ABS (1993), and an ISIC-GTAP provided by Dimaranan and McDougall (2002). For GTAP sectors not related to agriculture and food manufacturing, our mapping of cost shares draws on a concordance adapted from Mastoris and Travis (1998, Table 14.2.A2).¹⁶

¹⁵ Due to data limitations, these calculations assume that average hours worked in each four-digit industry within the same two-digit industry are the same and that wages by qualification do not differ across industries.

¹⁶ It is necessary to create several aggregated GTAP sectors to complete our ANZIC-GTAP concordance. Composite sectors generated to complete the concordance include: cereals and grains (paddy rice, wheat, cereal grains nec, oilseeds, sugar), other crops (fruits, vegetables and nuts; crops nec), animal products (bovine cattle, animal products nec, raw milk), oil and gas (oils and gas), other food (processed rice and vegetable oils and fats).