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How Would Global Trade Liberalization Affect Rural and Regional Incomes in Australia?

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Abstract

Agricultural protection in rich countries, which had depressed Australian farm incomes via its impact on Australia‟s terms of trade, has diminished over the past two decades. So too has agricultural export taxation in poor countries, which had the opposite impact on those terms of trade. Meanwhile, however, import protection for developing country farmers has been steadily growing, and OPEC has been keeping up prices of energy raw materials. To what extent are Australian farmers and rural regions still adversely affected by farm and non-farm price-distortive policies abroad? This paper draws on new evidence on the current extent of those domestic and foreign distortions first to model their net impact on Australia‟s terms of trade (TOT, using the World Bank‟s Linkage model of the global economy), and second to model the effects of that TOT impact on rural vs urban and other regions and households within Australia as of 2004 (using Monash‟s multi-regional TERM model of the Australian economy). The results vindicate the continuing push by Australia‟s rural communities for multilateral agricultural trade liberalization.

JEL classification: F13; Q18; C68; R13.

Keywords: trade liberalisation, rural income, regional CGE modeling

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Throughout the post-World War II period Australian farmers have been discriminated against by policies at home and abroad. At home, Australia‟s manufacturing protection policies far more than offset the country‟s agricultural support policies, so the farm sector and farm household incomes were smaller than they would have been without those policies. But domestic reforms in the past three decades have virtually removed that part of the discrimination. Abroad, the Australian farm sector was an indirect beneficiary, through improved terms of trade, of anti-agricultural policies of developing countries such as export taxes, but has been harmed by pro-agricultural policies in other high-income countries. The former have greatly diminished over the past quarter-century, and even the latter have diminished somewhat in their trade impact over the past two decades.

This paper summarizes recent research showing the changing extent of policy distortions to agricultural incentives in Australia and in the rest of the world, drawing on the results of a World Bank multi-country research project, and provides economy-wide modeling results of the impact of remaining distortions on farm versus non-farm incomes and on rural versus other areas in Australia.

The Australian case is different from that of other high-income countries in at least two respects. First, agriculture has never been assisted more than non-agricultural sectors in Australia, in contrast to virtually all other OECD countries. In that sense it is much more like a primary product-exporting developing country. And second, since the mid-1970s Australian exports of minerals and energy raw materials have been indirectly assisted by quotas on petroleum production (agreed to by members of OPEC, the Organization of the Petroleum Exporting Countries). Hence sectoral policies abroad hurt Australian farmers and rural areas not only relative to urban areas but also relative to (mainly remote) areas specializing in mining. OPEC‟s policy of output restraint is not (yet) subject to negotiation at the World Trade Organization (WTO), so has to be accepted as is rather than be treated as a policy amenable to reform. Agricultural policies, on the other hand, are an integral part of the WTO‟s current round of multilateral trade negotiations and so in principle are subject to reform. Hence information on their effects is valuable in that it can be used to generate support for policy reform. Past studies have provided information on the effects of those policies on the farm sector and overall economy nationally (e.g., Anderson and Martin 2006), but to our knowledge there have been no studies that have shown their effects regionally. Yet the degree of price distortion varies hugely between products, and hence can be expected to affect regions differentially according to their commodity specializations.[1]

The paper is organized as follows. After summarizing results from the World Bank‟s price distortion project for Australia and for the rest of the world over the past half-century, we describe the two-stage modeling approach used. The first stage involves modeling the net impact on Australia‟s terms of trade of distortions to agricultural and other goods markets abroad as of 2004 (derived from the World Bank‟s Linkage CGE model of the global economy); the second modeling stage uses the TERM CGE multi-

[1] This approach to examining the impact of foreign policies on different regions and households within a national economy, by using the combination of a global model and a compatible national model, will have ever-more applications as globalization proceeds. An obvious example is the impact of climate change and responses to it by the rest of the world.

regional model of the Australian economy to estimate the regional and net farm vs nonfarm income consequences of the terms of trade effects of those discriminatory policies as of 2004. We then discuss model results. We point out that while the growth of agricultural protection in rich countries has reversed a little recently, developing countries as a group have transitioned from effectively taxing their farmers to assisting them relative to their manufacturers, particularly via food import restrictions. If this trend continues, Australian farmers and rural regions will have even more reason to press for an ambitious reform outcome from the agricultural part of the multilateral trade negotiations under the WTO.

Distortions to agricultural incentives since the 1950s

Australia‟s Industries Assistance Commission began calculating estimates of the nominal rates of assistance (NRA, the percentage by which government policies have raised gross returns to producers above what they would be without the government‟s intervention) for major agricultural commodities beginning with the year 1970-71. This series has been continued by its successors, the Industry Commission and the Productivity Commission. For the years before 1970-71, a comprehensive series is published in Lloyd (1973, pp. 149-58). It covers the major agricultural commodities for which data were available at the time, for the years 1946-47 to 1970-71. The Lloyd and Commission series use essentially the same methods. Anderson, Lloyd and MacLaren (2007) bring these series together and obtain a weighted average NRA for agriculture as a whole. Their results show that the average nominal rate of agricultural assistance in Australia rose during the 1950s and 1960s but subsequently declined so that by the end of the 1990s its average was virtually zero (middle line in Figure 1). So too did the dispersion of industry NRAs within the farm sector: the standard deviation around the weighted mean peaked at more than 50 percent in the early 1970s, but is now less than 0.5 percent (Anderson, Lloyd and MacLaren 2007).

It is *relative* prices and hence relative rates of government sectoral assistance that affect producers‟ incentives, not just agricultural prices alone. In a two-sector model an import tax has the same effects on the export sector as an export tax (the Lerner (1936) Symmetry Theorem), and this carries over to a model that also includes a third sector producing only non-tradables (Vousden 1990, pp. 46-47). It was this understanding that led Gruen (1968) to point out that raising assistance to agriculture in the presence of high assistance to manufacturing could increase rather than reduce national economic welfare. For that reason it is necessary to report estimates not only of the average nominal rate of assistance (NRA) for the tradable parts of the agricultural sector, but also of the average NRA for the tradable parts of all non-agricultural sectors, based on NRA estimates for individual industries. With those two sectoral NRAs we can then calculate a Relative Rate of Assistance, RRA, defined as:

(1) $$RRA = 100[(1+NRAag^t/100)/(1+NRAnonag^t/100) - 1]$$

where $NRAag^t$ and $NRAnonag^t$ are the average percentage NRAs for the tradables parts of the agricultural and non-agricultural sectors, respectively. Since the NRA cannot be less than -100 percent if producers are to earn anything, so too must the RRA. This measure is useful: if it is below zero, it provides an internationally comparable indication of the extent to which the policy regime has an anti-agricultural bias, and conversely when the RRA is positive.

Estimates of the NRA for manufacturing for the period prior to 1968-69, when Tariff Board estimates begin, rely on tariffs only. During 1952 to 1960 there were also protective quantitative restrictions on imports of manufactures, but since estimates of the protective effects of those import licenses are unavailable, Anderson, Lloyd and MacLaren (2007) assume their impact on the average NRA for non-agricultural tradables is exactly offset by the negative impact of the ban on key mining exports in those years.[2] Since Australia"s imports pre-1969 were almost exclusively manufactures, customs revenue as a percentage of the value of all merchandise imports provides a reasonable proxy for the country"s nominal rate of tariff protection for manufacturing. For the period since 1968-69, the Productivity Commission and its predecessors provide estimates of both nominal and effective rates of assistance to manufacturing, for industry sub-categories down to the 4-digit level. In addition to tariffs these cover subsidies, bounties, discriminatory sales taxes and, from 1982-83, quantitative restrictions and local content plans.

The weighted average nominal rate of assistance on outputs (NRAs) for the whole non-agricultural tradables sector is generated by assuming only (and all) service sectors produce non-tradables, and that non-agricultural primary sectors received a zero NRA on average. It is shown as the upper line in Figure 1, with the manufacturing-only NRA

[2] In years prior to the 1950s, the relatively low international prices of mineral and energy products (World Bank 2000), combined with the very high cost of transporting bulky coal and iron ore from Australia to the North Atlantic"s industrial hub, means that the ban on exports of Australian coal and iron ore up to 1960 was probably redundant. The ban – which had signalled Australia"s unwillingness to provide industrial raw materials to Japan – was removed after the signing of the Australia-Japan trade agreement in 1957.

shown just above it (indicating that the weight of non-farm primary activities is very low). The NRAs for both farm and non-farm tradable sectors are used to calculate the RRA, using the formula in equation (1) above. That is shown as the lowest of the lines in Figure 1.

These estimates reveal two key facts. First, for all of the post World War II period Australian sectoral and trade policies have discriminated against the agricultural sector (and even more so the mining sector). Even though production subsidies were given to farmers for most years from the early 1950s to the late 1990s, the assistance they received was much less than that provided to manufacturing via import barriers. Hence the relative rate of assistance (RRA) has been negative. Second, it is clear from Figure 1 that the extent of Australian policy discrimination against farmers has more or less continuously declined throughout that period and has now almost disappeared. The only manufacturing protection remaining is for textiles and motor vehicles, and even those tariffs are scheduled for further cuts to low levels in 2010.

Australia contrasts with other high-income countries. According to new results from a World Bank research project that provides results for 75 countries accounting for 90 percent of global agriculture (Anderson 2009a), most have followed a similar path to Australia‟s in the sense of raising their relative rates of assistance to farmers as their national incomes have risen. However, except for New Zealand, the RRAs for other high-income countries have risen from higher bases and to higher levels than for Australia, and more so the weaker their economy‟s comparative advantage in agriculture (Figure 2). While there is a hint of a structural break to the growth of agricultural protection around the time of the Uruguay Round Agreement on Agriculture coming into force in 1995, no other OECD country except New Zealand has made as dramatic a reduction in agricultural assistance – in terms of driving the RRA towards zero – as Australia.

Developing countries, on the other hand, are on average much more like Australia, although their RRAs were even lower in the early years of their independence from imperial powers, and some have risen even faster than Australia‟s. Indeed as a group they have now „overshot‟, in the sense that their average RRA is above zero for developing countries as a whole (Figure 3). In the past, those disincentives to developing country farmers assisted Australia and other agricultural-exporting countries by making farm products scarcer in international markets. By the turn of the century, however, their policies were adding to the downward pressure on prices in international food markets caused by high-income country policies.

That is, taken together these estimated RRAs suggest that by 2004 the policies of both high-income and developing countries were depressing the international prices of farm products. Their weighted average moved from being negative to being positive in the 1980s.[3] These facts suggest that the prices received by farmers in an open, non-distorting country such as Australia were probably depressed in 2004 by policies in the rest of the world, although it depends on the distribution of NRAs across commodities. To determine their net effects, the new price distortion estimates need to be inserted in a model of the world‟s trading nations that is capable of generating their impact on Australia‟s terms of trade, which in turn need to be inserted in a model of the Australian economy that is disaggregated sectorally and regionally.

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[3] That timing is consistent with the modelling finding by Tyers and Anderson (1992, Table 6.9) that, as of 1980-82, the depressing impact on international food prices of positive assistance to rich-country farmers was almost exactly offset by the price-raising impact of negative assistance to food producers in developing countries.

Modeling approach

The above suggests that to get a sense of just how much agricultural and trade policies abroad are impacting on farmers and others in Australia, a two-stage modeling procedure is needed. For the first stage we use a global model to estimate the net impact on Australia"s terms of trade of distortions to agricultural and other goods markets abroad in 2004 (known as the Linkage Model, described in van der Mensbrugghe 2005). For the second stage, a national model with regional details (known as the TERM Model, described in Horridge, Madden and Wittwer 2005) is used to estimate the regional consequences of the terms of trade effects of those discriminatory policies. Since Australia had virtually no sectoral or trade distortions of its own by 2004, there is no need to also simulate own-country reform.

The global (Linkage) model

Global results, based on the comparative static version of the LINKAGE model, use a modified version of the latest pre-release of the Version 7 database of the Global Trade Analysis Project (www.gtap.org), in that the distortions to developing country agriculture are replaced with ones from the World Bank"s new estimates of distortions to agricultural incentives (from Anderson and Valenzuela 2008a,b). These simulated global results are transmitted to the Australian national model via changes in the vectors of import prices and export demands. The latter are implemented as vertical shifts in the export demand curves (that is, of the willingness to pay for Australian exports – see below).

The Australian (TERM) model

The national results use the Australian TERM model, which is a "bottom-up" CGE model with features that enable it to deal with the detailed behavior of producers, consumers and government economic agents in many regions of the country. We simulate the impacts of the removal of current distortions to world markets on Australia by dividing the national economy into 59 regions (Statistical Divisions) and 27 industrial sectors. We also define three super-regions of urban, rural and mining localities, based on the ratio of the sectoral value added share for each region to the national share of sectoral value added (see Appendix Tables 1 and 2 for the regional and sectoral classifications and the regions" relative sectoral value added shares, respectively). The 13 urban regions comprise just over 73 percent of the population and 71 percent of national GDP, and the 13 mining regions comprise 9 percent of the nation"s population and 13 percent of GDP. Thus the 33 rural regions account for the residual 18 percent of the population and 16 percent of GDP.

The data structure in TERM allows the model to capture explicitly the behavior of industries, households, investors, exporters and the government all at the regional level. The model"s theoretical structure is based on that of the well-known CGE model, ORANI (Dixon et al. 1982). Producers in each regional industry are assumed to maximize profits subject to a production technology that allows substitution between primary factors (labor, capital and land) and between geographical sources of supply for intermediate inputs. A representative household in each region purchases goods in order to obtain the optimal bundle in accordance with its preferences and its disposable income. Investors seek to maximize their rate of return. In the short-run, this desire is expressed as a positive relationship between regional industry investment and rates of return. In the medium- to long-run assumed here, it is expressed as the endogenous physical capital supply to each regional industry at exogenous rates of return.

Commodity demands by foreigners are modeled via export demand functions that capture the responsiveness of foreigners to changes in Australian supply prices. Economic agents decide on the geographical source of their purchases according to relative prices and a nested structure of substitution possibilities. The first choice facing the purchaser of a unit of a particular commodity is whether to buy one that has been imported from overseas or one that has been produced in Australia. If an Australian product is purchased, a second decision is made as to the particular region the commodity originates from. It is assumed that Australian-made brands are considerably more substitutable than is an Australian brand with a foreign brand. The national data include regional margins for transportation and retailing, with the possibility of substitution of the margins sources based on their relative prices.

Simulation design

Anderson, Valenzuela and van der Mensbrugghe (2009) present terms of trade results, for a wide range of countries including Australia, from the World Bank‟s LINKAGE model under a long-run scenario in which world agricultural and other goods market distortions as of 2004 are removed. The first three columns of Table 1 report those results for Australia. To use the TERM model to assess the implications of that set of price impacts at Australia‟s national border for various sectors and regions of its economy, we translate into TERM inputs or shocks the two sets of LINKAGE outputs: movements in foreign currency prices for Australian imports, and vertical (willingness to pay) movements in foreign demand schedules for Australian exports.

For movements in foreign currency import prices, the communication of results between the two models is relatively straightforward. We translate movements in foreign currency import prices classified by LINKAGE commodity into movements in foreign currency import prices classified by TERM commodity via equation (2):

$$(2) \quad \left\lfloor \sum_{k \in Linkage} \mathrm{H}^{(\mathrm{M})}_{\mathrm{c,k}} \right\rfloor p^{(Term)*}_{(c,2)r} = \sum_{t \in Linkage} \mathrm{H}^{(\mathrm{M})}_{\mathrm{c,t}} \, p^{(Linkage)*}_{(t,2)} \qquad (c \in \mathrm{COM}, r \in \mathrm{REG})$$

where $\mathrm{H}^{(\mathrm{M})}_{\mathrm{c,k}}$ is a matrix of values showing the distribution of imports of TERM commodity *c* across LINKAGE commodities *k*; $p^{(Term)*}_{(c,2)r}$ is the percentage change in the foreign currency price of TERM commodity *c* used in region *r*; and $p^{(Linkage)*}_{t,2}$ is the percentage change in the foreign currency price of TERM commodity t (values for which are reported in column 3 of Table 1). Results for $p^{(Term)*}_{c,2}$ are reported in column 2 of Appendix Table 3. Notice that in equation (1) the exogenous percentage movements in the foreign currency price of commodity *c* ($p_{(c,2)r}^{(Term)*}$) are assumed to be identical across all regions, a feature of our shocks that assists in the interpretation of regional results.

Translating LINKAGE results for foreign currency export prices into TERM shocks is more complicated. As Horridge and Zhai (2006) argue with the help of Appendix Figure 2, the appropriate things to communicate to the national model are the willingness-to-pay shifts implicit in the price and quantity movements produced by the global model. Horridge and Zhai show that these can be calculated via the formula:

(3) $fp_t^{(Linkage)} = p_t^{(Linkage)*} + q_t^{(Linkage)*} / \eta_t^{(Linkage)}$

where $fp_t^{(Linkage)}$ is the percentage vertical shift in the export demand schedule for LINKAGE commodity *t*; $p_t^{(Linkage)*}$ is the percentage change in the foreign currency export price for LINKAGE commodity *t*; $q_t^{(Linkage)*}$ is the percentage change in the quantity of exports of LINKAGE commodity *t*; and $\eta_t^{(Linkage)}$ is the export demand elasticity for LINKAGE commodity *t*. Unlike national models, where the export demand elasticity typically appears as an explicit parameter, in global models like LINKAGE, $\eta_t^{(Linkage)}$ is implicit in the theory and parameters governing how agents in each country substitute between alternative sources of supply for each commodity. We explain our method for calculating $\eta_t^{(Linkage)}$ in the Appendix. Column (4) of Table 1 reports our $\eta_t^{(Linkage)}$ estimates.

The results for $fp_t^{(Linkage)}$ are translated to vertical shifts for TERM commodities, $f_c^{(4)}$, via equation (4):

$$(4) \quad \left[\sum_{k \in Linkage} \mathrm{H}_{\mathrm{c,k}}^{(\mathrm{X})}\right] f_{c,r}^{(4)} = \sum_{t \in Linkage} \mathrm{H}_{\mathrm{c,t}}^{(\mathrm{X})} \, fp_t^{(Linkage)} \qquad (c \in \mathrm{COM}, r \in \mathrm{REG})$$

where $\mathrm{H}_{\mathrm{c,k}}^{(\mathrm{X})}$ is a matrix of values showing the distribution of the value of TERM exports of commodity *c* across LINKAGE commodities *k*; $f_{c,r}^{(4)}$ is the vertical shift in the TERM export demand schedule for commodity *c* from region *r*; and $fp_t^{(Linkage)}$ is the vertical shift in foreign demands for Australian exports implicit in the LINKAGE simulation results reported in the first two columns of Table 1. Results are reported in column 1 of Appendix Table 3. Like equation (2), equation (4) assumes that the movements in commodity-specific export demand schedules ($f_{c,r}^{(4)}$) are identical across regions. This is helpful in interpreting the regional results below.

Model closure

We use a long-run comparative-static closure of TERM. This closure has the following characteristics:

- Physical capital is in elastic supply to each regional industry at exogenous rates of return;
- Agricultural land supplies are exogenous and land rental rates are endogenous;
- National employment is exogenous and the national real wage is endogenous;
- National population is exogenous and, subject to this constraint, regional populations follow regional employment outcomes;
- Labour is largely free to move between regions, although there is some regional stickiness in labour supply by allowing the gap between the regional wage and the national wage to be positively related to the movement in regional employment;
- Regional industry investment/capital ratios are exogenous and national investment is endogenously determined as the sum of regional industry investments;
- National consumption (public plus private) is a fixed proportion of gross national disposable income and, subject to this national constraint, private consumption at the regional level is indexed to regional income; and
- The ratio of real public consumption spending to real private consumption spending in each region is exogenous.

Results: effects of distortions on incomes of Australian farmers and rural areas

To understand the impacts through the terms of trade effects on Australia of the rest of the world‟s farm and trade policies, we begin with the macroeconomic effects before turning to the sectoral and regional results. The macro impacts are decomposed into two effects: those attributable to changes in demand for Australian exports (column 1 of Table 2); and, those attributable to changes in the prices Australia pays for its imports (column 2). Column 3 reports the sum of those two effects.

Removal of distortions in global goods markets has a favourable effect on Australia"s terms of trade: they improve by 1.8 percent, made up of a 2.3 percent improvement in export prices and offset by a 0.5 percent change in import prices (Table 2, row 8). The increasing demand for agricultural exports lifts rental rates on agricultural land, by almost one-quarter (24 percent, row 14). Together with the increase in the terms of trade, this encourages expansion of the long run national capital stock (row 3). With the capital stock higher than otherwise, so too is real GDP (row 1). The positive movements in real GDP and the terms of trade account for the positive outcome for real consumption (row 4), which rises by 0.5 per cent relative to what it would otherwise have been. Approximately 0.35 percentage points of the total outcome for real consumption is attributable to the positive terms of trade outcome, with the remaining 0.15 percentage points due to the increase in real GDP. The strong positive movement in the terms of trade allows the real GNE outcome to exceed the real GDP outcome. This accounts for the movement towards deficit in the real balance of trade, which is expressed as a contraction in the aggregate volume of exports and an expansion in aggregate import volume (rows 6 and 7, column 3). The mechanism that achieves this is real appreciation, amounting to 2.4 percent (row 9 of Table 2).

That real appreciation of the exchange rate means tradable sectors whose prices do not rise much could be under pressure to contract. And indeed this is what happens.

The bias towards agriculture in the improvement in Australia‟s terms of trade ensures that output of agricultural and food manufacturing industries expand, but the real exchange rate appreciation causes other main trade-exposed sectors to contract. This can be seen from Figure 5, where it is evident that virtually all agricultural and food industries expand (with dairying and rice benefiting most) but other manufacturing output shrinks by about 1 percent overall, and mining output shrinks by 2 percent.

Our modelling assumes all regions within Australia experience the same commodity-specific percentage changes in export and import prices from removal of world agricultural and other trade distortions. As a result, regional differences in the industrial composition of local economic activity determine much of the dispersion in regional economic impacts.[4] That is, regional income effects are strongly positive for rural regions, slightly negative for mining-intensive regions (the less-agricultural regions of Western Australia and South Australia, the Northern Territory, and Mackay and Fitzroy in Queensland), and mixed for urban regions (Figure 5). The urban results depend among other things on the extent to which an urban centre is specialized in servicing more the agricultural sector (as with Adelaide and Melbourne) rather than the mining sector (as in Perth and Darwin, which is where many miners live when they are not working on remote mine sites). In terms of geography, these output results are reported also on the map of Australia (Figure 6).

[4] Adams, Horridge and Parmenter (2000) show that an industry can make a positive contribution to a region‟s relative growth rate if it is a fast (slow)-growing industry and is over (under)-represented in the region, or if it grows more quickly in the region than it does in the nation as a whole. In applying the LINKAGE model results to the bottom-up regional model TERM, we had no basis for differentiating the region-specific shocks to commodity-specific import and export prices. Hence, with the sizes of commodity-specific movements in import and export prices the same across regions, the share effect plays a dominant role in explaining the above differences in gross regional product (GRP) outcomes.

Notice from Figure 5 that the income gains to rural areas are by no means uniform. Indeed there is a wide variation, ranging from less than 0.1 percent in Far North Queensland (where mining also occurs – see Appendix Table 2) to more than 4 percent in the agriculturally lush Western Districts of Victoria. Again this reflects the regional differences in the industrial composition of local economic activity, given the wide range of output changes shown in Figure 5. It also correlates with the regions most adversely affected by drought recently (see Horridge, Madden and Wittwer 2005) and by Dutch-disease effects flowing from the mining boom (Horridge and Wittwer 2008).

The bottom line

The key net effects of the changes reported above are that real net rural incomes in Australia would be 1.2 percent higher, and real returns to agricultural land in particular would be 24 percent higher, in the absence of price distortions resulting from agricultural and trade policies in the rest of the world.[5] Clearly those policies abroad are hurting Australia"s rural households, adding to the adverse impact of drought over recent years (Horridge, Madden and Wittwer 2005, Horridge and Wittwer 2008), but to varying extents depending on the product specialization of various regions and households. The upturn in international food prices in 2007-08 brought a welcomed reprieve, which Australian farmers and trade negotiators hope will help revive the agricultural part of the

[5] Even though incomes in mining regions would be 0.7 percent lower on average, those regions currently enjoy incomes that are substantially higher than in the rest of Australia and so could well absorb that shock.

multilateral trade negotiations under WTO‟s Doha Development Agenda. The above results vindicate the continuing push by Australia‟s rural communities for multilateral agricultural trade liberalization, and give additional reason for doing so to those regions most adversely affected by policies abroad.

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Table 1: Impact of rest of world‟s trade policies on prices and volume of Australia‟s exports and imports, 2004

(LINKAGE Model results, long-run percentage change relative to baseline)

LINKAGE Model commodity:	Foreign currency export prices (1)	Export volumes (2)	Foreign currency import prices (3)	LINKAGE export demand elasticities (4)
Paddy rice	4.0	28.7	n.a.	6.2
Wheat	4.2	-7.9	n.a.	7.7
Other grains	4.3	29.1	n.a.	6.7
Oilseeds	4.3	-34.2	5.2	5.5
Sugar cane	n.a.	n.a.	n.a.	6.6
Plant-based fibres	4.2	27.6	-1.3	8.3
Vegetables and fruits	4.2	4.5	2.3	5.3
Other crops	4.2	0.4	1.2	5.5
Cattle sheep etc.	4.0	-7.9	8.3	5.2
Other livestock	4.0	-11.0	1.0	5.4
Raw milk	n.a.	n.a.	-1.3	5.5
Wool	4.2	10.9	10.0	3.7
Beef and sheepmeat	3.3	59.3	11.2	5.4
Other meat products	3.2	19.4	0.6	5.0
Vegetable oils and fats	2.6	12.6	1.0	5.5
Dairy products	3.2	243.8	12.1	5.5
Processed rice	2.9	-3.2	3.6	6.1
Refined sugar	2.9	6.2	1.1	8.2
Other food, beverages and tobacco	2.7	54.7	3.4	5.4
Other primary products	2.6	-10.2	4.0	6.0
Textiles and wearing apparel	2.3	6.5	-0.3	5.7
Other manufacturing	2.3	-6.5	0.1	5.7
Services	2.6	-10.9	-0.3	2.9

Source: Anderson, Valenzuela and van der Mensbrugghe (2009)

Table 2: National macroeconomic results, Australia, 2004

(percent)

	Due to changes in:		
	Export prices	**Import prices**	***Total change***
Real GDP at market prices	0.19	-0.03	0.15
Aggregate employment	0.00	0.00	0.00
Aggregate capital stock	0.32	-0.06	0.27
Real consumption (private & public)	0.63	-0.14	0.49
Real investment	0.64	-0.09	0.54
Real exports	-0.67	-0.11	-0.77
Real imports	1.60	-0.56	1.04
Terms of trade	2.30	-0.53	1.77
Real exchange rate	2.54	-0.16	2.37
Nominal exchange rate (foreign currency/$AUD)	2.08	-0.02	2.06
Consumption deflator (private & public)	0.01	-0.03	-0.02
Investment price deflator	-0.29	-0.01	-0.30
Rental price of capital	-0.45	0.00	-0.45
Rental price of land	23.7	0.56	24.3

Source: Authors" calculations using the TERM Model

Table 3: Aggregate sectoral real income effects, Australia, 2004

(percent)

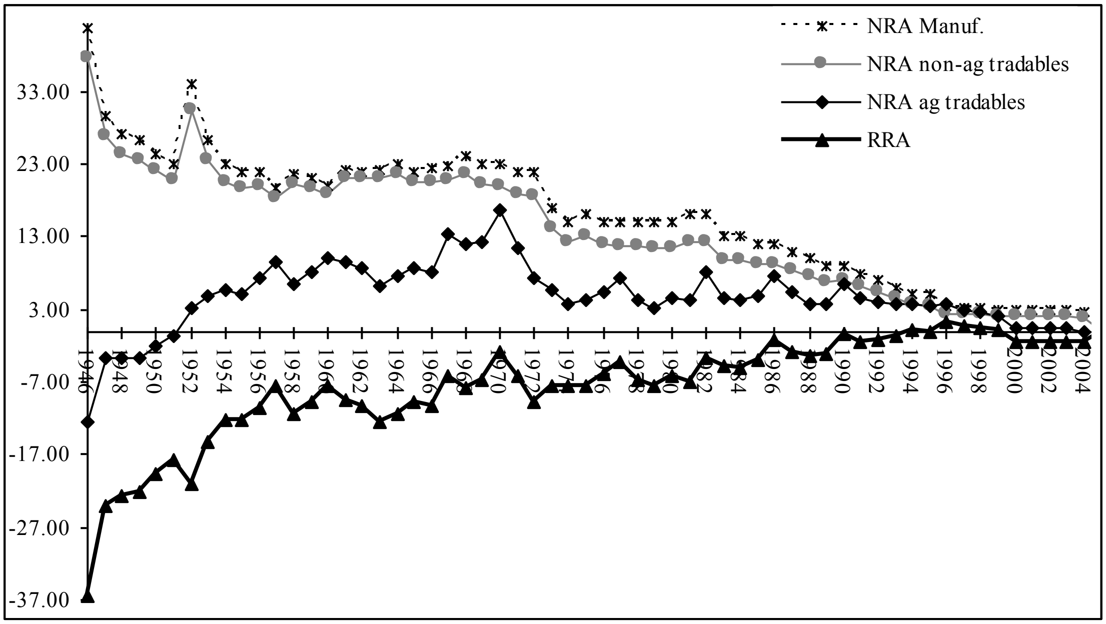
	Change in net income
Real net *farm* income (agricultural value added)	17.45
Real net *non-farm* income (non-agricultural value added)	-0.08
of which food processing	*6.47*
Overall real national income[a]	**0.49**

[a] Nominal GDP at market prices, deflated by the price of consumption

Source: Authors‟ calculations using the TERM Model

Figure 1: Nominal rates of assistance to manufacturing, all non-agricultural tradables, all agricultural tradable industries, and relative rate of assistance,[a] Australia, 1946-47 to 2004-05

(percent)

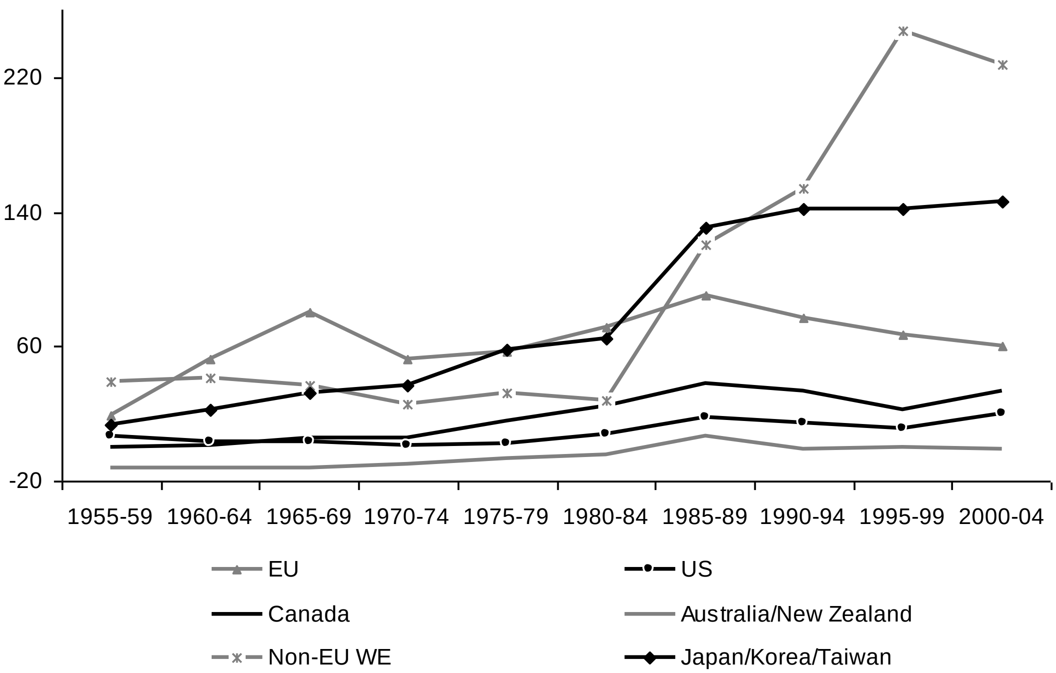


[a] The RRA is defined as 100*[(100+NRAag^t)/(100+NRAnonag^t) – 1]

Source: Anderson, Lloyd and MacLaren (2007)

Figure 2: Relative rates of assistance to agriculture,[a] Australia and other high-income countries, 1955 to 2004

(percent)



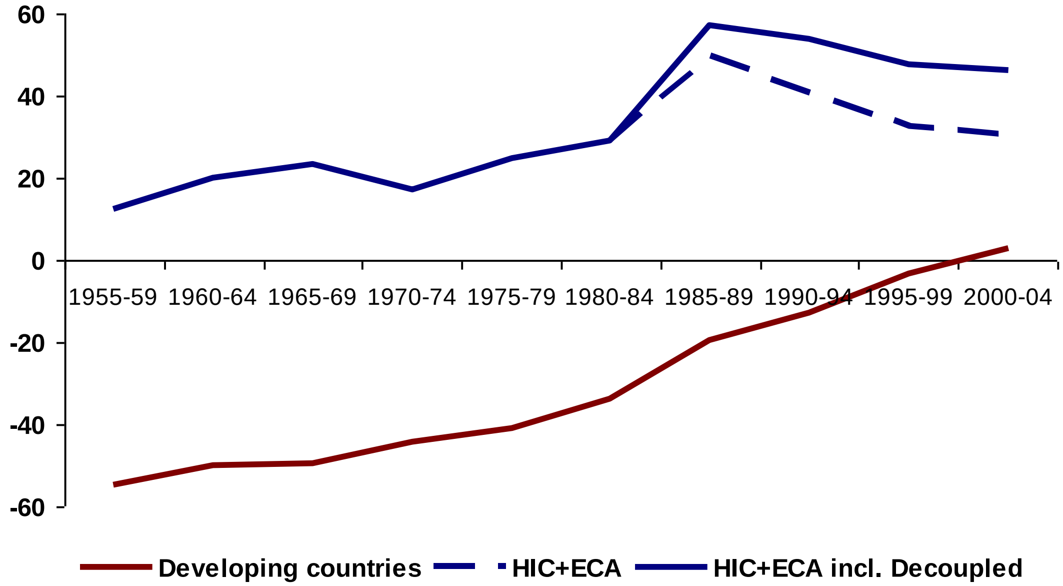
(-0.76) (-0.28) (0.10) (0.69) (0.79)

[a] The RRA is defined as $100*[(100+NRAag^t)/(100+NRAnonag^t) - 1]$. The numbers in brackets are indexes of agricultural comparative advantage, defined as net exports as a ratio of the sum of exports and imports of agricultural and processed food products (hence bound between -1 and +1), averaged over the twenty years from 1960, from Sandri, Valenzuela and Anderson (2006).

Source: Anderson, Lattimore, Lloyd and MacLaren (2009), Gardner (2009), Hayami and Honma (2009), Josling (2009).

Figure 3: Relative rates of assistance to agriculture,[a] high-income[b] and developing countries, 1955 to 2004

(percent)

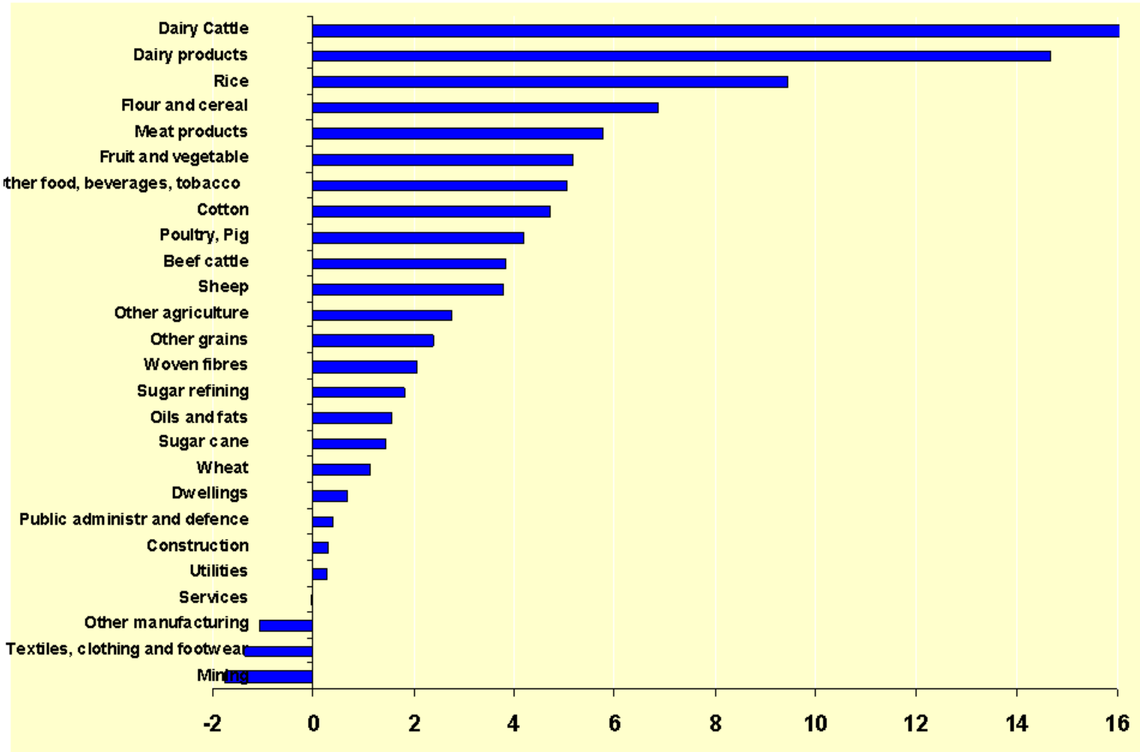


[a] The RRA is defined as $100*[(100+NRAag^t)/(100+NRAnonag^t) - 1]$

[b] HIC+ECA is the sum of high-income OECD member countries plus Turkey and the transition economies of Europe and Central Asia (that is, Eastern Europe, and the former Soviet Union).

Source: Anderson (2009a)

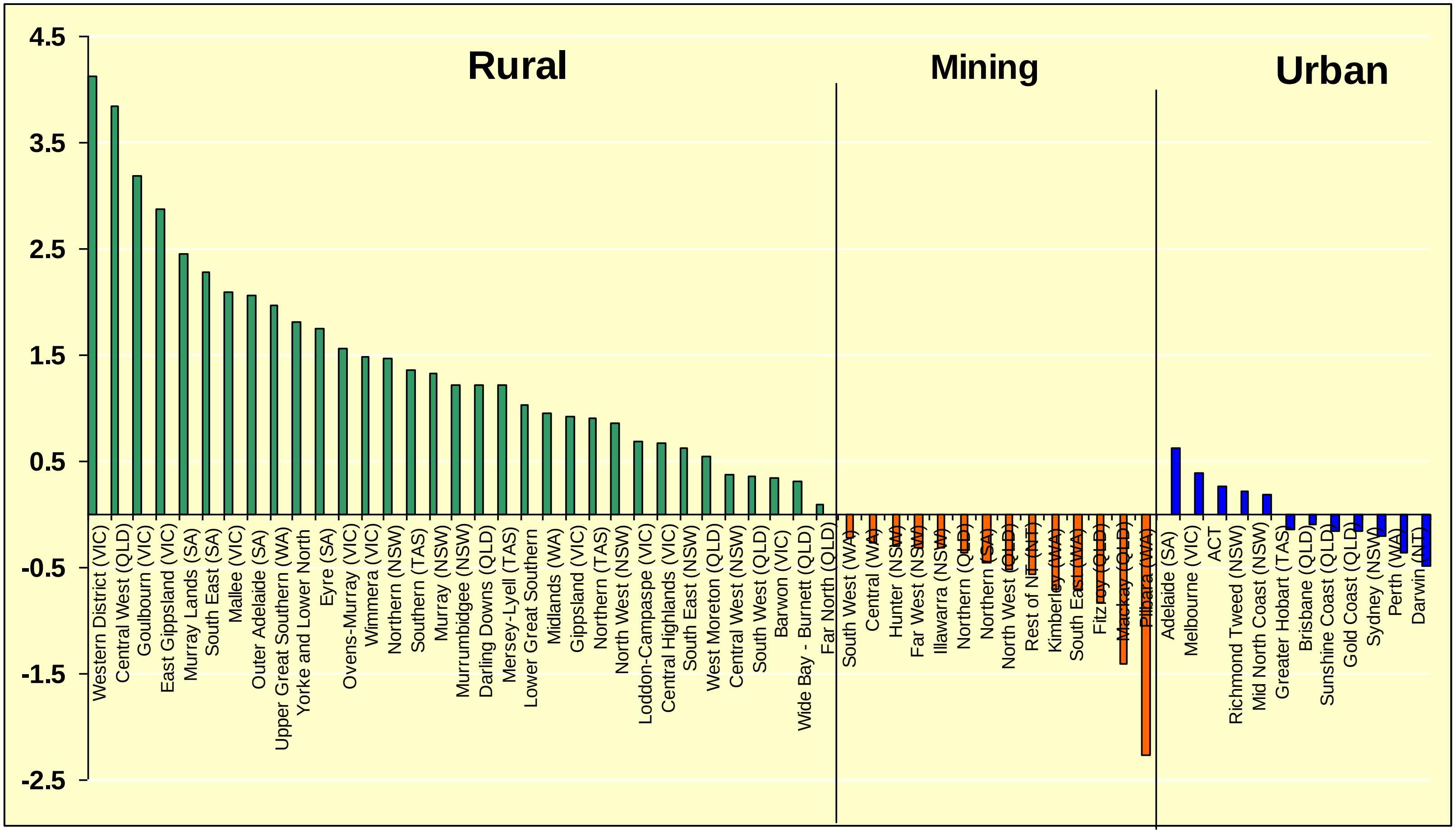
Figure 4: Changes in sectoral output, Australia, 2004
(percent)



Source: Authors‟ TERM Model results

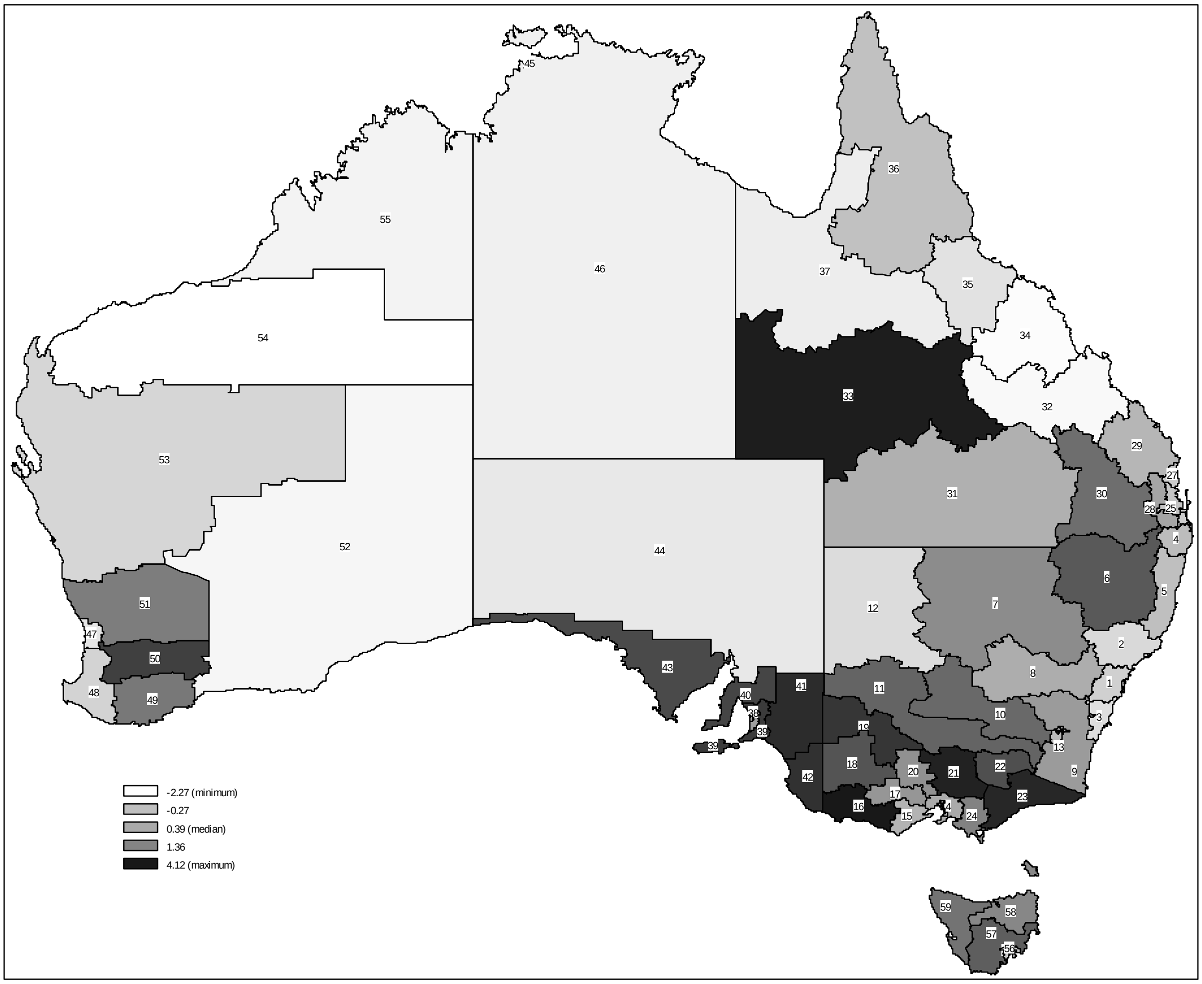
Figure 5: Regional income impacts in Australia, 2004

(percent change)



Source: Authors" TERM Model results

Figure 6: Geographical distribution of real gross regional product outcomes in Australia, 2004



Source: Authors‟ TERM Model results. See Appendix Table 1 for names of regions.

APPENDIX: Derivation of export demand elasticities implicit in LINKAGE's parameters and theoretical structure

Economic agents within each country in LINKAGE face a two-stage sourcing decision problem. This is described by Appendix Figure 1. First, agents assemble a composite commodity *i* via a CES aggregation of domestic commodity *i* and a composite of imported commodity *i*. Second, the composite import is assembled from alternative foreign sources via a CES aggregation function.

Following the approach outlined in Dixon and Rimmer (2002, pp. 222-25) we derive the Australia-specific export demand elasticities implicit in LINKAGE as follows. On the assumption that only the price of the Australian good is varying, from the familiar form for the linearised cost-minimising demand equations implicit in the economic problem represented in the bottom nest in Appendix Figure 1, we know that demand for the Australian good is given by:

(1) $$x_{i,Aust} = x_{i,Imp} - \phi_i^{(2)}(p_{i,Aust} - S_{i,Aust}\,p_{i,Aust})$$

or

(2) $$x_{i,Aust} = x_{i,Imp} - \phi_i^{(2)}(1 - S_{i,Aust})\,p_{i,Aust}$$

where $S_{i,Aust}$ is Australia"s share in world trade in *i*.

From the top nest, we know that demand for the imported good is given by:

(3) $$x_{i,Imp} = x_i - \phi_i^{(1)}(p_{i,Imp} - p_i)$$

On the assumption that only the price of the Australian good is varying (3) simplifies to:

(4) $$x_{i,Imp} = x_i - \phi_i^{(1)}(S_{i,Aust}\,p_{i,Aust} - S_{i,Imp}S_{i,Aust}\,p_{i,Aust})$$

which simplifies to:

(5) $x_{i,Imp} = x_i - \phi_i^{(1)} S_{i,Aust} S_{i,Dom} p_{i,Aust}$

Finally, we assume that demand for X_i is sensitive to its own price. We represent this with the following constant elasticity demand schedule

(6) $x_i = -\eta_i \, p_i$

Assuming that only the price of the Australian good is varying, this simplifies to:

(7) $x_i = -\eta_i \, S_{i,Aust} S_{i,Imp} p_{i,Aust}$

Substitute (7) and (4) into (2)

(8) $x_{i,Aust} = -[\eta_i \, S_{i,Aust} S_{i,Imp} + \phi_i^{(1)} S_{i,Aust} S_{i,Dom} + \phi_i^{(2)} (1 - S_{i,Aust})] p_{i,Aust}$

In equation (8), $p_{i,Aust}$ is the purchaser‟s price in the foreign country of Australian good *i*. Movements in this price can be divided into two parts: movements in the f.o.b price of Australian good *i*, and movements in transaction charges and taxes related to getting the good from Australia to the user in the foreign country. In the absence of changes in such charges and taxes, $p_{i,Aust}$ depends only on $p_{i,Aust}^{fob}$, the percentage change in the f.o.b price of Australian good i, and $S_{i,Aust}^{fob}$, the share of the f.o.b price in the foreign country purchaser‟s price:

(9) $p_{i,Aust} = S_{i,Aust}^{fob} p_{i,Aust}^{fob}$

Substituting (9) into (8) we have:

(10) $x_{i,Aust} = -[\eta_i \, S_{i,Aust} S_{i,Imp} + \phi_i^{(1)} S_{i,Aust} S_{i,Dom} + \phi_i^{(2)} (1 - S_{i,Aust})] S_{i,Aust}^{fob} p_{i,Aust}^{fob}$

Hence, the Australian export demand elasticity for good *i* implicit in the LINKAGE theory and database is:

$$\eta_t^{(Linkage)} = -[\eta_i S_{i,Aust} S_{i,Imp} + \phi_i^{(1)} S_{i,Aust} S_{i,Dom} + \phi_i^{(2)}(1 - S_{i,Aust})] S_{i,Aust}^{fob}$$

and so its value can be determined from the LINKAGE values of:

η_i The elasticity of demand for good i (irrespective of source) in the foreign country. Typically, we might expect the value for η_i to be low, perhaps around 0.10.

$S_{i,Aust}$ Australia‟s share in world trade for good *i*. For wool, the value for $S_{i,Aust}$ is quite high (around 0.65). For most commodities it is quite low (around 0.05)

$S_{i,Imp}$ The import share in world usage of commodity i. A typical value for $S_{i,Imp}$ is around 0.15.

$S_{i,Dom}$ The domestic sourcing share in world usage of commodity i (=1- $S_{i,Imp}$). A typical value for $S_{i,Dom}$ is around 0.85.

$\phi_i^{(1)}$ The elasticity of substitution between domestic and imported varieties of good i. In LINKAGE, a typical value for $\phi_i^{(1)}$ is around 4.

$\phi_i^{(2)}$ The elasticity of substitution between alternative foreign sources of supply for imported good i. In LINKAGE, a typical value for $\phi_i^{(2)}$ is around 8.

$S_{i,Aust}^{fob}$ The share of the f.o.b price in the foreign country purchaser‟s price of good i. A typical value for $S_{i,Aust}^{fob}$ is 0.7.

Hence, in LINKAGE, a typical value for the Australian export demand elasticity for commodity *t* is:

$$\eta_t^{(Linkage)} = -[0.10 \times 0.05 \times 0.15 + 4 \times 0.05 \times 0.85 + 8 \times (1 - 0.05)] \times 0.7 = -7.7$$

Appendix Table 1: Regional and sectoral classification in the TERM model of Australia‟s economy

Regional classification		Sectoral classification
Rural	**Mining**	1. Sheep
6. Northern (NSW)	2. Hunter (NSW)	2. Wheat
7. North West (NSW)	3. Illawarra (NSW)	3. Other grains
8. Central West (NSW)	12. Far West (NSW)	4. Rice
9. South East (NSW)	32. Fitzroy (QLD)	5. Beef cattle
10. Murrumbidgee (NSW)	34. Mackay (QLD)	6. Dairy cattle
11. Murray (NSW)	35. Northern (QLD)	7. Other livestock
15. Barwon (VIC)	37. North West (QLD)	8. Cotton
16. Western District (VIC)	44. Northern (SA)	9. Vegetables and fruit
17. Central Highlands (VIC)	46. Rest of NT (NT)	10. Sugar cane
18. Wimmera (VIC)	48. South West (WA)	11. Other agriculture
19. Mallee (VIC)	52. South East (WA)	12. Mining
20. Loddon-Campaspe (VIC)	53. Central (WA)	13. Meat products manuf
21. Goulbourn (VIC)	54. Pilbara (WA)	14. Dairy products manuf
22. Ovens-Murray (VIC)	55. Kimberley (WA)	15. Fruit and vegetable manuf
23. East Gippsland (VIC)		16. Oils and fats manuf
24. Gippsland (VIC)		17. Flour and cereal manuf
28. West Moreton (QLD)	**Urban**	18. Other food, bev. & tobacco
29. Wide Bay-Burnett (QLD)	1. Sydney (NSW)	19. Sugar refining
30. Darling Downs (QLD)	4. Richmond Tweed (NSW)	20. Woven fibres
31. South West (QLD)	5. Mid North Coast (NSW)	21. Textiles, clothing & footwear
33. Central West (QLD)	13. ACT	22. Other manufacturing
36. Far North (QLD)	14. Melbourne (VIC)	23. Utilities
39. Outer Adelaide (SA)	25. Brisbane (QLD)	24. Construction
40. Yorke, Lower North (SA)	26. Gold Coast (QLD)	25. Dwellings
41. Murray Lands (SA)	27. Sunshine Coast (QLD)	26. Public admin. & defence
42. South East (SA)	38. Adelaide (SA)	27. Services
43. Eyre (SA)	45. Darwin (NT)	
49. Lower Great Southern (WA)	47. Perth (WA)	
50. Upper Great Southern (WA)	56. Greater Hobart (TAS)	
51. Midlands (WA)		
57. Southern (TAS)		
58. Northern (TAS)		
59. Mersey-Lyell (TAS)		

[a] Numbers for regions refer to those shown on the map in Figure 6

Source: TERM model‟s database, drawn from Australian Bureau of Statistics data

Appendix Table 2: Sectoral shares of gross regional product and regional shares of GDP and population, Australia, 2004

	Sectoral shares (%, relative to sectoral share of national GDP)			**Share of national GDP (%)**	**Share of national popn (%)**
	Agri-culture	**Mining**	**Other sectors**		
Rural				**15.9**	**19.1**
CentlWestQLD	14.92	0.1	0.56	0.1	0.1
UpperGtSthWA	14.14	0.1	0.58	0.1	0.1
MidlandsWA	13.60	0.3	0.52	0.4	0.3
EyreSA	10.96	0.2	0.73	0.2	0.2
YorkLwrNthSA	10.33	0.2	0.74	0.2	0.2
WimmeraVIC	9.80	0.4	0.72	0.3	0.4
SouthEastSA	8.78	0.3	0.79	0.3	0.3
WestnDistVIC	7.99	0.5	0.82	0.5	0.5
SouthWestQLD	7.80	0.1	0.39	0.3	0.1
SouthernTAS	7.36	0.2	0.86	0.1	0.2
MalleeVIC	6.97	0.3	0.87	0.4	0.3
DarlDownsQLD	6.41	1.1	0.81	1.1	1.1
NorthernNSW	6.25	0.9	0.89	0.8	0.9
MurrayLndsSA	6.20	0.3	0.90	0.3	0.3
LowerGtSthWA	5.49	0.3	0.87	0.3	0.3
NorthWestNSW	5.42	0.6	0.81	0.5	0.6
GoulbournVIC	4.87	0.8	0.95	0.9	0.8
EastGippsVIC	4.55	0.3	0.93	0.3	0.3
MurrayNSW	3.92	0.6	0.98	0.5	0.6
MrmbidgeeNSW	3.58	0.7	0.99	0.7	0.7
WideByBntQLD	3.51	1.3	0.89	0.9	1.3
OtrAdelaidSA	3.38	0.6	0.99	0.5	0.6
MerseyLylTAS	3.19	0.6	0.93	0.4	0.6
WMoretonQLD	3.11	0.4	0.88	0.3	0.4
CentrlWstNSW	2.98	0.9	0.87	0.9	0.9
NorthernTAS	2.79	0.7	1.01	0.5	0.7
OvensMrryVIC	2.33	0.5	1.04	0.4	0.5
GippslandVIC	2.19	0.8	0.95	1.0	0.8
FarNorthQLD	2.03	1.2	0.99	1.0	1.2
SouthEastNSW	1.76	1.0	1.06	0.9	1.0
CentHilndVIC	1.64	0.6	1.05	0.6	0.6
LoddonCmpVIC	1.54	1.0	1.04	0.7	1.0
BarwonVIC	1.34	1.3	1.07	1.2	1.3

Appendix Table 2 (cont.): Sectoral shares of gross regional product, Australia, 2004

	Sectoral shares (%, relative to sectoral share of national GDP)			**Share of national GDP (%)**	**Share of national popn (%)**
	Agri-culture	**Mining**	**Other sectors**		
Mining				**13.1**	**9.0**
PilbaraWA	0.06	11.1	0.15	1.7	0.2
KimberleyWA	1.83	8.69	0.30	0.4	0.2
FarWestNSW	0.97	7.39	0.44	0.2	0.1
SouthEastWA	1.46	6.90	0.47	0.5	0.3
NorthWestQLD	3.84	6.81	0.39	0.3	0.2
MackayQLD	1.17	6.65	0.50	1.4	0.8
CentralWA	3.39	6.24	0.46	0.5	0.3
NorthernSA	2.30	4.87	0.61	0.5	0.4
FitzroyQLD	2.06	4.29	0.67	1.6	1.0
RoNT	0.68	4.07	0.74	0.8	0.7
SouthWestWA	1.39	2.40	0.86	1.1	1.0
IllawarraNSW	0.14	2.0	1.05	1.8	2.0
NorthernQLD	1.13	1.88	0.92	1.0	1.0
HunterNSW	0.36	1.51	0.98	3.1	3.0
Urban				**71.0**	**72.0**
SydneyNSW	0.05	20.7	1.12	22.0	20.7
ACT	0.02	1.6	1.12	2.0	1.6
AdelaideSA	0.21	5.5	1.11	4.6	5.5
GrtHobartTAS	0.48	1.0	1.10	0.7	1.0
MelbourneVIC	0.11	18.2	1.10	17.7	18.2
RichTweedNSW	0.80	1.1	1.09	1.8	1.1
MidNthCstNSW	0.76	1.4	1.09	0.8	1.4
GoldCoastQld	0.54	2.5	1.07	2.0	2.5
BrisbaneQLD	0.11	8.8	1.07	8.2	8.8
SunshnCstQld	0.72	1.4	1.04	1.1	1.4
PerthWA	0.21	7.3	0.97	7.8	7.3
DarwinNT	1.04	0.3	0.88	0.5	0.3
National average shares	**3.2**	**7.8**	**89.0**	**100.0**	**100.0**

Urban = Capital cities and other regions with relative share >1.03 unless rural relative share is greater (viz. BarwonVIC, SouthEastNSW, CentHilndVIC, LoddonCmpVIC, OvensMrryVIC)

Mining = regions with relative share >1.5 unless rural relative share is greater (SouthWestQLD, CentrlWstNSW), or it is a capital city (viz. Perth, Darwin)

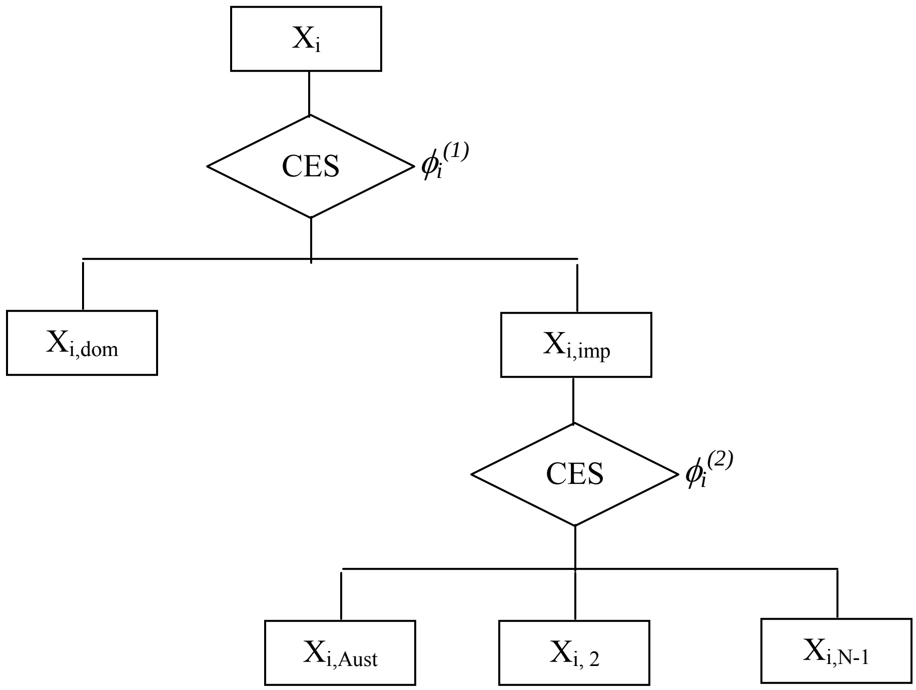
Source: TERM model"s database, drawn from Australian Bureau of Statistics data

Appendix Table 3: Commodity-specific import price shocks, and estimates of export price impacts on Australia, 2004

Australian TERM Model sector:	**Vertical (willingness-to-pay) shifts in export demand**	**Changes in import prices**
1. Sheep	9.93	10.59
2. Wheat	3.14	0.00
3. Other grains	5.02	2.58
4. Rice	8.33	0.00
5. Beef cattle	2.34	8.25
6. Dairy cattle	0.00	-1.31
7. Other livestock	1.74	1.03
8. Cotton	7.31	-1.30
9. Vegetables and fruit	5.03	2.32
10. Sugar cane	0.00	0.00
11. Other agriculture	4.28	0.94
12. Mining	0.75	4.01
13. Meat products manufacturing	11.18	5.90
14. Dairy products manufacturing	29.08	12.05
15. Fruit and vegetable manufacturing	11.43	3.41
16. Oils and fats manufacturing	4.85	0.98
17. Flour and cereal manufacturing	10.74	3.52
18. Other food, beverages, and tobacco manufacturing	11.43	3.41
19. Sugar refining	3.66	1.10
20. Woven fibres	7.14	9.95
21. Textiles, clothing and footwear	3.45	-0.34
22. Other manufacturing	1.10	0.09
23. Utilities	-1.37	-0.27
24. Construction	-1.37	-0.27
25. Dwellings	-1.37	-0.27
26. Public administration and defence	-1.37	-0.27
27. Services	-1.37	-0.27

Source: Derived by the authors" from Linkage model results reported above in Table 1 (from Anderson, Valenzuela and van der Mensbrugghe 2009).

Appendix Figure 1: The LINKAGE Model‟s commodity sourcing structure

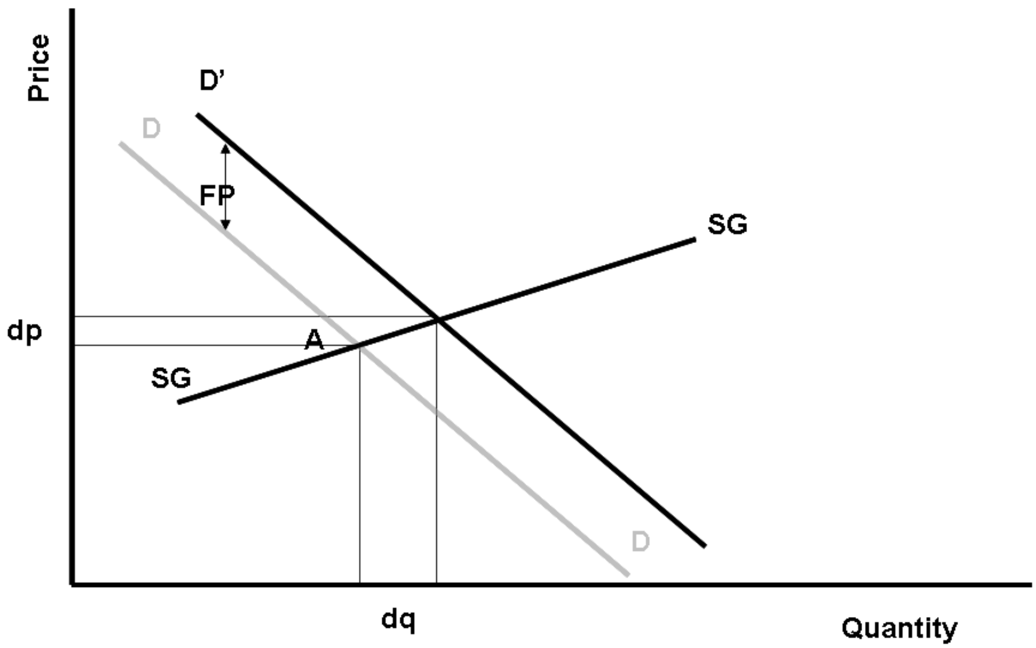


where:

X_i	is a particular country‟s demand for commodity i;
CES	is a constant elasticity of substitution function;
$X_{i,Dom}$	is the quantity of commodity i sourced from domestic producers;
$X_{i,\mathrm{Imp}}$	is the quantity of commodity i sourced from foreign producers;
$\phi_i^{(1)}$	is the Allen elasticity of substitution between domestic and imported *i*;
$\phi_i^{(2)}$	is the Allen elasticity of substitution between alternative foreign sources of imported *i*;
$X_{i,Aust}$	is the quantity of imported i that is supplied by Australia; and
$X_{i,r}$	is the quantity of imported i that is supplied by country *r*.

Source: van der Mensbrugghe (2005)

Appendix Figure 2: Transmitting export results from the global to the national model



$$fp_t^{(Linkage)} = p_t^{(Linkage)*} + q_t^{(Linkage)*} / \eta_t^{(Linkage)}$$

where $fp_t^{(Linkage)}$ is the percentage vertical shift in the export demand schedule for LINKAGE commodity *t*; $p_t^{(Linkage)*}$ is the percentage change in the foreign currency export price for LINKAGE commodity *t*; $q_t^{(Linkage)*}$ is the percentage change in the quantity of exports of LINKAGE commodity *t*; and $\eta_t^{(Linkage)}$ is the export demand elasticity for LINKAGE commodity *t*.

Source: Horridge and Zhai (2005)