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Medium- and Long-run Consequences for Australia of an APEC Free-Trade Area: CGE Analyses using the GTAP and MONASH Models

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General Paper No. G-111 Revised December 1996

ISSN 1031 9034ß ISBN 0 7326 0724 8

Reissued December 1999

The Centre of Policy Studies (COPS) is a research centre at Monash University devoted to quantitative analysis of issues relevant to Australian economic policy.

Explanatory Note

CoPS/Impact General Paper No. 111 was first issued in its present form in 1996. An earlier version under the authorship of Huff, McDougall, Pearson and Powell appeared in Proceedings of Pan-Pacific Conference XII, Dunedin and Queenstown, New Zealand (Sang M. Lee, Andre Everett and Victor Gray, eds) in May 1995, pages 244-248.

Abstract

Two large applied general equilibrium models, *GTAP* and *MONASH,* are used in this paper to simulate the elimination of trade barriers among the members of APEC. These models focus respectively on global trading relations and on the detailed sectoral, occupational, and regional dimensions of the Australian economy.

We find that the mature industrialized members of APEC are likely to experience modest increases in real GDP from the trade reform, but that there is scope for very big advances in real GDP in some Asian member countries (especially those with high initial trade barriers against imports of capital goods). Relative to base case, Thailand/ Philippines (treated as a single aggregate in these simulations) is projected (after an adjustment period of one to two decades) to have the potential for a 39 per cent rise in GDP due to the formation of an APEC trade block. Other countries reaching double figures are South Korea (14 per cent), New Zealand (11 per cent) and Indonesia (10.5 per cent). These increases are partly at the expense of non-APEC countries which experience on average a 1 per cent fall in GDP due to lost markets and deteriorating terms of trade.

A substantial limitation of these projections is that we have not been able to keep track of the ownership of assets; thus rises in GDP do not necessarily imply increases in welfare.

The potential long-run increases in APEC members' GDP are highly dependent on international capital mobility. Relative to the case of full mobility, limiting capital growth to what can be financed internally within regions causes the sizes of the projected increases to fall in all member regions except North America. In the case of Thailand/ Philippines, the 39 per cent increase falls dramatically to about 2.5 per cent.

The projected long-run rise in Australia's GDP when capital is mobile is about 3 per cent (relative to the no-APEC case). Considerable structural changes accompany this rise: milk and meat products do extremely well (with rises in real output of over 30 per cent relative to base case); traditionally highly protected industries (e.g., synthetic fibres, cotton yarns, footwear and motor vehicles) experience long-run falls of approximately 10 to 20 per cent. Over two thirds of the gain in the rise in the demand price for Australian milk products is due to the opening up of the Japanese market.

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1. INTRODUCTION

Meeting in Bogor, Indonesia, in November 1994, the heads of government of seventeen Pacific Rim countries committed themselves to establish by 1996 a program and timetable for the removal of impediments to trade within the region. Including the United States, Canada, Japan, parts of South and most of South-East Asia, APEC is a grouping accounting for about one half of the world's current economic activity. The membership of China and the rapidly growing 'tigers' of Asia means that the grouping — if it survives — will encompass more than half of the world's economic activity early in the new millennium. For countries such as Australia and New Zealand that have limited opportunities for increasing their traditional exports to Europe, APEC looms large as the way of the future.

During 1995 Australia became alarmed about a potential loss of momentum with the APEC initiative, to the point where, despite the Keating government's strong commitment to virtually universal free trade, it seemed to be prepared to consider membership of an APEC instituted as a preferential trading zone with external trade barriers.[1] The change of government in 1996 probably has not affected this stance. It is such a scenario that underlies the computer simulations reported in this paper: trade barriers are eliminated among the members of APEC, but no change in tariffs on imports from other countries into APEC countries occurs.

The two models used in this paper, *GTAP*[2] and *MONASH*[3] are large applied general equilibrium models. 'Large' here means that many tens of thousands of equations are solved simultaneously in each case. These models focus respectively on global trading relations and on the detailed sectoral, occupational, and regional dimensions of the Australian economy.

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* The authors are grateful to W. Jill Harrison for assistance with computing, and to Budiono Sri Handoko, Brian Parmenter, Jay Menon, Terrie Walmsley and an anonymous referee for helpful comments. Any errors or omissions are the sole responsibility of the authors. Research was supported in part by Australian Research Council grant no. A79231695.

1 *The Australian*, March 1st 1995, pp.1&2.

2 *GTAP* is documented in Hertel (1997). See especially Hertel and Tsigas (1997).

3 *MONASH* is the successor to the *ORANI* model — see Dixon, Parmenter, Sutton and Vincent (1982). An annotated listing of the *MONASH* model in the *TABLO* language is available in Centre of Policy Studies (1994); *TABLO* is the algebraic language used by the *GEMPACK* software suite used to solve many large economic models, including *MONASH*. For a brief introduction to *GEMPACK*, see Harrison and Pearson (1996a); comprehensive documentation is available in Harrison and Pearson (1996b). The source *TABLO* code for the *MONASH96* model is available on request from the first-mentioned author. Comprehensive documentation of this model should be available in mid-1997.

Applied general equilibrium models are designed specifically to work out how the relative prices of various inputs and outputs change under some shock, and the consequences of these changes on the input and output mixes of one or more economies. In this paper we use *GTAP* to provide the global context for the trade liberalizations, and *MONASH* to assess the detailed impacts on Australia.

The plan of the paper is as follows. In Section 2 we give some details of the pre-APEC data base from which we are working. Section 3 reports the APEC simulations from *GTAP* in stand-alone mode, while Section 4 contains results from the *MONASH* model driven by *GTAP* in a tops-down fashion. The latter simulations focus on Australia. The broad features of our modelling methodology are covered in passing in Sections 1-4; technicalities and detailed documentation are relegated to the appendices.

2. INITIAL TRADE PATTERNS AND BARRIERS

Our initial simulation uses the *GTAP* data base[4] which features statistically reconciled and balanced, bilateral trade data derived from United Nations trade statistics. The support and protection portion of the data base is derived from several sources and is not comprehensive. The main highlights of the protection data include bilateral import tariffs for non-agricultural merchandise trade based on the original, individual country submissions to the GATT for use in Uruguay Round negotiations; bilateral export tax equivalents of Multifibre Arrangement (MFA) import quotas; estimates of antidumping duties for Canada, the United States and the European Union; and agricultural support data based on measures developed by both the OECD and the Economic Research Service (ERS) of the U.S. Department of Agriculture[5].

The version of *GTAP* used here distinguishes the eleven regions shown in Table 1, and the thirty-seven commodities listed in Table 4. Aggregation to about this level is necessary to make computation feasible on a powerful personal computer. APEC encompasses the first ten regions in Table 1. A post-NAFTA version of the *GTAP* data base aggregated to this 37×11 level is employed in the top level simulation.

The levels of import protection present in the pre-simulation data base are described by Table 2. This table presents trade-weighted, bilateral import tariffs[6]. No clear pattern of protection emerges from this table except to show that prior to the implementation of APEC, no member region favoured other members over the ROW region. After APEC is implemented, the only tariffs remaining are those applied by ROW on imports from APEC members (last column) and those applied to imports from ROW into any APEC member region (bottom row).

In the *GTAP* simulations reported in Section 3, all tariffs (and tariff equivalents of other trade barriers) on APEC-sourced imports are removed by each APEC country. This matches one of the three simulations reported (but at a much higher level of commodity aggregation) by Young and Huff (1997).

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4 See Gehlhar *et al.* (1997) in Hertel (1997) for a detailed description of the *GTAP* data base.

5 Again see Gehlhar *et al.* (1997) for the methodology employed to develop the support and protection data found in *GTAP*.

6 Note that not all diagonal entries are zero. When several countries are aggregated into a single region in *GTAP*, intra-regional trade barriers remain.

Table 1: Regional Entities recognized in *GTAP* (as used in this paper)

Identifier	Countries in region
1. NAM	*North America* — United States, Canada & Mexico
2. JPN	Japan
3. AUS	Australia
4. NZL	New Zealand
5. CHN_HKG	China and Hong Kong
6. SKOR	South Korea
7. TWN	Taiwan
8. MYS_SGP	Malaysia and Singapore
9. THA_PHL	Thailand and the Philippines
10. IDN	Indonesia
11. ROW	The rest of the world

Table 2: Trade-weighted average, bilateral, import tariff rates for merchandise trade (per cent of cif values)[(a)]

	Region levying the tariff										
Region against which tariff is levied ↓	NAM	JPN	AUS	NZL	CHN_HKG	SKOR	TWN	MYS_SGP	THA_PHL	IDN	*ROW*
NAM	0.6	24.2	11.8	17.4	7.7	30.8	22.5	1.9	27	13.2	*7.3*
JPN	19.4	0	16.7	28.5	12.3	17.1	5.1	3.5	33.4	13.2	*13.8*
AUS	7.3	18	0	12	14.2	25.7	10.6	1.9	21.1	12	*5.7*
NZL	13.5	26.4	8.4	0	8.1	16.8	21.8	1.9	21.9	13.1	*20.6*
CHN_HKG	9.7	17.7	14.5	14.4	13.1	67.4	7.7	1.6	28	18.7	*9.2*
SKOR	8	7.7	14.8	18.9	8.8	0	7.1	3	30.8	16.7	*8.4*
TWN	9.6	11.2	12.7	23.3	12.5	16.7	0	4.7	38.5	18.1	*10*
MYS_SGP	5.3	3.4	12.6	29.8	6.6	25.8	6	3.7	28.5	10.8	*7.9*
THA_PHL	7	13.3	8.9	15.7	4.6	91.3	14.2	3.1	35.7	12.8	*12.5*
IDN	8.4	4.3	9	18.6	14.5	17.4	4.8	1.6	30.5	0	*12.4*
ROW	*7*	*6.4*	*12.6*	*15.7*	*12.9*	*15.8*	*8.4*	*2.3*	*28.4*	*13*	*8.4*

(a) A commodity × destination version of this table appears below as Table 7.

Table 3: Aggregate bilateral trade flows, fob prices [a,b]

	Destination											
Source	NAM	JPN	AUS	NZL	CHN_HKG	SKOR	TWN	MYS_SGP	THA_PHL	IDN	ROW	total exports
NAM	41.8	27.7	26.3	20.4	11.0	24.5	24.7	15.3	14.4	15.4	18.4	815381
JPN	13.3	0.0	16.8	13.2	17.4	24.0	35.9	20.8	26.2	22.1	8.9	381850
AUS	0.6	5.2	0.0	22.2	1.4	3.4	2.8	2.1	2.2	4.9	0.9	49550
NZL	0.2	0.8	5.0	0.0	0.2	0.8	0.4	0.4	0.4	0.5	0.3	13236
CHN_HKG	4.9	7.0	6.0	7.6	32.3	6.2	3.1	6.0	5.4	4.3	3.6	208034
SKOR	2.6	5.2	3.3	1.5	4.2	0.0	3.4	4.5	4.6	6.9	2.3	94429
TWN	3.3	4.1	3.7	2.5	8.2	2.3	0.0	4.8	5.2	4.8	1.7	96740
MYS_SGP	2.9	5.0	5.9	4.4	4.5	4.6	8.3	16.6	11.9	8.4	2.3	124952
THA_PHL	1.6	3.6	1.5	0.9	1.7	1.2	1.2	3.7	0.6	1.6	1.0	51610
IDN	0.6	4.4	2.1	0.5	1.3	2.6	2.0	3.1	1.0	0.0	0.5	37998
ROW	28.2	37.1	29.3	26.8	17.9	30.4	18.1	22.7	28.0	31.0	60.2	1403876
sum	100	100	100	100	100	100	100	100	100	100	100	3277657
total imports	824768	303012	47562	11502	214660	90208	66529	117349	56547	30233	1515287	3277657

Source: Version 2 of the *GTAP* data base – see Gehlhar *et al.* (1997) – updated to a post-NAFTA solution by *GTAP*

a The numbers in the body of the table are the percentages of the total imports of the region listed at the head of the table that are sourced from the region named in column 1.

b The dollar value in 1992 ($ U.S. million) of total imports by the region listed at the head of the table is shown in the last row; the value of exports by the region listed in the 1st column is shown in the last column.

Merchandise trade patterns prior to the implementation of APEC are summarized in Table 3 which presents bilateral, aggregate exports by source and destination. For the sake of brevity, it is not possible to present bilateral exports by commodity, but this table does give an idea of the relative importance of each region's trading partners. Looking across the row headed by Australia, her most important trading partners prior to implementation of APEC include Japan and ROW at 31.7 per cent and 26.8 per cent of Australian exports, respectively[7]. Looking down the column headed by Australia it can be seen that the bulk of Australia's imports come from ROW and North America at 29.3 per cent and 26.3 per cent, respectively.

The structure of production in the *GTAP* model is described in detail in Hertel (1997); however, the technology can briefly be described as nested CES, with a value-added nest and a nest for intermediate inputs which are sourced domestically and from imports. The Armington assumption is made to determine the import demands. Table 4 breaks down Australian sectoral use of intermediate inputs by domestic intermediates and those sourced from APEC partners and the ROW, respectively.

The domestic supply of intermediate inputs is most important for all sectors with only the fisheries; coal; textiles; wearing apparels; lumber; pulp and paper; petrochemical and

7 To calculate the flow of exports from Australia to Japan, multiply 0.052 by 303,012 (obtaining 15,757); similarly the flow of exports from AUS to ROW is 0.009 × 1,515,287 = 13,638; as percentages of Australia's total exports of 49,550 these are 31.8 and 27.5, which differ slightly from the figures in the text due to rounding errors.

Table 4: Source of intermediate inputs by sector for the Australian economy (percentage of total value of intermediate input use)

Commodity (1)		Domestic inter-mediates (2)	Imported intermediates from APEC partners (3)	Imported intermediates from ROW (4)
1 pdr	paddy rice	93	5	2
2 wht	wheat	91	7	2
3 gro	grains	92	6	2
4 ngc	non-grain crops	89	8	3
5 wol	wool	91	7	2
6 olp	other livestock	95	4	1
7 for	forestry	89	8	3
8 fsh	fisheries	82	13	5
9 col	coal	82	13	5
10 oil	oil	87	10	3
11 gas	gas	88	9	3
12 omn	other minerals	86	10	4
13 pcr	processed rice	95	4	1
14 met	meat products	98	1	1
15 mil	milk products	97	2	1
16 ofp	other food products	94	5	1
17 b_t	beverages and tobacco	94	4	2
18 tex	textiles	83	13	4
19 wap	wearing apparels	85	11	4
20 lea	leather, etc.	86	11	3
21 lum	lumber	84	12	4
22 ppp	pulp, paper, etc.	76	18	6
23 p_c	petroleum & coal	71	22	7
24 crp	chemicals rubbers & plastics	77	18	5
25 nmm	non-metallic minerals	90	8	2
26 i_s	primary ferrous metals	92	6	2
27 nfm	non-ferrous metals	94	4	2
28 fmp	fabricated metal products	89	8	3
29 trn	transport industries	63	28	9
30 ome	machinery and equipment	71	22	7
31 omf	other manufacturing	81	14	5
32 egw	electricity, water & gas	96	3	1
33 cns	construction	87	10	3
34 t_t	trade and transport	89	8	3
35 osp	other services (private)	90	8	2
36 osg	other services (govt)	82	13	5
37 dwe	ownership of dwellings	97	2	1

coal products; chemicals, rubber and plastic; transport equipment; machinery and equipment; other manufacturing; and other services (government) sectors sourcing 15 per cent or more of intermediate inputs from outside sources. APEC partners appear to be the next preferred source followed by the ROW region.

The shocks imposed on the model start from a situation in which the NAFTA trade liberalization has already taken place. We have used Young and Huff's method (but at the level of regional and commodity detail shown in Tables 1 and 4 respectively) to produce a post-NAFTA data base and to calculate the sizes of the shocks to tariff rates required to simulate the formation of APEC (details will be found in Appendix A).

Our *GTAP* simulations produce projections of changes in the production, bilateral (source- and destination-specific) trade, and relative prices of the thirty-seven commodities listed in Table 4. These shifts are computed under two closures of the capital market (to be explained in the next section): an immobile closure (in which *aggregate* capital stocks within regions are unaltered by the APEC shocks) and a mobile closure (in which *aggregate* capital stocks in the different regions *are* affected by the shocks). In both closures, the net upshot of the changed trading environment is an improvement in Australia's terms of trade (of which, more later).

3. IMPACT ON APEC MEMBERS

3.1 Preliminaries — time frame for the simulations

Loosely speaking, the closures underlying the simulations reported below may be termed a *medium-run* and a *long-run* closure. In the former, the overall size of the capital stock in each of the 11 regions is treated as being unaffected by the APEC trade liberalization, as is the size of the workforce in each economy; hence changes in overall output in each country come about because of more efficient use of capital and labour, rather than as changes in the amounts of them. This shows up as increases in the sizes of some, and declines in the sizes of other, industries within each economy. Thus the medium-term time frame is one which is long enough to allow a good deal of reorganization within national economies, but not long enough for the relative sizes of national economies to have diverged from base case. Whilst we cannot be very definite about how this translates into calendar time, a period of about 5 to 7 years may be appropriate.

In the long-run closure, both the global quantity of capital and its regional distribution are allowed to respond to the changed profit opportunities created by APEC. Labour, on the other hand, is still assumed to be exogenous, both with respect to its total amount and its geographic placement. The same is true of agricultural land. Again it is difficult to translate this comparative-static frame into calendar time, but perhaps 15-20 years is of the right order. It is a period long enough for disturbances in rates of return among industries and regions that were created by APEC to have dissipated, and for a new comparative-static equilibrium in rates of return to have been established. The technical details of these closures will be found in Appendix A.

3.2 Reprise of Young and Huff's results; effect of aggregation level

We reproduce Young and Huff's results for the terms of trade, real GDP and a household utility index in Table 5. These *GTAP* simulations were implemented in a version of the model that distinguished just three commodity groups: food & agriculture, resources & manufacturing, and services. As well, Young and Huff treated Australia and New Zealand as one regional entity. In the same table we show also our own *GTAP* results at the 37-commodity level of disaggregation and with Australia and New Zealand treated as separate regions. Thus this table tells us something about the sensitivity of *GTAP* simulations in two dimensions:

Table 5: Impact on Terms of Trade, GDP and 'Welfare', of the Formation of APEC as a Preferential Trading Zone [a]

Region	Terms of trade			Real GDP at market prices			Per capita utility[b]		
	with capital:			with capital:			with capital:		
	←Immobile→		Mobile	←Immobile→		Mobile	←Immobile→		Mobile
	Y & H[c]	←this study→		Y & H[c]	←this study→		Y & H[c]	←this study→	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	← ***medium run***	→	***long run***	← ***medium run***	→	***long run***	← ***medium run***	→	***long run***
North America	-1.03	-2.00	-1.79	-1.03	0.13	0.04	-0.11	-0.11	-0.16
Japan	4.08	4.64	5.08	0.78	0.43	0.44	2.29	1.80	1.87
Australia (*GTAP* alone)	-0.84[d]	0.78[e]	1.21[f]	-0.18[d]	0.12	2.82	-0.07[d]	0.49	2.91
(*MONASH* driven by *GTAP*)		3.61	5.58	n.a.	0.08	2.22	n.a.	n.a.	n.a.
New Zealand	-0.84[d]	3.64	1.63	-0.18[d]	0.85	11.4	-0.07[d]	3.56	12.0
China & Hong Kong	0.96	-0.25	-0.28	0.53	1.67	7.49	1.28	1.88	6.38
South Korea	-2.01	-1.47	-1.60	4.32	3.69	13.9	3.16	5.58	15.0
Taiwan	0.81	1.31	1.55	1.78	0.73	3.02	2.40	2.80	5.21
Malaysia & Singapore	1.17	1.50	1.35	0.38	1.19	9.35	2.42	4.11	11.8
Thailand & Philippines	-6.29	-6.05	-10.4	1.30	2.33	39.0	-3.05	-1.11	29.9
Indonesia	-1.05	1.89	-1.34	0.46	1.73	10.4	-0.17	2.04	10.0
The rest of the world	-1.17	-1.06	-1.06	-0.04	-0.05	-1.16	-0.34	-0.17	-1.16

[a] All results are to be interpreted as percentage differences from what would have been the case in the absence of the implementation of the APEC agreement. In the headings to the table, "Mobile" means mobile between regions. "Immobile" means immobile between regions but mobile between industries within regions. Except in the case of the second row for Australia, results are from the *GTAP* model. The exceptional results for Australia are from *MONASH* driven by *GTAP*. The Young and Huff results are from Young and Huff (1997). The total capital stock in each region is exogenous and set to zero change in the closure of *GTAP* underlying columns (2), (3), (5), (6), (8) and (9); world capital stocks are free to grow and are mobile between regions in the closure underlying columns (4), (7) and (10) — for more details, see Appendix A.

[b] Component of utility from private expenditure only is included here.

[c] Young and Huff (1997).

[d] Australia and New Zealand appear as one region in Young and Huff's 10 by 3 disaggregation.

[e] If the *GTAP* result is recomputed using the *MONASH* definition of the terms of trade and the trade shares from the *MONASH* data base, it becomes 3.41.

[f] If the *GTAP* result is recomputed using the *MONASH* definition of the terms of trade and the trade shares from the *MONASH* data base, it becomes 3.86.

level of commodity aggregation, and length of run. In the case of Australia, reported results from both *GTAP* stand-alone and from the *MONASH-driven-by-GTAP* simulations are given.

Figure 1 compares the estimated medium-run shifts in regions' terms of trade brought about by APEC under the two commodity aggregation schemes. Does aggregation affect our perception of the consequences of the formation of APEC? Pairwise comparisons of columns (2) and (3), (5) and (6), and (8) and (9), of Table 5, and inspection of Figure 1, clearly demonstrate that the answer is 'yes'.

There are two striking features of Figure 1. The first is the large gain in terms of trade experienced by Japan and the large fall experienced by Thailand/Philippines. The second is the fact that the level of aggregation matters a great deal, especially in the cases of Australia, New Zealand, Indonesia and China/Hong Kong — for these regions, the sign of the terms of trade change reverses between the 3- and the 37-commodity aggregations.

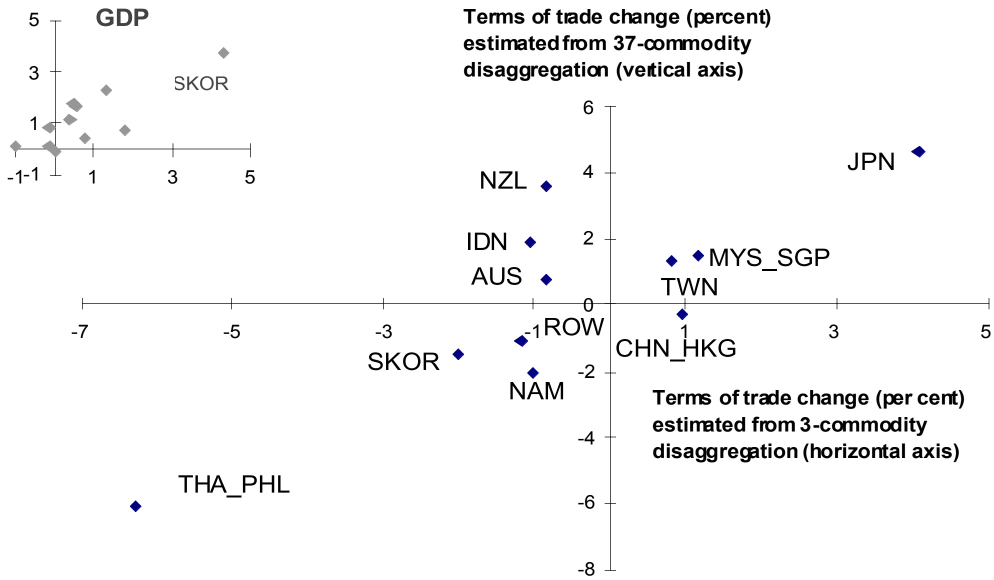

Figure 1: Scatter plot of estimates of medium-run changes in the terms of trade due to instituting APEC as a preferential trading zone. GDP is shown in the inset.

However, with the outliers Indonesia and New Zealand removed from Figure 1, the regression slope is 0.96 and the R^2 is 0.92, revealing that the 3- and the 37-commodity levels of aggregation are in rough agreement about the terms-of-trade effects of APEC.

The level of agreement about GDP (columns (5), (6) and (7) of Table 5) is similar. The striking feature of the GDP result (Figure 1, inset) is that South Korea experiences the largest increase in GDP despite having an unambiguous decline in its terms of trade. In the long run (columns 4 and 7 of Table 5), South Korea and Thailand/Philippines experience large increases in GDP in spite of falls in their terms of trade.

3.3 Long-run effects of APEC trade liberalization in regions other than Australia[8]

The long-run impact of the reforms for countries other than Australia[9] are shown in Table 6. The explanation for the results hinges partially on the pre-APEC average tariff rates which are shown on a destination and commodity-specific basis in Table 7.

Column (VIII) of Table 6 shows the response of wage rates in each region to the tariff cuts. In all cases wages rise, with the largest deviations above base case occurring in Thailand/Philippines, South Korea, Malaysia/Singapore, Indonesia and New Zealand. The wage response in a region reflects two main factors: (a) the redistribution of tariff income to fixed factors of production (labour and land); and (b) changes in returns to fixed factors resulting from the real-income effects of terms of trade movements (see column IX). In Thailand/Philippines, for example, the share of labour in returns to fixed factors prior to the implementation of the tariff cuts was 86 per cent and tariff revenue as a percentage of fixed-factor returns was 42 per cent. Thus holding all else constant, the removal of tariffs on imports

8 In this subsection we draw heavily on Adams, Horridge and Zhang (1996).

9 Australia is dealt with separately below in the context of the *MONASH* simulations.

Table 6: Lonrun effects of APEC trade liberalization on macro variables in regions other than Australia[(a)]

Region	Percentage change in:								
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
	real private consump-tion	export volume	import volume	real GDP (factor cost)	real GDP (market prices)	aggregate capital stock	capital rental	labor wage	terms of trade
1. NAM	-0.2	8.7	6.5	-0.1	0.0	-0.2	-1.8	-2.3	-1.8
2. JPN	1.9	12.0	22.6	0.0	0.4	0.0	6.2	5.7	5.1
4. NZL	12.1	25.0	32.7	10.4	11.4	25.1	-6.0	12.7	1.7
5. CHN_HKG	6.4	26.1	27.2	5.6	7.5	15.1	0.1	13.9	-0.3
6. SKOR	15.2	33.6	38.9	9.6	13.9	22.1	2.9	20.7	-1.6
7. TWN	5.2	11.5	18.3	2.3	3.0	5.8	3.1	7.7	1.5
8. MYS_SGP	11.8	12.6	14.8	8.2	9.4	14.4	2.6	15.1	1.4
9. THA_PHL	30.2	80.6	69.5	35.4	39.0	56.7	-12.1	29.2	-10.4
10. IDN	10.1	31.2	36.9	8.7	10.4	13.8	3.5	18.8	-1.3
11. ROW	-1.2	-1.3	-2.8	-1.1	-1.2	-2.8	-0.6	-3.2	-1.1

(a) Results in this table are computed in the long-run non-isolation closure of *GTAP.*

from the rest of APEC would be expected to increase the average wage by about 0.86 × 42 = 36 per cent. According to our projections, wages increased by 29 per cent. The difference can be accounted for mostly by the 10 per cent decline in the terms of trade.

This type of calculation is an example of use of the formula for the nominal wage rate obtained by equating the GDP deflators from the income and expenditure sides (Adams (1996)):

$$p_L(r)=\frac{S_A(r)p_A(r)+\{S_X(r)p_X(r)-S_M(r)p_M(r)\}-S_K(r)p_K(r)-S_N(r)p_N(r)-S_T(r)(\tau(r)+p_M(r))}{S_L(r)},$$

in which the S_Js are shares in GDP *($J=A$ ⇔ absorption; $J=X$ ⇔ exports; $J=M$ ⇔ imports; $J=K$ ⇔ capital; $J=N$ ⇔ land; $J=L$ ⇔ labour; $J=T$ ⇔ indirect taxes minus subsidies, here identified with tariffs; the p_Js are the corresponding price indexes).* In the case of Thailand/Philippines most of the action is in the term $\tau(r)$ (the tariff change) and in the term in curly parentheses (the terms of trade). In Adams (1996) it is shown how application of this formula successfully identifies the sources of the wage changes in the different regions.

The long-term effects of APEC liberalization on capital rentals are shown in column (VII) of Table 6. In our long-run simulation, the percentage deviations of rates of return from base case are equal in all regions. The percentage deviation in the global rate of return turns out to be small. Thus capital rentals are effectively indexed to the costs of creating capital. In all of the small regions (i.e. regions other than North America, Japan and Rest of the World) inputs to capital creation are import-intensive and, prior to APEC subject to large tariffs (see rows 25 to 31 of Table 7). Hence, in these regions the removal of tariffs tends to reduce capital costs, and hence the capital rental, relative to the general price of output. This is particularly so in Thailand/Philippines, South Korea and New Zealand. In the large regions, capital goods are mainly domestically sourced. In these regions, the cost of creating capital and capital rentals move in line with the general output price.

The last part of the above argument (the effect of tariff removals on rentals) also applies in the medium run. The rental price movements feed into rates of return, which in this closure are free to vary across regions — and do so widely. Figure 2 demonstrates that with capital relatively inflexible, the trade liberalization shocks manifest themselves largely as changes in rates of return. Again Thailand/Philippines is the outlier, with a 23½ per cent *(not percentage point)* deviation above base case in its medium-run rate of return.

In the long-run closure, this uneven displacement of rates of return is eliminated, with all regions returning to the same pattern of rates of return on capital as in the base case. This equilibration is due to the mobility of capital between regions in the long run; very large changes (relative to base case) in capital stocks occur for some regions. Figure 2 demonstrates that the disturbance in rates of return in the medium run is a moderately good predictor of the ultimate deviations induced in the sizes of the capital stock in different regions.

The quantities of labour and agricultural land are exogenous in both closures of *GTAP*. It comes as no surprise, then, that the long-run deviations in capital stocks are good predictors of long-run deviations in real GDP. This is shown in Figure 3.

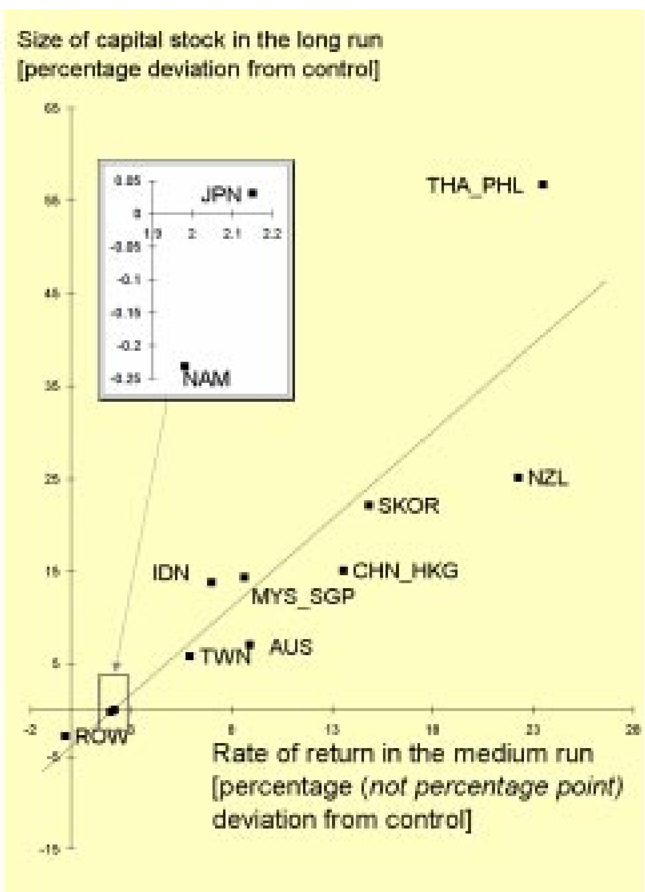

Figure 2:
Scatter plot of projected long-run deviations in the capital stock of regions against medium-run deviations in regional rates of return due to instituting APEC as a preferential trading zone (slope = 1.90, R^2 = 0.81.

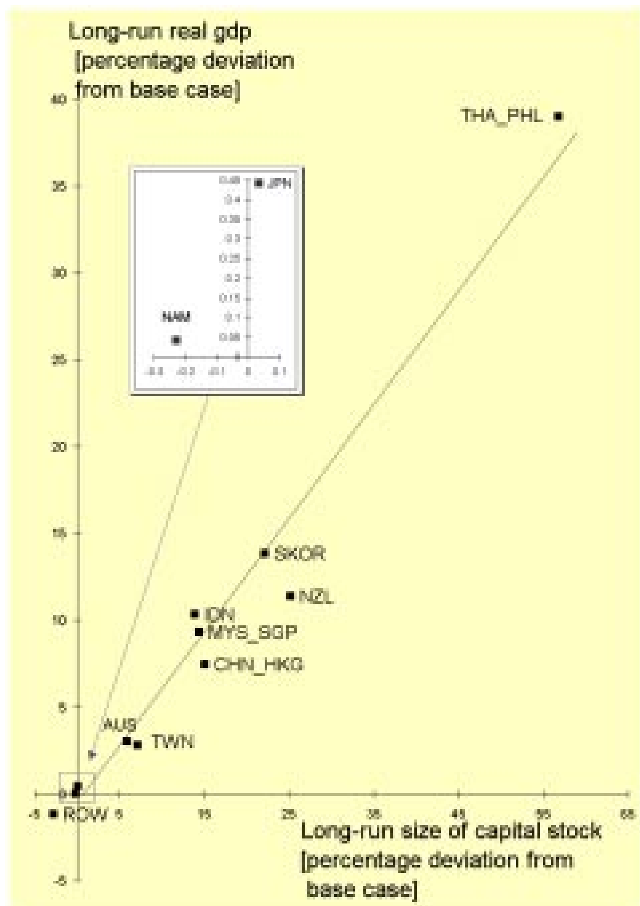

Figure 3:
Scatter plot of projected long-run deviations in real gdp against long-run deviations in the capital stocks of regions due to instituting APEC as a preferential trading zone (slope = 0.66, R^2 = 0.97).

We now return to our consideration of just the long-run results. Explaining the deviations from base case in relative factor payments in any region also explains the deviation in the region's labour/capital ratio, and hence, given the fixity of employment and land, the deviation in capital stock (see column (VI) of Table 6) and in real GDP at factor cost (column (IV)). Deviations in real GDP at market prices (column (V)) are related to deviations in real GDP at factor cost by the addition of real indirect taxes net of subsidies. In terms of real GDP (market prices) the regions which gain most from APEC liberalization are Thailand/ Philippines, South Korea, New Zealand and Indonesia. All these regions have high pre-APEC levels of protection, directed, in part, to investment-oriented sectors. The regions which gain least are the Rest of the World, North America, Japan and Taiwan, all with low pre-APEC protection.

Columns (I) to (III) of Table 6 relate to the expenditure side of GDP. In our simulations, nominal private and public consumption in each region move in line with nominal GDP at market prices. Differences between changes in real consumption and real GDP at market prices mainly reflect changes in the terms of trade. An increase in the terms of trade implies a decrease in the private consumption deflator (which includes imports but not exports) relative to the GDP deflator (which includes exports but not imports). Hence in regions experiencing a terms-of-trade improvement we generally see an increase in real private consumption relative to real GDP at market prices — that is, the result recorded in column (I) exceeds that in column (V). In regions experiencing a terms-of-trade deterioration mostly we see a reduction in real consumption relative to real GDP (market prices).

Columns (II) and (III) of Table 6 clearly show the trade-enhancing effects of tariff reductions within APEC and the trade diverting effects experienced by non-APEC countries. All APEC regions gain in terms of export volume at the expense of the Rest of the World, with the greatest gains occurring in regions with the highest initial levels of protection.

Changes in net trade volumes (i.e. changes in the difference between export volume and import volume) are implied by changes in the difference between real GDP (at market prices) and real GNE. In these simulations real investment moves with the capital stock, and real private and public consumption moves with real GDP (at market prices). Thus our simulations show increases in net trade volumes wherever capital increases by less than real GDP (at market prices), and decreases wherever capital increases by more than real GDP.

From column (IX) of Table 6 we see that Japan experiences a significant terms-of-trade gain from the APEC liberalization. The other regions which gain are New Zealand, Taiwan, Malaysia/Singapore and Australia. The biggest losers are Thailand/Philippines and South Korea. To understand these results we adopt the approach suggested in McDougall (1993), and decompose the change in the terms of trade of each region into three parts: the *world price effect*, the *export price effect* and the *import price effect*. The decomposition begins with an expression for the percentage change (i.e., deviation from base case) in region r's terms of trade:

$$tot(r) = px(\bullet, r) - pm(\bullet, r) \tag{1}$$

where $px(\bullet, r)$ is the percentage change in price received for exports and $pm(\bullet, r)$ is the percentage change in price paid for imports. The two variables on the RHS of (1) are defined by:

$$px(\bullet,r) = \sum_{i=1}^{37} SX(i,r)\, px(i,r) \tag{2}$$

$$pm(\bullet,r) = \sum_{i=1}^{37} SM(i,r)\, pm(i,r) \tag{3}$$

where $SX(i,r)$ and $SM(i,r)$ are export and import shares of commodity i in region r, and $px(i,r)$ and $pm(i,r)$ are percentage deviations of the export and import prices of i in r. Substituting (2) and (3) into (1) and then manipulating gives McDougall's decomposition:

$$tot(r) = \sum_i (SX(i,r) - SM(i,r))(pw(i) - pw(\bullet)) \quad \textit{(World price effect)}$$

$$+ \sum_i SX(i,r)(px(i,r) - pw(i)) \quad \textit{(Export price effect)}$$

$$- \sum_i SM(i,r)(pm(i,r) - pw(i)) \quad \textit{(Import price effect).}$$

The *world price effect* is the sum over all traded commodities of the product of a region's net trade share for commodity i and the change in world price of i relative to an average of world prices ($pw(\bullet)$). Thus, if on average region r is a net exporter of commodities for which trade-liberalization means higher world prices, then the world price effect for r will be positive. Not surprising, given the commodity pattern of protection before liberalization, the commodities for which $pw(i) - pw(\bullet)$ is most positive in our simulation are: wool, primary ferrous metals, rice (paddy and processed), machinery and equipment, transport industries and non-ferrous metals.

The *export price effect* is the export-share weighted sum of changes in the ratio of region r's export price for commodity i to the average world price of i. Since products are differentiated by source in *GTAP*, terms of trade change can occur due to divergences between the export price for commodity i produced in region r and the average world price for that commodity.

The *import price effect* is the reverse of the export price effect. It is the import-share weighted sum of changes in the relativities between the region-specific import price for i and its world average price.

Table 8 shows the results of the decomposition for each region's terms of trade. In almost all cases the export-price effect dominates. The size of $(px(i,r) - pw(i))$ for commodity i produced by r depends in part on the structure of the initial bilateral tariff rates, and on the degree of competition faced by r on markets for i from other regions. For example take r = JPN and i = ome (machinery and equipment). According to the initial data base, $SX(ome, JPN)$ = 0, with most of the exports bound for North America. On that market Japan's major competitor is the ROW and North America itself (recall that NAM consists of the US, Canada and Mexico). Imports into NAM face zero tariffs in the initial (post-NAFTA) data base). Thus removing tariffs on APEC-sourced imports translates

Table 8: Decomposition of regional terms-of-trade changes(a)

	Contribution to percentage change in terms of trade due to:			
	(I)	(II)	(III)	(I) + (II)
Region	world price effect	export price effect	import price effect	- (III) (b)
1. NAM	0.1	-1.7	-0.1	-1.4
2. JPN	0.3	5.2	-0.5	5.9
3. AUS	0.1	2.5	0.3	2.3
4. NZL	0.0	3.2	0.7	2.6
5. CHN HKG	-0.3	0.7	0.2	0.1
6. SKOR	-0.5	-2.4	0.9	-3.7
7. TWN	-0.3	2.9	1.0	1.6
8. MYS SGP	0.0	2.0	0.5	1.4
9. THA_PHL	-0.4	-6.8	1.1	-8.2
0. IDN	-0.5	2.3	0.5	1.2
1. ROW	0.0	-1.1	-0.5	-0.6

a) Results in this table were computed under the long-run non-isolation closure of *GTAP*.

) Due to rounding, components in columns I-III may not sum exactly to total terms-of-trade effect shown in this column.

into a strong increase in North American demand for imports of ome only from Japan. This implies a large positive value for

$$SX(ome, JPN)(px(ome, JPN) - pw(ome)).$$

Similar arguments apply to i = trn and omf for r = JPN. Thailand/ Philippines provides a contrasting example. It exports mainly light manufacturing (textiles, wearing apparels, etc.) to APEC countries, where it faces little competition from the rest of the world. Pre-APEC, its products faced relatively low tariffs, so that removal of the tariff results leads to large negative values for $SX(i, r)(px(i,r) - pw(i))$ for i = tex, wap, lea, ome and r = THA_PHL.

4. IMPLICATIONS FOR AUSTRALIA

4.1 The tops-down modelling approach: calculation of the shocks for MONASH

Our detailed projections with the *MONASH* model use *GTAP* to work out the changes in Australia's trading conditions brought about by APEC. This is done without any feedbacks from *MONASH* to *GTAP* — thus we are treating Australia as a relatively small country. A check on the validity of this assumption in the *GTAP* context is available. If we 'turn off' all reactions by Australia in so far as they affect the rest of the world, and recompute the terms-of-trade and GDP results above in Table 5, the results for countries other than Australia should not change appreciably. With the possible exception of New Zealand, this is indeed the case.[10]

The APEC shocks that are fed into *MONASH* are calculated by allowing *GTAP* to determine the demand prices for Australia's exports, and the supply prices for Australia's imports, that would result from APEC at (exogenously set) pre-APEC bilateral levels of real flows of imports, exports, saving, and capital goods into and out of Australia (that is, with Australia 'turned off'). This closure of *GTAP* (more fully explained in Appendix A) is referred to as the *isolation closure*. These shocks are the price deviations shown in Table 9. Thus Table 9 shows *GTAP*'s projections of the percentage upward shifts in the demand schedules for Australia's main exports and in the supply schedules for Australia's imports that come about because of the formation of APEC *before Australia adjusts to the new trading environment.*

4.2 Australia's improved terms of trade

The definitions of the terms of trade in the *GTAP* and *MONASH* models are not strictly comparable. In the former "one simply deducts the change in the price index for goods purchased, at world prices, from the change in the price indexes for goods sold"[11]. Capital goods, which are produced, sold and installed exclusively in the region in which they

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10 The following is a list of the medium-run GDP results with Australia treated like other regions, and [in square parentheses] with Australia's trade and international capital flows frozen at the pre-APEC levels: North America: 0.13 [0.12]; Japan: 0.43 [0.42]; New Zealand: 0.85 [0.64]; China/Hong Kong 1.67 [1.62]; South Korea 3.69 [3.61]; Malaysia/Singapore: 1.19 [1.15]; Thailand/Philippines 2.33 [2.32]; Indonesia: 1.73 [1.66]; Rest of the world: -0.05 [-0.05]. In the case of a few products where Australia has significant market power, the discrepancies are larger: for example, the medium-run world average export price of wool in the standard case deviates 4.5 per cent above base case; with Australia's trade flows frozen at the pre-APEC levels, however, this deviation would be 8.2 per cent.

11 Comment from the *TABLO* source code.

Table 9: Projected Changes in Australia's Trading Conditions due to APEC: GTAP-generated shocks for Monash [a]

identifier	commodity	Percentage deviations from base case of the supply prices to Australia of imports and of the demand prices of Australian exports at initial Australian trade volumes with capital: immobile		mobile	
(1)	(2)	(3)	(4)	(5)	(6)
		(medium run) supply price	demand price	**(long run)** supply price	demand price
1 pdr	paddy rice	0.5	-2.0	2.8	-2.0
2 wht	*WHEAT*	-1.0	3.2	-0.6	4.5
3 gro	*GRAINS*	-0.2	7.5	0.0	8.9
4 ngc	non-grain crops	0.6	16.7	1.7	19.4
5 wol	*WOOL*	8.7	9.4	7.9	11.0
6 olp	other livestock	8.0	7.9	7.9	10.3
7 for	forestry	-1.0	3.3	-1.5	4.4
8 fsh	*FISHERIES*	1.9	5.0	-0.5	5.2
9 col	*COAL*	1.5	0.8	1.6	1.6
10 oil	oil	2.8	2.0	0.4	2.9
11 gas	gas	3.7	5.9	-4.4	5.1
12 omn	*OTHER MINERALS*	-0.3	3.9	-0.6	4.5
13 pcr	processed rice	2.5	1.9	5.1	4.0
14 met	*MEAT PRODUCTS*	2.2	12.0	2.1	12.3
15 mil	*MILK PRODUCTS*	4.2	32.5	3.4	33.5
16 ofp	*OTHER FOOD PDTS*	-1.0	-0.9	-1.4	-0.11
17 b_t	beverages & tobacco	-1.8	1.4	-1.9	1.4
18 tex	textiles	-3.6	-1.2	-3.8	-0.6
19 wap	wearing apparels	-3.9	2.3	-3.9	2.6
20 lea	leather, etc.	-0.9	0.7	-1.0	0.8
21 lum	lumber	1.2	2.6	0.2	2.4
22 ppp	pulp, paper, etc.	-0.6	13.8	-0.9	16.0
23 p_c	petroleum and coal	0.2	2.0	-0.4	3.0
24 crp	chem, rubbers & plastics	1.0	2.3	-1.1	3.5
25 nmm	non-metallic minerals	-0.1	10.5	-0.4	11.7
26 i_s	primary ferrous metals	1.0	4.8	0.6	6.4
27 nfm	*NON_FERROUS METALS*	-0.6	2.3	-1.2	3.5
28 fmp	fabricated metal pdts	0.5	6.7	0.3	8.0
29 trn	transport industries	0.8	2.3	0.9	2.9
30 ome	machinery and eqpt	-0.6	-1.4	-0.7	-0.29
31 omf	other manufacturing	-0.3	2.3	-0.6	2.9
32 egw	electricity, water, gas	-2.3	-1.5	-2.1	-1.3
33 cns	construction	3.6	2.3	3.1	3.2
34 t_t	trade and transport	0.5	0.9	0.3	1.1
35 osp	other services (private)	-0.4	-0.9	-0.8	-0.9
36 osg	other services (govt)	-0.4	-0.9	0.1	-0.4
37 dwe	ownership of dwellings	1.8	1.7	-0.6	1.2

[a] The total capital stock in each region is exogenous and set to zero change in the closure of GTAP underlying columns (3) and (4); the world capital stock is free to grow or decline and capital is mobile between regions in the closure underlying columns (6) and (7) — for more details, see Appendix A. All of the price changes refer to the situation *before* Australian exports and imports respond to the new trading conditions. Australia's traditional exports are denoted by *UPPER-CASE ITALICS* in column (2); the percentage price changes refer to fob prices.

are produced, are included among *GTAP*'s 'goods sold' in the terms of trade calculation. The *MONASH* model's terms of trade follow a more conventional calculation in which prices paid are reckoned as the difference between the import-value-weighted sum of percentage deviations in the cif prices of tradeables, and the exported-value-weighted sum of percentage deviations in their fob prices. Besides this difference of principle, the data base for *MONASH* (1995-96) is more recent than the Australian data in the version of the *GTAP* data base used by us (1985-86 updated to 1992). The differences between the *GTAP* and the *MONASH* calculations of terms of trade in Table 5 are large, but narrow considerably when the *MONASH* definitions and weights are used (see the footnotes to that table).

According to our simulations, the formation of APEC is good news for Australia irrespective of how changes in the terms of trade are measured. Relative to base case, the terms of trade on the *GTAP* definition improve in the medium and long terms by 0.8 and 1.2 per cent respectively (see Table 5 – on the Monash definitions, these *GTAP* results would produce much larger values, namely 3.4 and 3.9). From the isolation closure discussed above, we find that these terms of trade improvements would be much greater (2.7 and 3.4 per cent respectively) if Australia's trade pattern did not respond to APEC. In other words, the terms of trade effects of Australia's own adjustments are about -1.9 (= 0.8 - 2.7) and -2.2 (=1.2 - 3.4) per cent in the medium and long runs respectively. Thus although Australia is a small country in a macro sense, it does influence the prices of its principal exports significantly enough to cause a fall in its own terms of trade of about 2 per cent (on the *GTAP* definitions).

We now turn to the *MONASH* simulations in which the shocks were the price changes shown in Table 9, plus Australia's abolishing her tariffs against all other APEC members. Macro results and results for key trade aggregates are given in Table 10. As for *GTAP*, *MONASH* was solved in a medium-run and in a long-run closure. Broadly these are similar to the corresponding *GTAP* closures: in the medium-run closure, capital stocks of all industries are exogenous, and rates of return adjust; this is reversed in the long-run closure where the rates of return for all industries are held exogenously to base-case values, and capital stocks of industries adjust endogenously (for further details, see Appendix B).

The GDP results in the two closures (0.08 and 2.22 per cent for medium and long run, respectively) reveal that the capital deepening available in the long-run closure is a key element in securing the additional growth available from the trade liberalization. It should be noted, however, that we have not kept track in these simulations of the ownership of assets, and hence the 7.4 per cent increase over base case in long-run capital stocks is not necessarily financed by domestic saving – hence the rentals may be accruing to foreigners.

In the medium-run simulations, all components of real GNE are indexed to each other, so that public and private consumption and real investment all stand about ½ per cent above base case (rows 5 through 8 of Table 10). The long-run closure of *MONASH* used here follows *GTAP* in that the share of nominal private consumption in nominal GDP is held fixed. Public and private real consumption remain linked, recording increases over base case of nearly 3½ per cent; investment, however, is linked to the capital stock (as in the *GTAP* long run closure), each standing about 7½ per cent above base case (rows 4 and 7).

Real wages as an income to labour increase to levels about 4 and 7½ per cent above base case in the medium and long runs respectively (row 20 of Table 10). The increase in the real wage as a cost is about ½ to 1½ percent less due to the fact that the GDP deflator rises proportionately more than the CPI (rows 1 and 24). This in part reflects cheaper imported intermediate

14); the removal of Australian tariffs on APEC-sourced inputs, however, has a substantial further cost-cutting impact, so that the after-duty price of imports deviates 14 to 16 per cent below control in the two closures (last row of Table 10).

The improvement in the terms of trade leads to real appreciations of the Australian dollar of about 3 and 6 per cent respectively in the medium and long runs (row 19 of Table 10). This causes severe problems for industries that are highly exposed to foreign competition by virtue of relatively flat export demand curves. The tourism activity in *MONASH*, which is a conglomerate consisting mainly of hotel, entertainment, and transportation services, is a case in point. The price index for tourism exports rises roughly by the same percentage as the general appreciation, leading to substantial deviations of export levels below base-case (12 and 19 per cent respectively in the medium long runs – see row 18 of Table 10).

Table 10: Medium- and Long- term Impact of APEC __ Macroeconomic and Trade Indicators for Australia from the *MONASH* Model

	Mnemonic	Variable	Percentage deviation from base case with capital: immobile	mobile
1	xi3	Consumer price index (numeraire)	0	0
2	toft	Terms of trade	3.61	5.58
3	gdpreal	Real GDP from expenditure side	0.08	2.22
4	k_r_wgts	Real capital stock	0[a]	7.35[b]
5	gner	Real GNE	0.49	4.24
6	cr	Real household consumption	0.49	3.47
7	ir	Aggregate real investment expenditure	0.49	7.52
8	othreal	Real government spending	0.49	3.47
9	expvalf	Foreign currency value of exports	6.24	2.65
10	impvalf	Foreign currency value of imports	5.12	8.51
11	expvol	Export volume index	2.84	-2.34
12	impvol	Import volume index	5.43	8.90
13	xi4	Exports price index	1.02	0.90
14	xim	Imports price index	-2.50	-4.44
15	xi4tour	Price index for tourism exports	3.27	5.22
16	gx4_abare_mi	Total mining exports	-0.54	-1.93
17	gx4_abare_ru	Total rural exports	6.00	-2.73
18	agg_tour	Aggregate export of tourism services	-11.59	-18.75
19	realdev	Real devaluation index	-2.90	-5.60
20	real_wage_c	Real wage rate as seen by employees	3.94	7.60
21	real_wage_e	Real wage rate as seen by employers	3.52	6.30
22	xi2	Aggregate investment price index	-2.83	-2.19
23	xi5	"Other" demands price index	1.62	3.55
24	xigdp	GDP price index (expenditure side)	0.41	1.22
25	ximp0	Duty-paid imports price index	-13.97	-15.72

[a] Compares with 0 in GTAP stand-alone simulation (set exogenously in both models).
[b] Compares with 7.09 in GTAP stand-alone simulation.

4.3 Long-run structural pressures on industries

Projected changes in activity levels by Australian industries in the long run are shown in Figure 4. The broad patterns is for the 'winners' — the industries in the left-hand ladder of Figure 4 — to belong to one of the following groups:

(a) export-oriented agricultural products or their suppliers

(b) export-oriented mining

(c) industries supplying investment

(d) domestic consumption related industries.

The losers — the industries in right-hand ladder of Figure 4 — on the other hand, tend to be in initially relatively highly protected industries (textiles, clothing, footwear and motor vehicles), and in industries supplying services to tourism (e.g., hotels and air transportation).

With the exception of the wool-producing industries (the high-rainfall, pastoral and wheat-sheet zones), Australian exporters face relatively flat export demand curves in *MONASH*. Hence the key to understanding the prospects of industries in the groups (a) and (b) above is the impact of APEC on their prices and costs. The 1.2 per cent deviation above control of the GDP deflator (row 22 of Table 10) gives a rough guide to the escalation in their costs; a guide to the size of the price rises for their products (before Australia has adjusted its export volumes) can be gleaned from column (6) of Table 9. With Milk products in GTAP mapping to Dairy products and Milk cattle in *MONASH*, it is not surprising to find these commodities showing the greatest demand stimulus in Table 9 and the greatest supply response in Figure 4. The other big agricultural exporter to do very well in the *MONASH* simulations is Meat products, which carries with it the non-diversified up-stream industry, Northern beef. The price stimulus for Meat products in Table 9 is correspondingly substantial at 12.3 per cent (column (6)).

The heavily naturally protected investment supplying industries appearing in positions 5 through 8 of the left-hand ladder of Figure 4 are responding to the 7_ increase in real investment (row 7 of Table 10), and record rises of a comparable magnitude. The consumption-related industries tend to fare well where there is little or no import competition: witness the services of the stock of dwellings, which is about 5 per cent above base case (Figure 4), somewhat above the 3_ real increase in consumption (row 6 of Table 10) — presumably due to relative price effects in the consumer budget. Other consumption-related industries, as we have seen, fare badly where they face substantial import competition and where this competition has sharpened as a results of the APEC reforms.

4.4 Tracing the shift in overseas demand for Australian exports of milk products

We can trace the sources of the increased demand for Australian exports in *GTAP;* Milk Products is discussed by way of example. According to row 15 of column (6) in Table 9, in the long run the demand price for Australian exports of milk products increases by 33.5 per cent relative to base due to APEC liberalization. In terms of the GTAP data base, this is equivalent to an expansion of 226m real 1992 US dollars (at the initial quantity of exports). All of Australia's APEC partners contribute to this stimulus — see Table 11. The largest

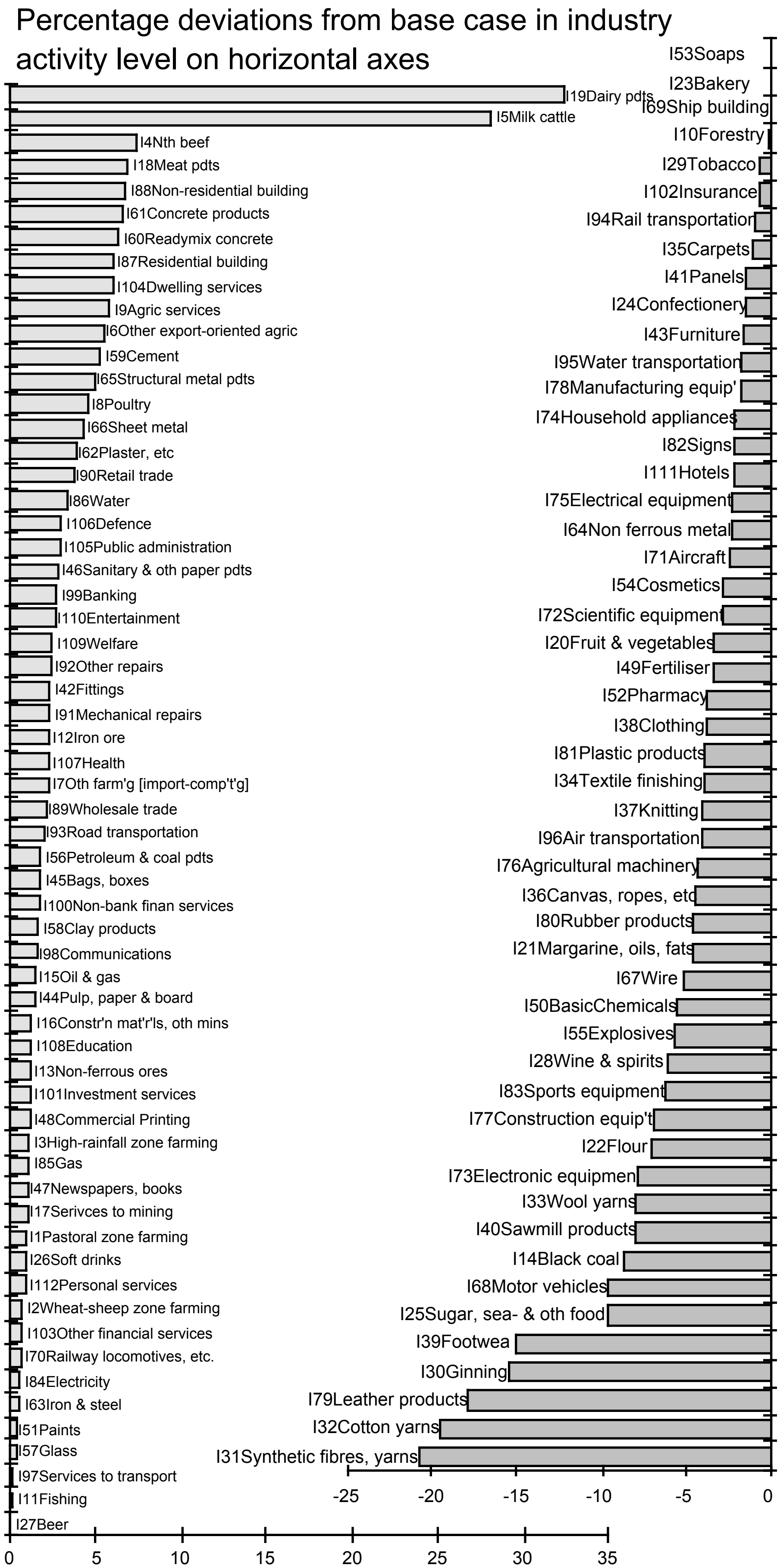

Figure 4: Long run effects of APEC on Australian industries'

Table 11: Sources of increases in demand for Australian milk products flowing from the formation of APEC

Source region	Base value of exports ($US m)	Percentage change export price (fob)	Contribution[(a)]
NAM	19	74.7	2.1
JPN	133	115.0	22.7
NZL	3	14.2	0.1
CHN_HKG	42	7.7	0.5
SKOR	5	82.7	0.6
TWN	50	36.9	2.7
MYS_SGP	136	7.0	1.4
THA_PHL	129	15.5	3.0
IDN	22	22.8	0.8
ROW	137	-1.5	-0.3
Total	676		33.5

(a) The numbers in this column show the contribution of each source region to the overall increase in export price (fob) of Australian milk products. A region's contribution is calculated as percent change in price times base value of exports divided by total exports.

contributions come from Japan (which contributes 22.7 percentage points to the overall increase of 33.5 per cent), Thailand/Philippines (3.0 percentage points), Taiwan (2.7percentage points) and North America (2.1 percentage points). Demand by non-APEC countries makes a negative contribution of 0.3 percentage points. The proportional contributions of the different overseas markets to the rise in the demand price for Australian milk products is shown in Figure 5.

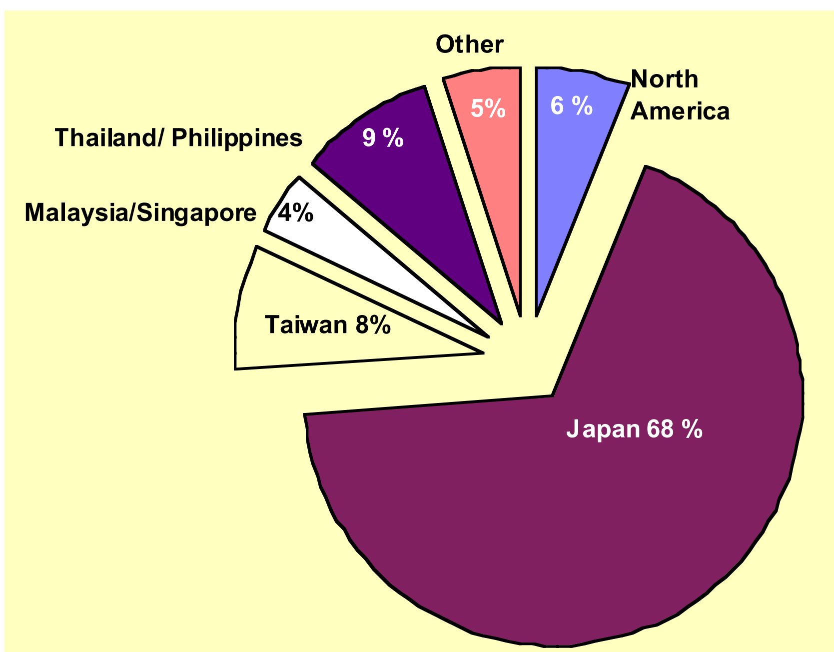

Figure 5: Contributions of different markets to the increase in the demand price for Australian milk products

The large contribution made by Japan to the overall increase in export price (fob) of Australian milk products reflects: (a) Japan's high initial share in Australian exports (around 20 per cent); and (b) the large increase in price (fob) of Australian produced milk products on the Japanese market. The increase in price in Japan reflects the very high pre-APEC tariff on milk products in Japan (around 350 per cent).

5. CONCLUDING REMARKS

Whilst the implementation of APEC is projected to cause its 'mature' industrialized members to grow, the positive (and therefore welcome) changes in the growth rates of Japan, North America and Australia are very modest. For example, after an adjustment period which may be measured in decades, Australia is projected to be only 2-3 per cent bigger (in terms of real GDP) as the result of APEC. In terms of annual growth rates this would affect a digit occurring after the decimal point. In the case of North America and Japan (especially the former) the effects on the growth rate of GDP are tiny.

APEC does, however, have the potential to revolutionize patterns of trade and growth among the developing nations of Asia. The most extreme examples are Thailand/ Philippines and South Korea where real GDP in the long run is projected to be 39 and 14 per cent above base case respectively. These changes after 1 to 2 decades are big enough to be evident in growth rates. They will not occur, however, without substantial inter-regional capital mobility: without such mobility these deviations in real GDP collapse to just 2.3 and 3.7 per cent above base case respectively, and hence would be scarcely visible in terms of growth rates.

A substantial limitation of these projections is that we have not been able to keep track of the ownership of assets; thus rises in GDP do not necessarily imply increases in welfare.

For Australia the good news for exporters as usual is set against bad news for those import-competing industries which have experienced long-term adjustment difficulties: textiles, clothing, and motor vehicles. With capital not mobile between regions, the long-run gains in real GDP would be well under 1 per cent; with global capital mobility they could be of the order of 2-3 per cent.

In terms of the political economy of APEC it is, perhaps, ironic that the regions which apparently have more to gain (at least in terms of GDP) seem to be those least enthusiastic about actually implementing the trade reforms. Securing high rates of growth in relatively poor countries, however, may be a self-serving priority for the developed economies of APEC in view of the benefits conferred by the greater political stability that may flow from such growth.

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Appendix A

Documentation of the Version of GTAP, its Closure, Database and Parameter File as used in this Paper

This appendix documents the equations, data base, and parameter settings of the *GTAP* model as used in this study. It also describes the software and hardware used to solve the model. This information is provided so that our results can be replicated if desired by independent researchers. The economic model, *GTAP,* is as described in Hertel (ed.) (1997), with some additional equations and variables. The model is encoded for *GEMPACK* in *TABLO* language as GTAP96.TAB.

A1.1 Variables

To understand the results of this paper we need focus on just two new variables and two new equations. The variables are a region-specific ratio of the rate of return in the simulated period to the rate of return expected in that period for the period following it; and a scalar variable for the global capital stock. In *TABLO* language [see, e.g., Pearson and Harrison (1996a&b)] the declarations for these variables are:

```
VARIABLE
(all,r,REG) ror_rat(r)  # Ratio of current to expected rate of return #;
VARIABLE
 kb_tot      # Global stock of capital  #;
```

A1.2 Equations

The equations of the economic model consist of those used in the *GTAP* model as described in Hertel (ed.) (1997), but with two additional equations. The first facilitates a long-run closure[1] in which:

- The capital stock in every region (and therefore, the global capital stock) is endogenous.
- The real rate of return in all industries in all regions is driven to equality in the (relatively distant) future year simulated.
- The rate of return in the year simulated and the prospective rate of return in the year following the year simulated are driven to equality.

This first equation is:

```
EQUATION   E_ROR_RAT
(all,r,REG)    ror_rat(r) = rorc(r) - rore(r) ;
```

1 The closure reported here is an adaptation of the long-run closure of the ORANI model as devised by Horridge (1987) on the basis of the seminal paper of Dixon, Parmenter and Rimmer (1984) and as

When ror_rat(r) is set exogenously to zero for all r, the above equation sets the (percentage deviation from control of the) rate of return on capital in the simulated year in each region equal to the prospective rate of return there in the year following the year simulated. This corresponds to the idea that sufficient time has elapsed after the APEC shock for the world rate of return to have reached a new comparative-static equilibrium. It can be seen that the equality of rore(r) and rorc(r) for all r also implies the equality of ke(r) and kb(r) from the following equation (in which the coefficient RORFLEX(r) is non-zero for all r) from the standard *GTAP* *TABLO* file:

```
EQUATION ROREXPECTED
! Expected rate of return depends on the current return and investment !
        (all, r, REG)      rore(r) = rorc(r) - RORFLEX(r) * [ke(r) - kb(r)] ;
```

The interpretation of the equality

ke(r) = kb(r)

is that the capital stock at the end of the simulated period deviates from control by the same percentage as the capital stock at the beginning of that period. Thus the rate of growth over time of the capital stock in the period simulated is invariant to the shock.

The second equation added by us simply defines a world aggregate capital stock variable. It is

```
EQUATION E_KB_TOT
Sum(r,REG,VKB(r))*kb_tot  =
          Sum(r,REG,VKB(r)*kb(r));
```

where REG is the set of all 11 regions shown in Table 1.

A1.3 Data Base and Parameter Settings

The data base and parameter file used are the standard *GTAP* version 2 data base (see Gehlhar *et al.* (1997)). The post-NAFTA updated data are described below under heading A1.5.

A1.3 Software[2] and hardware

The model was solved using the *TABLO* facility of the *GEMPACK* software package (see Pearson and Harrison (1996a&b) mounted on a Pentium Pro (clock speed 200 mHz) personal computer with 98 megabytes of RAM and ample disk space, running in a DOS box under Windows 95. Solutions of *GTAP* using the 2-4-6 step, 5-subinterval, midpoint solution procedure took about 2 hours to compute.

2 The process of solving the linear equations used the Harwell sparse matrix code (Duff and Reid, 1993).

A1.4 Closures of the GTAP Model defined

Four basic closures were used:

- ***medium-run standard closure*** This is the standard *GTAP* closure with aggregate capital stocks exogenous in every region and with the world pool of real capital goods allocated in the fixed proportions that applied in the base-case data (i.e., RORDELTA is set to 0). The list of exogenous variables (as abstracted from the command (.CMF) file used to run the *TABLO*-generated simulation program) is as follows:

EXOGENOUS

tms txs
pop
psave
profitslack incomeslack endwslack
cgdslack saveslack govslack tradslack
ao af afe ava atr
to tx tm
qo(ENDW_COMM,REG) ;

REST ENDOGENOUS ;

The set ENDW_COMM is the set of endowment 'commodities': land, labor and capital. An environment file STRUCTLU.EN4 is saved from the implementation of this closure. This closure underlies columns (3), (6) and (9) of Table 5 and the Young and Huff results (columns (2), (5) and (8) of the same table).

- ***medium-run isolation closure*** This modifies the previous closure in the following way. The global supply of capital resources is allocated to regions according to rates of return expected in the solution period to apply to the period following the solution period (i.e., RORDELTA is set to 1). Our intention was to remove all feedbacks from the Australian economy to other regions. Formally this involved exogenizing (at zero change) the following:

(1) all (real) bilateral trade flows into and out of Australia;
(2) the flow from Australia of the saving good into the global pool of saving (i.e., the impact of Australia on the size of the global supply of capital);
(3) the flow from the global pool of saving of real capital funds into Australia.

The endogenous instruments (which are exogenous in the standard *GTAP* closure) respectively are:

(1) all tax rates on bilateral trade flows into and out of Australia, tms(i,r,s), where one of r or s = "aus";
(2) the slack variable (cgdslack("aus")) in equation RORGLOBAL;
(3) the slack variable (incomeslack("aus")) in equation

This closure was effected by swapping exogenous/endogenous variables relative to the environment file STRUCTLU.ENV produced when running the medium-run standard closure. The first command in the following abstract from the command file APEC.CMF specifies what the swaps are relative to; the second and third commands implement (1) above; the fourth and the fifth commands respectively implement (2) and (3).

```
MODIFY CLOSURE from environment file structlu ;
  swap qxs(TRAD_COMM,"aus",REG_NOTOZ)
     =txs(TRAD_COMM,"aus",REG_NOTOZ);
  swap qxs(TRAD_COMM,REG_NOTOZ,"aus")=
   tms(TRAD_COMM,REG_NOTOZ,"aus");
  swap cgdslack("aus")=qcgds("aus");
  swap incomeslack("aus")=qsave("aus");
```

Above TRAD_COMM is the set of 37 traded commodities listed in Table 4, and REG_NOTOZ is the set of 10 regions listed in Table 1 but excluding Australia.

This closure was used to produce the shocks for the medium-run MONASH results reported in the text.

Rather late in the work program it was discovered that one flow between Australia and the rest of the world (involving exports from Australia to the global transport industry) had not been exogenized at zero change; it is believed that this makes very little difference to the results.

- ***long-run Horridge-style (Walmsley) closure (with Australia treated like other regions)*** This is currently being developed by Walmsley (1996); it is an extension to *GTAP* of the long-run closure of ORANI developed by Horridge (1987) from Dixon, Parmenter and Rimmer's (1984) seminal work. This closure was effected using the extended *GTAP TABLO* source file described above under headings 1.1 and 1.2 by making a single exogenous/endogenous variable swap relative to the environment file STRUCTLU.ENV discussed above *after* setting RORDELTA = 1 in the parameter file. The swap appears in the command file as:

```
MODIFY CLOSURE from environment file structlu ;
  swap ror_rat = qo("capital",REG) ;
```

This closure underlies columns (4), (7) and (10) of Table 5. In it regional rates of return, as well as regional capital stocks, are endogenous. Moreover, regional rates of return are driven to equality with the world rate of return, which can be seen from the following equation from the *TABLO* file.

```
EQUATION RORGLOBAL
  (all,r,REG)     RORDELTA*rore(r) +
   [1 - RORDELTA] * {[REGINV(r)/NETINV(r)] * qcgds(r)
    - [VDEP(r)/NETINV(r)] * kb(r)}
```

With RORDELTA = 1 this may be rewritten:

rore(r) = rorg ,

where r ranges over all 11 regions.

- ***long-run isolation closure*** Relative to the medium-run isolation closure, this is obtained by adding the commands

```
MODIFY CLOSURE from environment file structlu ;
    swap ror_rat = qo("capital",REG) ;
```

to the list of commands in the command file used to run the simulation (see notes above on the previous two closures). This closure was used to produce the shocks for the long-run MONASH results reported in the text.

A1.5 Generating the post-NAFTA data base

The aggregation used retains all 37 commodities present in the version 2 *GTAP* database, but aggregates from 24 to 11 regions. An aggregation template input file, APEC1137.TXT, is needed. Working in a GTAPDATA directory containing the *GTAP* aggregation software (as current at the end of 1994), the following command is issued:

DATA-AGG APEC1137

This tells DATA-AGG.BAT (which is part of the aggregation software supplied) to use template APEC1137.TXT and produces aggregated data files in subdirectory APEC1137 as follows:

GSET.HAR, GDAT.HAR, GPAR.DAT .

The first two of these aggregated data files were renamed GSET1137.HAR, GDAT1137.HAR respectively. The GPAR.DAT data file is where the parameter RORDELTA, which determines the investment allocation mechanism (described above), is set. For the first closure listed above RORDELTA is set to zero, which is the value contained in GPAR.DAT; for easier identification this file is renamed 0PAR1137.DAT. For the other three closures, RORDELTA = 1 and 0PAR1137.DAT is edited accordingly, producing 1PAR1137.DAT.

A post-NAFTA data base NAF1137.HAR was obtained by running TP1137.EXE (a *TABLO*-generated program obtained from GTAP1137.TAB) taking inputs from the command file NAF1137.CMF. Here the only shocks were to import tariffs (tms) within North America (NAM) taken from the file TMS1137.SHK. This realization of NAFTA is as carried out by Young and Huff (1997) in their 3-commodity, 10-region work. The main output from this stage is the post-NAFTA data file NAF1137.HAR which is a levels solution of the *GTAP* model taking into account the NAFTA trade reforms.

A1.6 Generating the APEC shocks for GTAP

Different shocks are needed for the isolation and the non-isolation closures (since the tariff rates in Australia, tms(i, r, "aus") are endogenous in the former and shocked in the latter). In both cases the required shocks are read from the same file, which contains the set of tms(i, r, s) shocks for the full APEC implementation. In the case of the isolation closures, the shocks to Australia's tariff rates are not read (as explained below).

The shock file was generated by running SHK1137.EXE (obtained from source file SHK1137.TAB), starting from the post-NAFTA data file NAF1137.HAR and using the command file NSHK1137.CMF.

A1.7 Running the GTAP simulations of APEC

All four simulations use the *TABLO*-generated program GTAP96.EXE (obtained by compiling and linking the Fortran program GTAP96.FOR obtained from the source file GTAP96.TAB by using the stored input file GTAP96.STI to run *TABLO*). For the medium-run standard closure, the simulation is carried out with a command file, STRUCTLU.CMF, that simply lists the default set of exogenous variables as displayed in Section A1.4 above. The other files needed as inputs are:

the file containing the post-NAFTA data base	GDAT1137.HAR
the file containing the tms shocks	APEC1137.SHK
the parameter file with RORDELTA set to 0	0PAR1137.DAT
the file containing the definitions of sets used	GSET1137.HAR

The outputs of this simulation are an environment file, STRUCTLU.EN4, and a solution file APEC_ST0.SL4.

For the remaining three simulations, the environment file STRUCTLU.EN4 is used as an input to specify the closure using swap statements as detailed above in Section 1.4 above. Common as inputs to all three remaining simulations are the following files:

the file containing the post-NAFTA data base	GDAT1137.HAR
the file containing the tms shocks	APEC1137.SHK
the parameter file with RORDELTA set to 1	1PAR1137.DAT
the file containing the definitions of sets used	GSET1137.HAR

In addition, each simulation required its own command file as follows (the medium-run non-isolation closure is repeated for completeness):

	non-isolation closures	*isolation closures*
medium run	STRUCTLU.CMF	APEC_SR0.CMF
long run	APEC_STL.CMF	APEC_LR1.CMF

In the case of the isolation closures, these command files cause GTAP96.EXE to read from APEC1137.SHK only the shocks to tariffs imposed by APEC countries other than Australia. The results of these simulations are in the following solution files:

	non-isolation closures	*isolation closures*
medium run	APEC_ST0.SL4	APEC_SR0.SL4
long run	APEC_STL.SL4	APEC_LR1.SL4

The endogenous results for variables pcif_ave(i, “aus”) and p_fob_ave(i, “aus”) from the simulations in the isolation closures were used as the shocks to MONASH (see Appendix B below).

APPENDIX B

Documentation of the Version of *MONASH*, its Closure, Database and Parameter File as used in this Paper

This appendix documents the equations, data base and parameter settings of the ***MONASH*** model used in this study. The software and hardware used to solve the model are those used to solve *GTAP*; see Appendix A.

B1 Variables and Equations

The version of ***MONASH*** used in this paper is encoded in *TABLO* language as the text file MONASH96.TAB. This can be obtained by writing to Philip Adams, Centre of Policy Studies, Monash University, Clayton Vic 3168, Australia. Formal documentation of the model is currently underway, but the first complete draft will not be available until mid-1998.

B2 Data Base and Parameter Settings

The ***MONASH*** database is organized essentially in two separate files. The first contains input-output data which provide the basis for computing initial cost and sales shares for industries and their products. The second stores elasticity parameters, such as values for export demand elasticities, which are invariant to time. For this paper we used the model's 1995-96 database. This was generated by updating the most recently available set of input-output accounts from the Australian Bureau of Statistics via simulation with ***MONASH***.

The 1995-96 input-output file is stored as the Header Array file fid96.har, and the corresponding parameters file as par96.har.

B3 Closure

The closure of ***MONASH*** used for the projections in this paper is the standard long-run closure. In it:

- capital stocks in each industry are endogenous and move to equalize disturbances in rates of return;
- economy-wide employment is fixed (it is assumed that in the long-run aggregate employment is determined by demographic factors, such as migration, which are unaffected by APEC liberalization) and the economy-wide real wage adjusts to clear the labour market;
- investment and capital move together at the industry level; and
- nominal consumption (private and public) moves with nominal GDP.

The variables which are exogenous and shocked by percentage changes received from *GTAP* are:

- powtaxm (powers of tariff rates by commodity);
- pm (foreign currency import prices (cif), by commodity);
- fep (vertical shifts in foreign demand curves, by commodity other than tourism services); and
- fep_tour (vertical shifts in foreign demand for Australian tourism services).

B4 Running the simulations

Step 1

MONASH94.TAB was converted to MONASH96.EXE by running *TABLO* taking inputs from files TMONASH.CMF.

Step 2

The shocks for the four ***MONASH*** variables listed above were produced from the *GTAP* solution file APEC_LR1.SL4 using program SLTOHT and header mapping file APECRES.HAM. The header mapping file picks out just the pcif_ave, pfob_ave and tms_ave results from APEC1137.SL4.

The TABLO Input file MONSHK2.TAB was processed by TABLO taking inputs from Stored-input file TMONSHK2.STI to produce the TABLO-generated program MONSHK2.EXE. This was run taking inputs from Command file MONSHK2.CMF. One input to the MONSHK2.CMF job is the file GTAPINFO.TXT which contains the correspondence between the 37 *GTAP* commodities and the ***MONASH*** commodities.

The output file MONSHOCK.OUT from the MONSHK2.CMF job contains the shocks for the four ***MONASH*** variables. This file was manually split into the four shocks files for these variables.

Step 3

The ***MONASH*** simulation was run by running MONASH96.EXE taking inputs from the Command file MONAPEC.CMF. The input data files were 1995/96 data files FID96.HAR, PAR96.HAR and SETINFO.HAR. The closure used in MONAPEC.CMF was actually set up via Command file STRUCTLU.CMF.

The results from MONAPEC.CMF are in file MONAPEC.SL4. The solution method used was 6,8,10-step midpoint.

APPENDIX C
Long-Run Wage Effects in GTAP Simulations of APEC[1]

by

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A rough check on the plausibility of *GTAP's* wage results goes as follows. Let $pgdp(r)$ be the percentage change in price of gdp in region r. Then from the income side

$$pgdp(r) = S_L(r)p_L(r) + S_K(r)p_K(r) + S_N(r)p_N(r) + S_T(r)(\tau(r) + p_\bullet(r)) \qquad \text{(C1)},$$

where: the subscripts L, K and N refer to labor, capital and land; the subscript T refers to commodity taxes net of subsidies; the $S_i(r)$ $i = L,K,N$ and T are the relevant shares in market-price GDP; the $p_i(r)$ $i = L,K$ and N are percentage changes in primary factor prices; $\tau(r)$ is the percentage change in the average *ad valorem* rate of net indirect tax; and $p_\bullet(r)$ is the percentage change in the average price (before-tax) of the taxed commodities. From now on we assume that tariffs are the only form of indirect taxes in each region, and that there are no commodity subsidies. Thus $\tau(r)$ is interpreted as the percentage change in the average *ad valorem* rate of tariff in region r, and $p_\bullet(r)$ is set equal to $p_M(r)$, the percentage change in average import price (cif) in region r.

We can also write from the expenditure side of GDP that

$$pgdp(r) = S_A(r)p_A(r) + S_X(r)p_X(r) - S_M(r)p_M(r) \qquad \text{(C2)},$$

where: the subscripts A, X and M refer to domestic absorption, exports and imports; and the Ss and ps are the relevant shares and prices.

Equating (C1) and (C2) and re-arranging gives the following expression for the percentage change in wage in region r:

$$p_L(r) = \frac{S_A(r)p_A(r) + S_X(r)p_X(r) - S_M(r)p_M(r) - S_K(r)p_K(r) - S_N(r)p_N(r) - S_T(r)(\tau(r) + p_M(r))}{S_L(r)} \qquad \text{(C3)}.$$

In Table C1 we list values for the GDP-shares taken from the post-NAFTA *GTAP* database used for the APEC simulations. Table C2 shows *GTAP*'s projections of the effects of APEC liberalization on the prices contained in (C3). Note that these are based on a 1-step Johansen simulation.

[1] [illegible]

Table C1: GDP-Shares by region

	North America	Japan	Australia	New Zealand	China/ HK	South Korea	Taiwan	Malaysia/ Singapore	Thailand/ Philippines	Indonesia	ROW
$S_L(r)$	0.62	0.58	0.59	0.51	0.51	0.47	0.57	0.38	0.26	0.28	0.60
$S_K(r)$	0.37	0.40	0.37	0.43	0.37	0.44	0.40	0.57	0.63	0.63	0.37
$S_N(r)$	0.00	0.01	0.02	0.03	0.08	0.04	0.02	0.03	0.04	0.07	0.01
$S_T(r)$	0.01	0.01	0.01	0.03	0.03	0.05	0.02	0.02	0.06	0.02	0.01
$S_A(r)$	1.00	0.98	0.99	0.94	1.03	1.02	0.88	0.99	1.05	0.95	1.01
$S_X(r)$	0.13	0.12	0.20	0.40	0.44	0.35	0.46	1.30	0.40	0.33	0.15
$S_M(r)$	0.13	0.10	0.19	0.34	0.48	0.37	0.33	1.29	0.45	0.28	0.15

Table C2: Price projections

	North America	Japan	Australi a	New Zealand	China/ HK	South Korea	Taiwan	Malaysia/ Sing.	Thailand/ Phil.	Indonesia	ROW
$p_L(r)$	-1.5	4.5	3.0	7.5	11.8	15.6	7.0	10.7	20.5	11.8	-2.6
$p_K(r)$	-1.3	4.5	-1.5	-5.8	0.3	1.8	2.3	1.3	-10.2	1.1	-0.8
$p_N(r)$	8.2	-27.3	15.2	26.2	11.6	-9.6	-2.0	15.7	29.8	8.7	-4.1
$\tau(r)$	-68.0	-82.0	-71.1	-75.9	-79.8	-80.7	-85.5	-81.3	-73.1	-70.2	0.0
$p_A(r)$	-1.8	2.8	-0.5	-2.7	1.6	0.7	1.0	0.9	-6.1	2.0	-1.8
$p_X(r)$	-1.7	3.5	0.5	0.2	0.2	-1.6	2.0	0.5	-5.7	0.0	-1.7
$p_M(r)$	-0.8	-1.0	-0.4	-0.3	-0.3	0.1	0.4	-0.1	0.1	-0.2	-1.0
$pgdp(r)$	-1.9	3.2	-0.4	-2.4	1.9	0.1	1.6	1.7	-8.3	1.9	-1.9

Applying the data in Tables C1 and C2 to equation (C3) yields the estimates for $p_L(r)$ in the first row of Tabble C3; the values in the second row are from the full non-linear (multistep) solution of *GTAP*.

Table C3: Wage rate changes computed from equation (C3) and from multistep solution

$\hat{p}_L(r)$	North America	Japan	Australi a	New Zealand	China/ HK	South Korea	Taiwan	Malaysia/ Sing.	Thailand/ Phil.	Indonesia	ROW
Eqn (C3)	-1.7	4.9	2.8	7.2	12.0	15.2	6.9	10.7	19.5	11.5	-2.7
multistep	-2.3	5.7	4.8	12.7	13.9	20.7	7.7	15.1	29.2	18.8	-3.2

The values in the first row of Table C3 are very close to the actual projections shown in the first row of Table C2 (simple correlation squared = 0.98). The linearization error linking the second row of Table C3 with the Johansen 1-step solutions shown in the first row of Table C2 is very close to a uniform 39 per cent, so that equation (C3) maps very closely to the full non-linear solution after multiplication by 1.39 (see Figure C1).

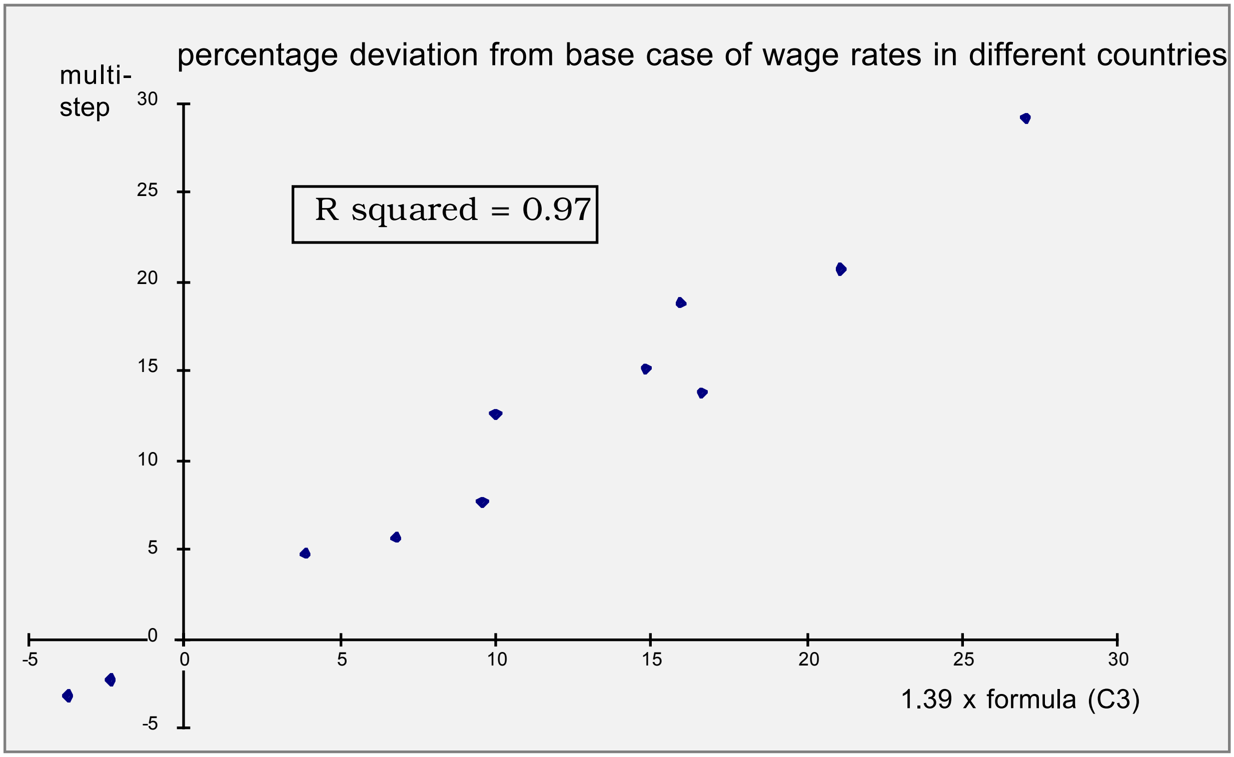

Figure C1: Scaled results for wage changes from implementation of formula (C3) on one-step values of components compared to multi-step solution values for 11 regions.

We continue by decomposing $p_A(r)$. We assume that

$$p_A(r) = W_D(r)p_D(r) + W_M(r)(powt(r) + p_M(r)) \quad \text{(C4)},$$

where: the W's are weights reflecting the shares in domestic absorption of expenditure on domestically-produced and imported commodities; $p_D(r)$ is the percentage change in the price of a typical domestically-produced commodity in region r; and $powt(r)$ is the percentage change in the power of the average *ad valorem* tariff. Note that

$$powt(r) = \frac{T(r)}{1 + T(r)}\tau(r) \quad \text{(C5)},$$

where $T(r)$ is the level of the average *ad valorem* tariff rate in region r.

We approximate the price of the typical domestically-produced commodity in (C4) as:

$$p_D(r) = R_L(r)p_L(r) + R_K(r)p_K(r) + R_N(r)p_N(r) + R_M(r)(powt(r) + p_M(r)) \quad \text{(C6)},$$

where the R's are the relevant shares in the aggregate costs (excluding the cost of domestically-produced materials) of the domestic industry producing the typical domestically-produced commodity.

Substituting (C6) and (C5) into (C4) gives (after dropping the reference to region r)

$$p_A = W_D(R_L p_L + R_K p_K + R_N p_N) + (W_D R_M + W_M)(\frac{T}{1+T}\tau + p_M) \quad \text{(C7).}$$

Table C4 contains base-case values for the shares in equation (C7).

Table C4: GNE shares by region

	North America	Japan	Australia	New Zealand	China/ HK	South Korea	Taiwan	Malaysia/ Sing.	Thailand/ Phil.	Indonesia	ROW
W_D	0.93	0.97	0.91	0.82	0.81	0.92	0.87	0.71	0.80	0.87	0.94
W_M	0.07	0.03	0.09	0.18	0.19	0.08	0.13	0.29	0.20	0.13	0.06
R_L	0.62	0.57	0.55	0.49	0.45	0.40	0.51	0.36	0.30	0.38	0.59
R_K	0.34	0.38	0.38	0.41	0.35	0.43	0.40	0.41	0.57	0.51	0.34
R_N	0.00	0.00	0.00	0.00	0.08	0.03	0.01	0.01	0.02	0.05	0.01
R_M	0.04	0.04	0.07	0.10	0.12	0.14	0.08	0.22	0.11	0.07	0.06

Applying the data in Tables C4 and C3 to equation (C7) yields the following estimates for $p_A(r)$:

	North America	Japan	Australia	New Zealand	China/ HK	South Korea	Taiwan	Malaysia/ Sing.	Thailand/ Phil.	Indonesia	ROW
$\hat{p}_A(r)$	-1.8	3.4	-0.2	-1.9	2.7	2.8	2.4	2.2	-4.2	3.1	-1.8

These are fairly close to the actual projections shown in the fifth row of Table C2.