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Reaching the Planners: Generating Detailed Commodity Forecasts from a Computable General Equilibrium Model

by

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Abstract

The largest computable general equilibrium (CGE) models currently in operation produce forecasts divided into about 100 commodities (goods and services). This level of detail may seem overwhelming to macroeconomists but is often inadequate for micro planning. For example, a forecast for business services (a typical commodity at the 100-level) is of marginal interest in planning educational programs for sub-categories of business services such as accountancy, advertising and architecture. As a step towards generating information for micro planning, this paper describes a tops-down method for disaggregating CGE forecasts. The method relies on detailed sales data often collected by input-output sections of statistical agencies. An application is reported in which forecasts from a 114-commodity CGE model are disaggregated into forecasts for 780 commodities. Within each of the 114 core commodities, differences in prospects are forecast for sub-commodities reflecting differences in their sales patterns and in the degree to which they face import competition.

Keywords: Computable general equilibrium forecasting; disaggregated economic forecasting; input-output data; microeconomic forecasting.

J.E.L classification nos: C68, C81, C53.

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1. Introduction

Computable general equilibrium (CGE) modelling started with the work of Johansen (1960). After 35 years, it is now a well established technique for analysing economic problems in which the central interest is in the diversity of outcomes for producers of different commodities (goods and services).[1] The effect on a nation's economy of reductions in its trade barriers, for example, is a good CGE issue. As quantified by CGE models, such reductions harm the nation's producers of import-competing commodities while benefiting the producers of exportable commodities.

The largest CGE models currently in operation produce output forecasts divided into about 100 commodities. Typical commodity categories at this level of detail are clay products, business services and intensive-farming products. This level of detail may seem overwhelming to macroeconomists and is usually more than adequate for contributors to public discussions of the effects of broad changes in policies concerning trade, taxes and the environment. However, people wanting to use CGE models in business and public sector planning are often frustrated by lack of relevant detail.

In thinking about investment possibilities, these people want to know about prospects for clay bricks, roofing tiles, flooring tiles, wall tiles, and ceramic construction goods. They do not know how to use a story derived from a CGE model about prospects for the overall category, clay products. In planning education programs, they want to know about employment prospects for architects which depend on growth in the demand for architectural services. They are unsatisfied when they learn that the model provides projections only for the overall category, business services, which contains architectural services, along with other services such as surveying services, real-estate agent services, legal services, accounting services, and advertising services. In looking at regional adjustment problems, they need information which separates apples and pears (grown in temperate regions) from sugar cane and cotton (grown in semi-tropical regions). They are disappointed when all they get from the model is a projection for intensive-farming products encompassing commodities from both temperate and semi-tropical regions.

In this paper, we describe a tops-down method for disaggregating CGE forecasts. The method relies on detailed sales data often collected by the

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1 Surveys of CGE modelling include Shoven and Whalley (1984), Pereira and Shoven (1988), Robinson (1989, 1991), Bandara (1991), Bergman (1990) and Dixon and Parmenter (1996).

input-output sections of statistical agencies. We apply the method to disaggregate forecasts from MONASH (a 114-commodity CGE model of Australia) into forecasts for 780 commodities. This disaggregation takes the level of detail from clay products to clay bricks, roofing tiles, etc.; from business services to architectural services, surveying services, etc.; and from intensive-farming products to apples, pears, sugar cane etc.

The remainder of the paper is organised as follows. In the next section we give a brief description of MONASH including some results from a recent MONASH forecasting exercise. In Section 3 we specify the structures of MONASH's input-output database and of the supplementary sales data used in the disaggregation of MONASH results. The theory of the disaggregation method is set out in Section 4 and in the Appendix. Section 5 provides some illustrative disaggregated results. Concluding remarks are in Section 6.

2. Background: the core MONASH model

The core MONASH model is a 114 commodity/112 industry CGE model of Australia. It is a descendant of ORANI (Dixon *et al.*, 1982) which has been applied in Australian policy debates since the 1970s.[2] The main theoretical extension in MONASH relative to ORANI is dynamics. MONASH produces sequences of annual solutions connected by accumulation relationships for capital stocks. ORANI, on the other hand, is a comparative static model. It shows for a single year the differences produced in the economy by changes in taxes, tariffs and other exogenous variables.

Our objective in developing MONASH is to derive insights of interest to people concerned with industry prospects. Apart from dynamics, other features of our modelling which we think are important in working towards this objective are:

- our use in MONASH of macro forecasts generated by business economists through the application of standard macroeconometric techniques;
- our use in MONASH of forecasts prepared by specialists in particular aspects of the economy, e.g., agriculture, mining, tourism and industry policy; and
- our use in MONASH of detailed scenarios on changes in consumer tastes and changes in technology.

Thus, in designing MONASH, we have aimed for an open specification, i.e., one which allows the model to incorporate detailed views from well-informed sources on a wide variety of variables.

In the remainder of this section we provide a brief description of a recent set of MONASH forecasts. By doing this, we hope to give readers an adequate idea of what we will be disaggregating, without requiring them to be familiar

2 For an overview of ORANI applications, see Powell and Snape, (1993).

with the details of the MONASH model. Specification of the core MONASH model and detailed descriptions of MONASH forecasts are in Adams *et al.* (1994a and b).

MONASH forecasts of outputs of 114 commodities

Table 1 shows forecast growth rates over the period 1993-4 to 2001-2 (years ending June 30) for outputs of the 114 commodities in the MONASH core. Reflected in these forecasts are: the view of a prominent Australian business forecaster, Syntec (1995), on Australia's macro prospects; the views of the Australian Bureau of Agricultural and Resource Economics (ABARE, 1995) concerning prospects on world markets for Australia's primary commodities; the view of the Bureau of Tourism Research (BTR) concerning the likely trend in tourist arrivals in Australia; the view of the Industry Commission (IC) regarding likely changes in industry policy; and the views of the Centre of Policy Studies (Dixon and McDonald, 1993a and b) on trends in technology and consumer preferences.

In the Syntec macro forecasts, GDP growth is 3.3 per cent. In the MONASH forecasts, this fixes the output weighted average of the 114 growth rates in Table 1 at 3.3 per cent.

Consistent with ABARE forecasts, Table 1 shows good prospects for most of Australia's export-oriented mineral products, especially commodities 18, 15, 17 and 16. However, for commodities 14 and 65 (ferrous metal ores and basic iron and steel), ABARE expects low export growth. This explains the low rankings in Table 1 of these two products. Fishing (13), most farm commodities (e.g., 2, 8, 10, 1, 3, 5, 6, and 4) and most lightly transformed farm commodities (e.g., 24, 32, 27 and 20) also appear low in the ranking of Table 1. ABARE's view is that these products face either contraction in their export sales or slow growth.

The BTR forecasts average annual growth in international tourist arrivals in Australia of about 10 per cent. Strong growth is expected in connection with the Sydney-2000 Olympic Games and several other major events. In Table 1, the influence of the BTR's forecast can be seen in the high rankings for commodities 98 (air transport) and 113 (restaurants, hotels).

The IC forecasts for industry policy imply continuing reductions in tariffs on textiles, clothing and footwear (TCF) and on motor vehicles (MV). Many of the commodities the TCF and MV sectors already face large import shares in their domestic markets. For these commodities (e.g., 70, 35, 40, 39, 33, 34, and 41), tariff reductions are an important part of the reason why they rank near the bottom of Table 1.

A major influence on the results in Table 1 is our scenarios for changes in industry technologies and household preferences. These scenarios were derived by extrapolating recent movements in input-output coefficients[3] and

[3] Input-output coefficients, usually denoted as a_{ij}, show the usage of commodity i per unit of output in industry j.

Table 1. MONASH Forecasts of Average Annual Growth Rates (%) in Commodity Outputs: 1993-94 to 2001-02

Rank		Commodity	Rate	Rank		Commodity	Rate
1	100	Communication	7.3	58	69	Other Metal Products	2.9
2	76	Household Appliances	6.9	59	71	Ships and Boats	2.9
3	98	Air Transport	6.6	60	2	Sheep	2.8
4	18	Other Minerals	6.5	61	24	Flour and Cereal Products	2.8
5	50	Commercial Printing	6.4	62	66	Non-Ferrous Metals	2.8
6	15	Non-Ferrous Metal Ores	5.9	63	81	Leather Products	2.8
7	104	Insurance	5.8	64	86	Electricity	2.8
8	75	Electronic Equipment	5.6	65	12	Forestry and Logging	2.7
9	91	Wholesale Trade	5.5	66	28	Soft Drinks, Cordials	2.7
10	103	Investment Services	5.3	67	32	Cotton Ginning, etc.	2.7
11	67	Structural Metal Products	5.2	68	8	Sugar Cane, Cotton and Other	2.6
12	68	Sheet Metal Products	5.2	69	27	Other Food Products	2.6
13	74	Scientific Equipment	5.1	70	30	Other Alcoholic Drinks	2.6
14	101	Banking	5.1	71	51	Chemical Fertilisers	2.6
15	19	Services to Mining nec	5.0	72	109	Health	2.6
16	113	Restaurants, Hotels	5.0	73	11	Services to Agriculture	2.5
17	49	Publishing, printing, advertising	4.8	74	23	Margarine, Oils, Fats nec	2.5
18	93	Mechanical Repairs	4.7	75	59	Glass and Glass Products	2.5
19	17	Crude oil, gas and brown coal	4.6	76	10	Poultry	2.4
20	114	Personal Services	4.6	77	14	Ferrous Metal Ores	2.4
21	22	Fruit and Vegetable Prods	4.5	78	20	Meat Products	2.4
22	52	Other Basic Chemicals	4.4	79	46	Pulp, Paper, Paperboard	2.4
23	92	Retail Trade	4.3	80	47	Bags and Containers	2.4
24	16	Black Coal	4.2	81	48	Paper Products nec	2.4
25	58	Petrol and Coal Products	4.1	82	36	Textile Finishing	2.2
26	73	Aircraft	4.1	83	70	Motor Vehicles and Parts	2.2
27	80	Other Machinery	4.1	84	83	Plastic Products	2.2
28	88	Water, Sewerage, Drainage	4.1	85	84	Signs, Writing Equipment	2.2
29	99	Services to Transport	4.1	86	13	Fishing and Hunting	2.0
30	102	Non-Bank Finance	4.1	87	95	Road Transport	2.0
31	94	Other Repairs	4.0	88	106	Ownership of Dwellings	2.0
32	53	Paints and Varnishes	3.9	89	26	Confectionery and Cocoa	1.9
33	79	Construction Machinery	3.8	90	97	Water Transport	1.9
34	90	Other Construction	3.7	91	1	Wool	1.8
35	21	Milk Products	3.6	92	35	Wool, Worsted Fabrics	1.8
36	87	Gas	3.6	93	64	Non-Metallic Mineral Prods	1.8
37	105	Other Business Services	3.6	94	3	Wheat	1.7
38	37	Textile Floor Coverings	3.5	95	82	Rubber Products	1.7
39	38	Other Textile Products	3.5	96	25	Bread Cakes and Biscuits	1.6
40	54	Pharmaceutical Goods	3.5	97	96	Rail and Other Transport	1.6
41	111	Welfare Services	3.5	98	5	Other cereal grains	1.5
42	112	Entertainment, Leisure	3.5	99	6	Meat cattle	1.4
43	9	Fruit, veg. and nuts	3.4	100	31	Tobacco Products	1.4
44	42	Sawmill Products	3.4	101	63	Concrete Products	1.3
45	55	Soap and Detergents	3.4	102	89	Residential Building	1.3
46	77	Other Electrical Goods	3.4	103	62	Ready Mixed Concrete	1.1
47	85	Other Manufacturing	3.4	104	72	Railway Rolling-stock	1.1
48	7	Milk Cattle and Pigs	3.3	105	108	Defence	1.1
49	57	Other Chemical Goods	3.3	106	61	Cement	1.0
50	43	Veneers and Wood Boards	3.2	107	60	Clay Products	0.3
51	45	Furniture and Mattresses	3.2	108	65	Basic Iron and Steel	0.3
52	44	Joinery and Wood Products	3.1	109	40	Clothing	-0.3
53	29	Beer and Malt	3.0	110	39	Knitting Mills	-0.5
54	78	Agricultural Machinery	3.0	111	33	Man-Made Fibre, Yarns	-1.1
55	107	Public Administration	3.0	112	34	Cotton Yarns, Fabrics	-1.7
56	110	Education, Libraries	3.0	113	41	Footwear	-1.9
57	56	Cosmetics and Toiletries	2.9	114	4	Barley	-4.9

in the parameters of the household utility function.[4] Among the commodities which owe their high rankings in Table 1 to assumed shifts in technologies and preferences favouring their use are: high-tech services and related equipment such as 100, 76, 75 and 74; financial-advising and transaction-facilitating services such as 104, 103, 101 and 102; printed advertising media (50 and 49); light building materials (67 and 68); and healthy foods (22). Among the commodities which get a low ranking in Table 1 because of apparent shifts in consumer preferences or technologies against their use are: alcoholic drinks and tobacco (30 and 31); heavy building materials (63, 62, 61); transport services (95, 97 and 96); paper and paper-related products (46, 47 and 48); and electricity (86).

Another pervasive influence in Table 1 is strong growth in Australia's trade in manufactured goods. Since the mid 1980s, Australia's trade in manufactures, both imports and exports, has grown by about 10 per cent a year. In our forecasts, this rapid growth continues. As well as reductions in tariffs, other contributing factors are likely to be: continuing decline in the real costs of transport and communications associated with international trade; a continuing tendency towards intra-industry specialisation in, for example, the production of cars; and continued technological change favouring the use of hi-tech manufactured inputs which are largely imported to Australia.

For most of Australia's manufactured commodities (those apart from processed food and minerals), MONASH generates only a single growth rate for exports.[5] Thus our forecasts tend to show good prospects for Australian production of manufactured commodities in which exports are a significant share (more than 10 per cent) of sales. Manufactured commodities which owe their above-average rankings in Table 1 to their comparatively high export shares are 52, 58, 73, 80, 53, 79, 21, 54, 42, 85 and 78. On the import side, each manufactured commodity has its own growth rate in our forecasts reflecting changes in the commodity composition of domestic demands and changes in the costs of imported products relative to the costs of competing Australian products. However, to generate forecasts which give a realistically high growth rate for aggregate imports, we add to these commodity-specific import growth rates the effects of a uniform twist in Australian preferences toward imported products. This twist means that commodities in which imports occupy a large share (more than 20 per cent) of the domestic market tend in our forecasts to have poor prospects. Commodities which owe their below-average rankings in Table 1 primarily to large import shares are 69, 71, 81, 51, 23, 59, 83, 84, 82 and 60.

Most commodities for which public consumption is the primary source of demand (e.g., 111, 107, 110, 109 and 11) appear in the middle third of the

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4 Household preferences in MONASH are described by the Klein and Rubin (1948-49) utility function: $U=\sum_i \beta_i \ln(X_i-\gamma_i)$ where X_i is consumption per household of good i, and γ_i and β_i are parameters with $\beta_i>0$ and $\sum_i \beta_i = 1$. Changes in preferences can be handled in MONASH by changes in the β_is and γ_is.

5 The group of manufactured commodities for which we generate only a single export growth rate accounts for about 15 per cent of Australia's total exports.

rankings in Table 1. These commodities are neither imported nor exported and we assume that public demand for them grows approximately in line with GDP. An outlier is commodity 108 (defence). It has a very low ranking in Table 1 because we assume that with the easing of tensions in its region, Australia will continue to reduce its defence budget as a share of its public expenditure.

In the construction sector, Table 1 shows contrasting prospects. Residential building (89) is ranked 102, whereas non-residential construction (90) is ranked 34. Both construction activities are highly cyclical. In the initial year of the forecasts (1993-94), residential building was at a high point in its cycle while non-residential construction was at a low point.

A final ingredient in the MONASH forecasts which is worth mentioning is expenditure elasticities. Consider commodities 25 (bread etc.) and 37 (textile floor coverings). Neither of these is strongly linked to international trade and neither is noticeably affected in our forecasts by changes in consumer preferences. Commodity 37 is moderately high in the growth rankings in Table 1 because its expenditure elasticity is high, i.e., household demand expands strongly in response to growth in income per household. Commodity 25 is low in the rankings because its expenditure elasticity is low.

3. Input-output databases

The principal data input to most CGE models is a set of input-output tables published by a national statistical agency. These published tables are either square or approximately square, i.e., they identify approximately the same number of commodities (rows) as industries (columns). In preparing square tables, statistical agencies usually work with rectangular data containing considerably more commodity detail than is eventually published. These rectangular data arise from questionnaires which typically ask for information concerning purchases of over a thousand commodities but require firms to place themselves in one of only about 100 industries. Although statistical agencies do not usually publish their rectangular data, they may be willing to supply them to research workers. This is the case in Australia. Our method of disaggregating CGE results depends on the availability of detailed rectangular data.

The first step in explaining our disaggregation method is to set out the structures of square and rectangular input-output datasets. We do this for the databases available in Australia for use in MONASH. While the structures of input-output databases vary between countries, the Australian case is representative.

The square input-output database

Figure 1 illustrates the approximately square (114 commodities × 112 industries) database on which the core MONASH model is built. These data are provided by the Industry Commission (IC) working with input-output

Figure 1. Structure of the core *MONASH* Input-Output Database

			Final Demands:				
		Intermediate demand by industries j=1,...,112	Investment by industries j=113...,224	Private consumption j=225	Exports j=226	Other demands j=227	
Direct sales	Domestically produced commodities i=1...114, s=1			V(i,s,j)			Row sums = total direct usage of domestic goods
of:	Imported commodities i=1...114, s=2						- Duty Z(i); Row sums = total imports (c.i.f)
Margins usage of (r,1),	use of (r,1) associated with flows of (i,1), i=1...114			V(r,1;i,s,j)			Row sums = use of (r,1) as margin on domestic flows
for (r,1)∈ MARCOM	use of (r,1) associated with flows of (i,2), i=1...114						Row sums = use of (r,1) as margin on imports
Sales	on flows of (i,1), i=1...114			T(i,s,j)			Row sums = taxes on domestic commodities
taxes:	on flows of (i,2), i=1...114						Row sums = taxes on imports
Primary	Labour (10)	LAB(occ,j)					
inputs:	Capital (1)	CAP(j)					
	Land (1)	LAN(j)					
	Other costs (1)	OTH(j)					
		Column sums = outputs of industries	Column sums = total private and public investment by industry	Column sum = total private consumption	Column sum = total exports	Column sum = total other demand	

Domestic commodities i=1,...114	Y(i,j)	Row sums = production of domestic commodities
	Column sums = output of industries	

tables published by the Australian Bureau of Statistics (ABS). The latest set of IC/ABS tables are for 1989-90. An on-going task at the Centre of Policy Studies is updating the tables to a recent year (currently 1993-94) in preparation for forecasting runs of the MONASH model.

In Figure 1, V(i,s,j) shows the flow of good i, i=1,...,114, from source s (s=1 for domestically produced goods and s=2 for imported goods) to user j. The uses of commodity (i,s) are: as an intermediate input, j=1,...,112; as an input to capital creation, j=113,...,224; as a input to household consumption, j=225; as an export, j=226; and as an input to other demand, j=227. Other demands cover public consumption and inventory accumulation. In MONASH there are no flows of imports which are exported without some transformation in a domestic industry [i.e., V(i,2,226)=0 for all i=1,..., 114]. However, it is inconvenient to exclude imported exports from our notation.

All the flows V(i,s,j) are valued in basic prices. For flows of domestic commodities, basic prices are those received by producers. For imported commodities, basic prices are landed-duty-paid prices. By subtracting duty (the vector Z) from the sums [$\sum_{j=1}^{227}$ V(i,2,j)] across the import rows in Figure 1, we obtain the vector of imports valued on a c.i.f. basis.

Flow V(r,1;i,s,j) in Figure 1 is the use of commodity (r,1) as a margin service in facilitating the flow of good i from source s to user j. In the case of exports, V(r,1;i,1,226) is the use of (r,1) in facilitating the flow of (i,1) from domestic producers to ports of exit. In the case of imports, V(r,1;i,2,j) is the use of (r,1) in facilitating the flow of (i,2) to user j from ports of entry. The MONASH input-output database identifies 9 domestically produced services that can be used as margins (i.e., MARCOM contains 9 commodities). These are: wholesale trade; retail trade; road transport; rail transport; water transport; air transport; services to transport; insurance; and hotel and club services (e.g., retailing drinks). There are no imported margin services, and there are no margin services associated with the delivery of margins, i.e., there are no margins on margins.

The distinction between direct uses of (r,1) and margins uses can be understood by an example. If a firm in industry j uses a cab to take an employee to the airport, then this is a direct use of road transport and it is part of V(r,1,j) for r=road transport. If a truck is used to deliver domestic concrete to industry j, then this is a margin use of road transport and it is recorded in V(r,1;i,1,j) for r=road transport and i=concrete.

Sales taxes on all commodity flows are given in Figure 1 by T(i,s,j). The cost of labour in each industry, disaggregated into 10 broad occupational groups (occ=1,...,10), is in matrix LAB. The vectors CAP and LAN contain returns in each industry to capital and land. Other costs (e.g., production taxes) are gathered in vector OTH.

The column sums in Figure 1 for j=1,...,112 are the values of industry outputs. Industry outputs can also be obtained as column sums of the matrix Y. This matrix shows the output of each commodity by each industry. In the MONASH core there are 7 agricultural industries modelled as producing 9 commodities. The other 105 industries are each the unique producers of one commodity, giving the core model 2 more commodities than industries (114 compared with 112).

The total output of commodity (r,1) is the rth row sum of the Y matrix. If r is a non-margin commodity, then its domestic output is also the rth row sum in Figure 1 given by $\sum_{j=1}^{227} V(r,1,j)$. If r is a margin commodity, then to obtain its output we add to $\sum_{j=1}^{227} V(r,1,j)$ (the direct uses of r) all the flows V(r,1;i,s,j), i=1,...,114, s=1,2 and j=1,...,227 (the margins uses of r).

One way of visualising the core MONASH model is as a system of equations describing the movements of the cells of Figure 1. For each cell, there are quantity, price and technology or preference variables. These variables are linked by conditions such as: prices equal costs; demands equal supplies; supplies and direct demands are compatible with optimising behaviour by producers, consumers and investors; and demands for margin services are proportional to associated commodity flows. Summations in the model of projections for the individual cells give projections of variables such as: output, employment and investment by 112 industries; and output of 114 commodities.

The rectangular database

As well as the input-output data in Figure 1, we also have sales data which we were able to manipulate [see Adams and Dixon, 1995a] into the form shown in Figure 2. The underlying data are unpublished but can be purchased from the ABS.

For each direct flow V(i,s,j) appearing in Figure 1, in Figure 2 we have a disaggregation into the flows V(i_q,s,j), q=1,...,n(i). Altogether, direct flows of the 228 MONASH core commodities (114 domestic and 114 imported) are disaggregated into direct flows of 1540 commodities (770 domestic and 770 imported), i.e., $\sum_{i=1}^{115} n(i) = 770$.

The flows V(r_q,1;•,•,j) shown at the bottom of Figure 2 are margin usages of commodity (r_q,1) for (r,1)∈MARCOM and q = n(r)+1, ..., nm(r) where nm(r) is the number of disaggregated margins commodities in the core category r. As indicated by the dots, V(r_q,1;•,•,j) is the margins usage of r_q in facilitating **all** flows to user j, i.e. V(r_q,1,•,•,j) = $\sum_i \sum_s V(r\_q,1;i,s,j)$. As indicated by the range of q, for all nine margin commodities in the MONASH core, the disaggregated database identifies the margin components as separate

Figure 2. Structure of the Disaggregated Rectangular Database

	MONASH core commodities (114)	Disaggregated commodities (780)	Intermediate demands by industries j=1,...112	Investment by industries j=113,...224	Private consumption j=225	Exports j=226	Other demand j=227
Direct sales of domestically produced commodities	1	1_1 1_2 . . 1_n(1)					
	2	2_1 . . 2_n(2)					
	. . .	. . .					
	114	114_1 . . 114_n(114)					
Direct sales of imported commodities	1	1_1 1_2 . . 1_n(1)			V(i_q,s,j)		
	2	2_1 . . 2_n(2)					
	. . .	. . .					
	114	114_1 . . 114_n(114)					
Margin usage of 10 commodities, (r_q,1)∈DMARCOM					V(r_q,1;•,•,j)		

commodities, i.e., none of the disaggregated margin commodities is used directly. In the case of one of the core margin commodities, the disaggregated database splits the margin component into two separate commodities [nm(r)=2]. For the other eight, nm(r)=1. Thus the disaggregated database contains 10 margins commodities, giving a total for the number of commodity categories in Figure 2 of 780

4. Equations for Extending the MONASH Commodity forecasts from 114 to 780 Categories

The data in Figure 2 are not sufficient to allow complete incorporation of commodity detail at the 780 level into a CGE framework. This is because Figure 2 does not show inputs to production of disaggregated commodities. Consequently, it does not provide a basis for calculations in the core of a CGE model of the effects on outputs of disaggregated commodities of cost-affecting shocks such as changes in wages, interest rates, taxes, tariffs, world commodity prices, and technology. Nevertheless, Figure 2 does provide valuable information on the sales patterns of domestically produced disaggregated commodities and on their exposures to competition from imports. We use this information in a post-CGE calculation to disaggregate core MONASH forecasts at the 114 level into forecasts at the 780 level.

Disaggregated non-margin demands

We relate demands for non-margin disaggregated commodities [i.e., (i_q,s) $\notin$DMARCOM] to direct demands forecast in the core MONASH model for parent commodities according to

$$x(i\_q,s,j) = x(i,s,j) + \phi(i\_q,s,j)[x(i,1,j) - x(i,2,j)] \qquad (4.1)$$

and

$$x(i\_q,s) = \sum_{j=1}^{227} B(i\_q,s,j)\, x(i\_q,s,j) \qquad (4.2)$$

for all (i_q,s)$\notin$DMARCOM, s=1,2, and j=1,...,227,

where

x(i_q,s,j) is the percentage change between years t and t+1 in the demand for disaggregated commodity (i_q,s) by user j;

x(i_q,s) is the percentage change between years t and t+1 in the total demand for (i_q,s);

$x(i,s,j)$ is the forecast generated in the core MONASH model of the percentage change between years t and t+1 in the demand for the parent commodity (i,s) by user j;

$B(i\_q,s,j)$ is the share, calculated from the data in Figure 2, of the sales of (i_q,s) accounted for by user j; and

$\phi(i\_q,s,j)$ is a coefficient.

In the simplest version of (4.1), the ϕ coefficients are zero. Then each disaggregated demand moves by the same percentage as the parent demand, giving

$$x(i\_q,s) = \sum_{j=1}^{227} B(i\_q,s,j)\ x(i,s,j)\ . \qquad (4.3)$$

Under (4.3), the percentage change in the total demand for commodity (i_q,s) can vary from the percentage change in the total demand for its parent commodity (i,s) if the distribution of sales of the disaggregated commodity across the 227 users (j) differs from the distribution of sales of the parent commodity. For example, if exports of (i,1) are projected in the core MONASH model be growing relatively strongly $[x(i,1,226)>x(i,1)]$, then under (4.3), export-oriented components of i_q $[B(i\_q,1,226)>B(i,1,226)]$ will tend to have above-average growth prospects $[x(i\_q,1)>x(i,1)]$.

With non-zero values for the ϕ coefficients, we allow for variations in the extent to which the components of commodity i face import competition. As explained in the Appendix, we set $\phi(i\_q,1,j)$ to reflect the difference between the import share in user j's purchases of good i_q and an average import share in user j's purchases of good i. If user j's purchases of i_q are import-intensive relative to j's overall purchases of good i, then $\phi(i\_q,1,j)$ is positive. Conversely, if j's purchases of i_q are domestic-intensive relative to j's overall purchases of good i, then $\phi(i\_q,1,j)$ is negative.

With the $\phi(i_q,1,j)$s set in this way, (4.1) implies that demand (i_q,1,j) will grow less quickly than the parent demand (i,1,j) if

either

> j's demand for i_q is relatively import-intensive $[\phi(i\_q,1,j)>0]$ and j's demand for imported good i is growing relatively quickly $[x(i,1,j)<x(i,2,j)]$,

or

> j's demand for i_q is relatively domestic-intensive $[\phi(i\_q,1,j)<0]$ and j's demand for imported good i is growing relatively slowly $[x(i,2,j)<x(i,1,j)]$.

Thus, we assume that if the core MONASH model indicates that user j is switching towards imported good i $[x(i,1,j)<x(i,2,j)]$, then this will impinge negatively on the domestic output prospects of components of commodity i that are relatively heavily imported. If, on the other hand, the core MONASH model

indicates that user j is replacing imports of i with domestic products [x(i,2,j)<x(i,1,j)], then this provides a relatively small benefit to the producers of components of i that face little import competition.

Similarly, given our settings for the ϕ(i_q,1,j)s, (4.1) implies that demand (i_q,1,j) will grow more quickly than the parent demand (i,1,j) if

either

j's demand for i_q is domestic-intensive [ϕ(i_q,1,j)<0] and j's demand for imported good i in growing relatively quickly [x(i,1,j)<x(i,2,j)],

or

j's demand for i_q is import-intensive [ϕ(i_q,1,j)>0] and j's demand for imported good i is growing relatively slowly [x(i,2,j)<x(i,1,j)].

In our calculation of disaggregated import demands (i_q,2,j), the settings of the ϕ(i_q,2,j)s are symmetrical to the settings of the ϕ(i_q,1,j)s. In the formulas derived in the Appendix, domestic shares in j's purchasers of components of good i play the same role in ϕ(i_q,2,j) as import shares play in ϕ(i_q,1,j).

For both s=1 and 2, our settings of ϕ(i_q,s,j), q=1,...,n(i), satisfy the condition

$$\sum_{q=1}^{n(i)} H(i\_q,s,j)\ \phi(i\_q,s,j) = 0 \qquad (4.4)$$

where

H(i_q,s,j) is the share, calculated from the data in Figure 2, of j's purchases of commodity (i,s) accounted for by (i_q,s).

Condition (4.4) is necessary to ensure that our results for disaggregated commodities add up to our results from the MONASH core, i.e., (4.4) ensures that

$$\sum_{q=1}^{n(i)} H(i\_q,s,j)x(i\_q,s,j) = x(i,s,j) \quad \text{for all i,s and j.} \qquad (4.5)$$

Disaggregated margin demands

To satisfy the demands for margin services, only domestic products are used. Consequently, there are no ϕ coefficients in our equations for disaggregated demands for margin services. We assume that these disaggregated demands move in line with parent demands generated in the core MONASH model. That is we assume that

$$x(r\_q,1;i,s,j) = x(r,1;i,s,j)\ , \qquad (4.6)$$

for (r_q,1)$\in$DMARCOM, i=1,...,114, s=1,2 and j=1,...,227,

where

x(r_q,1;i,s,j) and x(r,1;i,s,j) are the percentage changes between years t and t+1 in the demands for (r_q,1) and (r,1) for facilitating the flow of good i from source s to use j.

Ideally, we would like to relate margin demands for (r_q,1) to the use of (r,1) in facilitating flows of disaggregated commodities. However, because the disaggregated data in Figure 2 show only the use of (r_q,1) in facilitating all flows to user j, they do not provide a basis for going beyond (4.6).

To project growth in the total demand for margin commodity (r_q,1), we compute

$$x(r\_q,1) = \sum_i \sum_s \sum_j B(r\_q,1;i,s,j)\, x(r\_q,1;i,s,j) \tag{4.7}$$

where

B(r_q,1;i,s,j) is the share of the total usage of (r_q,1) absorbed in facilitating the flow of (i,s) to user j.

Figure 2 does not provide the data we need to calculate the shares B(r_q,1;i,s,j). We estimate these shares by assuming that the share of (r_q,1) in the margins use of (r,1) is the same for all flows (i,s) to j, i.e., we assume that

$$V(r\_q,1;i,s,j) = V(r,1;i,s,j)V(r\_q,1;\bullet,\bullet,j) / \sum_{u=n(r)+1}^{nm(r)} V(r\_u,1;\bullet,\bullet j), \tag{4.8}$$

for q=n(r)+1,...nm(r),

where V(r,1;i,s,j) is taken from the database in Figure 1, and V(r_u,1;•,•j), u=n(r)+1,...,nm(r) is taken from the database in Figure 2.

From here, we compute

$$B(r\_q,1;i,s,j) = V(r\_q,1;i,s,j) / \sum_i \sum_s \sum_j V(r\_q,1;i,s,j) \ . \tag{4.9}$$

Relative to the detail it provides on direct demands, Figure 2 gives little information on margin demands. Consequently, our calculations of disaggregated margin demands add little to the projections of margin demands obtained from the core MONASH model. As mentioned in Section 3, eight of the nine margin commodities in the MONASH core have only one margin sub-component. Under (4.6)-(4.9), our projected growth rates for these eight sub-components are the same as the growth rates for margin use of their eight parent commodities projected by the MONASH core.

5. Illustrative Disaggregated Results

In this section, we disaggregate the MONASH results in Table 1 using the method described in Sections 3 and 4 and the Appendix. As explained in those theory sections, our method makes full use of detailed sales and import data (Figure 2), but covers the lack of cost data and time-series demand data by four commonality assumptions, (A5)-(A8). These assumptions are that: prices of disaggregated commodities move at the same rate as those of their parent commodities; demands by user j for domestic/import aggregates of disaggregated commodities in the same core category move at a common rate; the domestic/import preferences of user j for disaggregated commodities in the same core category move at a common rate; and user j's domestic/import substitution elasticities have a common value for all disaggregated commodities in the same core category. These or similar assumptions are unavoidable. However, they lead to the question of whether we have imposed so much commonality across disaggregated commodities in the same core category that disaggregation is unlikely to give worthwhile new information. To throw light on this question, we examine the within-core variability of our projections for domestic outputs of disaggregated commodities.

In Figure 3, variability is measured by the absolute differences between the average annual growth rates in the outputs of disaggregated commodities and those of their parents (given in Table 1). Nearly 50 per cent (i.e., 363 out of 780) of the disaggregated commodities have forecast growth rates that are more than 1 percentage point away from their parent's growth rate, with 27 per cent (209 out of 780) more than 2 percentage points away. Deviations of two percentage points or more can be considered large: the projected growth rate for real GDP (i.e., the projected average growth rate for all commodities) is 3.3 per cent per annum.

Figures 4 to 7 show that this degree of variability persists across all of the major sectors of the economy (agriculture, mining, manufacturing and services). In agriculture, 41 per cent of disaggregated commodities have growth rates more than 1 percentage point away from their parent's growth rate. In mining, manufacturing and services the shares are 48 per cent, 50 per cent and 35 per cent.

The causes of within-core variability differ between core commodities. However, for most core commodities the main source of variability is differences across disaggregated commodities in their exposures to international trade (export and import shares). The other source of variability allowed for in our calculations, differences in sales patterns across domestic users, plays a major role for only a few commodities. Differences in trade exposure dominate because (i) in many core categories there are considerable differences in the trade exposures of the constituent disaggregated commodities and (ii) growth rates in exports and imports are, on average, more than twice the growth rates of domestic demands. As explained in Section 2, manufactured exports and imports are forecast to grow at about 10 per cent a year and growth in total trade is likely to be about 8 per cent a year. Forecast growth rates for the domestic expenditure aggregates are 3.6 for private consumption, 4.0 for investment and 2.8 for public consumption.

To illustrate the causes of within-core variability, we provide in Table 2 growth projections for four core commodities and their components. The four core commodities were chosen as representative of four broad types of activity in the Australian economy. Commodity 21 (Milk products) is a manufactured product with developing export markets. Commodity 5 (other cereal grains) is a typical agricultural product with heavy reliance on long-established export

Figure 3. Annual Output Growth Differences: All Commodities

(Growth rates for 1993-94 to 2001-02: disaggregated commodites relative to their core commodity)

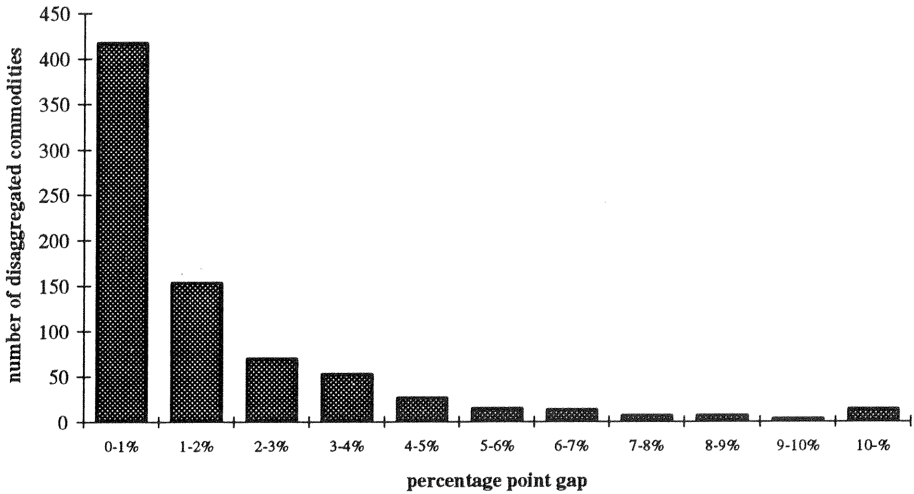

Figure 4. Annual Output Growth Differences: Agriculture

(Growth rates for 1993-94 to 2001-02: disaggregated commodities relative to their core commodity)

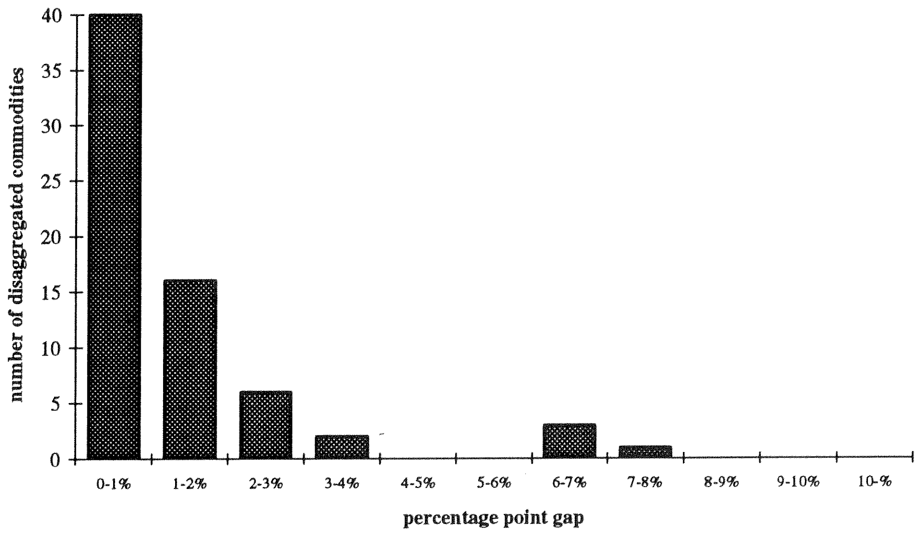

Figure 5. Annual Output Growth Differences: Mining

(Growth rates from 1993-94 to 2001-02: Disaggregated commodities relative to their core commodity)

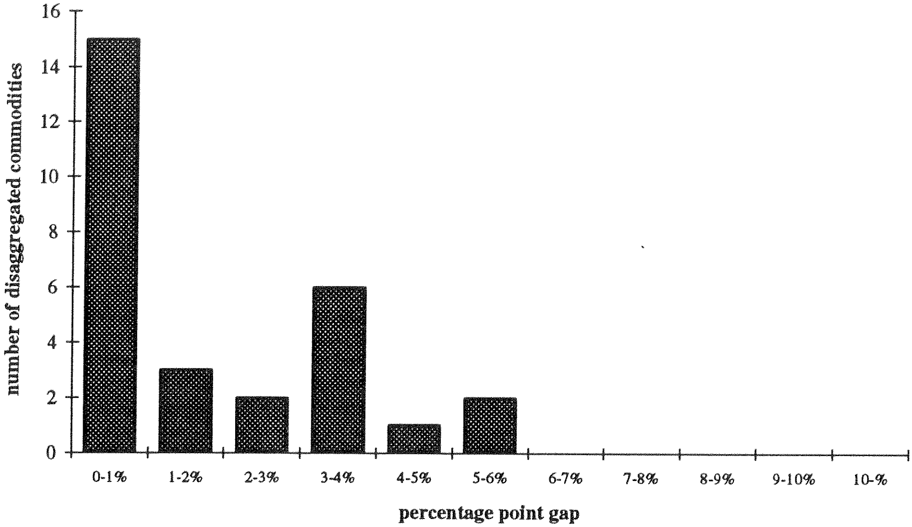

Figure 6. Annual Output Growth Differences: Manufacturing

(Growth rates for 1993-94 to 2001-02: disaggegated commodities relative to their core commodity)

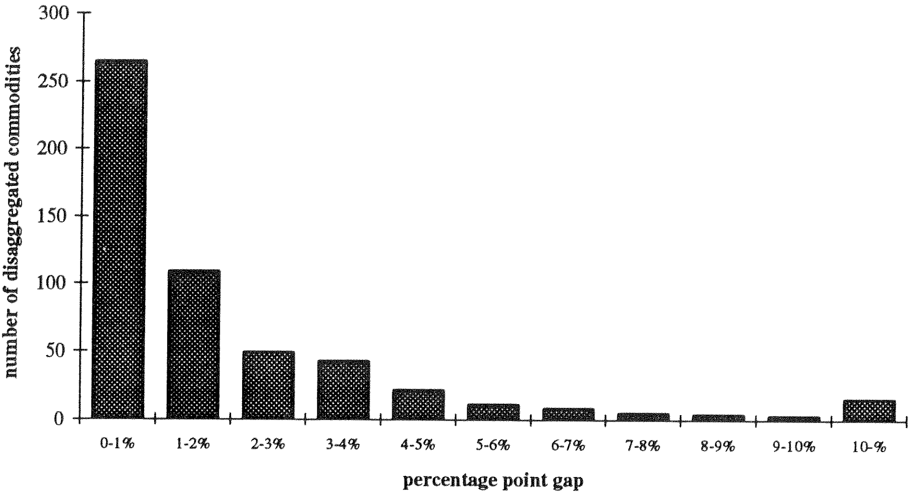

Figure 7. Annual Output Growth Differences: Services

(Growth rates for 1993-94 to 2001-02: disaggregated commodities relative to their core commodity)

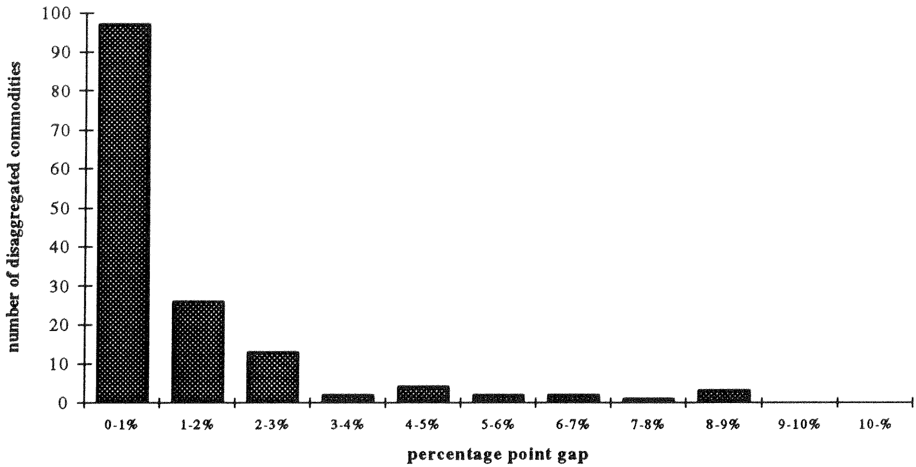

Table 2. MONASH Forecasts and Data for Selected Commodities

	Commodity	Forecast growth 1993/94 to 2001/02	1993-94 share of disagg. commodity in core	1993-94 share of exports in total output	1993-94 import share in domestic market
21	*Milk products*	*3.6*	*100.0*	*20.7*	*4.1*
_1	Liquid milk & cream, graded or chilled	4.0	7.6	4.3	0.6
_2	Flavoured whole milk and skim milk	1.9	4.5	0.1	0.0
_3	Liquid milk and cream nec	1.1	17.9	0.0	0.0
_4	Cream, not concentrated or sweetened	2.9	5.2	3.0	0.0
_5	Cultured milk products	4.0	4.2	16.3	0.9
_6	Liquid buttermilk	0.1	0.1	0.0	13.9
_7	Condensed skim and buttermilk	9.6	7.7	79.4	0.9
_8	Fats and oils derived from milk	7.6	0.5	62.4	8.4
_9	Butter	3.5	7.2	19.4	0.4
_10	Whey (liquid, powder, concentrated)	3.0	0.8	23.7	22.3
_11	Cheese (incl. processed)	2.8	22.8	21.8	12.4
_12	Infants, invalid and health beverages	3.6	2.3	22.2	2.1
_13	Malt extract	4.0	0.5	30.6	8.7
_14	Milk products nec	4.8	18.7	33.7	14.6
5	*Other cereal grains*	*1.5*	*100.0*	*48.4*	*0.0*
_1	Maize, unmilled	2.4	4.3	25.3	0.0
_2	Oats, unmilled	3.4	19.0	35.7	0.0
_3	Rice, in the husk	9.4	7.7	0.0	0.0
_4	Grain, sorghum	8.1	18.9	21.0	0.0
_5	Oilseeds	-2.4	9.0	39.8	0.0
_6	Legumes	-4.9	41.1	78.5	0.0
49	*Publishing, printing and advertising sales*	*4.8*	*100.0*	*2.2*	*17.5*
_1	Publishing	-0.1	19.9	4.6	42.0
_2	Printing	1.2	13.9	9.3	37.7
_3	Advertising sales	6.6	66.3	0.0	0.0
105	*Other business services*	*3.6*	*100.0*	*2.8*	*3.2*
_1	Real estate agent	3.6	8.1	0.0	0.1
_2	Property operator and developer	3.6	16.4	0.4	0.8
_3	Architectural	3.4	4.9	0.4	0.3
_4	Surveying	3.7	2.2	2.0	5.3
_5	Technical nec	3.8	6.8	10.3	12.0
_6	Legal	3.9	11.0	2.7	0.6
_7	Accounting	3.5	7.4	0.8	0.4
_8	Data processing	3.4	5.1	5.8	4.6
_9	Advertising	3.5	16.1	1.0	2.6
_10	Market and business consultancy	3.2	14.3	1.6	2.1
_11	Typing, copying and mailing	2.9	4.7	0.0	0.0
_12	Collecting and credit reporting	3.5	0.5	0.0	0.0
_13	Pest control	2.8	0.4	0.0	0.0
_14	Cleaning	3.1	2.1	1.3	0.2

markets. Commodity 49 (publishing etc) is representative of import-competing manufactured commodities. Finally, commodity 105 (other business) is a service with little exposure to international trade either as an exporter or as an import competitor.

Over the last five years, exports of milk products have doubled. We expect further strong growth through our forecast period. This is because the main markets for these exports are in rapidly expanding Asian economies. In Table 2, strong export growth accounts for the very bright prospects which we are forecasting for the export-oriented disaggregated commodities within milk products. Commodities 21_7 and 21_8 have export shares of over 60 per cent, giving them growth rates in our forecasts of over 7 per cent. By contrast, the components of milk products that rely mainly on the domestic market are projected in Table 2 to have no better than moderate growth prospects. Because the expenditure elasticity for milk products is low, growth prospects are poor for component commodities sold mainly to household consumption. Examples are 21_2, 21_3 and 21_6. Commodity 21_6 has the additional negative factor of facing significant import competition.

Commodity 5 (other cereal grains) is about 50 per cent exported. However, unlike milk products, other cereal grains has poor export prospects. Guided by ABARE (1995), we are forecasting an average annual decline in exports of 6.8 per cent. Thus, commodity 5's two most highly exported-oriented sub-components (5_5 and 5_6) are shown in Table 2 with negative growth rates. The remaining sub-components have moderate or good prospects. Because of drought, in the first year of our forecasts (1993-94) production of nearly all components of commodity 5 was unusually low and inventories were depleted. With normal weather, we expect a sharp recovery in the production of 5_3 and 5_4, neither of which has a large export share. For both, we expect inventory rebuilding to be a major source of demand. The outlooks for 5_1 and 5_2 are moderate. They are likely to benefit from strong inventory demand but to suffer from weak export demand.

Commodity 49 (publishing, printing and advertising sales) has a low export share and a relatively high import share. In Table 1, the core commodity has above-average growth prospects, attributable mainly to our assumption that the trend towards its greater use per unit of output in customer industries will continue. A negative influence is rapid growth in imports, at a forecast annual rate of 7.9 per cent Because import competition occurs only in the markets for 49_1 and 49_2, these two sub-components are shown in Table 2 as having poor growth prospects relative to those of 49_3.

The final core commodity in Table 2, 105 (other business services), has low export and import shares and widespread domestic sales. Consequently, its forecast growth rate (3.6 per cent) is close to that of GDP (3.3 per cent). All of the sub-commodities of 105 have low trade shares but some (e.g., 105_3 and 105_4) have a heavy reliance on a particular part of the domestic economy (e.g. investment). Thus, it is potentially possible for their forecast growth rates to vary significantly from that of their parent. However, in the present forecasts there is not sufficient variation between the growth projections for relevant parts of the economy (e.g. investment versus the rest of GNE) for this to happen. In Table 2, all sub-components of 105 have growth rates within one percentage point of their parent growth rate.

6. Concluding Remarks

CGE models such as MONASH emphasise two types of links between different parts of the economy. The first is input-output relationships. Industries i and j are linked because i provides inputs to support output in j; and industry j and households are linked because j provides households with products and households provide j with labour. The second type of link is through economy-wide constraints. All industries compete for the economy's scarce factors including labour in different skill categories; capital; land; foreign currency; and the pollution-carrying capacity of the environment. Output expansion in industry r can impinge on industry j by affecting wage rates and rentals on capital and land; export growth generated by industry y can affect industry x through the exchange rate; and emissions from industry q can change the outlook for industry u by leading to more stringent environmental laws.

The ability of CGE models to quantify these links is their main strength. However, a weakness of CGE models from the view point of microeconomic planning in business and government is their lack of detail. This has meant that those microeconomic planners who are willing to use quantitative forecasting methods usually rely on small models (often a single equation) focussed exclusively on their area of interest. They are prepared to de-emphasise or ignore linkage effects in return for increased detail relevant to their product, industry, region or occupation.

Because we think that linkage effects are potentially important in micro planning, together with our colleagues we have been working on several projects which tie disaggregated databases to a CGE model. This allows insights derived from the CGE model concerning linkages to be applied at a level of detail of interest to micro planners. In earlier papers,[6] we have used this approach to obtain MONASH-driven forecasts at a disaggregated level for occupations, regions and households. In this paper, we have disaggregated MONASH commodity projections.

Our disaggregated occupational forecasts have been of interest in Australia to employment and training departments of the state and federal governments; our regional forecasts are used by state regional planning authorities; and our household forecasts are quoted in public discussions of income distribution and taxation reform. Eventually, we plan to attach occupational, regional and household dimensions to our disaggregated commodity database. Then disaggregated commodity forecasts will allow us to strengthen our analyses of prospects for occupations, regions and households. In the meanwhile, as a stand-alone product, we hope that our disaggregated commodity forecasts will be of interest to businesses.

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6 See for example Parmenter and Meagher (1989), Adams and Dixon (1995b) and Meagher (1996).

In all our disaggregated forecasting exercises, we are faced with datasets covering only a few variables. For instance, the rectangular dataset described in Section 3 gives sales information but no cost information. This means that in generating disaggregated forecasts we cannot avoid commonality assumptions such as those discussed in Section 5 and the Appendix. A second problem is that disaggregated data are rarely available as a worthwhile time-series. This leaves little hope for statistically validating disaggregated forecasts.

Despite these problems, we think that the use of disaggregated datasets in forecasting exercises can lead to valuable insights. For example, in this paper we saw that MONASH indicates above-average growth prospects for milk products. By looking at disaggregated sales data, we concluded that not all activities in the milk products industry are likely to prosper. On the basis of the results in Table 2, we would certainly be happier to invest in firms specialising in condensed skim and buttermilk than in firms specialising in flavoured whole milk and skim milk.

Appendix: The theoretical underpinnings of (4.1) and formulas for the ϕs

As discussed in Section 4, the simplest approach to projecting percentage changes in disaggregated demands, x(i_q,s,j), is to assume that they are equal to percentage changes in parent demands, x(i,s,j). The weakness of this method is that it does not allow for differences in the levels of import competition faced by domestic producers of the disaggregated commodities, i_q, q=1,...,n(i). If the core MONASH forecasts show strong growth in imports of commodity i, then we would expect relatively low growth in domestic production of the sub-commodities of i for which there are high import shares in the domestic market.

In formulating an approach to capture this effect, we start with equations describing substitution between domestic and imported variants of the disaggregated commodity i_q purchased for use j. We assume that

$$x(i\_q,s,j) = x(i\_q,\bullet,j) - \sigma(i\_q,j)[p(i\_q,s,j) - \sum_{v=1}^{2} S(i\_q,v,j)p(i\_q,v,j)] - [D(s) - S(i\_q,1,j)]twist(i\_q,j) \qquad (A1)$$

for q=1,...,n(i), s=1,2 and all j.

New notation appearing in (A1) is defined as follows:

x(i_q,•,j) is the percentage change between years t and t+1 in j's overall usage [an aggregate over domestic and imported varieties] of good i_q;

σ(i_q,j) is j's elasticity of substitution between the domestic and imported varieties of good i_q;

p(i_q,v,j) is the percentage change between years t and t+1 in the price of (i_q,v) to user j;

S(i_q,v,j), which can be calculated from the data in Figure 2, is the share of j's purchases of i_q that comes from source v;

D(s) is a dummy variable which has the value one if s=1 and the value zero if s=2; and

twist(i_q,j) is a variable allowing for changes in user j's preferences between domestic and imported i_q. A positive value for twist (i_q,j) corresponds to a change in j's preferences towards the imported product.

If twist(i_q,j) is zero, (A1) will be recognised as an outcome of the CES cost minimising problem[7] for user j:

choose X(i_q,s,j), s=1,2

to minimise $$\sum_{v=1}^{2} P(i\_q,v,j)X(i\_q,v,j) \tag{A2}$$

subject to $$X(i\_q,\bullet,j) = CES\{X(i\_q,1,j), X(i\_q,2,j)\} \tag{A3}$$

where the uppercase Xs and Ps are the levels of variables whose percentage changes we have previously denoted by lowercase xs and ps, and CES denotes the CES function.

Thus, apart from the twist term, (A1) is consistent with the assumptions: (a) that (i_q,1) and (i_q,2) are imperfect substitutes in satisfying j's requirements for i_q; (b) that in choosing the mix of (i_q,1) and (i_q,2) to satisfy these requirements, j is a price-taking cost minimiser; and (c) that j's domestic/import preferences reflected in the parameters of the CES function are constant.

To understand the nature of the change in j's preferences introduced by non-zero values of twist(i_q,j), we examine (A1) with prices and j's requirements for i_q held constant. Under these conditions, we find that the percentage change in the ratio of imports to domestic products in j's purchases of i_q, is given by

$$x(i\_q,2,j) - x(i\_q,1,j)$$

$$= \{[D(1) - S(i\_q,1,j)] - [D(2) - S(i\_q,1,j)]\}\ twist(i\_q,j)$$

$$= twist(i\_q,j) \quad .$$

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7 This formulation of domestic/import choice follows Armington (1969, 1970). The Armington approach is adopted in almost all CGE models. For a textbook treatment, see Dixon *et al.* (1992, pp. 142-8).

Thus, if we set twist(i_q,j) at 10, say, then we are imposing a twist in j's preferences (a change in the parameters of the CES function) that causes a 10 per cent increase in the ratio of imported to domestic products in j's purchases of i_q.

An important property of the change in j's preferences imposed by non-zero settings for twist(i_q,j) is cost neutrality, i.e., in the absence of changes in prices, there is no change in the cost to j of satisfying any given requirement level for inputs of i_q. Notice that the percentage change in j's costs of satisfying its requirements for inputs of i_q is given by:

$$c(i\_q,j) = \sum_{s=1}^{2} (p(i\_q,s,j) + x(i\_q,s,j))\, S(i\_q,s,j) \; . \qquad \text{(A4)}$$

By substituting from (A1) into (A4) with prices and X(i_q,•,j) held constant, we obtain c(i_q,j)=0, irrespective of the value adopted for twist(i_q,j). Cost neutrality implies that twist(i_q,j) imposes a change in j's preferences focused only on the composition of j's purchases of i_q. In the absence of price changes, non-zero values of twist(i_q,j) do not induce j to substitute between commodity i_q and other commodities.

Now we make four simplifying assumptions:

$$p(i\_q,s,j) = p(i,s,j) \qquad \text{for } q=1,\ldots,n(i); \qquad \text{(A5)}$$

$$x(i\_q,\bullet,j) = x(i,\bullet,j) \qquad \text{for } q=1,\ldots,n(i); \qquad \text{(A6)}$$

$$twist(i\_q,j) = twist(i,j) \qquad \text{for all } q=1,\ldots,n(i); \qquad \text{(A7)}$$

and

$$\sigma(i\_q,j) = \sigma(i,j) \qquad \text{for all } q=1,\ldots,n(i) \; . \qquad \text{(A8)}$$

Assumption (A5) reflects the lack of cost detail in our disaggregated data (Figure 2). Without knowing the structure of inputs to disaggregated production or the disaggregated structure of taxes and tariffs, we have no basis for assuming differences in price movements across the components of (i,s). Assumptions (A6)-(A8) reflect a lack of knowledge at the disaggregated level concerning demand behaviour. In the absence of time-series on which to base disaggregated modelling of demand behaviour we have assumed in (A6) that j demands components of i in fixed proportions implying that j's usages of the domestic/import aggregates i_q, q=1,...,n(i), move at a common rate, x(i,•,j). We have assumed in (A7) that j's domestic/import preferences move at the common rate twist(i,j) for all components of i. In (A8), we have assumed that j's domestic/import substitution elasticity has the same value for all components of i.

Finally, we insist that our forecasts at the disaggregated level are consistent with those from the core MONASH model, i.e., we impose (4.5). From here, the derivation of (4.1) and the formulas for the ϕ coefficients is a matter of algebra.

By substituting from (A1) and (A5)-(A8) into (4.5) and by recognising that $\sum_{q=1}^{n(i)} H(i\_q,s,j)=1$, we obtain

$$x(i,s,j) = x(i,\bullet,j) - \sigma(i,j)[p(i,s,j) - \sum_v p(i,v,j) \sum_q H(i\_q,s,j)S(i\_q,v,j)]$$

$$- twist(i,j)[D(s) - \sum_q H(i\_q,s,j)S(i\_q,1,j)] \quad . \tag{A9}$$

With s=1,(A9) gives

$$x(i,1,j) = x(i,\bullet,j)$$

$$- \sigma(i,j)[p(i,1,j)\{1 - \sum_q H(i\_q,1,j)S(i\_q,1,j)\} - p(i,2,j) \sum_q H(i\_q,1j)S(i\_q,2,j)]$$

$$- twist(i,j)[1 - \sum_q H(i\_q,1,j)S(i\_q,1,j)] \quad . \tag{A10}$$

Remembering that $S(i\_q,1,j) + S(i\_q,2,j) = 1$, we simplify (A10) to

$$x(i,1,j) = x(i,\bullet,j) - \sigma(i,j)\ \psi(i,2,j)[p(i,1,j) - p(i,2,j)] - \psi(i,2,j)twist(i,j) \tag{A11}$$

where

$$\psi(i,2,j) = \sum_q H(i\_q,1,j)S(i\_q,2,j) \quad . \tag{A12}$$

Similarly, with s=2, (A9) gives

$$x(i,2,j) = x(i,\bullet,j) - \sigma(i,j)\psi(i,1,j)[p(i,2,j) - p(i,1,j)] + \psi(i,1,j)\ twist(i,j), \tag{A13}$$

where

$$\psi(i,1,j) = \sum_q H(i\_q,2,j)S(i\_q,1,j) \quad . \tag{A14}$$

From (A11) and (A13) we find that

$$x(i,\bullet,j) = \sum_s \frac{x(i,s,j)\psi(i,s,j)}{\sum_v \psi(i,v,j)} \tag{A15}$$

and

$$twist(i,j) = \frac{x(i,2,j) - x(i,1,j)}{\sum_s \psi(i,s,j)} + \sigma(i,j)[p(i,2,j) - p(i,1,j)] \quad . \tag{A16}$$

By substituting from (A15), (A16) and (A5)-(A8) into (A1), we establish (4.1) and the formulas for ϕ:

$$x(i\_q,s,j) = x(i,s,j) + \phi(i\_q,s,j)[x(i,1,j) - x(i,2,j)], \quad s=1,2 \quad ,$$

with

$$\phi(i\_q,1,j) = \frac{S(i\_q,2,j) - \psi(i,2,j)}{\sum_s \psi(i,s,j)} \tag{A17}$$

and

$$\phi(i\_q,2,j) = -\frac{S(i\_q,1,j)-\psi(i,1,j)}{\sum_s \psi(i,s,j)} \quad . \tag{A18}$$

From (A12) we see that $\psi(i,2,j)$ is a weighted average of the import shares in j's purchases of the different components of commodity i, with the weights being $H(i\_q,1,j)$, $q=1,\ldots,n(i)$. Thus, as asserted in Section 4, if i_q is an import-intensive component of user j's purchases of good i $[S(i\_q,2,j) > \psi(i,2,j)]$ then $\phi(i\_q,1,j)$ is positive. Similarly, if i_q is domestic-intensive $[S(i\_q,2,j) < \psi(i,2,j)]$ then $\phi(i\_q,1,j)$ is negative.

From (A14) we see that $\psi(i,1,j)$ is a weighted average of the domestic shares in j's purchases of different components of i. Thus, as asserted in Section 4, the role of domestic shares in the formula for $\phi(i\_q,2,j)$ is symmetrical to the role of import shares in the formula for $\phi(i\_q,1,j)$. An apparent asymmetry between the formulas for $\phi(i\_q,1,j)$ and $\phi(i\_q,2,j)$ is the different signs in front of the expressions on the RHS of (A17) and (A18). The sign change is necessary because on the RHS of (4.1) the square bracketed term is $x(i,1,j)-x(i,2,j)$ for both s=1 and 2.

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