HISTORICAL SIMULATIONS WITH THE MONASH REGIONAL EQUATION SYSTEM[1]

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ABSTRACT MONASH-RES combines a top-down regional equation system with the MONASH dynamic model of Australia to produce regional forecasts or policy analysis. Experience indicates that MONASH-RES gives acceptable rankings of regional economic prospects but understates inter-regional differences. We investigate the model's properties by attempting to reproduce observed patterns of State/Territory economic performance from 1986-87 to 1993-94. Industries are classified either as *national*, producing commodities that are readily traded between regions, or as *local*, producing goods or services that are not traded between regions. Regional outputs of *national* industries are assumed to be independent of regional demand for them but regional outputs of *local* industries must meet regions' demands. The results demonstrate that MONASH-RES forecasts are improved significantly by the inclusion of region-specific macro data and accurate information about the regional distribution of output changes in *national* industries. They confirm that the treatment of *local* industries in MONASH-RES is satisfactory.

1. INTRODUCTION

As part of forecasts and policy analyses produced with the MONASH model (Dixon and Rimmer, 2000), researchers at the Centre of Policy Studies (CoPS) have used a top-down Regional Equation System (RES) to produce results for States and Commonwealth Territories and for statistical divisions (Adams and Dixon, 1995). How reliable are these regional projections? Our forecasting experience to date indicates that while MONASH-RES gives accurate projections of the ranking of regional economic prospects, it may understate the scale of inter-regional differences. In this paper, we investigate the reasons for apparent problems with the MONASH-RES system by attempting to make it reproduce observed patterns of regional economic performance over a recent historical period. This is an extension of earlier historical simulations in which

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the MONASH model was forced to reproduce observed patterns of structural change at the national level (Dixon and McDonald, 1993).

The paper is organised as follows. In Section 2, we outline the structure of MONASH-RES. Section 3 contains an explanation of the design of the historical simulations. The data used in the simulations are set out in Section 4. Section 5 provides a discussion of the simulation results. Overall conclusions are given in Section 6.

2. THE STRUCTURE OF MONASH-RES

The RES that has been incorporated into MONASH-RES was developed originally for use with ORANI (Dixon, Parmenter, Sutton and Vincent, 1982, Chapter 6). It is a top-down method (Parmenter, Pearson and Jagielski, 1985) that, with minimal requirements for regional data, allows us to infer from national-level results (generated in MONASH or ORANI) the implications of forecasting scenarios or policy shocks for growth of output and employment at the regional level.

Following a method originally applied by Leontief *et al*. (1965), the RES first divides the industries distinguished in the national-level model into two groups, *national* industries and *local* industries. *National* industries produce commodities that are readily traded between regions (e.g., most agricultural, mineral and non-perishable manufactured goods and some services such as Public administration). *Local* industries produce perishable goods or services that are not traded between the regions. The full list of *local* and *national* industries is presented in Table 1.

In the RES, the regional outputs of *national* industries are assumed to be independent of regional demand for them. Using the system in conjunction with MONASH, percentage changes in the regional outputs of *national* industries are assigned exogenously in ways that are compatible with the relevant MONASH national-level results. In this context, these percentage changes could be growth rates through time corresponding to a forecasting or historical simulation with MONASH, or deviations from control in a policy simulation. An obvious default assignment is to assume that for a given *national* industry all regional percentage changes are the same as the national-level percentage change, i.e.,

$$g\,(j,r) = g\,(j), \text{ for all } r, \tag{1}$$

where:

g (j,r) is the percentage change in the output of *national* industry *j* in region *r*; and

g (j) is the percentage change in the industry's economy-wide output in the relevant MONASH simulation.

Table 1. *National* and *Local* Industries

A. *National* Industries	
1 Pastoral Zone	47 Newspapers and Books
2 Wheat-Sheep Zone	48 Commercial Printing
3 High-Rainfall Zone	49 Fertiliser
4 Northern Beef	50 Basic Chemicals
5 Milk Cattle	51 Paints
6 Other Farming Export	52 Pharmaceuticals
7 Other Farming Imp. Ctg	53 Soaps and Detergents
8 Poultry	54 Cosmetics
10 Forestry	55 Explosives
11 Fishing	56 Petrol
12 Iron Ore	57 Glass
13 Non-Ferrous Ores	61 Pipes
14 Black Coal	62 Plaster Products
15 Oil and Gas	63 Iron and Steel
16 Other Minerals	64 Non-Ferrous Metals
17 Services to Mining	65 Structural Metal
18 Meat Cattle	66 Sheet Metal
19 Dairy Products	67 Wire Products
20 Fruit and Veg. Products	68 Motor Vehicles
21 Oils and Fats	69 Ships and Boats
22 Flourmill Products	70 Trains
24 Confectionery	71 Aircraft
25 Seafood and Sugar	72 Scientific Equipment
28 Other Alcoholic Drinks	73 Electronic Equipment
29 Tobacco Products	74 Household Appliances
30 Fibre Processing	75 Electrical Equipment
31 Synthetic Yarn	76 Agricultural Machinery
32 Cotton Yarn	77 Construction Machinery
33 Wool Yarn	78 Manufacturing Machinery
34 Textile Finishing	79 Leather Products
35 Carpets	80 Rubber Products
36 Canvas Products	81 Plastic Products
37 Knitting Mills	82 Signs
38 Clothing	83 Sports Equipment
39 Footwear	85 Gas
40 Sawmill Products	94 Rail Transport
41 Panels and Veneers	95 Water Transport
42 Fittings	96 Air Transport
43 Furniture	97 Services to Transport
44 Pulp and Paper	105 Public Administration
45 Bags and Boxes	106 Defence
46 Sanitary Products	113 Other Services

Table 1 *(contd).* *National* and *Local* Industries

B. *Local* Industries	
9 Services to Agriculture	98 Communication
23 Bakery Products	99 Banking
26 Soft Drinks	100 Non-Bank Finance
27 Beer	101 Investment Services
60 Readymix Concrete	102 Insurance
84 Electricity	103 Other Financial Services
86 Water	104 Ownership of Dwellings
87 Residential Building	107 Health
88 Other Building	108 Education
89 Wholesale Trade	109 Welfare
90 Retail Trade	110 Entertainment
91 Mechanical Repairs	111 Hotels and Clubs
92 Other Repairs	112 Personal Services
93 Road Transport	

Assignments in which (1) does not apply for all regions are also possible so long as they conform to the constraint:

$$\sum_{r} S(j,r)\, g(j,r) = g(j), \tag{2}$$

where $S(j,r)$ is the share of region r in the aggregate national output of industry j. In forecasting with MONASH-RES, we use assignments of the latter kind to allow us to incorporate information available from the Australian Bureau of Agricultural and Resource Economics and other sources about the location of new mines and mineral processing plants or the closure of existing ones. In policy analysis, such assignments allow us to investigate scenarios about the geographical pattern of the responses of industries affected directly by the policy shocks. For example, for the Productivity Commission's 1996-97 inquiry into tariff protection for the Australian motor-vehicle industry, we computed two sets of projections of the effects of tariff reductions (Dixon *et al.*, 1997). In the first, we assumed that the induced contraction in motor-vehicle output was spread evenly across the motor-vehicle-producing states (i.e., we used assignment (1)). In the second set of projections, we departed from assignment (1) to examine the possibility that the industry might respond to the tariff cuts by closing down its operations in South Australia and consolidating in Victoria.

The RES includes regional multiplier effects by requiring that the outputs of *local* industries in region *r* meet the region's demand for *local* commodities. In computing a region's demand for *local* commodities, the system includes the intermediate and investment demands of the region's *national* and *local* industries, household demand and government demand. As it does for *national* industries, the system ensures that the percentage changes in the regional outputs of *local* industries are consistent with the economy-wide percentage changes generated by MONASH, i.e., constraint (2) applies for *local* industries.

3. DESIGN OF THE HISTORICAL SIMULATIONS

Our historical simulations with RES project the regional implications of a MONASH historical simulation covering the period 1986-87 to 1993-94. In all, we report seven simulations. They all use the same economy-wide projections from MONASH but differ in the amount of additional regional information that is used. Simulations 1-6 use the standard version of the RES, including the *national*/*local* split of industries that is set out in Table 1. For the seventh simulation, the RES was configured with all industries treated as *national*.

Figure 1 gives a schematic account of simulations 1-6. It shows that they are cumulative in the sense that each adds information to the one immediately preceding it. The purpose is to examine how the performance of RES in tracking regions' historical growth rates improves with the addition of exogenous regional information. Simulation 1, which is described as a "basic" RES run, includes no shocks to regional variables. The only input is the changes to economy-wide variables taken from MONASH. The regional assignment of the percentage changes in the outputs of *national* industries is according to the default (1). This is typically how RES is used for policy analysis with MONASH.

In making forecasts with MONASH-RES, we usually impose region-specific forecasts of government demands, population growth (at least for non-working groups such as retired persons) and investment (at least for sectors such as mining and mineral processing, for which details of the location of planned developments are readily available). The same sort of regional information is available for the historical period that is the subject of the historical simulations (see Section 4). In simulations 2-4 we introduce historical data for regional macro variables but we continue to assign changes in the outputs of *national* industries according to the default (1). For simulation 5, we overwrite this default in the case of agricultural and mineral industries, replacing it with historical data on the industries' regional growth rates. In simulation 6, we impose historical data on regional growth rates for all *national* industries.

As noted in the first paragraph of this section, we conducted a seventh simulation. It differed from the first six by treating all industries as *national* industries. In assigning regional growth rates, we imposed historical data for all industries, just as we did for the standard set of *national* industries in simulation 6. Hence, by comparing simulations 6 and 7 we can obtain a picture of the effectiveness of the standard RES treatment of *local* industries.

4. DATA FOR REGIONAL SIMULATIONS

4.1 Regional Data for RES

Four items of regional data are read into the RES. These are:

1. the shares of the States and Territories in outputs by industry;
2. investment by industry;
3. exports by commodity; and
4. government demand by commodity.

Variable	**Simulation 1:** Basic RES	**Simulation 2:** Includes Aggregate Government Demand by Region	**Simulation 3:** Includes Population by Region	**Simulation 4:** Includes Aggregate Investment by Region	**Simulation 5:** Includes Output by Region for Agricultural and Mineral Industries	**Simulation 6:** Includes Output by Region for all *National* Industries
MONASH Variables	✔	✔	✔	✔	✔	✔
Shifters in Government Demand Share Equations		✔	✔	✔	✔	✔
Population by Region			✔	✔	✔	✔
Shifters in Regional Investment Equations				✔	✔	✔
Shifters in Agricultural and Mineral Output Equations					✔	✔
Shifters in all *National* Industry Output Equations						✔

Figure 1: Shocks for Historical Simulations

These data were compiled mainly from *Census 91*. Full documentation of the procedure used to map the *Census 91* data to *MONASH* industries and regions is given in Kenderes (1993). This procedure follows the method described in Fallon (1981 and 1982).

4.2 Main Features of MONASH Historical Projections

As mentioned in Section 3, our RES simulations take as input results for a wide variety of economy-wide variables from a MONASH historical simulation covering the period 1986-87 to 1993-94. Table 2 presents some key macro results from this historical simulation. Table 3 contains the corresponding results for output by industry.

Table 2 shows that through the historical period there was moderate growth of real GDP with strong growth of private consumption but sluggish growth of investment. Aggregate exports and aggregate imports both grew at more than twice the rate of growth of GDP.

According to Table 3, the strongest growing industries were *Non-Ferrous Ores* and *Metals* (13 and 64), *Communication* (98) and *Electronic Equipment* (73), *Air Transport* (96) and industries in the financial-services sector (99-102). A number of industries suffered output contractions through the historical period, notably arid-zone agriculture (1 and 4), *Oils and Fats* (20) *Bakery* and *Confectionary* products (23 and 24), *Beer* and *Tobacco* (27 and 29), industries in the textiles, clothing, footwear and leather-products sector (31-39 and 79), *Sawmill Products* (40), *Fertiliser* (49), *Locomotives* (70) and *Agricultural* and *Construction* machinery (76 and 77). Note that these output movements reflect the major changes in technology and consumer preferences that have occurred in recent years, e.g., the communication and electronics revolution, the shift to healthy foods and the increased popularity of Australia as a tourist destination.

4.3 Regional Macroeconomic Data

As explained in Section 3, in simulations 2-4 we introduce shocks to regional shares in aggregate government consumption, to regional employment growth and to regional shares in aggregate investment. The shocks are listed in Table 4. The table indicates that during the period 1986-87 to 1993-94:

- real government consumption grew more slowly in NSW, Victoria, South Australia and Tasmania than in Australia as a whole but more rapidly in Queensland and the two Commonwealth Territories;
- population grew more slowly in NSW, Victoria, South Australia and Tasmania than in Australia as a whole but more rapidly in all other regions; and
- investment grew more slowly in Victoria, South Australia, Tasmania and the two Commonwealth Territories than in Australia as a whole but more rapidly in NSW, Queensland and Western Australia.

Table 2. Macro Results from MONASH Historical Simulation,1986-87 to 1993-94

Variable	Aggregate Percentage Change	Average Annual Percentage Growth Rate
Real GDP	19.72	2.61
Real Consumption	24.81	3.22
Real Investment	5.05	0.71
Real Government spending	20.99	2.76
Volume of exports	62.74	7.20
Volume of imports	59.01	6.85
Terms of trade	5.40	0.75

Table 3. Industry Output Results from MONASH Historical Simulation, 1986-87 to 1993-94. Average Annual Percentage Growth Rates

Industry	Growth Rate	Industry	Growth Rate
1 Pastoral Zone	-1.1	58 Clay Products	0.8
2 Wheat-Sheep Zone	1.9	59 Cement	-0.8
3 High-Rainfall Zone	1.0	60 Readymix Concrete	0.9
4 Northern Beef	-0.2	61 Pipes	1.6
5 Milk Cattle	3.4	62 Plaster Products	4.7
6 Other Farming Export	1.6	63 Iron and Steel	1.3
7 Other Farming Imp. Ctg	3.1	64 Non-Ferrous Metals	5.0
8 Poultry	3.8	65 Structural Metal	1.7
9 Services to Agriculture	1.2	66 Sheet Metal	1.0
10 Forestry	-0.1	67 Wire Products	1.4
11 Fishing	3.6	68 Motor Vehicles	2.0
12 Iron Ore	3.7	69 Ships and Boats	3.1
13 Non-Ferrous Ores	10.3	70 Trains	-7.1
14 Black Coal	2.6	71 Aircraft	3.6
15 Oil and Gas	4.5	72 Scientific Equipment	4.8
16 Other Minerals	3.4	73 Electronic Equipment	12.5
17 Services to Mining	0.3	74 Household Appliances	1.8
18 Meat Cattle	3.5	75 Electrical Equipment	-0.2
19 Dairy Products	3.3	76 Agricultural Machinery	-1.1
20 Fruit and Veg. Products	4.9	77 Construction Machinery	-23.1
21 Oils and Fats	-6.3	78 Manufacturing Machinery	1.8
22 Flourmill Products	4.1	79 Leather Products	-1.9
23 Bakery Products	-0.8	80 Rubber Products	1.6
24 Confectionery	-1.1	81 Plastic Products	0.6
25 Seafood and Sugar	3.1	82 Signs	-0.2

Table 3 *(contd).* Industry Output Results from MONASH Historical Simulation, 1986-87 to 1993-94. Average Annual Percentage Growth Rates

Industry	Growth Rate	Industry	Growth Rate
26 Soft Drinks	2.9	83 Sports Equipment	-2.1
27 Beer	-0.7	84 Electricity	3.7
28 Other Alcoholic Drinks	4.6	85 Gas	3.3
29 Tobacco Products	-2.6	86 Water	1.8
30 Fibre Processing	6.2	87 Residential Building	4.8
31 Synthetic Yarn	-0.7	88 Other Building	0.0
32 Cotton Yarn	0.4	89 Wholesale Trade	2.1
33 Wool Yarn	-5.5	90 Retail Trade	2.5
34 Textile Finishing	-0.8	91 Mechanical Repairs	0.0
35 Carpets	-3.7	92 Other Repairs	0.0
36 Canvas Products	0.0	93 Road Transport	3.0
37 Knitting Mills	-6.1	94 Rail Transport	2.7
38 Clothing	-2.0	95 Water Transport	2.7
39 Footwear	-6.3	96 Air Transport	7.5
40 Sawmill Products	-2.0	97 Services to Transport	3.3
41 Panels and Veneers	3.4	98 Communication	9.1
42 Fittings	0.3	99 Banking	8.4
43 Furniture	1.6	100 Non-Bank Finance	9.0
44 Pulp and Paper	1.7	101 Investment Services	9.3
45 Bags and Boxes	1.3	102 Insurance	13.2
46 Sanitary Products	1.0	103 Other Financial Services	3.3
47 Newspapers and Books	-0.3	104 Ownership of Dwellings	3.1
48 Commercial Printing	4.0	105 Public Administration	3.3
49 Fertiliser	-4.2	106 Defence	1.2
50 Basic Chemicals	3.2	107 Health	3.1
51 Paints	2.3	108 Education	3.4
52 Pharmaceuticals	7.3	109 Welfare	5.6
53 Soaps and Detergents	-3.3	110 Entertainment	3.5
54 Cosmetics	-1.5	111 Hotels and Clubs	2.9
55 Explosives	5.3	112 Personal Services	2.1
56 Petrol	3.0	113 Other Services	0.1
57 Glass	1.7		

Table 4. Shocks to Regional Macro Variables in Simulations 2-4

Region	Variable		
	Percentage Change in Share of Real Government Final Consumption[(a)]	**Percentage Change in Population[(b)]**	**Percentage Change in Share of Real Aggregate Investment[(c)]**
New South Wales	-0.86	8.21	0.25
Victoria	-9.47	7.03	-10.08
Queensland	5.01	18.83	19.85
South Australia	-2.13	5.49	-14.83
Western Australia	0.01	14.36	8.03
Tasmania	-0.90	5.45	-13.24
Australian Capital Territory	34.49	14.33	-8.45
Northern Territory	0.69	10.41	-20.21
Australia	*n.a.*	*10.00*	*n.a.*

Notes:
(a) Calculated from ABS Catalogue No. 5220, Table 6.
(b) Calculated from ABS Catalogue No. 5220, Table 1 and 2.
(c) Calculated from ABS Catalogue No. 5220, Table 6.

4.4 Estimates of Historical Movements in Regional Industry Outputs

Labour force growth data over the period 1986-87 to 1993-94 were used to distribute the growth in national output of a sector across the regions. This was done in a way that ensures that the sum of the output changes for a given industry across all regions equals the change in the output of that industry at the national level (obtained from MONASH) while retaining the dispersion in regional growth rates evident from the labour force growth information. The formula for calculating the regional changes in industry output is:

$$q(j,r) = qmon(j) + l(j,r) - \sum_{r} S(j,r)\, l(j,r) \qquad (6)$$

where:

- *q(j,r)* is the percentage change in output in industry *j* in region *r*;
- *qmon*(*j*) is the percentage change in industry *j*'s output from MONASH;
- *l(j,r)* is the percentage change in the labour force growth rate in industry *j* in region *r*; and
- *S(j,r)* is the share of industry *j* in region *r* in the RES data.

5. RESULTS OF THE RES HISTORICAL SIMULATIONS

In reporting the results of our historical simulations with the RES, we concentrate on two issues: the ability of the model to reproduce observed growth rates of real gross regional product (GRP) at factor cost, and industries' contributions to deviations in regional from national growth of gross product.

5.1 Results for Gross Regional Product

Table 5 contains results for real GRP. The first seven columns refer to our seven MONASH-RES simulations. The eighth column contains our preferred observations of historical growth rates of real GRP. The ABS publishes estimates of nominal GRP at factor cost but not real GRP at factor cost. In the absence of regional constant-price data, our preferred method for generating the observations is to deflate the ABS estimates of growth rates of nominal GRP at factor cost using the national GDP price deflator. That is, we assume implicitly that the (unobserved) deflators for GRP at factor cost all move with the (observed) deflator for GDP at market prices. The results of this calculation are reported in the final column of Table 5. Aggregating over regions gives 2.90 per cent as an estimate of the growth rate of real GDP at factor cost. The corresponding growth rate from the MONASH historical simulations is 3.29 per cent. The final step in deriving our preferred observations of growth rates of real GRP at factor cost is to scale all the numbers in the final column of Table 5 by 3.29/2.90. This gives the penultimate column.

Table 5. Average Annual Percentage Changes in Gross Regional Product, 1986-87 to 1993-94.

	---------- MONASH-RES Simulations[a] ----------								
Sector	**Sim 1**	**Sim 2**	**Sim 3**	**Sim 4**	**Sim 5**	**Sim 6**	**Sim 7**	**Scaled ABS[c]**	**ABS[b]**
New South Wales	3.31	3.30	3.17	3.19	3.28	3.32	3.42	*3.15*	*2.78*
Victoria	3.03	2.77	2.76	2.65	2.64	2.28	2.31	*2.20*	*1.94*
Queensland	3.39	3.56	4.00	4.17	3.98	4.41	4.56	*5.03*	*4.43*
South Australia	3.11	3.07	2.91	2.74	2.63	2.54	2.47	*2.51*	*2.21*
Western Australia	4.00	4.01	4.07	4.13	4.44	4.79	4.44	*4.78*	*4.21*
Tasmania	3.55	3.54	3.15	3.02	2.99	2.20	2.01	*1.71*	*1.51*
Australian Capital Territory	3.04	3.98	3.91	3.71	3.63	3.65	3.36	*5.05*	*4.45*
Northern Territory	4.40	4.43	4.13	3.78	2.57	2.20	1.68	*1.94*	*1.71*
Australia	*3.29*	*3.29*	*3.29*	*3.29*	*3.29*	*3.29*	*3.29*	*3.29*	*2.90*

Notes:

[a] For details of the simulations, see Section 3, especially Figure 1.

[b] Calculated as average annual percentage change in nominal GSP at factor cost by region deflated by national GDP price deflator.

[c] ABS data scaled to annual average change in GDP from Monash model (3.29 percent).

Table 6. Percentage Point Deviation of Average Annual Percent Changes in Gross Regional Product from the Average Annual Percent Change in GDP, 1986/87 to 1993/94

	---------- MONASH-RES Simulations --------							
Sector	**Sim 1**	**Sim 2**	**Sim 3**	**Sim 4**	**Sim 5**	**Sim 6**	**Sim 7**	**Scaled ABS**
New South Wales	0.02	0.01	-0.12	-0.10	-0.01	0.03	0.13	-0.14
Victoria	-0.26	-0.52	-0.53	-0.64	-0.65	-1.01	-0.98	-1.09
Queensland	0.10	0.27	0.71	0.88	0.69	1.12	1.27	1.74
South Australia	-0.18	-0.22	-0.38	-0.55	-0.66	-0.75	-0.82	-0.78
Western Australia	0.71	0.72	0.78	0.84	1.15	1.50	1.15	1.49
Tasmania	0.26	0.25	-0.14	-0.27	-0.30	-1.09	-1.28	-1.58
Australian Capital Territory	-0.25	0.69	0.62	0.42	0.34	0.36	0.07	1.76
Northern Territory	1.11	1.14	0.84	0.49	-0.72	-1.09	-1.61	-1.35
Mean Absolute Deviation	*0.36*	*0.48*	*0.52*	*0.52*	*0.57*	*0.87*	*0.91*	*1.24*

Source: Calculated from Table 5.

Table 7. Percentage Point Deviations of GRP Results in Simulations 1-7 from Scaled ABS Observations

	---------- MONASH-RES Simulations --------							
Sector	**Sim 1**	**Sim 2**	**Sim 3**	**Sim 4**	**Sim 5**	**Sim 6**	**Sim 7**	**Scaled ABS**
New South Wales	0.16	0.15	0.02	0.04	0.13	0.17	0.27	0
Victoria	0.83	0.57	0.56	0.45	0.44	0.08	0.11	0
Queensland	-1.64	-1.47	-1.03	-0.86	-1.05	-0.62	-0.47	0
South Australia	0.60	0.56	0.40	0.23	0.12	0.03	-0.04	0
Western Australia	-0.78	-0.77	-0.71	-0.65	-0.34	0.01	-0.34	0
Tasmania	1.84	1.83	1.44	1.31	1.28	0.49	0.30	0
Australian Capital Territory	-2.01	-1.07	-1.14	-1.34	-1.42	-1.40	-1.69	0
Northern Territory	2.46	2.49	2.19	1.84	0.63	0.26	-0.26	0
Mean Absolute Deviation	*1.29*	*1.11*	*0.94*	*0.84*	*0.68*	*0.38*	*0.44*	*0*

Source: Calculated from Table 5.

Tables 6 and 7 are different ways of presenting the information given in Table 5. For example, Table 5 shows that in Simulation 1 the growth rate of NSW GRP is 3.31 per cent (column 1), that the scaled ABS growth rate is 3.15 per cent (column 8) and that the GDP growth rate is 3.29 per cent. Table 6 shows

deviations between the GRP growth rates and the GDP growth rate. Hence, it indicates that in Simulation 1, NSW GRP growth was 0.02 percentage points (i.e., 3.31 - 3.29) per annum faster than the GDP growth. Table 7 shows for each of our seven simulations the deviations of GRP growth rates from the scaled ABS growth rates. Hence, in Table 7 the deviation for NSW in Simulation 1 is 0.16 percentage points (3.31 - 3.15). The last rows of Tables 6 and 7 show the simple averages of the absolute deviations. In Table 6 these are measures of the dispersion between regions in their GRP growth rates in the simulations and in the scaled data. In Table 7 they are measures of the overall closeness of the simulation results to the scaled data.

The results in Tables 5 - 7 can best be considered in two tranches. The first tranche comprises Simulations 1-4, which use only national results from MONASH and observed changes in regional macroeconomic variables, namely, government consumption, population and aggregate investment. In the second tranche (Simulations 5-7), data on changes in output by region are gradually introduced, first in the agricultural and mining sectors, then for all *national* industries and finally, in Simulation 7, for all industries.

Simulation 1 uses only the MONASH results. Neither in terms of regions' rankings nor in terms of our summary measures does it do very well in reproducing the ABS data. It identifies Western Australia as a relatively fast-growing region and Victoria as relatively slow growing but it fails to identify the ACT and Queensland as fast-growing or the Northern Territory and Tasmania as slow growing. The mean absolute deviation in Table 6 indicates that there is far too little dispersion between regional growth rates in this simulation. In Table 7, the mean absolute deviation indicates that the growth rates from Simulation 1 deviate from the ABS growth rates by more than do the rates from any of the other simulations.

The main effects of introducing data on regional government demands (Simulation 2) are to increase the growth rates of the ACT and Queensland, and to reduce Victoria's growth rate. This moves the simulated growth rates closer to the ABS data – the mean absolute deviation from Table 7 moves from 1.29 to 1.11. It also increases the dispersion between simulated regional growth rates (see the last row of Table 6).

The introduction in Simulation 3 of regional population data reduces the simulated growth rates of NSW, South Australia, Tasmania and the two territories, and increases the rates of Queensland and Western Australia. All these changes take the simulated rates closer to the ABS data. The dispersion between regions in their growth rates increases slightly (Table 7).

Introducing the regional investment data in Simulation 4 moves most of the simulated growth rates closer to the ABS data, further reducing the mean absolute deviation in Table 7. The exceptions are New South Wales and the ACT. But the addition of the regional investment data does not increase the dispersion of the results (Table 6).

After all the regional macro data have been incorporated, the Northern Territory and Tasmania still have simulated growth rates much higher than their observed rates, and the ACT, Queensland and Western Australia have simulated

growth rates well below their observed rates (see column 4 of Table 7). But overall, our conclusion from examining the results of simulations 1-4 is that augmenting MONASH-RES with regional macroeconomic forecasts for changes in government spending, population and investment is likely to produce GRP forecasts that are more credible than those from using the standard MRES procedure. Nevertheless the simulated regional growth rates will still be more compressed than observed rates.

We turn now to the second tranche of simulations (5-7) in which we introduce regional data about growth of output by industry. Using such data for agricultural and mineral industries only (Simulation 5), reduces the deviations of simulated from observed GRP growth rates for Western Australia, South Australia and the Northern Territory but increases the deviation for Queensland. The mean absolute deviation in Table 7 falls. There is also a slight increase in the dispersion of the regional growth rates (Table 6).

Extending the data to all *national* industries in Simulation 6 reverses the increase in Queensland's deviation that occurred in Simulation 5. It also reduces the deviations of simulated from observed growth rates for Victoria, South Australia, Western Australia, Tasmania and the Northern Territory. But it has very little impact on the large negative deviation for the ACT. The mean absolute deviation in Table 7 falls to 0.38. The dispersion of the regional results increases from 0.57 to 0.87 (Table 6). Overall, Simulation 6 provides a satisfactory representation of the data. Nevertheless, it still underestimates growth for the ACT and Queensland, and overestimates growth for Tasmania.

In Simulation 7, we treated all industries in the RES as *national* industries and imposed growth rates by region that were estimated directly using employment data in the procedure described in Section 4.4. This reduced the deviations of simulated from observed growth rates for Queensland and Tasmania, but increased further the ACT's large negative deviation and introduced a negative deviation for Western Australia. The dispersion of the regional growth rates in this simulation is closer to the dispersion in the ABS data than was the case for any of the other six simulations (Table 6). But by the mean average deviation criterion, Simulation 7 is inferior to Simulation 6 in its fit of the simulated regional growth rates to the ABS data (Table 7).

An assumption implicit in the procedure described in Section 4.4 is that, for each industry, movements in labour productivity are uniform across regions. One possible explanation for the failure of Simulation 7 to reproduce the ABS GRP data precisely is that this assumption is not empirically valid. In particular, it suggests that growth in labour productivity may have been faster in the ACT than in Australia as a whole over the relevant period. A second possibility is that the industry shares in regions' value added in the RES might be inconsistent with the shares implicit in the ABS data.

5.2 Industry Contributions to Deviations in Growth

We do not have the information necessary to disaggregate the ABS GRP data into industry contributions. In the absence of this information, we will use the

contributions in Simulation 7 as a benchmark for examining the contributions in the other simulations. As noted in the previous section, in Simulation 7 we imposed, for all industries, growth rates by region that were estimated directly using employment data in the procedure described in Section 4.4. The GRP results in this simulation match the scaled ABS data quite well.

From Table 6, we see that in Simulation 7 four regions have GRP growth rates that exceed the growth rate of GDP and four have GRP growth rates below the GDP growth rate. Tables 8 and 9 contain industry contributions to the deviations of GRP from GDP growth for the fast-growing and slow-growing regions[2]. The contributions have been aggregated from the 113 industries in MONASH to 22 broader sectors.

For Queensland, it can be seen in Table 8 that there are four main sectors driving the relatively high rate of economic growth: *Construction*, *Community services*, *Trade related* and *Finance related*. All these sectors grew faster than GDP at the national level and all have relatively large weights in the Queensland economy.

In Western Australia, the second-fastest growing region, the *Mining* sector is the main driver of the high rate of growth. This sector is growing fast and is heavily represented in Western Australia. Similar to Queensland, the other significant contributors to the region include the *Construction* and *Finance related*.

GRP growth in New South Wales is only slightly faster than GDP growth. The major contributors to the small positive deviation in growth are *the Agriculture and forestry* sector and the *Construction* sector. *Agriculture and forestry* grows slowly at the national level compared with GDP but it is relatively under-represented in NSW. More importantly, the sector grew faster in NSW than in the rest of Australia. Non-residential construction is similar to the agricultural sector – it grew slowly at the national level compared with GDP but is under-represented in NSW and grew faster in NSW than in the rest of Australia. Residential construction grew faster than GDP at the national level, is relatively over-represented in NSW and grew faster in NSW than in the rest of Australia.

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[2] Industry *i* makes a positive contribution to the deviation of region *r*'s GRP growth [*grp*(*r*)] from GDP growth [*gdp*] if: (a) the industry's economy-wide growth rate [*g*(*i*)] exceeds the GDP growth rate and its share in region *r*'s GRP [*S*(*ir*)] exceeds its share in GDP [*S*(*i*)]; (b) the industry's economy-wide growth rate is smaller than the GDP growth rate and its share in region r's GRP is smaller than its share in GDP; or (c) the industry's growth rate in region *r* [*g*(*ir*)] exceeds its economy-wide growth rate. The contributions are the terms in the sum on the right hand side of the following formula:

$$grp(r) - gdp = \text{Sum}\,(i)\{[g(i) - gdp][S(ir) - S(i)] + S(ir)[g(ir) - g(i)]\},$$

where "Sum (*i*){ }" denotes the sum over *i* of the terms in the curly bracket. See the subsection on "Reporting variables" in Section 2.2 of CoPS Working Paper OP-95 referred to in footnote 1.

Table 8. Contributions to Deviations in GSP Growth Rates in Simulation 7: Fast-growing Regions

Sector	**Qld**	**WA**	**NSW**	**ACT**
Agriculture and Forestry	-0.06	-0.08	0.07	-0.08
Mining	-0.12	0.42	-0.01	-0.05
Food	-0.02	-0.06	0.03	0.04
TCF	0.05	0.05	0.01	0.05
Wood-related	0.05	-0.02	0.00	-0.09
Paper-related	0.01	0.03	0.00	0.05
Chemical/Oil	0.03	0.04	-0.01	0.00
Nonmetal	0.04	0.02	0.00	0.01
Metal	0.13	0.03	-0.04	0.03
Transport Equipment	-0.02	0.02	-0.01	-0.00
Other Machinery	0.02	0.01	-0.00	-0.04
Other Manufacturing	0.03	-0.01	-0.00	0.00
Utilities	0.01	0.04	0.02	0.11
Construction	0.31	0.24	0.07	-0.45
Trade related	0.20	-0.05	-0.10	0.25
Transport & Storage	0.05	0.12	0.00	-0.07
Communications	-0.01	-0.02	0.02	0.08
Finance related	0.16	0.15	0.00	-0.13
Dwelling ownership	0.10	0.04	-0.03	0.05
Public administration	0.03	0.11	0.05	0.08
Community Services	0.21	0.00	0.04	0.15
Recreation	0.04	0.02	-0.01	0.06
Growth Deviation: (GSP Growth - Ausralian Growth)	*+1.23*	*+1.11*	*+0.12*	*+0.06*

In the ACT, strong positive contributions from *Trade related*, *Community services* and *Utilities*, which grew relatively quickly in the ACT, cushioned the region from the relative underperformance of the *Construction* sector.

Turning now to Table 9, we see that most sectors made negative contributions to the SA's growth deviation. *Construction*, *Finance related* and *Mining* are all prominent despite growing faster than GDP at the national level. All three are relatively under-represented in SA.

Table 9. Contributions to Deviations in GSP Growth Rates in Simulation 7: Slow-growing Regions

Sector	**SA**	**VIC**	**TAS**	**NT**
Agriculture and Forestry	0.01	0.00	0.10	-0.60
Mining	-0.08	-0.04	-0.03	-0.00
Food	0.01	0.01	-0.19	0.02
TCF	-0.03	-0.06	0.03	0.05
Wood-related	0.02	-0.01	-0.15	-0.01
Paper-related	-0.02	-0.02	-0.06	0.01
Chemical/Oil	-0.01	-0.00	-0.18	0.00
Non-metal	-0.02	-0.01	-0.09	-0.06
Metal	0.01	-0.03	-0.15	-0.09
Transport Equipment	0.04	-0.01	0.10	0.04
Other Machinery	0.03	-0.02	0.05	-0.04
Other Manufacturing	-0.02	-0.00	-0.00	0.01
Utilities	-0.03	-0.05	-0.05	0.16
Construction	-0.29	-0.24	0.07	-0.39
Trade related	-0.02	0.03	-0.29	-0.01
Transport & Storage	0.04	-0.08	-0.12	-0.03
Communications	-0.06	0.00	-0.03	0.01
Finance related	-0.15	-0.08	-0.04	-0.57
Dwelling Ownership	-0.04	-0.03	-0.05	0.00
Public Administration	-0.09	-0.13	0.16	0.10
Community Services	-0.04	-0.17	-0.23	0.04
Recreation	-0.05	0.00	-0.08	-0.22
Growth Deviation: (GSP Growth - Australian Growth)	*-0.80*	*-0.96*	*-1.25*	*-1.58*

Victoria has only five sectors making positive contributions. These were outweighed by the negative contributions of the other 17 sectors, among which *Construction*, *Community services* and *Public administration* are prominent. These sectors all grew considerably slower in Victoria than elsewhere in Australia. Note that the contribution of the slow-growing *TCF* sector is only 0.06 percentage points, a function of its small importance to even the Victorian economy.

Tasmania has a number of sectors with positive contributions, notably *Public administration* and *Transport equipment*. These sectors grew much more strongly in Tasmania than in the rest of Australia. However, slower-than-average growth in sectors including *Wholesale and retail trade*, *Community services*, *Food* and *Chemicals* restricted Tasmania's GRP growth grew relative to GDP growth.

Table 10. Contributions to Deviations in GSP Growth Rates – Queensland

	Simulations						
Sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Agriculture and Forestry	-0.04	-0.04	-0.04	-0.04	-0.07	-0.07	-0.06
Mining	-0.01	-0.01	-0.01	-0.01	-0.12	-0.12	-0.12
Food	0.00	0.00	0.01	0.01	0.01	-0.01	-0.02
TCF	0.03	0.03	0.03	0.03	0.03	0.05	0.05
Wood-related	0.00	0.00	0.00	0.00	0.00	0.05	0.05
Paper-related	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Chemical/Oil	0.00	0.00	0.00	0.00	0.00	0.03	0.03
Non-metal	0.00	0.00	0.00	0.00	0.01	0.04	0.04
Metal	0.02	0.02	0.02	0.02	0.02	0.13	0.13
Transport Equipment	-0.03	-0.03	-0.03	-0.03	-0.03	-0.02	-0.02
Other Machinery	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Other Manufacturing	0.01	0.01	0.01	0.01	0.01	0.03	0.03
Utilities	0.01	0.01	0.03	0.03	0.03	0.04	0.01
Construction	0.04	0.05	0.08	0.18	0.18	0.18	0.31
Trade related	0.01	0.03	0.12	0.15	0.14	0.17	0.20
Transport & Storage	-0.01	-0.00	0.01	0.01	0.01	0.03	0.05
Communications	0.02	0.02	0.04	0.04	0.04	0.04	-0.01
Finance related	0.02	0.04	0.11	0.13	0.12	0.17	0.16
Dwelling Ownership	-0.01	0.01	0.12	0.12	0.12	0.12	0.10
Public Administration	0.01	0.01	0.01	0.01	0.01	0.03	0.03
Community Services	-0.01	0.07	0.11	0.11	0.11	0.11	0.21
Recreation	0.00	0.01	0.04	0.04	0.04	0.04	0.04
Growth Deviation: (GSP Growth – Australian Growth)	*0.09*	*0.26*	*0.68*	*0.85*	*0.67*	*1.08*	*1.23*

Surprisingly, in the Northern Territory, with an annual average growth rate of only 1.7 per cent, most sectors made positive contributions to the region's growth deviation. However, there are large negative contributions from *Agriculture and forestry* (mainly the slow-growing Northern beef industry which is a major industry in the NT), *Construction*, *Finance related* and *Recreation*.

We have generated industries' contributions to regions' growth deviations for all of our seven simulations. Tables 10 and 11 give two examples: for Queensland and Tasmania.

Table 10 gives the deviations for Queensland, a region for which our RES simulations consistently underestimate growth, although the fit of the simulation results to the ABS data does improve as we introduce more regional information into the simulations. Consistent with Table 4, in Table 10:

Table 11. Contributions to Deviations in GSP Growth Rates – Tasmania

	Simulations						
Sector	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Agriculture and Forestry	0.02	0.02	0.02	0.02	0.11	0.11	0.10
Mining	0.05	0.05	0.05	0.05	-0.03	-0.03	-0.03
Food	0.03	0.03	0.03	0.03	0.03	-0.20	-0.19
TCF	0.01	0.01	0.01	0.01	0.01	0.03	0.03
Wood-related	-0.06	-0.06	-0.06	-0.06	-0.06	-0.15	-0.15
Paper-related	-0.03	-0.03	-0.03	-0.03	-0.03	-0.06	-0.06
Chemical/Oil	-0.03	-0.03	-0.03	-0.03	-0.03	-0.18	-0.18
Non-metal	-0.03	-0.03	-0.03	-0.03	-0.03	-0.09	-0.09
Metal	0.06	0.06	0.06	0.06	0.06	-0.15	-0.15
Transport Equipment	0.02	0.02	0.02	0.02	0.02	0.10	0.10
Other Machinery	0.01	0.01	0.01	0.01	0.01	0.05	0.05
Other Manufacturing	0.01	0.01	0.01	0.01	0.01	-0.00	-0.00
Utilities	0.02	0.02	0.01	0.00	-0.00	-0.05	-0.05
Construction	0.02	0.02	-0.01	-0.09	-0.09	-0.10	0.07
Trade related	0.02	0.02	-0.06	-0.08	-0.08	-0.17	-0.29
Transport & Storage	-0.02	-0.02	-0.03	-0.03	-0.04	-0.07	-0.12
Communications	0.01	0.01	-0.00	-0.01	-0.01	-0.01	-0.03
Finance related	0.01	0.01	-0.05	-0.06	-0.08	-0.13	-0.04
Dwelling Ownership	0.03	0.03	-0.05	-0.05	-0.05	-0.05	-0.05
Public Administration	0.03	0.03	0.03	0.03	0.03	0.16	0.16
Community Services	0.03	0.02	-0.03	-0.03	-0.03	-0.04	-0.23
Recreation	0.01	0.01	-0.02	-0.02	-0.02	-0.02	-0.08
Growth Deviation: (GSP Growth - Australian Growth)	*0.25*	*0.24*	*-0.14*	*-0.27*	*-0.30*	*-1.07*	*-1.25*

- the introduction of data on regional government spending (Simulation 2) increases the contributions of *Community services*;
- the introduction of data on regional population (Simulation 3) increases the contributions of *Dwelling ownership*, *Trade related* and *Finance related*; and
- the introduction of data on regional investment (Simulation 4) increases the contribution of *Construction*.

Our data on the regional growth rates of agricultural and mineral industries indicate that these industries grew slower in Queensland than in the rest of Australia. Hence, introducing these data (Simulation 5) reduces the contributions of these industries to the deviation of the state's GRP growth from GDP growth. As we noted in explaining Tables 7, introducing these data increases the deviation of Queensland's GRP growth from the ABS data on GRP growth, i.e., it reduces the already underestimated deviation from GDP growth (see Table 8 or

the last row of Table 10). Introducing data on regional growth rates for other industries (Simulations 6 and 7) significantly reduces Queensland's deviation from the ABS growth rate mainly by increasing the contributions of *Metal* (Simulation 6), and *Construction* and *Community services* (Simulation 7).

Table 11 allows a similar tracing of the sector-dimension consequences of the regional information included in our RES simulations for the case of Tasmania. For Tasmania, the simulations consistently overestimate growth, although with each additional piece of regional information, this overestimation declines until by Simulation 7 the deviation falls from 1.84 to 0.30 (Table 7). The main improvements are due to:

- the negative contributions of *Trade related*, *Finance related* and *Dwelling ownership* produced by the introduction of regional population data which indicate that Tasmania's population grew considerably slower than the national average (Table 4);
- the negative contribution of the *Construction* sector produced by the introduction of data on the regional investment growth rates in Simulation 4;
- the large negative contributions of *Food*, *Wood-related*, *Chemical/oil* and *Metal* produced by the introduction of data on the regional growth rates of these sectors in Simulation 6; and
- the increase in the size of the negative contributions of *Trade related* and *Community services* that is produced by using data on the regional growth rates of these sectors rather than treating them as *local* industries.

Interestingly, the introduction of regional data on the agricultural and mining sectors in Tasmania had little effect on that state's GRP with the expansion in the Agricultural sector being cancelled out by a decline in the state's mining prospects.

6. CONCLUSION

The results reported in this paper confirm our earlier view that MONASH-RES forecasts in which no region-specific macroeconomic data are used and in which regions' shares in *national*-industry outputs are held constant, will fail to capture important features of regional economic development. In particular, they are likely to underestimate the dispersion between regions' growth rates that typically occurs. On the other hand, the results demonstrate that the performance of MONASH-RES in forecasting is significantly improved by the inclusion of region-specific macro data and accurate information about the regional distribution of output changes in *national* industries. Moreover, the results indicate that the treatment of *local* industries in MONASH-RES is satisfactory.

In Table 7, the following specific features of the results are worth noting:

- the importance for Victoria and the ACT of information about government spending;
- the importance for Queensland and Tasmania of recognising population movements;
- the importance for Western Australia and the NT of data on agriculture and mining;

- the apparent relatively slow growth of *national* industries in Victoria and the NT and their apparent relatively fast growth in Queensland and Western Australia; and
- the apparent relatively fast growth of labour productivity in Western Australia and the NT.

A final issue is the extent to which the results are relevant to the use of MONASH-RES for policy analysis as opposed to forecasting. In most applications to policy analysis, we would rely on the model's projections of the effects of the policy change on output by industry at the regional level to determine the regional macroeconomic effects. But the macroeconomic effects of most of the policy changes considered (changes in protection, for example) are in any case likely to be small. The importance of the effects of the policy changes on the regional location of the outputs of *national* industries is usually investigated via scenario analysis. For example, in recent analysis of the effects of tariff reform for the Australian motor-vehicle industry, we considered two scenarios, one in which the reform was assumed not to affect the regional distribution of motor-vehicle output (i.e., the default rule (1) was adopted) and a second in which it was assumed that the reform led to a consolidation of motor-vehicle output into Victoria.

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