EXTERNAL INFLUENCES ON OUTPUT: AN INDUSTRY ANALYSIS

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Abstract

The correlation of Australian output with that of the OECD, and the United States in particular, has been well documented. This paper explores foreign linkages by looking at the production side of the national accounts for Australia and the United States, which is often characterised as the country at the technological frontier. Industrial structures in the two countries are broadly similar, and about two-thirds of Australian output is found to be linked to that of the United States. The US links in the agricultural and mining sectors seem to be related to aggregate demand in the United States, in both the short and long run. But in manufacturing – and notably in goods for which production is technology intensive and changing over time – there are persistent, long-run links with the corresponding sector in the United States. Combined with other evidence, the conjecture is that the US links in manufacturing are driven by the supply-side: technological change, innovation and new products are transmitted from the United States and elsewhere to Australia, mostly within two to three years. Domestic demand seems to dominate service sectors, although US aggregate demand can be relevant, as, for example, in the finance and property sector. While links with the United States are pervasive, domestic events and policies are shown to be important to economic outcomes, particularly in the short to medium term.

JEL Classification Numbers: C22, E32, F41, L60, O56.

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1. Introduction

It is, by now, a well-known feature of the Australian economy that the domestic business cycle is highly correlated with that of the OECD, and that of the United States in particular (McTaggart and Hall 1993; Gruen and Shuetrim 1994). There is not only a high contemporaneous correlation between Australian and OECD/US output growth, but domestic output seems to track the path of foreign output over time, indicating that this relationship is persistent and long run. Gruen and Shuetrim (1994), Debelle and Preston (1995) and de Roos and Russell (1996) sought to explain this relationship by using data from the expenditure side of the national accounts. This paper takes a different tack to explaining international output connections by exploring *production* linkages across a range of industries in Australia and the United States.

In Section 2, summary statistics on output in the two countries are examined. The strength and nature of the relationship between domestic and US production is explored using cointegration analysis in Section 3. In particular, the focus is on identifying the relationship of sectoral outputs in Australia with the corresponding US sector and aggregate private output in both Australia and the United States. In Section 4, some implications of the analysis are explored in more detail. The conclusion summarises the paper.

We find that Australian and US industrial structures are basically similar, and that about two-thirds of Australian sectoral output is affected by US output, often both in the short and the long run. The US links in agriculture and mining largely occur through aggregate demand. There are also some strong links between corresponding industries. These are clearly stronger in goods than in services, and for manufacturing durable or non-consumable goods in particular. The distinguishing feature of these types of goods is that their production processes are technology intensive and changing over time. These links are most important in explaining long-term, rather than transitory, developments in production. This suggests that inter-sectoral output links to the United States are driven by changes in the supply side. Institutional features, like foreign ownership or trade orientation, do not appear to explain the links, at least on available aggregated data. Service sectors are dominated by domestic aggregate demand, although US aggregate demand affects some of these sectors, particularly finance and property. While foreign developments are important, especially in the longer term, domestic policy and events, such as monetary and fiscal policies, affect output over the business cycle. Monetary policy, for example, has a substantial effect on manufacturing output, either directly or indirectly through the exchange rate or through policy's influence on aggregate demand. Indeed, policy has important short to medium-term effects, even when output is determined by overseas developments in the long term.

2. A Summary View of Sectoral Output

A number of papers have pursued an explanation of the strong contemporaneous and long-run relationship between Australian and OECD/US output. Debelle and Preston (1995), for example, looked at aggregate consumption and investment links with other countries. They found that US and Japanese activity provide some information about domestic income and hence have an indirect effect on Australian consumption. But they also reported that overseas developments contain little information about domestic investor confidence, profitability or investment.

Gruen and Shuetrim (1994) tried to explain the correlation of Australian and foreign output in terms of the strength of foreign demand for Australian goods and services. They found, however, that export shares reveal little about the importance of foreign demand.[1] De Roos and Russell (1996) explained that this will usually be the case since an increase in foreign demand lifts Australian exports, but the associated pick up in domestic demand induces a supply shift away from foreign markets to the home market. The net effect of an increase in foreign demand on exports may be quite small – indeed, the correlation of exports and national income is quite low.

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1 Bodman (1996), however, found that Australian GDP and exports are cointegrated and stable, but that the effect of exports on GDP is relatively small. He also reported that exports Granger-cause productivity, and that reverse causality is rejected.

They, accordingly, model Australian exports as a function of both foreign and domestic demand, and find that the effect of foreign aggregate demand on Australian exports can be high, particularly when the foreign-income elasticity of demand for Australian exports is high, as happens to be the case for Japan and the United States. They also found that the stock market in the United States affects that in Australia, and that this may induce a common cycle, especially in investment.

This paper shifts focus to the *production* side of the national accounts. Since production is a result of both supply and demand effects, this should not necessarily be interpreted as an examination of the supply linkages between Australia and the rest of the world. There appears to be nothing published on the transmission of foreign shocks to Australian output at the industry level. Prasada Rao, Shepherd and Pilat (1995) used input-output tables to compare the levels of Australian and US manufacturing productivity and real output. They report that the structures of the manufacturing sectors in Australia and the United States are similar, although Australian manufacturing uses more intermediate inputs in production and so has a lower value added. They find that output, value added and prices have tended to be higher in protected manufacturing sectors in Australia. Productivity levels are about half those in the United States, and are highest in agriculture and mining and lowest in heavy engineering. Ergas and Wright (1994) reported that openness, as indicated by trade intensities and FDI, has increased in manufacturing. These studies focussed on manufacturing rather than general industrial output, and they did not explore the interactions of domestic with overseas production.

In this study, output interactions for most industrial classifications are examined. The reference country is the United States, since it is the largest economy in the world and has the highest productivity levels, and so may be viewed as the leading source of productivity shocks. Moreover, recent work indicates that US productivity shocks propagate quickly to other economies, while those from Japan or Europe do not (Elliott and Fatas 1996). The relationship between Australian and US sectoral output is examined at the one and two-digit levels of aggregation from 1977 to 1993. There are 11 one-digit sectors and 12 manufacturing sub-sectors, and these are graphed in Figures 1 and 2. The data are annual, since this is the frequency of the US data, and descriptions and reconciliations of the data are provided in Appendix A. The limited number of observations makes it difficult to draw strong inferences from the data. Table 1 presents summary statistics, including the share of each sector in total private sector output, the contemporaneous correlation of output growth in each Australian industry sector with the rest of Australian output growth, and the correlations of Australian and US sectoral output growth.

There are three striking features in the summary statistics:

- while US production is about 20 times larger than Australia's, the industrial structures of the Australian and US economies are similar. For example, manufacturing accounts for about one-quarter of private sector output in both countries, and most other shares are broadly the same. The exceptions are that the US finance sector is relatively larger than Australia's, while the production of food and beverages is relatively more important in Australian manufacturing;

- when there is a significant correlation between sectoral outputs, it is almost always the case that the correlation is contemporaneous or, more typically, that the development in the United States leads that in Australia. Australia follows the United States, rather than the other way round; and

- the correlations appear to be concentrated in the manufacturing sector, and in areas which involve processing and technology. There is little correlation in services sector output, although construction and finance are the exceptions here. As a casual observation, both of these sectors would be thought to be the more open and traded of the services sectors.

Table 1: Summary Statistics on Australian and US Sectoral Output

	Per cent of total private sector output (period average)		Sectoral & total output correlation	Correlation of Australian and US outputs -1 (+1) indicates Australia (US) leads		
	Level			First difference		
	Australia	US	Australia	-1	0	+1
Total GDP(P)	100	100	–	-0.26	**0.54****	**0.65*****
Agriculture	6	3	0.16	0.08	0.03	-0.40
Mining	5	3	0.33	0.23	0.29	0.26
Manufacturing	22	27	**0.78*****	-0.39	**0.44***	**0.46***
Food, beverages and tobacco	21	11	–	0.06	0.00	0.11
Textiles	2	2	–	-0.13	-0.18	0.30
Clothing	4	3	–	-0.17	**0.55****	0.08
Wood and furniture	5	3	–	-0.04	0.28	**0.84*****
Paper, printing and publishing	8	11	–	-0.13	0.35	**0.52****
Chemical, petroleum and coal	10	12	–	-0.26	0.04	**0.51****
Non-metallic mineral products	5	3	–	-0.18	0.10	0.35
Basic metal products	11	5	–	-0.01	**0.51****	0.00
Fabricated metal products	7	7	–	**-0.44***	**0.54****	**0.63*****
Transport equipment	11	12	–	**-0.45***	0.17	0.03
Other machinery and misc mfg	15	26	–	-0.23	**0.51****	**0.50****
Utilities	4	4	**0.55****	-0.24	0.00	0.15
Construction	10	6	**0.88*****	-0.33	0.31	**0.43***
Wholesale trade	11	8	**0.82*****	-0.32	0.19	0.02
Retail trade	13	13	**0.62*****	0.19	0.19	0.02
Transport and storage	6	5	**0.62*****	-0.18	-0.02	**0.60****
Rail	10	14	–	-0.08	-0.03	**0.50****
Water	11	6	–	0.17	0.22	-0.06
Air	18	20	–	-0.29	0.12	0.39
Road	62	60	–	0.06	-0.23	0.30
Communications	2	4	0.38	-0.29	-0.13	0.24
Finance	15	25	**0.61*****	-0.22	0.25	**0.53****
Recreation and personal services	6	3	**0.64*****	0.25	0.28	0.00

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

Figure 1: Real Sectoral Output

Index: 1977-1993 = 100

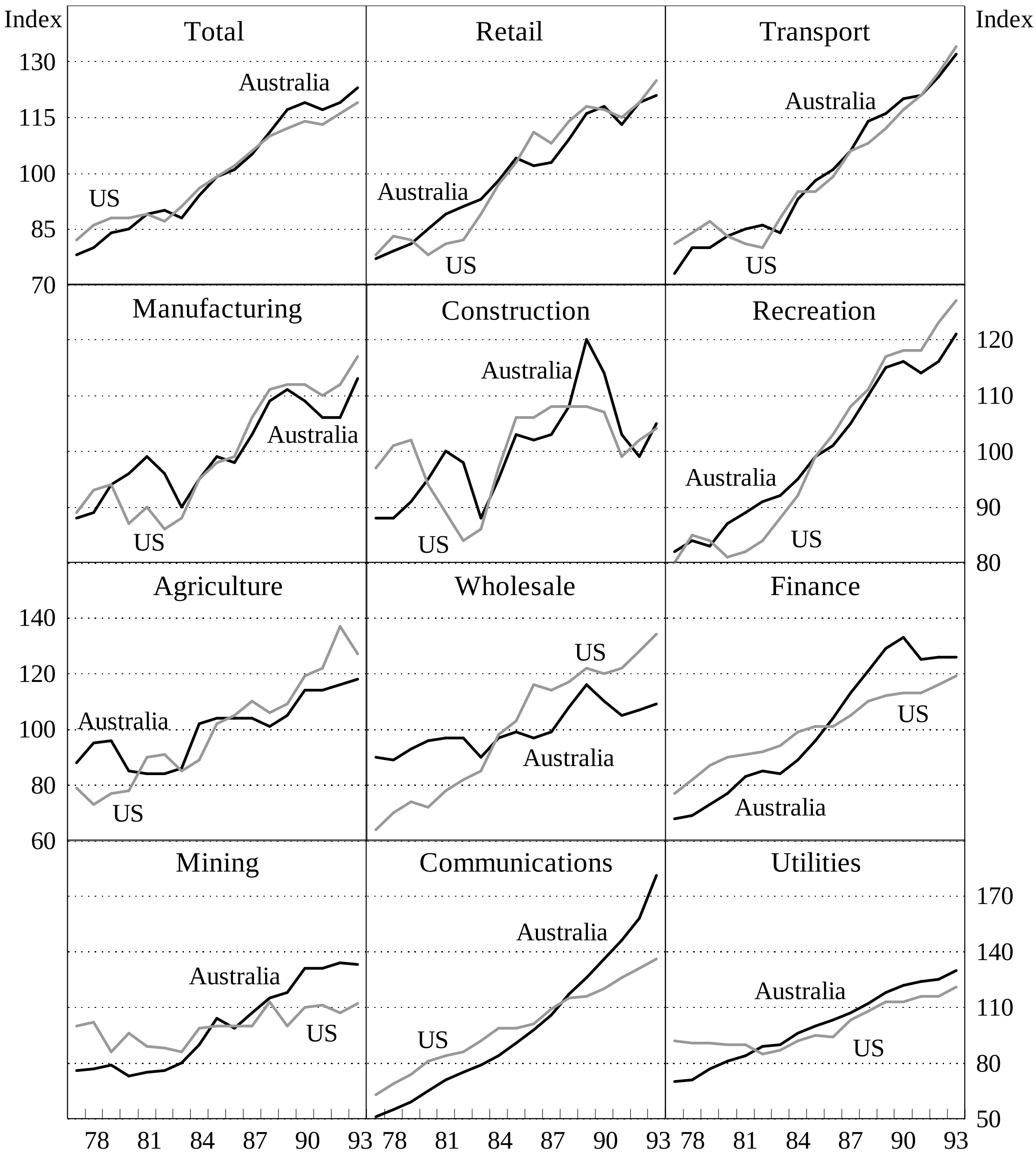
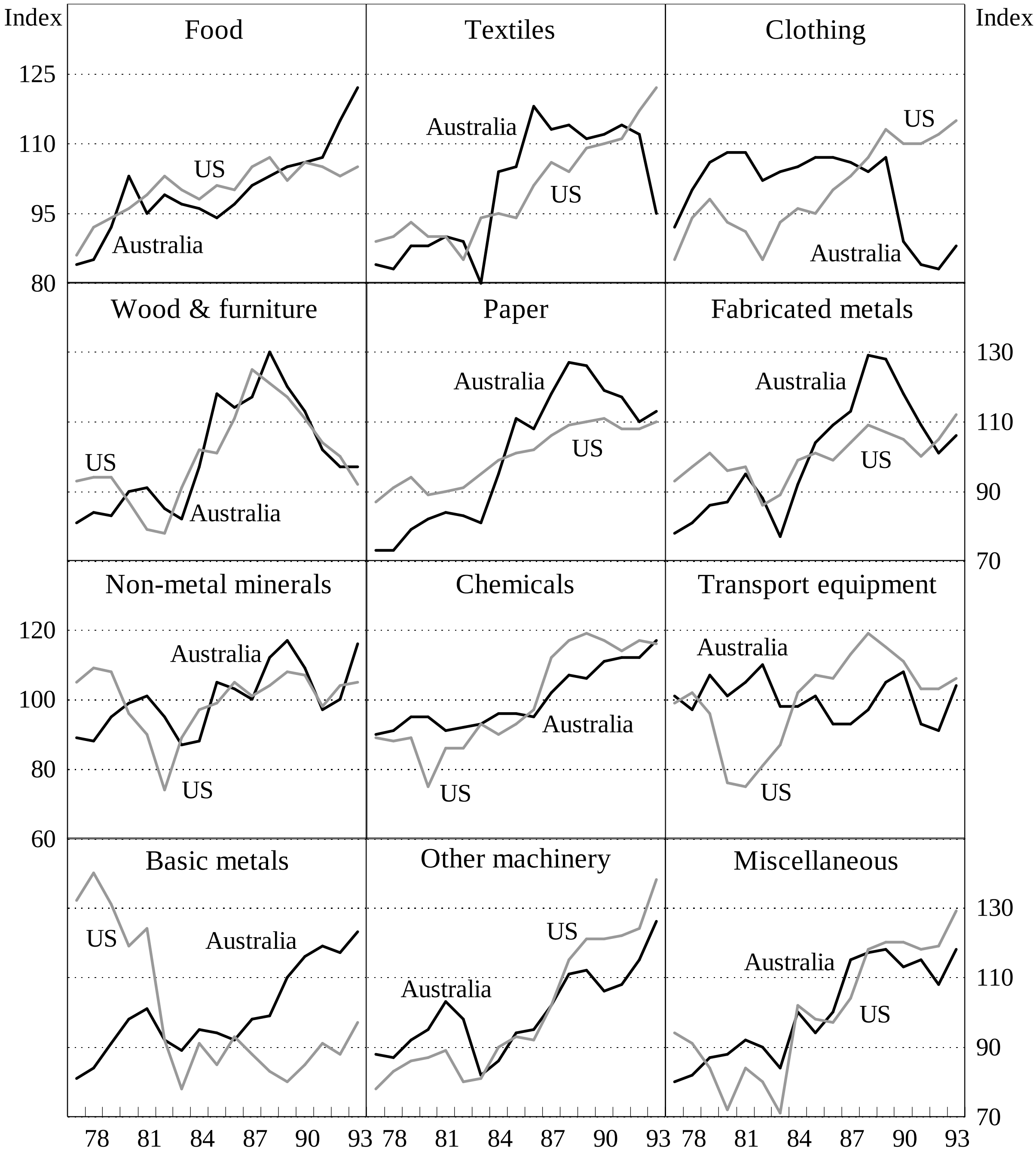


Figure 2: Real Manufacturing Output

Index: 1977-1993 = 100



3. A Closer Look at Sectoral Links

Correlation and graphical analysis provides a useful first pass at assessing whether there are sectoral output links between Australia and the United States, but it tells little about the dynamics and form of the relationship, and it does not control for other effects. Accordingly, we estimate an unrestricted error-correction model of the relationship of domestic sectoral output with US sectoral output, the rest of domestic aggregate output and the rest of aggregate US output:

$$\begin{aligned}\Delta y_t^i = b_0 + b_1 y_{t-1}^i + b_2 \tilde{y}_{t-1}^i + b_3 y_{t-1}^{aggregate} + b_4 \tilde{y}_{t-1}^{aggregate} \\ + b_5 \Delta\tilde{y}_t^i + b_6 \Delta y_t^{aggregate} + b_7 \Delta\tilde{y}_t^{aggregate} + b_8 \Delta y_{t-1}^i\end{aligned} \tag{1}$$

where y is output, the superscript i represents the sector, the tilde denotes the foreign sector, *aggregate* indicates total output less the sector under consideration and $b_1 < 0$.[2] Table 2 presents the preferred specification.[3] The equations are estimated in system form using the seemingly unrelated regression (SURE) technique. As outlined in Appendix B, there is considerable correlation between the error terms of these equations at both the one and two-digit levels when they are estimated by OLS. SURE estimation uses the correlation between the error terms of each equation to increase the precision of the coefficient estimates (although if any equation is misspecified all estimates may be inconsistent). The OLS results are also presented in Appendix B. The estimates are less precise but the overall story is qualitatively similar.

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2 The results are the same when aggregate output is defined as total output inclusive of the relevant sector.

3 The distribution of the lagged-level terms in Equation (1) lies between the Dickey-Fuller (1981) distribution and the standard t distribution (Kremers, Ericsson and Dolado 1992). The standard t distribution is the benchmark for statistical significance in Table 2. The 10 per cent, 5 per cent and 1 per cent Dickey-Fuller significance levels for 25 observations (which is seven more than we have) are 4.12, 5.18 and 7.88, respectively. Generally speaking, when levels variables are significant in an equation, they are also significant at these much higher cut-off points, even at the 1 per cent level. The distribution of the dynamics terms follows the standard t distribution.

The long-run impact of a change in foreign output on domestic output is estimated as $-b_2/b_1$. A 1 per cent rise in US GDP(P) leads to a 1¼ per cent rise in Australian GDP(P), similar to the coefficient estimated by Gruen and Shuetrim (1994). This coefficient varies between sectors. It is considerably higher in fabricated metals and finance, indicating that growth in these sectors is strong relative to the United States. The final column gives the explanatory power of the equation.[4]

The estimation procedure isolates the influence of foreign sectoral effects and domestic and foreign aggregate demand effects on domestic sectoral output. Moreover, it identifies whether these effects are 'fundamental' or long run, as indicated by an error-correction/cointegration relationship between them and domestic sectoral output, or are simply transitory, as indicated by short-run dynamics. Columns 2 to 5 indicate long-run relationships, while columns 6 to 9 indicate short-run dynamics.

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4 When the marginal statistical significance of the equation is above 10 per cent, which roughly corresponds to an R-bar-squared less than about 0.25, we treat the outcome as a 'non-result'.

Table 2: Australian and US Sectoral Output Error-Corrections (1977-1993)

	Constant β_0	Sector adjustment β_1	US sector adjustment β_2	Aggregate adjustment β_3	US aggregate adjustment β_4	US sector impact β_5	Aggregate impact β_6	US aggregate impact β_7	Lag sector impact β_8	$\bar{R}^2$
Total GDP(P)	1.72** (0.51)	**-0.74**** **(0.19)**	**0.92**** **(0.23)**	–	–	**0.54**** **(0.19)**	–	–	–	0.62
Agriculture	*1.65*** *(0.69)*	***-0.91******* ***(0.13)***	–	–	***0.83******* ***(0.14)***	–	–	***1.31******* ***(0.36)***	*0.37**** *(0.09)*	*0.57*
Mining	-8.08*** (1.05)	**-1.26***** **(0.12)**	**0.60***** **(0.18)**	–	**2.08***** **(0.23)**	**0.26***** **(0.10)**	–	**1.23***** **(0.31)**	–	0.41
Manufacturing	*3.10*** *(0.57)*	***-0.51******* ***(0.07)***	***0.37******* ***(0.05)***	–	–	***0.19******* ***(0.06)***	*0.71**** *(0.16)*	–	–	*0.73*
Food	2.27*** (0.87)	**-0.54***** **(0.12)**	–	–	**0.34***** **(0.10)**	–	–	–	–	0.17
Textiles	*0.94* *(1.33)*	***-0.54******* ***(0.12)***	–	–	***0.33**** ***(0.21)***	–	*1.42*** *(0.63)*	–	–	*0.16*
Clothing	8.09*** (0.94)	-0.49*** (0.06)	–	-0.35*** (0.05)	–	**0.57***** **(0.09)**	1.03*** (0.26)	–	–	0.62
Wood & furn.	*3.08**** *(0.55)*	**-0.52***** **(0.10)**	**0.29***** **(0.11)**	–	–	**0.22**** **(0.10)**	2.21*** (0.47)	–	–	*0.48*
Paper	1.65*** (0.39)	**-0.32***** **(0.06)**	**0.27***** **(0.10)**	–	–	–	1.88*** (0.31)	–	–	0.52
Chemicals	*2.39**** *(0.50)*	***-0.43******* ***(0.07)***	***0.28******* ***(0.04)***	–	–	***0.06******* ***(0.03)***	–	–	–	*0.43*
Non-met min.	1.96* (1.06)	**-0.67***** **(0.08)**	**0.25***** **(0.06)**	0.20** (0.09)	–	–	1.85*** (0.49)	–	–	0.54
Basic metals	*-2.30*** *(0.94)*	***-0.61******* ***(0.11)***	***0.23******* ***(0.05)***	*0.53**** *(0.11)*	–	***0.35******* ***(0.05)***	–	–	–	*0.48*
Fabr'd met.	0.12 (0.46)	**-0.43***** **(0.05)**	**0.83***** **(0.13)**	–	–	–	2.00*** (0.26)	**1.27***** **(0.27)**	–	0.78
Trans. equip.	*15.24**** *(1.77)*	*-1.64**** *(0.19)*	*-0.23**** *(0.07)*	–	–	–	–	–	*0.94**** *(0.13)*	*0.53*
Other mach.	5.11***	**-0.87*****	**0.45*****	–	–	**0.45*****	–	–	0.63***	0.59

	(0.63)	**(0.10)**	**(0.08)**			**(0.10)**			(0.09)	
Misc manuf.	*3.42**** *(0.69)*	***-0.54******* ***(0.11)***	***0.31******* ***(0.08)***	–	–	***0.48******* ***(0.06)***	–	–	–	*0.63*
Utilities	-1.09*** (0.37)	-0.27*** (0.04)	–	0.28*** (0.06)	–	–	0.49*** (0.09)	–	–	0.73
Construction	*2.31**** *(0.58)*	*-0.50**** *(0.07)*	–	*0.21**** *(0.05)*	–	–	*1.99**** *(0.23)*	–	*0.34**** *(0.05)*	*0.83*
Wholesale	2.22*** (0.83)	-0.46*** (0.14)	–	0.20*** (0.07)	–	–	1.38*** (0.27)	–	–	0.67
Retail	*-0.80** *(0.45)*	*-0.77**** *(0.09)*	–	*0.70**** *(0.09)*	–	***0.29******* ***(0.07)***	*0.81**** *(0.17)*	–	–	*0.52*
Tran & storage	-4.50*** (0.77)	**-1.18***** **(0.14)**	**0.31***** **(0.06)**	1.13*** (0.15)	–	–	0.99*** (0.14)	–	–	0.77
Rail	-5.05*** (1.51)	-0.66*** (0.18)	–	0.77*** (0.22)	–	–	*1.69**** *(0.40)*	–	–	*0.55*
Water	-1.78** (0.86)	-0.76*** (0.20)	–	0.58*** (0.15)	–	–	1.08*** (0.39)	–	–	0.45
Air	*2.28*** *(0.99)*	***-0.45****** ***(0.19)***	***0.41******* ***(0.16)***	–	–	–	–	–	–	*0.24*
Road	-7.47*** (1.11)	-1.40*** (0.18)	–	1.60*** (0.22)	–	–	1.05*** (0.21)	***0.63******* ***(0.22)***	–	0.81
Communic'ns	*-0.27*** *(0.10)*	*0.14**** *(0.05)*	*-0.18*** *(0.07)*	–	–	–	*0.46**** *(0.15)*	–	–	*0.27*
Finance	-0.52 (0.40)	**-0.26***** **(0.06)**	–	–	**0.40***** **(0.11)**	–	0.60*** (0.18)	**0.53***** **(0.14)**	0.68*** (0.05)	0.75
Recreation & pers. services	*-1.72**** *(0.23)*	*-1.25 **** *(0.011)*	–	*1.08**** *(0.09)*	–	***0.13******* ***(0.05)***	*0.51**** *(0.07)*	***0.42******* ***(0.11)***	–	*0.74*

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively, using the standard *t*-distribution.

Consider, first, foreign effects. Taken overall, developments in the United States are relevant to assessing the prospects for Australian sectoral output. Indeed, after controlling for the effects of domestic demand, about two-thirds of Australian sectoral output has some direct relationship with US output. This connection occurs in a number of forms:

- there are *long-run* cross-country *sectoral* linkages, notably in mining, air transport and, in particular, manufacturing. In manufacturing, the long-run sectoral links arise in the production of wood products, paper-related products, chemicals, non-metal minerals, basic metals, fabricated metals, other machinery and miscellaneous manufactures. These sectors comprise about 20 per cent of private-sector output;

- there are *long-run* cross-country *aggregate* linkages, by which output in the agriculture, mining and finance sectors and the food and clothing sub-sectors is tied in the long run to aggregate US output. These sectors account for about 30 per cent of private-sector output; and

- there are *short run, transitory* effects of changes in sectoral or aggregate US output on particular industries, including mining, retail trade, finance, recreation services and various manufacturing sub-sectors. These sectors comprise a little less than two-thirds of private-sector output.

The sectors for which developments in the United States are *not* important in the long run are usually the ones where domestic aggregate demand *is* important. So, for example, domestic influences dominate in utilities, construction, wholesale and retail trade, transport and storage (apart from air transport), communications and recreation. There is, naturally enough, also a degree of overlap between domestic and foreign effects in some sectors. For non-metallic minerals and basic metals, both foreign and domestic demand are key long-run determinants of production. For textiles, clothing, wood, paper and fabricated metals production, domestic demand boosts sectoral output in the short run, and the domestic aggregate output impact multipliers are relatively large. Production in most manufacturing sub-sectors can be characterised as being linked to the corresponding US sector in the long run, but substantially affected by domestic aggregate demand in the short run.

What, then, are the distinguishing features of the sectors that are linked to the corresponding US sector? Consider some *institutional* features, like foreign ownership, export orientation and import competition. Foreign ownership may be relevant if the transmission of technology, human capital and knowledge of market trends is important. Export ratios may contain information about the strength of foreign demand for domestic goods and the importance of foreign preference and technology shocks. Import shares may contain information about the forces of competition in a sector. Thus, these institutional factors may affect the speed of diffusion and the correlation of output changes between countries.

It is difficult to test the hypothesis about the importance of foreign ownership, since information is scant, but Table 3 presents some statistics on foreign ownership by industry. The sectors where US sectoral output links exist are italicised. Columns 1 to 3 present 1982/83 estimates of the foreign, joint and domestic control of industry; column 4 presents the share of foreign investment by sector at June 1983, while columns 5 and 6 present the sectoral levels of foreign investment at June 1994 as a share of total foreign investment and of the sectoral capital stock respectively.[5] Foreign ownership in Australian investment flows in the mid 1980s was relatively high in the finance and property sector and the manufacturing sector – particularly in chemicals, basic metals and transport equipment. The level of foreign investment in finance and property, wholesale trade, mining and manufacturing – in this case, in food, paper, basic metals and transport equipment – is high relative to estimates of the capital stock in those sectors.

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5 The 1982/83 data may be outdated now, but they are around the middle of our sampling period, 1977 to 1993, and so are relevant to the analysis.

Table 3: Foreign Ownership and Trade Openness by Industry

Industry	Capital expenditure 1982/83 foreign control (Share of total)	Capital expenditure 1982/83 joint control (Share of total)	Capital expenditure 1982/83 local control (Share of total)	Level of foreign investment June 1983 (Share of total)	Level of foreign investment June 1994 (Share of total)	Level of foreign investment June 1994 (Per cent of capital stock)	Export share	Import share
	1	2	3	4	5	6	7	8
Agriculture	–	–	–	0.8	0.6	–	20.8	1.9
Mining	33.6	10.8	55.5	21.0	10.7	91	46.8	4.6
Manufacturing	42.1	13.7	44.1	21.8	18.9	92	10.2	20.9
Food	26.0	4.1	69.9	16.7	25.0	138	16.9	5.3
Textiles, clothing etc	32.1	0.1	67.9	2.3	1.3	32	6.9	18.8
Paper, printing	17.1	–	83.0	3.0	19.0	174	1.5	14.2
Chemicals	87.5	–	12.5	12.0	8.9	66	5.7	19.4
Basic metals	76.2	–	23.8	33.5	19.9	101	38.2	10.4
Fabricated metals	35.0	0.8	64.2	3.4	2.2	18	6.2	11.4
Transport equipment	85.0	–	15.0	8.6	4.2	100	5.9	35.8
Other manufacturing	18.9	2.3	78.8	10.6	5.2	87	4.5	45.4
Misc manufacturing	–	–	–	3.4	13.4	–	–	–
Finance, property & services	25.7	9.5	64.8	16.0	39.4	181	2.3	3.2
Utilities	0.7	–	99.1	6.2	1.0	4	0.1	0.1
Wholesale trade	44.6	0.2	55.3	{14.2	6.9	89	9.3	0.0
Retail trade	14.5	–	85.5	{14.2	1.5	26	0.0	0.0
Transport and storage	6.7	0.4	93.0	3.8	2.5	45	22.0	8.4
Other non-manufacturing	6.9	0.6	92.5	15.1	18.0	–	–	–
Total	**29.9**	**9.1**	**61.0**	**100.0**	**100.0**	**82**	**–**	**–**

Source: Columns 1 to 3 are from Table 3, ABS Cat. No. 5333.0 (naturalised firms are categorised as joint control); column 4 is from Table 27 of ABS Cat. No. 5305.0 1987/88; columns 5 and 6 are from Table 12, ABS Cat. No. 5306.0; data sources for capital stock, export and import shares are provided in Appendix A.

But the proposition that foreign linkages are related to the foreign penetration of the sector does not appear to be supported by these data.[6] Chemicals and paper production both have strong links with US output, for example, but their foreign ownership ratios were very different in the mid 1980s. Similarly, foreign ownership in the transport equipment sub-sector is high, but there is no obvious relationship with US output, despite the fact that the United States is the largest foreign investor in the transport equipment sector in Australia. Foreign penetration of the food sector has increased, and the level of foreign investment is relatively high to the capital stock, but food production is influenced only by the state of domestic demand.

Nor does the external openness of the sector, as measured by industrial export, import or trade shares, seem to be generally important. Columns 7 and 8 in Table 3 measure the proportion of exports and imports in the sector relative to output. But there is no apparent relationship between openness in trade and the existence of sectoral output links with the United States. For example, both basic and fabricated metals have a strong relationship with the corresponding US sectors, but their export intensities are very different.

At least with the data used in this paper, it does not seem that institutional features like foreign ownership or trade openness are relevant to the existence of a long-run or ‘equilibrium’ connection between Australian and US industrial outputs. (This does not mean that the relevance of these features would not be clear at a more microeconomic level.) The explanation of the relationship may lie more with the nature of the industries themselves. The obvious distinction is the difference between goods and services: the output of services is generally dominated by local conditions, while the production of goods is related to both domestic and overseas conditions. Air transport, for example, is the only service sector sensitive to the corresponding US sector in the long run. But all the other sectors for which there is a long-run US connection are in *traded* goods. These are mining and manufacturing.

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6 This also holds at a more technical level of analysis. We estimated linear probability, logit and probit models with the foreign penetration ratios presented in columns 1, 5 and 6 of Table 3 as independent variables, but the results were always statistically insignificant. The dependent variable was defined as ‘1’ when there was a long-run (or long-run and short-run) relationship between domestic sectoral output and US sectoral output, and ‘0’ otherwise. We also included other variables, such as the export, import and trade ratios of the industrial sector, but also with no success. A casual look at the data suggests that these tests are unlikely to be successful. One problem with the tests is the small number of observations.

While there is a long and short-run link between Australian and US mining outputs, the coefficients on both long and short-run aggregate US output are significantly larger, suggesting that *aggregate* external developments are the key in this sector. The aggregate effects are also important for agriculture, although cross-country sectoral links are not evident for that sector. For both of these sectors, real prices are set in world markets, and so the value of production is closely tied to world conditions. Since the United States is the largest economy, and in many ways the engine of world economic growth, the value of production is tied to US demand. This seems to be the case even though Australia's resource endowments differ from those of the United States.

The sectoral link is particularly extensive in manufacturing, and it seems to lie with particular sorts of goods. The connections, for example, tend to be in sectors engaged in the production of chemicals, machinery, metals and paper, rather than simply transformed, non-durable consumable goods like food, textiles and clothing. The latter, like services, seem to be produced for the domestic market, and are largely unrelated to sectoral conditions in the United States (although food and textiles are affected by US aggregate demand). Clothing and textiles have also been among the most highly protected sectors in Australia, skewing the market to import substitution and domestic demand. The key distinguishing feature of the first group of goods is that their production is subject to continuing and substantial technological change. For example, research and development, which are indicative of innovation and growth, tend to be highest in sectors like machinery, chemicals and pharmaceuticals.[7] Of course, the technology of food and clothing production has changed over time, but probably not by as much as in chemicals, machinery and metals. Moreover, the transport connection arises only in the air sub-sector, which is the transport sub-sector in which change and the diffusion of technology has been most rapid. Major technological innovations in that and other industries, for example, have led to a rapid expansion of air services and the general use of air freight worldwide. Overall, when the corresponding US sector is important, aggregate US output is *not*. And these links dominate the long-run behaviour of the

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[7] For example, in 1986-87, R&D was 3.3 per cent of value-added in transport equipment, 4.5 per cent in other machinery and 2.9 per cent in chemicals, well above the manufacturing average of 1.5 per cent (Bureau of Industry Economics 1990, p. 88).

domestic sector, such that innovations in the corresponding US sector have permanent, long-lived effects on the corresponding domestic sector. Put together, this leads to the conjecture that the links with US industrial output are driven, by and large, by technological innovations on the *supply* side. As the production frontier moves out and as innovation in goods takes place, changes in the United States and elsewhere are transferred to Australia. It is striking that the results are so strong when there are limited observations.

The two exceptions to this are domestic output of transport equipment and communications, which have rapidly changing technology, but are not associated with US developments. But there may be special reasons for this. The communications sector in Australia, for example, has grown much more rapidly than in the United States since the mid 1980s, probably due to catch-up after liberalisation. This makes it hard to identify a simple linear relationship with the US sector. Transport equipment, however, has been static and the correlation with US production may have been affected by changing tariff rates in Australia, and a hefty fall and restructuring in domestic US production in the late 1970s associated with the oil price shocks of 1973 and 1979.

The coefficient of adjustment to the long run is about 0.5 for most manufacturing sub-sectors, indicating that half the adjustment occurs after one year and that three-quarters of the adjustment occurs after two years. Changes in production are transmitted within a matter of two to three years. This speed of adjustment ‘makes sense’ relative to other ‘linked’ sectors. For example, adjustment in air transport, the other sector for which there is a long-run inter-sectoral link, is very similar to that of manufacturing. Furthermore, the adjustment in manufacturing is substantially slower than in agriculture or mining – US aggregate demand is central in both of these sectors, and adjustment is completed within a year. The result that it takes a couple of years for developments in US manufacturing to be fully passed through into Australian manufacturing fits in with the general view that the transmission of technology occurs relatively slowly (Costello 1993, p. 216). US studies indicate that the diffusion of knowledge about new products and production processes to rivals is fairly rapid, with the bulk of the spread complete within a year or so (Mansfield 1996, p. 119).

This raises the question of why there is a persistent gap in productivity levels between the United States and elsewhere in the face of continuing technological transfer. In other words, if technology and market trends are being continually transferred, why is Australian manufacturing productivity still only half that of the United States? It is not the case that productivity is higher in the industries where the corresponding sectoral output in the United States is the key driving force. According to Prasada Rao *et al.* (1995, p. 139), for example, productivity is lower in machinery sub-sectors, paper and wood products than in clothing or food. The sectors where the link with the corresponding US sector is important tend to be those with the *lowest* productivity relative to the United States. The oddity is probably explained by the nature of the production processes in the two countries (Ergas and Wright 1994). The United States, for example, is the world's largest economy, and this gives it special inherent advantages in economies of scale and market contestability and competition. It also has a labour market which is more flexible and adaptable. The capital stock in Australia may also be older than that in the United States, since updating of plant and equipment occurs less frequently.

4. Some Implications

There are four implications which flow from the analysis above.

4.1 New Information?

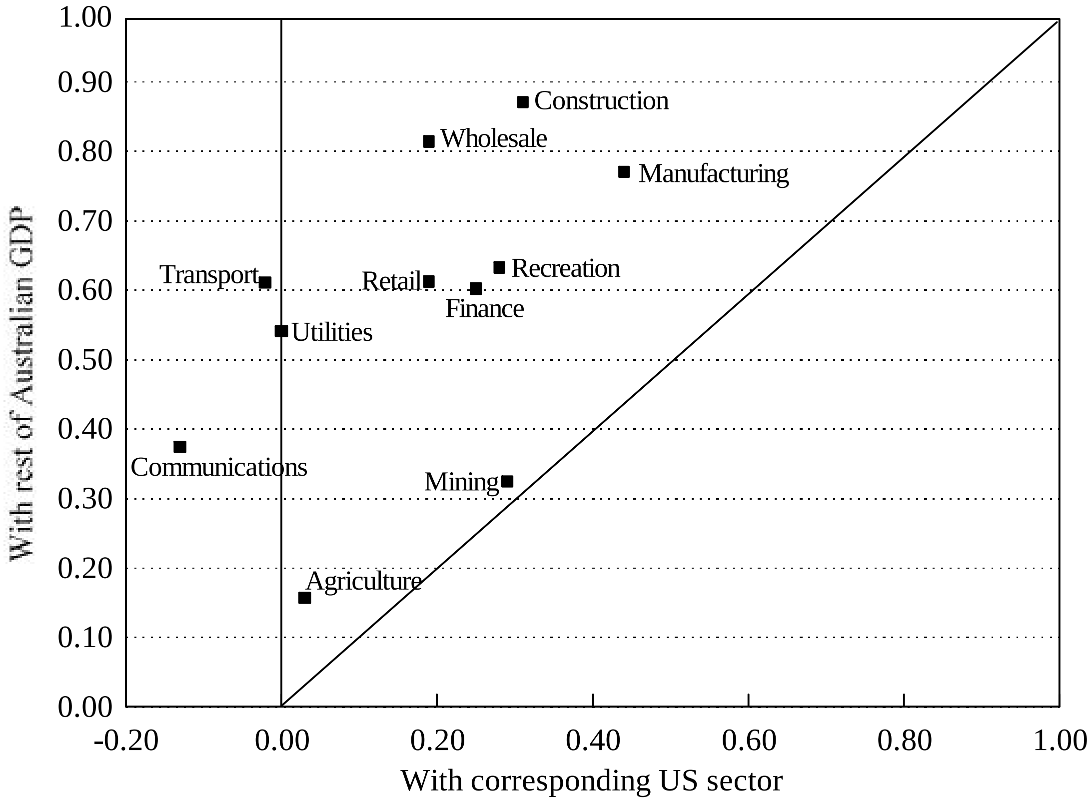
The first concerns the information that can be used to improve our understanding of the economic process and economic prospects. It is well accepted that foreign growth contains information about Australian growth. The analysis here suggests that US industrial production may contain information not only about US economic growth more generally, but also that knowledge of particular manufacturing sectors can help in forecasting domestic production. This would seem to hold for the production of basic and fabricated metals, chemicals, machinery and miscellaneous manufacturing, non-metallic minerals and paper products. This is a proposition to be tested.

4.2 The Relative Importance of Foreign and Domestic Influences

As the analysis above showed, while foreign output is important in some sectors, so too are domestic influences, particularly in the short run. Figure 3 summarises the relative importance of domestic and foreign shocks at the most general industrial level. It is a scatter-plot of the contemporaneous correlation of the one-digit Australian sectoral output growth rates with the growth in total Australian output (excluding the particular sector) and with growth in the corresponding US sector. When the outcome is above the 45 degree line, Australian sectoral output is affected more by contemporaneous events in the home economy than in the corresponding US sector. It appears that growth in Australian sectoral outputs is more related to growth in the rest of Australia than with growth in the corresponding industrial sector in the United States, at least on a contemporaneous basis.

This can also be explored at a more technical level. The international literature on the topic of the relative importance of international and domestic effects on output is extensive, largely because it has developed in response to the question raised by so-called 'real business cycle' economists of whether 'shocks' are explained by national fiscal and monetary policies or by technological change. The literature indicates that, for the G7 countries at least, cross-country sectoral output links are weak, at least in comparison to domestic influences. Stockman (1988) reported that changes in industrial production in European countries seem to be tied to what is happening in the home country itself, rather than what is happening to the industry in a range of other countries. Other papers have reached a similar conclusion (Costello 1993; Engle and Issler 1995; Helg *et al.* 1995; and Cecchetti and Kashyap 1996).

Figure 3: Correlation of Australian Industrial Output Growth



Stockman's (1988) panel data estimation method, explained in Appendix C, is used to assess the relative importance of national domestic and foreign sectoral shocks on domestic sub-sectoral manufacturing output from the OECD's STAN database from 1975 to 1994. The set of countries used for this test includes Australia, Canada, France, Germany, Korea, Japan, the United Kingdom and the United States. Using all the countries in our sample, more of the variation in sectoral output is explained by home-country effects (43 per cent) than foreign-industry-sector effects (30 per cent), even though the latter are clearly important. The inference is, therefore, that even though foreign output seems to explain a lot about domestic sectoral output, domestic influences like monetary and fiscal policy are also critically important. The results are similar (41 per cent and 32 per cent, respectively) when Australia is excluded from the set of countries, which, on the face of it, suggests that Australia is much the same as other countries in terms of the relative importance of domestic and foreign influences. More formal tests fail to reject the hypothesis that Australia exhibits the same relationship as the other countries in the sample.

One caution in interpreting these results is that they are based on an analysis of growth rates, and so are restricted to short-run relationships. The times-series analysis in Section 3 indicated that the United States is central in the long run, either because of aggregate demand effects or because of direct sectoral linkages. But, in the short run, domestic demand seems to dominate.

4.3 Controlling for Other Influences

To test the robustness of the link with US sectoral outputs, alternative specifications of two-digit manufacturing output were estimated. Apart from the influence of domestic demand and foreign (aggregate and sectoral) output, industrial output may also be sensitive to the real exchange rate, the terms of trade and the real interest rate (Gruen and Shuetrim 1994). Unfortunately, these other variables could not be included in the analysis in Section 3, because there were too few degrees of freedom. To gain these extra degrees of freedom, we use quarterly data. But, since US industrial output is not published on a quarterly basis, we only include US aggregate output.[8] The preferred specification for each industry is derived from the following unrestricted error-correction model:

$$\begin{aligned}\Delta y_t^i = {} & b_0 + b_1 y_{t-1}^i + b_2 y_{t-1}^{aggregate} + b_3 \tilde{y}_{t-1}^{aggregate} + \sum_{j=0}^{6} b_{4j} r_{t-j} \\ & + \sum_{j=1}^{4} b_{5j} \Delta y_{t-j}^i + \sum_{j=0}^{4} b_{6j} \Delta y_{t-j}^{aggregate} + \sum_{j=0}^{4} b_{7j} \Delta farm_{t-j} \\ & + \sum_{j=0}^{4} b_{8j} \Delta \tilde{y}_{t-j}^{aggregate} + b_9 rer_{t-1} + b_{10} tot_{t-1} + b_{11} era_t^i + b_{12} trend + e_t\end{aligned} \tag{2}$$

where notation is the same as for equation (1), *r* is the real cash rate, *farm* is farm output, *rer* is the log real exchange rate, *tot* is the log terms of trade for all goods

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[8] Although manufacturing output is a component of non-farm output, each individual manufacturing industry is only a very small proportion of non-farm output, so the simultaneity problem that arises is very small. We also substituted OECD output for US output, with little effect on the results.

and services and era^i is the effective rate of assistance for industry *i*. The analysis is restricted to manufacturing sub-sectors. Full results are reported in Appendix D.

The results indicate that international links are fairly robust to alternative specifications. Foreign aggregate output has significant and economically substantial impacts in eight of the 12 manufacturing sectors, even after controlling for domestic income. There is a long-run relationship with US aggregate output in three cases (basic metals, machinery and wood products), and a short-run relationship in five cases (textiles, clothing, paper products, fabricated metals and miscellaneous manufacturing). While there are fewer long-run links at the quarterly level than at the annual level (three compared to eight), these results are not directly comparable to those in Table 2, since the relationship here is with aggregate output. When the manufacturing equations in Table 2 are estimated with US aggregate output in place of US sectoral output, the explanatory power of the equations usually falls substantially, the dynamics terms all become insignificant, and the long-run coefficients becomes less significant, and in the case of wood products and furniture, insignificant.[9] Shifting the specification to aggregate US output itself substantially weakens the links with the United States.

The foreign impact is usually not contemporaneous, but delayed a quarter or two, which differs from models of aggregate output like Gruen and Shuetrim (1994). The lags of domestic aggregate output in the equations are relatively short, while those for foreign output are relatively long. This is consistent with the view, very loosely speaking, that domestic aggregate output captures demand effects while foreign aggregate output captures supply effects.

Other external variables, like the real exchange rate and the aggregate terms of trade, also have a substantial effect on some sectors. A real appreciation has a statistically significant, and economically substantial, negative impact in eight manufacturing sectors, including transport equipment, other machinery, and miscellaneous manufacturing. It appears to have little effect in sectors producing fairly simply transformed manufactures such as food, textiles, chemicals or basic metals. A rise in the terms of trade supports manufacturing, but the effect is

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9 These results are not reported but are available from the authors on request.

concentrated in a few sectors, notably those involved in commodity processing or the production of capital goods or consumer durables, like wood and furniture, non-metallic mineral products, basic metal products and fabricated metal products.

Not surprisingly, domestic monetary policy also affects output. In the simple modelling framework used in this paper, there are three possible transmission routes by which policy affects sectoral outputs. Apart from the direct interest rate effect, there are two indirect or feedback effects. The first is through policy's influence on the rest of output, and hence on domestic demand, and the second is the effect of policy on the exchange rate. The estimates in Appendix D suggest that monetary policy has a relatively fast and large impact on manufacturing industries. In many manufacturing industries, policy affects output in the same quarter or with just one lag, unlike for aggregate output where the effect seems to take up to two quarters. There is a range of responses in the various sub-sectors. The direct effect is important in most industries, with the largest effect being in other machinery, which produces investment goods and consumer appliances. Direct effects are not found for wood and furniture, for paper, printing and publishing, for chemicals, or for miscellaneous manufacturing, with the effect of policy in these industries wholly captured in the exchange rate and income channels.[10] The indirect income effect is strongest in food and fabricated metals, while the exchange rate effect is strongest in non-metallic mineral products and machinery.

4.4 Aggregate or Compositional Effects?

While US sectoral output clearly affects production in some manufacturing sub-sectors in Australia, it is unclear whether these links affect *aggregate* Australian output, as opposed to merely changing the composition of output. If the latter is the case, then total income is determined by some process other than through the international links that we have identified. This can be tested by drawing on the results from the panel data estimation. In particular, the panel data estimation provides a time series of shocks to each manufacturing sub-sector which are common to all countries. These represent 'foreign shocks'. These shocks are added

[10] The perverse result for *textiles* is picking up a spurious correlation between recent low real interest rates and a dramatic fall in output in this industry related to tariff reductions.

to obtain a variable measuring foreign shocks to manufacturing, where the weight is the value of the sub-sector in Australian manufacturing outputs. This annual series of shocks is converted to a quarterly series, and added as an explanatory variable in an equation for aggregate Australian output:

$$\begin{aligned}\Delta y_t^{agg} = b_0 + b_1 y_{t-1}^{agg} + b_2 \tilde{y}_{t-1}^{agg} + \sum_{i=2}^{6} b_{3i} r_{t-i} + \sum_{i=1}^{4} b_{4i} \Delta y_{t-i}^{agg} + \sum_{i=0}^{4} b_{5i} \Delta farm_{t-i} \\ + \sum_{i=0}^{4} b_{6i} \Delta \tilde{y}_{t-i}^{agg} + \sum_{i=0}^{4} b_{7i} shock_{t-i} + b_8 trend + e_t\end{aligned} \tag{3}$$

where y^{agg} is aggregate output, r is the real cash rate, *farm* is farm output, *shock* is the shock to manufacturing industry described above, and a tilde denotes the foreign sector.

If sectoral links to foreign output explain movements in aggregate output then we would expect a positive coefficient on the *shock* variable: an increase in manufacturing due to a foreign shock increases aggregate output. The full results of the regression are reported in Table C.3 in Appendix C. A positive coefficient is found, and the size of the coefficient is larger than the share of manufacturing in total output, although this difference is not statistically significant. This suggests that foreign-sourced shocks to manufacturing industries may, at least in the short run, have multiplier effects on aggregate output. This evidence supports our hypothesis that sectoral links do have a role in explaining movements in total Australian GDP.

5. Conclusion

This paper has focussed on the production side of the national accounts and found that, after controlling for the effects of domestic demand, about two-thirds of Australia’s private-sector industrial output is related in some way to developments in the United States. The foreign links that Gruen and Shuetrim (1994) identified are pervasive. Australian and US industrial structures are similar, and developments in the United States tend to lead Australia. Aggregate demand in the United States has strong, persistent short and long-run effects on agricultural, mining, and finance and property output. But the foreign links for the bulk of manufacturing lie not with general economic developments in the United States, but with what is happening in the corresponding US sector. These links are strongest in certain goods sectors, and are persistent or long run. The feature that distinguishes the production processes of these goods is that they involve high and often radically changing technology. The implication is, then, that these linkages with the United States, which is the world leader in productivity and innovation, are driven by the supply side. This result seems to be robust to alternative specifications, and is unexplained by institutional features, like foreign ownership or trade intensity. These shocks also affect aggregate output, and so the analysis is identifying something more fundamental than just compositional changes in aggregate output. Service sector output appears to be most affected by domestic aggregate demand.

The importance of the US economy should not obscure the result, however, that policy and events in the domestic economy are crucial, especially in the short and medium term. There is no implication that domestic monetary and fiscal policies are irrelevant. Indeed, even in simple modelling exercises, monetary policy can have large effects in different industries. Interest rate changes have both direct and indirect effects on sectoral outputs, the latter arising from the effect of an interest rate change on the exchange rate and on the state of aggregate demand. These particular effects vary across different manufacturing industries, with the sectors of manufacturing with higher import ratios more affected by the exchange rate, and the more domestic-oriented sectors more affected by domestic demand. While developments in the United States have persistent, long-run effects on local manufacturing output, domestic policies affect local aggregate demand which in turn can have a large impact on output in the short term.

Appendix A: Description and Sources of Data

A.1 Production Data

The data are constant-price series. For the United States, the output measure is gross product by industry, estimated as gross output (for example, sales plus the change in inventories) less intermediate inputs (consumption of goods and services purchased from other industries or from overseas). In most cases, constant dollar gross product is estimated by the double deflation technique (that is, constant-dollar gross output less constant-dollar purchased input by industry). US production data are based on the (American) Standard Industrial Classification (SIC). Estimates from 1977 to 1987 are based on the 1972 SIC, while those from 1988 onwards are based on the 1978 SIC. The two standards overlap in 1987. The changes appear minor, in the sense that the changes only occur at a highly disaggregated level (level 5) and only for a few categories (and here it seems that it is largely a name change). The exception is instruments (a level 5 category). The source of the data is the Bureau of Economic Analysis, Department of Commerce, United States Government.

The Australian data are constant-price output by industry (or industry-revalued estimates, as the ABS call them) from the ABS release, *National Income, Expenditure and Product*, Cat. No. 5206.0. The production data are in 1989/90 prices and the annual figures are the calendar year sum of the seasonally adjusted quarterly series. The industry classification of the national accounts changed in September 1994 from the ASIC to the ANZSIC system. The data used are all estimated on the ASIC basis. The latest data were drawn from the September quarter 1994 release. These data go back to September 1984. Data before this date were spliced onto these series using growth rates from the earlier periods. This way of backcasting avoids level shifts.

The ABS estimate constant-price industry output by one of three methods. The standard is the gross output method by which base year industrial output is extrapolated by movements in constant price estimates of output. The second, applied to *agriculture*, *mining* and *gas*, is double deflation, by which constant price estimates of intermediate input are subtracted from constant price estimates of gross output. The third, applied to *public administration*, *finance*, and *community services*, is to use hours worked to extrapolate base year gross product.

A.2 Capital Stock Data

Capital stock estimates for one-digit sectors are from ABS Cat. No. 5221.0. Capital stock estimates for the agriculture sector are not available. Capital stock estimates for the eight manufacturing sub-divisions were estimated using the perpetual inventory method (PIM). Quarterly gross fixed capital expenditure (GFCE) data were sourced from ABS Cat. No. 5626.0. Deflators for GFCE equipment and GFCE non-dwelling construction were sourced from Table 23 of ABS Cat. No. 5206.0. The mean asset life for non-dwelling construction was assumed to be 39 years. The mean asset life for equipment was assumed to be 20 years in the 1950s, declining by 5 per cent for each successive decade. Assets of the same class and vintage were assumed to exit simultaneously when they reached their mean asset life. Straight-line depreciation was assumed. Starting point estimates of the stock of non-dwelling constructions and equipment in June 1959 were sourced from Table 63 of the CBCS Secondary Industry Bulletin for 1958/59 (50 per cent of the value of land and buildings was assumed to be non-dwelling construction). The figures used in Table 3 are estimates for 1994.

A.3 Trade Concentration Data

The ratios listed in Table 3 are derived from the input-output tables and are estimated as the ratio of exports and imports to industry nominal value added. The input-output table for 1990/91 was used.

Table A.1: Reconciliation of Australian and US Data

Sector	Corresponding US sector
Agriculture	Agriculture, forestry, and fisheries
Mining	Mining
Manufacturing	Manufacturing
Food, beverages and tobacco	Food and kindred products; tobacco manufactures
Textiles	Textile mill products
Clothing	Apparel and other textile products
Wood and furniture	Lumber and wood products; furniture and fixtures
Paper, printing and publishing	Paper and allied products; printing and publishing
Chemical, petroleum and coal	Chemicals and allied products; petroleum and coal products
Non-metallic mineral products	Stone, clay, and glass products
Basic metal products	Primary metal industries
Fabricated metal products	Fabricated metal products
Transport equipment	Motor vehicles and equipment; other transportation equipment
Other machinery	Machinery, except electrical; Industrial machinery and equipment; electric and electronic equipment; electronic and other electric equipment; instruments and related products
Misc. manufacturing	Miscellaneous manufacturing industries; rubber and miscellaneous plastics products; leather and leather products
Utilities	Electric, gas, and sanitary services
Construction	Construction
Wholesale trade	Wholesale trade
Retail trade	Retail trade
Transport and storage	Transportation
Rail	Railroad transportation
Water	Water transportation
Air	Transportation by air
Road	Local and interurban passenger transportation; trucking and warehousing; pipelines, except natural gas; transportation services
Communications	Communications
Finance	Finance, insurance, and real estate
Recreation and personal services	Hotels and other lodging places; personal services; motion pictures; amusement and recreation services

Appendix B: Estimation Methodology for the Error-Correction Equations

The error-correction equations are estimated using the Seemingly Unrelated Regression (SURE) technique, a systems form of estimation which makes use of the cross-correlation of error terms in the equations to obtain more precise coefficient estimates. With the data set at hand, there is a strong expectation that 'shocks' to sectoral output are highly correlated. For example, a tightening of monetary policy would enter Equation (1) in the text as a shock but this would most likely be felt in all sectors. Similarly, a technological shock would most likely be experienced by a number of manufacturing sub-sectors, rather than be isolated to just one sub-sector. While equations estimated by OLS are consistent and unbiased, efficiency is improved by SURE estimation and making use of the contemporary correlation of the residuals of the equations. The downside is that precious degrees of freedom are lost in calculating the covariance matrix of residuals of the OLS equations. Our judgment is that using SURE substantially increases the efficiency of the estimates: as shown in Tables B.1 and B.2, correlations between the residuals of the OLS equations at the one and two-digit levels, respectively, are often high and significant. Accordingly, the standard errors of the SURE estimates tend to be substantially smaller than those of the OLS estimates, presented in Table B.3. Whatever the case, the interpretation does not change qualitatively between the two methods.

Table B.1: Correlation of OLS Residuals at Digit 1 Level

	Agriculture	Mining	Manu-facturing	Utilities	Con-struction	Wholesale	Retail	Transport	Comm-unications	Finance	Recreation
Agriculture	1	0.37	-0.13	0.31	-0.21	-0.27	-0.15	-0.02	-0.16	0.18	-0.60
Mining		1	-0.62	0.18	-0.72	-0.46	0.32	0.12	-0.38	0.13	-0.38
Manufacturing			1	-0.12	0.45	0.27	-0.35	0.14	0.80	-0.33	0.19
Utilities				1	0.00	0.12	-0.28	0.16	-0.41	-0.52	0.35
Construction					1	0.69	-0.03	-0.54	0.21	-0.37	0.41
Wholesale						1	-0.18	-0.44	-0.04	-0.21	0.40
Retail							1	-0.14	-0.22	0.40	0.22
Transport								1	0.01	0.09	-0.02
Communications									1	-0.28	-0.10
Finance										1	-0.37
Recreation											1

Table B.2: Correlation of OLS Residuals at Manufacturing Digit 2 Level												
	Food	Textiles	Clothing	Wood etc	Paper etc	Chemical	Minerals	Basic metal	Fabricated metal	Transport equipment	Other	Miscellaneous
Food	1	-0.49	0.09	-0.36	-0.57	0.37	0.16	0.27	-0.58	-0.07	0.26	0.19
Textiles		1	-0.24	0.24	0.32	-0.34	-0.61	-0.45	0.56	-0.19	-0.15	0.00
Clothing			1	0.24	0.09	-0.40	0.57	-0.06	0.06	-0.53	-0.23	0.38
Wood etc				1	0.71	-0.08	0.29	-0.37	0.61	-0.60	-0.38	-0.15
Paper etc					1	-0.10	-0.13	-0.28	0.72	-0.40	-0.26	0.18
Chemical						1	-0.15	-0.2	0.02	0.11	0.41	0.32
Minerals							1	-0.12	-0.18	-0.26	-0.32	-0.22
Basic metal								1	-0.53	0.48	0.21	0.01
Fabricated metal									1	-0.44	0.10	0.19
Trans equipment										1	0.41	-0.31
Other											1	0.07
Miscellaneous												1

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Table B.3: Australian and US Sectoral Output Error-Correlations (1977-93), OLS

	Constant β_0	Sector adjustment β_1	US sector adjustment β_2	Aggregate adjustment β_3	US aggregate adjustment β_4	US sector impact β_5	Aggregate impact β_6	US aggregate impact β_7	Lag sector impact β_8	$\overline{R}^2$
Total GDP(P)	1.72**	-0.74**	0.92**	–	–	0.54**	–	–	–	0.62
	(0.51)	(0.19)	(0.23)			(0.19)				
Agriculture	1.49	-0.85***	–	–	0.79***	–	–	1.40 **	0.44**	0.59
	(0.97)	(0.23)			(0.22)			(0.50)	(0.20)	
Mining	-6.47***	-1.01***	0.48	–	1.66***	0.28	–	1.55**	–	0.49
	(2.00)	(0.32)	(0.38)		(0.47)	(0.23)		(0.56)		
Manufacturing	2.16*	-0.39**	0.31**	–	–	0.07	0.93***	–	–	0.68
	(1.09)	(0.16)	(0.11)			(0.16)	(0.28)			
Food	1.50	-0.43*	–	–	0.31*	–	–	–	–	0.13
	(1.30)	(0.22)			(0.15)					
Textiles	0.45	-0.61	–	–	0.45	–	1.31	–	–	0.16
	(1.72)	(0.38)			(0.44)		(0.91)			
Clothing	5.70***	-0.35**	–	-0.24***	–	0.46*	0.88*	–	–	0.61
	(1.65)	(0.13)		(0.08)		(0.24)	(0.43)			
Wood & furn.	2.21**	-0.42*	0.32	–	–	0.23	1.85**	–	–	0.51
	(0.95)	(0.19)	(0.24)			(0.21)	(0.77)			
Paper	0.88	-0.14	0.07	–	–	–	1.93***	–	–	0.49
	(0.53)	(0.11)	(0.20)				(0.53)			
Chemicals	2.32**	-0.41**	0.27***	–	–	0.07	–	–	–	0.35
	(1.07)	(0.17)	(0.09)			(0.29)				
Non-met min.	0.67	-0.58**	0.15	0.26*	–	–	1.85**	–	–	0.55
	(1.44)	(0.26)	(0.16)	(0.14)			(0.71)			
Basic metals	-2.24	-0.45**	0.17*	0.44*	–	0.26**	–	–	–	0.36
	(1.71)	(0.20)	(0.09)	(0.21)		(0.10)				
Fabr'd met.	0.05	-0.28*	0.54	–	–	–	2.46***	0.85	–	0.77
	(0.88)	(0.14)	(0.41)				(0.72)	(0.85)		
Trans. equip.	15.60***	-1.66***	-0.27**	–	–	–	–	–	0.81**	0.56
	(3.60)	(0.37)	(0.12)						(0.31)	
Other mach.	4.96***	-0.86***	0.46**	–	–	0.53**	–	–	0.53**	0.61
	(1.50)	(0.25)	(0.15)			(0.22)			(0.20)	

Misc manuf.	2.64** (1.05)	-0.41** (0.17)	0.22 (0.14)	–	–	0.47*** (0.11)	–	–	–	0.56
Utilities	-0.77 (1.04)	-0.17 (0.13)	–	0.19 (0.17)	–	–	0.45** (0.17)	–	–	0.35
Construction	2.35** (1.07)	-0.50** (0.21)	–	0.21* (0.12)	–	–	2.06*** (0.41)	–	0.42** (0.16)	0.83
Wholesale	1.54 (1.31)	-0.38 (0.25)	–	0.18 (0.12)	–	–	1.47*** (0.37)	–	–	0.65
Retail	-0.83 (0.71)	-0.58** (0.23)	–	0.55* (0.25)		0.26 (0.18)	0.74** (0.25)	–	–	0.45
Tran & storage	-4.58*** (1.40)	-1.32*** (0.26)	0.36*** (0.10)	1.22*** (0.29)	–	–	0.96*** (0.19)	–	–	0.77
Rail	-6.55*** (2.03)	-0.88*** (0.26)	–	1.02*** (0.30)	–	–	1.66*** (0.48)	–	–	0.58
Water	-1.79 (1.03)	-0.76** (0.28)	–	0.59** (0.21)	–	–	1.05** (0.46)	–	–	0.45
Air	2.62** (1.13)	-0.53** (0.21)	0.47** (0.18)	–	–	–	–	–	–	0.25
Road	-7.69*** (1.39)	-1.44*** (0.23)	–	1.65*** (0.27)	–	–	1.03*** (0.25)	0.70** (0.28)	–	0.81
Communic'ns	-0.26* (0.14)	0.13 (0.08)	-0.17 (0.13)	–	–	–	0.47** (0.20)	–	–	0.27
Finance	-0.45 (0.75)	-0.25* (0.12)	–	–	0.37 (0.24)	–	0.60* (0.30)	0.58* (0.31)	0.59*** (0.14)	0.77
Recreation & pers. services	-1.59*** (0.37)	-1.21*** (0.25)	–	1.05*** (0.22)	–	0.23** (0.10)	0.54*** (0.11)	0.25 (0.20)	–	0.77

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively, using the standard *t*-distribution.

Appendix C: Panel Data Estimation Method

Following Stockman (1988), an error-components model is used to estimate the fraction of the variation in output growth that can be attributed to industry-specific shocks and the fraction that can be attributed to nation specific shocks:

$$\Delta y_{tni} = m_{ni} + f_{ti} + g_{tn} + u_{tni} \tag{C.1}$$

where Δy_{tni} is the growth rate of output in industry *i* within nation *n* at time *t*. The term m_{ni} is a constant specific to industry *i* within nation *n*. The term f_{ti} is a vector of dummy variables, multiplied by their coefficients, for each industry at each time but common to all nations. This term captures any variation in output that is confined solely to a particular industry regardless of its location. The term g_{tn} is a vector of dummy variables, multiplied by their coefficients, for each nation at each point in time, and captures the variation in output stemming from differences across nations. A random disturbance term u_{tni} is added.

Several normalisations are needed to identify the model. The nation effect is set to zero for one country, initially the United States. The results are not very sensitive to the choice of country for this normalisation. The estimated nation effects then measure the difference between the nation-specific component of output growth in nation *n* and the United States. The industry and nation effects were set to zero for the last period for all industries and all nations. These effects therefore must be interpreted relative to the last period in the sample (1994). The OECD's STAN database was used for these calculations.

The results for the set of countries including and excluding Australia are provided in Tables C.1 and C.2, respectively. The tables' sub-titles includes the number of observations, the explanatory power of the equation and the sum of squares attributable to Equation (C.1). In both cases, the model explains about one-half of the variation in industrial output growth rates. The rows list the industry and country specific effects. Column 1 tells the sum of squares explained by the factor; column 2 states the per cent of total effect the factor represents; column 3 gives the F-statistic; and column 4 gives the marginal significance. The industry and country specific effects are strongly significant.

To test whether Australia exhibited a significantly different pattern of shocks to the other countries, a set of dummy variables was inserted to pick out each of the Australian observations. The p-value for exclusion of all these variables is 0.74. The hypothesis that Australia exhibits the same pattern of shocks is not rejected.

Table C.1: Error Components Model of Output Growth

all 8 countries included, 4702 observations

R^2=0.55, total sum of squares (SS) attributable to Equation (C.1)=14.99

	SS 1	Per cent of total 2	F-statistic 3	Marginal significance 4
Orthogonal industry*time , f_{ti}	4.39	30%	1.54	0.0000
Orthogonal nation*time, g_{tn}	6.21	43%	10.20	0.0000

Table C.2: Error Components Model Of Output Growth

Australia excluded, 4094 observations

R^2=0.57, total sum of squares (SS) attributable to Equation (C.1)=13.01

	SS	Per cent of total	F-statistic	Marginal significance
Orthogonal industry*time , f_{ti}	4.13	32%	1.52	0.0000
Orthogonal nation*time, g_{tn}	5.29	41%	10.13	0.0000

Table C.3: Impact of Manufacturing Industry Shocks on Aggregate Output

Dependent variable: $\Delta y_t^{aggregate}$, Sample period: 1980:Q3 to 1994:Q4

Constant	-283.85***,	(35.49)
$y_{t-1}^{aggregate}$	-0.47***,	(0.06)
$\tilde{y}_{t-1}^{aggregate}$	0.57***,	(0.07)
$\sum_{i=2}^{6} r_{t-i}$	-0.066***,	{0.00}
$\Delta farm_{t-2}$	0.019**,	(0.08)
$\Delta farm_{t-4}$	-0.023***,	(0.08)
$\Delta\tilde{y}_t^{aggregate}$	0.38***,	(0.10)
$\Delta\tilde{y}_{t-1}^{aggregate}$	-0.33***,	(0.09)
$\Delta\tilde{y}_{t-2}^{aggregate}$	-0.27***,	(0.10)
$\Delta\tilde{y}_{t-4}^{aggregate}$	-0.27***,	(0.09)
shock_{t-1}	0.24***,	(0.07)
$\bar{R}^2$	0.71	
LM(1)	0.78	
LM(4)	3.42	

Notes: *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively. Numbers in parentheses ( ) are standard errors; the number in braces { } is the p-value for the joint significance of real cash rates. LM(1) and LM(4) are test statistics for Lagrange multiplier tests for first and first to fourth order residual autocorrelation.

Appendix D: Alternative Models Of Manufacturing Output

Table D.1: Growth in Manufacturing Sector Output (Δy_i)
1980:Q3 to 1994:Q1

	Food	Textiles	Clothing	Wood	Paper	Chemicals
y_{t-1}^{i}	-0.46*** (0.14)	-0.51*** (0.11)	-0.34*** (0.09)	-0.60*** (0.13)	-0.17*** (0.03)	-0.70*** (0.23)
$y_{t-1}^{aggregate}$	0.41*** (0.16)					0.49*** (0.16)
$\Delta y_{t}^{aggregate}$			1.53* (0.86)			
$\Delta y_{t-1}^{aggregate}$				1.16* (0.65)		
$\Delta y_{t-2}^{aggregate}$		2.61*** (0.88)		0.83** (0.42)		
$\Delta y_{t-3}^{aggregate}$						
$\Delta y_{t-4}^{aggregate}$						
$\tilde{y}_{t-1}^{aggregate}$				0.28** (0.13)		
$\Delta \tilde{y}_{t}^{aggregate}$		0.97* (0.54)				
$\Delta \tilde{y}_{t-1}^{aggregate}$						
$\Delta \tilde{y}_{t-2}^{aggregate}$			1.04** (0.40)			
$\Delta \tilde{y}_{t-3}^{aggregate}$						
$\Delta \tilde{y}_{t-4}^{aggregate}$					0.86** (0.41)	
$\Delta farm_{t}$						
$\Delta farm_{t-1}$						
$era_{i,t}$		0.005*** (0.001)	0.0003 (0.0002)	0.020*** (0.006)		
tot_{t-1}				0.36** (0.16)		
rer_{t-1}			-0.19** (0.08)	-0.30*** (0.09)	-0.13*** (0.04)	
$\sum_{i=2}^{6} r_{t-i}$	-0.0077** [0.01] {0 to 6}	0.0186*** [0.00] {0 to 6}	-0.0049*** [0.00] {1 to 6}			
$\bar{R}^2$	**0.11**	**0.40**	**0.18**	**0.27**	**0.14**	**0.30**

Notes: *,** and *** denote significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses ( ). Joint significance of all real cash rates are reported in square brackets [ ]. Lags of real cash rates are reported in braces { }. All variables are in logs except industry assistance (era) and real cash rates (r). Notation is the same as for Equation (2).

Table D.1: Growth in Manufacturing Sector Output (D_{y_i})
1980:Q3 to 1994:Q1 (Cont.)

	Non-metallic min. products	Basic metals	Fabricated metals	Transport equipment	Machinery	Miscellaneous
y_{t-1}^{i}	-0.60*** (0.15)	-0.39*** (0.08)	-0.39*** (0.11)	-0.83*** (0.17)	-0.27*** (0.09)	-0.41*** (0.08)
$y_{t-1}^{aggregate}$	0.37*** (0.06)		0.49*** (0.19)	0.43*** (0.13)		0.13* (0.07)
$\Delta y_{t}^{aggregate}$	1.21* (0.69)		2.30*** (0.55)			
$\Delta y_{t-1}^{aggregate}$						
$\Delta y_{t-2}^{aggregate}$						
$\Delta y_{t-3}^{aggregate}$					1.34** (0.60)	
$\Delta y_{t-4}^{aggregate}$	2.31*** (0.64)					
$\tilde{y}_{t-1}^{aggregate}$		0.56*** (0.13)			0.33*** (0.11)	
$\Delta\tilde{y}_{t}^{aggregate}$						
$\Delta\tilde{y}_{t-1}^{aggregate}$						
$\Delta\tilde{y}_{t-2}^{aggregate}$			0.86** (0.41)			1.37*** (0.41)
$\Delta farm_{t}$				0.07** (0.04)		
$\Delta farm_{t-1}$				0.08** (0.04)		
$era_{i,t}$			0.012*** (0.003)			
tot_{t-1}	0.40* (0.21)	0.26*** (0.07)	0.26*** (0.08)	0.23 (0.17)	0.21 (0.14)	
rer_{t-1}	-0.39** (0.18)		-0.26*** (0.07)	-0.21** (0.10)	-0.16* (0.10)	-0.20*** (0.06)
$\sum_{i=2}^{6} r_{t-i}$	-0.0109*** [0.00] {1 to 6}	-0.0027*** [0.00] {0 to 6}	.0009*** [0.00] {1 to 6}	-0.0134*** [0.00] {0 to 6}	-0.0122*** [0.00] {0 to 6]	
$\bar{R}^2$	**0.39**	**0.27**	**0.37**	**0.41**	**0.29**	**0.26**

Notes: *,** and *** denote significance at the 10%, 5% and 1% levels, respectively. Standard errors are in parentheses ( ). Joint significance of all real cash rates are reported in square brackets [ ]. Lags of real cash rates are reported in braces { }. All variables are in logs except industry assistance (era) and real cash rates (r). Notation is the same as for Equation (2).

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