

**MARKUP, RETURNS TO SCALE, THE BUSINESS CYCLE AND  
OPENNESS: EVIDENCE FROM AUSTRALIAN  
MANUFACTURING**

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**Abstract**

A Hall type model that includes intermediate materials in the production function and allows for non-stochastic time variation in the contribution of technical change to output growth is used to estimate markup and returns to scale for eight Australian manufacturing industries at approximately the two-digit level, during the period 1971-72 to 1984-85. Six of the eight manufacturing industries indicate markups that are greater than one, implying the widespread existence of market power in Australian manufacturing. Constant returns to scale are not rejected for any individual industry or jointly. Markups are generally found to be pro-cyclical, although there is some evidence to suggest that this relationship is not as strong in industries that are open to the international economy.

*JEL classification:* F1; L1; L6

*Keywords:* Markup; Business Cycles; Openness

## I. Introduction

The Solow residual is a measure of the contribution of technical change to economic growth using an aggregate production function approach (Solow, 1957). In a series of papers, Hall (1986, 1988, 1990) concludes that it is a flawed measure, as it does not take into account imperfect competition, and that market power is a major reason for the empirical observation that the Solow residual is pro-cyclical. In the process, Hall devises a method for estimating the industry markup (price divided by marginal cost) as a parameter in a single equation regression, thus avoiding the need to directly measure marginal cost. He finds that markup is significantly greater than one in most two-digit US industries.

Developments on the Hall method include adding intermediate factors into the production function, simultaneously measuring returns to scale and markup in the one estimating equation, and estimating the impact of cyclical and structural variables on markup. Domowitz et al (1988) find that the estimated markups in the US are not as great when intermediate inputs are included, however they are still significantly greater than one. This is the conclusion of most studies of this type when taken over a range of countries, although Norrbin (1993) finds that markup is not significantly different from one in nearly all US industries when non-wage compensation is added to labour costs.

Returns to scale, measured as average cost divided by marginal cost, can also be estimated as a parameter using Hall's (1990) method. Haskel et al (1995) and Linnemann (1999) find constant returns to scale in UK and German manufacturing industries, respectively, while Basu and Fernald (1997) and Klette (1999) find a mix of constant and decreasing returns to scale for US and Norwegian manufacturing industries, respectively.

In this paper, we estimate markup and returns to scale for eight Australian manufacturing industries using a Hall type model. The novelty of our approach is that we use fixed cross-section and time effects to try and account for the contribution of technical change to industry growth. Most of the authors mentioned above assume that this contribution can be represented as a constant and a random error term. However, the Solow residual may be pro-cyclical, even when imperfect competition is accounted for. One reason is that exogenous changes in technology may be driving the business cycle and the Solow residual. An alternative reason is that technology may be biased toward a particular input factor that is itself pro-cyclical, resulting in higher total factor productivity at the top of the cycle.

Extending the analysis further, we examine the impact of the business cycle and openness on markups. Macroeconomists have been interested in the cyclical nature of markups in order to support arguments about the cyclical nature of real wages and also to understand the extent to which markups affect booms (for discussions see Bils, 1987; and Rotemberg and Woodford, 1999). However, there is no consensus on the direction of the cyclical influences on markup. Pro-cyclical markups are found by Domowitz et al (1988) for US industries, Haskel et al (1995) for UK manufacturing industries, Beccarello (1996) for G-7 country manufacturing industries and Bloch and Madsen (2001) for Australian industries. Counter-cyclical markups are found by Oliviera Martins et al (1996) for 14 OECD countries and by Linnemann (1999) for German manufacturing industry.

Olive (2002) derives an industry pricing equation that includes real manufacturing demand as an independent variable. Using Australian manufacturing data for 24 industries, markups are positively related to manufacturing demand when costs are held constant. Using a similar method at the four-digit ISIC level, Bloch and

Olive (1999) find that aggregate demand only impacts on markup for low import share industries. This suggests that markups could become less responsive to aggregate demand the more open industries are to the international economy.

Openness to the international economy is seen to represent the extent of foreign competition, rather than the level of competitiveness in a market (Feinberg, 1986). However, markups are still found to be negatively related to openness in most applied studies (see Feinberg and Shannon, 1994; Katics and Peterson, 1994; Lopez and Lopez, 1996; and Ghosal, 2000). This is interpreted as trade increasing competition in the domestic market and thereby reducing domestic market power. As such, it is often used as an argument to support tariff reduction. Freedman and Stonecash (1997) outline the importance of this argument in the development of Australia's competition and trade policies.

In Section II, a Hall type model that includes intermediate materials is derived. Section III develops the model further to include fixed cross-section and time effects, and to allow for time variation in the markup. Also in this section, the data are outlined and the regression results are presented and analysed. As the cost of capital and materials are both difficult variables to capture accurately, the model and data selection avoid the need to include these variables in the empirical work. Section IV concludes the paper by summarising its important aspects.

## II. The Model

Although Hall (1986, 1988, 1990) starts by constructing the firm's marginal cost, we shall follow Norrbin (1993) and begin with a production function. Consider the following production function:

$$Q_t = F(K_t, L_t, M_t, A_t) \quad (1)$$

where output ( $Q_t$ ) is produced using capital ( $K_t$ ), labour ( $L_t$ ) and intermediate materials ( $M_t$ ) at a level of technical production ( $A_t$ ). While time is indicated by  $t$ , the cross-sectional subscripts have been left off, as it is assumed that (1) applies to a particular productive unit.

In equilibrium, each input factor's marginal product is equal to the cost of an additional unit of that factor divided by marginal cost. Totally differentiating (1) and dividing by output, we can write:

$$\Delta q_t = \mathbf{h}_{A_t} \Delta a_t + \mathbf{g}_t (s_{K_t} \Delta k_t + s_{L_t} \Delta l_t + s_{M_t} \Delta m_t) \quad (2)$$

where  $\Delta q_t$ ,  $\Delta a_t$ ,  $\Delta k_t$ ,  $\Delta l_t$  and  $\Delta m_t$  are the proportional rates of change of output, the level of technical production, capital, labour and materials, respectively, while  $\mathbf{h}_{A_t}$ ,  $\mathbf{g}_t$ ,  $s_{K_t}$ ,  $s_{L_t}$  and  $s_{M_t}$  are the elasticity of output with respect to technical production, returns to scale (average cost divided by marginal cost), the share of capital in total cost, the share of labour in total cost and the share of materials in total cost, respectively. It should be noted that the returns to scale multiplied by a factor share is equivalent to the total cost of that factor divided by marginal cost times output.

The contribution of technical change to output growth is represented by  $\mathbf{h}_{A_t} \Delta a_t$  in equation (2). Often studies assume that  $A_t$  is multiplicatively separable in the production function (Hicks-neutral technical progress). In this case  $\mathbf{h}_{A_t}$  is equal to one. However, if  $A_t$  is multiplied by an input factor in the production function, then  $\mathbf{h}_{A_t}$  will be a function of the level of that factor (biased technical progress). Also,  $\Delta a_t$

will only be constant when  $A_t = e^{at}$ , where  $a$  is a constant and  $t$  is time. Therefore, we have allowed for the possibility that  $\mathbf{h}_{A_t} \Delta a_t$  varies across time in (2).

Because the sum of the shares of each factor in total cost must sum to one, the share of capital in total cost can be written as  $s_{K_t} = 1 - s_{L_t} - s_{M_t}$ . Applying this to (2) and then manipulating gives:

$$\Delta q_t = \mathbf{h}_{A_t} \Delta a_t + \mathbf{g}_t \Delta k_t + \mathbf{g}_t [s_{L_t} (\Delta l_t - \Delta k_t) + s_{M_t} (\Delta m_t - \Delta k_t)] \quad (3)$$

Further, it can be seen that the returns to scale multiplied by a factor share in total costs is equivalent to the markup multiplied by the factor share in total revenue.

Therefore:

$$\mathbf{g}_t s_{L_t} = \left(\frac{AC}{MC}\right)_t \left(\frac{wL}{ACQ}\right)_t = \left(\frac{P}{MC}\right)_t \left(\frac{wL}{PQ}\right)_t = \mathbf{p}_t \left(\frac{wL}{PQ}\right)_t \quad (4)$$

$$\mathbf{g}_t s_{M_t} = \left(\frac{AC}{MC}\right)_t \left(\frac{wM}{ACQ}\right)_t = \left(\frac{P}{MC}\right)_t \left(\frac{wM}{PQ}\right)_t = \mathbf{p}_t \left(\frac{wM}{PQ}\right)_t$$

where  $w$ ,  $\mathbf{w}$ ,  $P$ ,  $AC$  and  $MC$  are the cost of an additional unit of labour, the cost of an additional unit of intermediate materials, output price, average cost and marginal cost, respectively. It can be seen from (4) that  $\left(\frac{wL}{PQ}\right)_t$  and  $\left(\frac{wM}{PQ}\right)_t$  represent the labour and material shares in revenue, while  $\mathbf{p}_t$  is the markup. Substituting (4) into (3) gives:

$$\Delta q_t = \mathbf{h}_{A_t} \Delta a_t + \mathbf{g}_t \Delta k_t + \mathbf{p}_t \left[ \left(\frac{wL}{PQ}\right)_t (\Delta l_t - \Delta k_t) + \left(\frac{wM}{PQ}\right)_t (\Delta m_t - \Delta k_t) \right] \quad (5)$$

### III. Data, Method of Estimation and Results

Annual data are pooled across eight Australian manufacturing industries for the period 1971-72 to 1984-85. The time period for this study has been chosen on the basis of the data availability. In 1985-86, data on materials was not collected by the Australian Bureau of Statistics (ABS) and only collected every three years after this date. The eight industries used in this study are defined according to the Industry Commission (1997) paper, *Productivity Growth and Australian Manufacturing Industry*. While these industries are based on the ANZSIC classification, there is some aggregation over particular two and three-digit industries.

Estimation is carried out assuming fixed cross-section and time effects, which are achieved by using cross-section and time dummy variables. In the first stage of estimation, we assume that markup and returns to scale are parameters to be estimated for each industry. This is achieved using slope dummy variables for each industry. Our statistical model is given as follows:

$$\Delta q_{it} = C_{it} + \mathbf{g}_i \Delta k_{it} + \mathbf{p}_i \left[ \left( \frac{wL}{PQ} \right)_{it} (\Delta l_{it} - \Delta k_{it}) + \left( \frac{wM}{PQ} \right)_{it} (\Delta m_{it} - \Delta k_{it}) \right] + \mathbf{e}_{it} \quad (6)$$

where  $C_{it}$  represents the fixed effects,  $\mathbf{e}_{it}$  is an error term and the subscript  $i$  indicates the particular industry.

In order to estimate (6), the proportional rate of change in real turnover is used to measure  $\Delta q_{it}$ , the proportional rate of change in hours worked is used to measure  $\Delta l_{it}$  and the proportional rate of change in capital stock is used to measure  $\Delta k_{it}$ . As capital services are relevant to the production function, the results will be biased unless capital services are proportional to the capital stock. However, this is a

common assumption in empirical work. Figures for real intermediate material are not available over the period, so it is assumed that they are proportional to real turnover. This is the assumption that ABS makes when calculating gross product and is given empirical support by Basu (1996). Further details on the construction of the variables and the data sources are given in the Data Appendix.

Although models of the Hall type are generally estimated using instrumental variables (IV), Basu and Fernald (1997) and Linnemann (1999) find that using OLS does not greatly affect the results. A Hausman specification test is carried out to indicate if OLS is an appropriate method for estimating equation (6). Under the null hypothesis that the right hand side variables in (6) are exogenous, OLS is efficient and unbiased, while IV estimation is inefficient and unbiased. Only OLS is biased under the alternative hypothesis. The test indicates that the null hypothesis is not rejected at the 5 percent level of significance [  $\chi^2(36) = 9.71$  ]. Therefore, OLS is employed.<sup>1</sup>

Table 1 shows the regression estimates for markup and returns to scale for eight manufacturing industries. The point estimates for markup are greater than one in

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<sup>1</sup> The list of instrumental variables are the fixed cross-section and time dummies,

$$\Delta k_{it-1}, \Delta l_{it-1}, \left(\frac{wL}{PQ}\right)_{it-1}, \left(\frac{wM}{PQ}\right)_{it-1} \text{ and } \left[\left(\frac{wL}{PQ}\right)(\Delta l - \Delta k)\right]_{it-1}.$$

The latter variables are obtained by multiplying a dummy variable with the particular variable. Therefore,

$\Delta k_{1t-1}$  represents a dummy variable multiplied by the lagged proportional rate of

change in the capital stock for the first industry, etc. Note that the proportional rate of change in materials is equal to the proportional rate of change of output. As the lag of this variable is only asymptotically independent of the error term in (6), it is left out of the list of instruments. However, the results of the Hausman test do not differ greatly from those presented here when materials are accounted for in the list of instruments.

Table 1

OLS estimates of markup and returns to scale for eight manufacturing industries

Industry	Markup	Returns to scale
Food, beverages and tobacco	1.31 (0.32)	1.15 (0.28)
Textiles, clothing, footwear and leather	1.17* (0.07)	1.19 (0.16)
Printing, publishing and recorded media	1.42** (0.14)	1.12 (0.14)
Petroleum, coal, chemicals and associated products	1.32** (0.13)	1.18 (0.25)
Basic metal products	1.27** (0.09)	1.20 (0.14)
Fabricated metal products	1.26** (0.08)	1.15 (0.21)
Transport equipment	1.09 (0.10)	1.04 (0.20)
Other manufacturing	1.24** (0.10)	1.11 (0.17)

Notes: Figures in parentheses are standard errors.

\* Indicates significantly greater than one using a one-tailed t test at the 5 percent level.

\*\* Indicates significantly greater than one using a one-tailed t test at the 1 percent level.

all industries, but are not significantly greater than one in Food, Beverages and Tobacco and in Transport Equipment using a one-tailed t test. The largest markups are in Printing, Publishing and Recorded Media and Petroleum, Coal, Chemicals and Associated Products, with markups of 1.42 and 1.32, respectively. These results suggest that market power exists in most Australian manufacturing industries.

The average markup estimate is 1.26, which compares to 1.21 found by Linnemann (1999) for German manufacturing, 1.02 found by Klette (1999) for Swedish manufacturing (the median is 1.05) and 1.58 found by Domowitz et al (1988) for US manufacturing. Using an alternative method developed by Roeger (1995),

Oliviera Martins et al (1996) find that the average markup for Australian manufacturing is 1.24. While the results tend to vary widely for different countries, the estimates by Oliviera Martins et al provide support for the results obtained in this study.

The point estimates for returns to scale are all greater than one and generally smaller than the markup point estimates. However, none of the estimates for returns to scale are significantly greater than one using a one-tailed t test. A Wald test is carried out to test if the returns to scale are jointly different from one.<sup>2</sup> The null hypothesis that all the returns to scale are one is not rejected at the 5 percent level of significance ( $\chi^2(8) = 4.24$ ). This suggests that Australian manufacturing industries exhibit constant returns to scale, a result that is consistent with overseas findings.

In the second stage of estimation, we assume that markup is a function of cyclical and openness variables. Bloch (1992) shows that fixed markups are a special case that result from firms having log-log demand functions. Empirical studies generally find that markups change with shifts in marginal cost and shifts in demand (for Australian manufacturing see Bloch, 1992; Bloch and Olive, 1996; and Bloch and Olive, 1999). Because marginal cost is not included as a determinant of markup in

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<sup>2</sup> Asymptotically, the Wald test is the same as the likelihood ratio test. However, it has the advantage of only needing to estimate the unrestricted equation. Let the vector  $d$  be the set of discrepancies  $(Rb-r)$ , where  $R$  is a matrix of restrictions,  $b$  is a vector of unrestricted parameter coefficients and  $r$  is their expected sum totals. Under the null hypothesis that the constraints are true,  $d$  represents sampling error and is normally distributed with a mean of zero. The Wald statistic is calculated as  $d'[\text{var}(d)]^{-1}d$ , where  $\text{var}(d)$  is the variance of the discrepancy. For greater detail see Greene (1990, pp189-191).

studies of the Hall type, the connection between markup and demand or cost shifting variables has to be interpreted as a reduced form relationship.

Our statistical model is as follows:

$$\Delta q_{it} = C_{it} + \mathbf{g}_i \Delta k_{it} + \mathbf{p}_{it} \left[ \left( \frac{wL}{PQ} \right)_{it} (\Delta l_{it} - \Delta k_{it}) + \left( \frac{wM}{PQ} \right)_{it} (\Delta m_{it} - \Delta k_{it}) \right] + \mathbf{e}_{it} \quad (7)$$

where  $\mathbf{p}_{it} = \mathbf{b}_i + G(\text{cycl}_t, \text{open}_{it})$ . In (7),  $\mathbf{b}_i$  is constant across time but varies across each industry,  $\text{cycl}_t$  is a variable that represents the business cycle and only varies across time, while  $\text{open}_{it}$  is a variable that represents industry openness to international competition and varies across time and across each industry. The  $\mathbf{b}_i$  represent the industry level effects, which are captured using slope dummy variables in the empirical analysis. It can be seen that the statistical model for equations (6) and (7) is the same if  $G(\text{cycl}_t, \text{open}_{it})$  is not included in the markup. Equation (7) is estimated assuming that coefficients for the cyclical and openness effects on markup are the same for each industry. Therefore,  $G(\text{cycl}_t, \text{open}_{it})$  multiplied by

$$\left[ \left( \frac{wL}{PQ} \right)_{it} (\Delta l_{it} - \Delta k_{it}) + \left( \frac{wM}{PQ} \right)_{it} (\Delta m_{it} - \Delta k_{it}) \right]$$

is pooled across all industries. As in (6), returns to scale are assumed to be time-invariant for each industry in (7) (the same assumption is made by Haskel et al, 1995; and Beccarello, 1996). This is equivalent to assuming a cost function that is homogeneous in output (see Bloch and Olive, 2001).

Real GDP and detrended real GDP are the two cyclical variables considered in this analysis. Detrended GDP is the residual after the natural logarithm of GDP is regressed on a time trend. Openness for each industry is measured as exports plus imports divided by domestic industry turnover plus imports. If all output is exported

or the only domestic market supply is from imports, then this variable is equal to one. If there are no imports and no exports, then openness is zero. In the current data set, the maximum and minimum mean values for openness are 0.36 for Basic Metal Products and 0.11 for Fabricated Metal Products, respectively. In most Australian manufacturing industries over the period, there is only a relatively small amount exported. This means that the openness variable is approximately equivalent to the import share of domestic market sales in most industries. The two industry exceptions are Food Beverages and Tobacco and Basic Metal Products. Full details of the cyclical and openness variables are given in the Data Appendix.

Table 2 shows the results of estimating equation (7) when markup is: (1) a linear function of detrended real GDP; (2) a linear function of openness; (3) a function of detrended real GDP, openness and detrended real GDP multiplied by openness; (4) a linear function of real GDP; and (5) a function of real GDP, openness and real GDP multiplied by openness. Specific industry coefficients are not included in the reported results for reasons of space. However, the results show that constant returns to scale is not rejected for any industry at the 5 percent level, while the implied markup for each industry is discussed below.<sup>3</sup>

The results from Table 2 indicate that detrended real GDP is significantly positive in regression (1) at the 5 percent level using a two-tailed t test, thus implying pro-cyclical markups in Australian manufacturing. As markups are generally found to be negatively related to marginal costs in Australian manufacturing (see Bloch and Olive, 1999), and given that marginal costs are pro-cyclical due to input price changes over the cycle (see Bills, 1987), then we would expect markups to be counter-cyclical

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<sup>3</sup> All results can be obtained from the author on request.

Table 2

The estimated impact of cyclical and openness variables on markup across eight manufacturing industries.

Regression Number	Detrended real GDP	Real GDP ( $\times 10^{-5}$ )	Openness	Openness multiplied by	
				Detrended real GDP	Real GDP ( $\times 10^{-5}$ )
(1)	4.51** (1.95)				
(2)			-2.33* (1.25)		
(3)	4.44 (4.65)		-1.27 (1.48)	-3.38 (15.69)	
(4)		-0.21 (0.33)			
(5)		1.91** (0.85)	6.58 (4.32)		-6.73** (2.94)

Notes: Figures in parentheses are standard errors.

\* Indicates significantly different from zero using a two-tailed t test at the 10 percent level.

\*\* Indicates significantly different from zero using a two-tailed t test at the 5 percent level.

if this relationship was supply driven.<sup>4</sup> Therefore, it is likely that the cyclical influences on markup are demand driven. In regression (2), openness is significantly negative at the 10 percent level using a two-tailed t test. This result by itself would imply that the extent of foreign competition is important in reducing markups. The finding of pro-cyclical markups and a negative relationship between openness and markups is also found by Beccarello (1996) for Canada, France, Germany, Italy, Japan and the UK.

When detrended real GDP, openness and detrended real GDP multiplied by openness are included in regression (3), the former variables maintain their sign and a

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<sup>4</sup> This analysis assumes that pro-cyclical factor costs dominate any tendency toward pro-cyclical marginal product in its affect on marginal cost.

negative sign is attached to the cross-variable. Now, however, none of these influences on markup are significant. A high level of collinearity amongst regressors is one possible explanation for this result.

In regression (4), real GDP is found to be insignificant. However, in regression (5), real GDP is significantly positive and real GDP multiplied by openness is significantly negative, both using a two-tailed t test at the 5 percent level. Openness, by itself is found to be insignificant. These results suggest that as openness increases, aggregate demand has a reduced impact on markup. One explanation for this behaviour is that as an industry becomes more open, increases in aggregate demand that would normally shift the demand curve outward cannot be taken advantage of by domestic firms increasing their prices for fear that they will lose market share to foreign competitors.

Studies of the impact of openness on markup often view openness as having a direct negative impact on industry concentration (for example see Katic and Peterson, 1994). This suggests a variation on the profit-concentration structural relationship, where concentration is modified for openness. The importance of a negative coefficient for the openness/cyclical cross-variable is that it suggests an indirect impact on markup that may be indistinguishable from any direct influence by openness, particularly in cross-sectional analysis. To see this, look at the following relationship for the markup:

$$p_{it} = \mathbf{b}_i + \mathbf{b}_1 \text{cycl}_t - \mathbf{b}_2 \text{cycl}_t \times \text{open}_{it} - \mathbf{b}_3 \text{open}_{it} \quad (8)$$

where  $\mathbf{b}_1$ ,  $\mathbf{b}_2$  and  $\mathbf{b}_3$  are positive parameters and  $\mathbf{b}_i$  indicates industry level effects.

In cross-section, the cyclical variable is constant and (8) becomes:

$$p_i = b_i + d_1 - (d_2 + b_3)open_i \quad (7)$$

where  $d_1$  and  $d_2$  are parameters related to the cyclical variable at a point in time. If markup is regressed on openness, the negative relationship may be due to either the direct or indirect effects of openness and the strength of the relationship may vary according to the phase of the cycle at that moment.

In order to get a feel for the impact that openness and the cycle have on markup, we calculate the implied markup for each industry, at each point in time. To do this we take the estimated coefficients from regression (5) and apply them to the following formula:

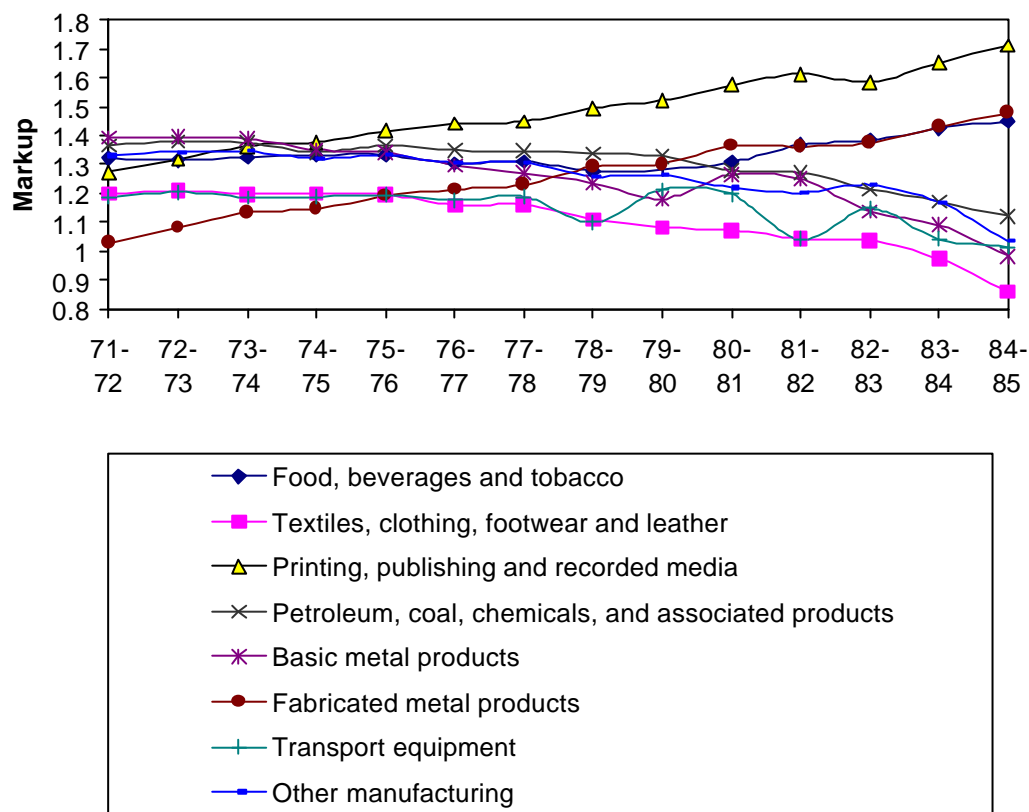
$$\hat{p}_{it} = \hat{b}_i + \hat{b}_1(realGDP)_t + \hat{b}_2(realGDP)_t \times openness_{it} + \hat{b}_3openness_{it} \quad (8)$$

where  $\hat{p}_{it}$  is the implied markup,  $\hat{b}_i$  is the estimated level effect, and  $\hat{b}_1$ ,  $\hat{b}_2$  and  $\hat{b}_3$  are the estimated coefficients for real GDP, real GDP multiplied by openness and openness, respectively.

Figure 1 shows the progression of the implied markup for each industry over the period 1971-72 to 1984-85. It can be seen that most industries exhibit large variation in their markup. Also, the impact of openness on the markup is evident. The least open industries in this period are Printing, Publishing and Recorded Media and Fabricated Metal Products, and these are the two industries that maintain a sustained increase in the markup. Of the other industries, Food, Beverages and Tobacco is the only industry where there is not a substantial increase in openness over the period and it can be seen that it is the only industry that does not have a sustained decrease in

markup. It is interesting to note that the impact of openness seems to have increased the variation in the markup across industries. Although not presented here, this is evident when the same exercise is carried out using the estimates from regression (3).

Figure 1: Movements in the implied markup for each industry



#### IV. Conclusion

This paper sets out to measure markup and returns to scale for eight Australian manufacturing industries and to explore the relationship between markup, the business cycle and openness to the international economy. A Hall type model is used for this purpose, where allowance is made for non-stochastic time variation in the contribution of technical change to output growth and intermediate materials are included in the production function.

Six of the eight manufacturing industries indicate markups that are significantly greater than one, implying the existence of market power in most Australian manufacturing industries. However, constant returns to scale is not rejected for individual industries using t tests, nor is it rejected jointly using a Wald test. These results are consistent with a number of studies for other countries.

Markups are found to be pro-cyclical, particularly in industries associated with low levels of openness. Markup appears to be negatively related to openness, however, this relationship becomes insignificant when cyclical variables are included in the regression. When openness multiplied by real GDP is included in the regression, the results suggest that the influence of the cycle on markups decreases as openness increases. This has implications for estimating markup – openness relationships, particularly in cross-sectional analysis.

#### Data Appendix

The following data are taken from the statistical appendix to the Industry Commission (1997) paper, *Productivity Growth and Australian Manufacturing Industry*.

$$\Delta q_{it}$$

Table 9 presents gross product at average 1989-90 prices for eight manufacturing industries. These values are derived by choosing gross product in the base year and extrapolating forward using real turnover. The proportional rate of change in real turnover is calculated by taking the natural logarithm of the gross product values in Table 9 and first differencing each series.

$$\Delta l_{it}$$

Table 11 presents an index of hours worked for eight manufacturing industries.

The proportional rate of change in hours worked is calculated by taking the natural logarithm of these values and first differencing each series.

$$\Delta k_{it}$$

Table 20 presents the value of net capital stock at average 1989-90 prices for eight manufacturing industries. These values are calculated using a perpetual inventory method. The proportional rate of change in capital stock is calculated by taking the natural logarithm of these values and first differencing each series.

$$\left(\frac{wL}{PQ}\right)_{it}$$

The labour share of revenue is calculated by multiplying labour cost shares in value added by value added divided by turnover. Table 13 presents labour cost shares in value added for eight manufacturing industries. These shares incorporate non-wage labour costs. The Industry Commission (1995) publication, *Manufacturing Industry and International Trade Data, 1968-69 to 1992-93*, has values for value added and turnover at two and three-digit levels. The concordance from Table A2 in *Productivity Growth and Australian Manufacturing Industry* is used, in order to have value added divided by turnover in the appropriate industry categories.

The following data are taken from the Industry Commission (1995) publication, *Manufacturing Industry and International Trade Data, 1968-69 to 1992-93*.

$$\left(\frac{wM}{PQ}\right)_{it}$$

The intermediate material share of revenue is calculated as purchases in divided by turnover.

$open_{it}$

Openness for each industry is measured as (exports – re-exports) plus (imports – re-exports) divided by (domestic industry turnover plus imports – re-exports).

The following data are from the *Australian National Accounts (5204.0)*, compiled by the Australian Bureau of Statistics.

$cycl_t$

Table 2 presents real GDP at 1979-80 prices.

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