# Import Competition and Labour Productivity*

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**Abstract**

The impact of import competition on labour productivity is examined using panel data for a sample of Australian manufacturing firms over the period 1984 to 1993. Import competition is found to interact with domestic competition; such the positive impact of import competition on the level and rate of growth of labour productivity rises with the degree of concentration among domestic producers. The results suggest that the movement towards lowering border protection on manufactured imports into Australia has led to enhanced productivity by domestic producers, especially those in highly concentrated industries.

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## 1. Introduction

The prospects for improved efficiency have been a cornerstone of economic argument for unfettered international trade since at least the writings of Adam Smith. While the theoretical analysis has emphasized gains through improved allocative efficiency, Harris (1984) among others argues improved productive efficiency offers much better prospects for large improvements in economic well being. Yet, direct empirical evidence of the impact of trade on measures of productive efficiency *at the firm* is limited. This reflects, at least in part, the difficulties in obtaining relevant firm-level data on measures of productive efficiency during periods of time when there has been substantial trade reform, offering the opportunity to distinguish productivity gains due to increased trade from alternative influences. More generally, Harrison (1994) notes that recent overviews on the links between trade reform and productivity growth (e.g., Nishimizu and Page, 1990, and Tybout, 1992) leave the debate on this issue unresolved.

In one of the rare empirical studies of trade and productivity at the level of an individual firm, Harrison (1994) finds evidence that productivity growth in manufacturing firms in the Ivory Coast rises dramatically following trade reform in the mid 1980s. However, she finds no clear relationship across industries between import penetration and productivity growth, nor does she explore the effects of concentration among domestic producers on the relationship between imports and productivity. Using industry panel data for a less dramatic case of trade reform, US manufacturing over the period from 1975 to 1987, MacDonald (1994) finds evidence that import penetration is positively related to productivity growth at the industry level. Further, he finds that this relationship is strongest in industries with high levels of concentration among domestic producers.

The present study examines the separate and joint influence of import penetration and domestic concentration on productivity in a panel of Australian manufacturing firms over the period 1983 to 1993. Foreign competition has arguably been more important in the Australian economy than in the US, although perhaps less important than in the Ivory Coast. Our study period comes after substantial reductions in border protection against imports of manufactured goods. The nominal rate of protection against imports for Australian manufacturing dropped from 16% in 1981/82 to 7% in 1992/93, following reductions in both tariff rates and import quotas.[1] Thus, we examine circumstances in which an impact of foreign competition on productivity is likely to be revealed, while still dealing with a relatively mature industrial economy.

Harrison (1994) incorporates Hall's (1988) analysis of bias in the measurement of firm productivity growth with imperfect competition. We extend this analysis to consider possible bias in the measured productivity level as well as measured productivity growth. Our use of firm data allows a focus on whether exposure to foreign competition affects productivity in surviving firms. Improvements in productivity at the industry level can either come through improved performance of surviving firms or through the removal of inefficient firms. A finding that increased exposure to foreign competition increases productivity of surviving firms suggests the presence of slack in firm efficiency without competitive pressure.

We begin in Section 2 by reviewing the determinants of labour productivity at the firm level. In Section 3, we examine the influence of competition on labour productivity, including the potential for measurement error associated with imperfect competition. Section 4 describes the data used in estimation. The regression results are presented and discussed in Section 5, while our conclusions are given in Section 6.

## 2. The distribution of labour productivity across firms

Wide variation in the productivity of labour among firms operating in the same industry is well established. Oulton (1998) provides evidence of such variation for UK industry and refers to previous studies showing substantial labour productivity variation in other industrialized countries.[2] Oulton also establishes that the productivity differences are not simply due to transitory shocks, with the regression of high or low productivity towards the mean being relatively small over a four-year period.

Labour productivity differences across firms can be consistent with cost-minimizing behavior if firms use different qualities or quantities of inputs. David Ricardo ([1817] 1911) provides the classic example of an ‘extensive margin’ in agriculture, due to the use of land with

[1] The data on the average rate of nominal assistance are taken from Industry Commission (1995). The measure of nominal assistance reported there includes import tariffs and an estimated tariff equivalent of non-tariff barriers to trade.

[2] An early study by Gregory and James (1975) shows substantial variation in labour productivity among Australian manufacturing firms, even when only new plants are considered.

different levels of fertility. Similar differences can arise due to varying qualities of natural resource inputs, labour skills or the technology embodied in capital equipment.[3] Differences across firms in labour productivity also occur with varying relative factor intensities, as labour productivity rises at the 'intensive margin' when greater quantities of complementary inputs are used.

A further source of differences in labour productivity across firms is 'X inefficiency'. The existence of X inefficiency is revealed with frontier production function estimates, as in the estimates for several industrialized countries provided in Caves (1992). Firms whose outputs for given input combinations fall short of the frontier have lower labour and/or capital productivity than those firms operating on the frontier for the same input combination. While the differences in labour productivity may be attributed to the quantity or quality of unmeasured inputs, including managerial organization, such differences are difficult to measure independently of productivity differences. Thus, in practice the effect of unmeasured inputs cannot be identified separately from X inefficiency.

Differences in labour productivity across firms as discussed above may be represented in terms of a standard production function:

$$Q_{ijt} = \theta_{ijt} f_j(K_{ijt}, L_{ijt}, M_{ijt}) \quad (1)$$

The amount of output, $Q$, produced by firm i in industry j at time t in (1) depends on the amounts of capital, $K$, labour, $L$, and materials, $M$, it uses in production as well as on the firm's index of technology, $\theta$. If the function, $f$, is linear homogeneous, the productivity of labour, $Q/L$, can be expressed as:

$$Q_{ijt} / L_{ijt} = \theta_{ijt} f_j(K_{ijt} / L_{ijt}, M_{ijt} / L_{ijt}) \quad (2)$$

In (2), differences in productivity across firms due to relative factor intensities are reflected in the capital-to-labour, $K/L$, and materials-to-labour, $M/L$, ratios. The effects of different input qualities and X-inefficiency are reflected in the technology index, $\theta$. Also, there may be different production technologies applying to different industries, which are reflected in the $f$ function.

[3] For example, Salter (1966) uses the embodiment of technology in capital equipment to explain observed differences between 'best practice' and average labour productivity across manufacturing establishments.

## 3. Competition and labour productivity

Perfect competition represents an ideal of efficiency in the sense that each firm in long-run perfectly competitive equilibrium operates at a level of average cost equal to the minimum for any firm in the industry. There is no dispersion of productivity across firms and no unexploited opportunity for increasing productivity of individual firms. Without long-run equilibrium, dispersion of productivity is possible. However, firms with relatively low productivity are likely to be incurring economic losses and must either improve their performance of exit the industry.

With imperfect competition, price is above marginal cost and can potentially remain above the average cost of the most productive firms in an industry. Shareholders interests are still to minimize cost, but as Caves (1992, 9) notes, ‘High concentration permits inefficiency to persist, should individual firms’ managers not be optimally motivated to eliminate it’. Thus, given the prevalence of incomplete contracts and distorted incentives to managers, the technology index, $\theta$, can be expected to be lower for firms operating in high concentration industries.

Productivity can also be spuriously related to the intensity of competition due to error in the measurement of labour productivity at the firm level with imperfect competition. The standard measure of real output for each firm is obtained by deflating firm revenues by an industry price index, $p_{ijt}Q_{ijt} / p_{jt}$. The measured labour productivity for the firm is then given by the following variation on (2):

$$(p_{ijt} Q_{ijt} / p_{jt}) / L_{ijt} = (p_{ijt} / p_{jt}) \theta_{ijt} f_j (K_{ijt} / L_{ijt}, M_{ijt} / L_{ijt}) \qquad (3)$$

If all firms have equal marginal cost, the ratio of firm price to industry price in (3) can be replaced by a firm’s markup of price on marginal cost, $\mu_{ijt} = p_{ijt} / x_{ijt}$, divided by the corresponding industry markup as follows:

$$(p_{ijt} Q_{ijt} / p_{jt}) / L_{ijt} = (\mu_{ijt} / \mu_{jt}) \theta_{ijt} f_j (K_{ijt} / L_{ijt}, M_{ijt} / L_{ijt}) \qquad (4)$$

The sample of firms for the empirical analysis below includes only large surviving firms, so it is reasonable to expect that they have above average markups for their industry and that their measured productivity overstates the properly deflated output measure. Further, this overstatement is likely to be larger; the less competitive is the industry in which they operate.

Thus, to the extent that domestic industry concentration and trade protection lessen competition, there may be a positive bias to the estimated impact of concentration or trade protection on productivity.

Hall (1988) argues that imperfect competition leads to systematic bias in measurement of productivity growth. He notes that the marginal cost associated with a change in firm output, $\Delta Q$, and labour input, $\Delta L$, at a economy-wide wage rate, $w$, is given by:

$$x_{ijt} = w_t \Delta L_{ijt} / \Delta Q_{ijt} \tag{5}$$

The influence of competition is isolated by rearranging (5) to solve for the rate of change of output in terms of the rate of change of labour, the markup of price on marginal cost and the share of labour cost in revenue, $\alpha_{ijt} = w_t L_{ijt} / p_{ijt} Q_{ijt}$, as follows:

$$\Delta Q_{ijt} / Q_{ijt} = (\mu_{ijt} \alpha_{ijt}) \Delta L_{ijt} / L_{ijt} \tag{6}$$

When there are changes in capital, $\Delta K$, and material inputs, $\Delta M$, as well as technical change, $\Delta\theta$, the expression for marginal cost becomes:

$$x_{ijt} = \frac{w_t \Delta L_{ijt} + r_t \Delta K_{ijt} + v_t \Delta M_{ijt}}{\Delta Q_{ijt} - \Delta \theta_{ijt} Q_{ijt}} \tag{7}$$

In (7), $r$ is the rental price of capital and $v$ is the price of materials. Using this definition of marginal cost and solving for the expression equivalent to (6) yields:

$$\Delta Q_{ijt} / Q_{ijt} = \mu_{ijt} (\alpha_{ijt} \Delta L_{ijt} / L_{ijt} + \beta_{ijt} \Delta K_{ijt} / K_{ijt} + \gamma_{ijt} \Delta M_{ijt} / M_{ijt}) + \Delta \theta_{ijt} \tag{8}$$

where $\beta_{ijt}$ is the share of capital cost in firm revenue and $\gamma_{ijt}$ is the corresponding share for material inputs. If there are constant returns to scale, the cost shares for all inputs sum to one. This means the product of the markup and the sum of the coefficients on the input changes in (8) sum to one, so we can solve for labour productivity growth as:

$$\Delta Q_{ijt} / Q_{ijt} - \Delta L_{ijt} / L_{ijt} = \mu_{ijt} (\beta_{ijt} (\Delta K_{ijt} / K_{ijt} - \Delta L_{ijt} / L_{ijt}) + \gamma_{ijt} (\Delta M_{ijt} / M_{ijt} - \Delta L_{ijt} / L_{ijt})) + \Delta \theta_{ijt} \tag{9}$$

Thus, it appears that by lowering the markup, competition decreases the impact on labour productivity growth of increases in capital and material intensity, provided that the shares of inputs in revenue are otherwise unaffected.[4]

The influence of competition on measured productivity and productivity growth through the markup may obscure the effect of any impact through the technology index. While competitive pressure reduces internal slack and increases the firm's technology index, increased competition reduces the markup. The reduced markup in turn leads to a reduction in measured productivity levels in (4), assuming as above that the markup for surviving firms falls more than the average for the industry. Reduced markups also reduce measured productivity growth in (9), provided that the intensity of use of capital and material is rising relative to labour, as has generally been the case in manufacturing since the industrial revolution. Thus, a positive effect of competition on productivity and productivity growth might be expected if the impact on the technology index dominates, while a negative effect may be expected if the impact on measurement error through the markup dominates.

## 4. Data and Descriptive Statistics

We estimate the impact of competition on firm productivity levels by treating both markups, $\mu_{ijt}$, and technology indexes, $\theta_{ijt}$, as functions of competition. Domestic firms in Australian manufacturing typically face competition from both domestic rivals and imported substitutes. There is also a possibility of competition with foreign firms in export markets, although historically manufactured exports from Australia have been minimal. We use concentration of domestic sales (CR) as an inverse measure of domestic competition. The share of domestic producers in domestic sales (DS), which is equal to one minus the share of competing imports, is used as an inverse measure of the strength of import competition. The importance of foreign competition in export markets is measured by the share of industry output exported (XS).

4 In the simplest case examined by Hall (1988) there are constant returns to scale, so the cost shares of inputs sum to one regardless of the markup. In this case, a rise in the markup leads to a rise in the ratio of revenue to cost and the shares of the inputs in revenue are inversely related to the markup. However, with economies or diseconomies of scale it is possible for the markup and revenue shares to move independently provided there are offsetting changes in output.

MacDonald (1994) finds evidence of interactive effects of domestic and import competition on productivity growth in US manufacturing, so we allow for an interaction between these sources of competition in our estimates by including their cross product as a variable. We also allow for the influence of each variable to change over time by including the cross product of each with a time trend (TT). Finally, we allow for procyclical variation in measured productivity by including the aggregate unemployment rate (UE) as a variable, with the expectation that its estimated coefficient will be negative.[5]

Our empirical analysis is based on a panel data set of Australian manufacturing firms drawn from a database of annual information on Australian firms of at least $20 million market capitalization. The database is maintained by IBIS Research and administered by the Melbourne Institute of Applied Economic and Social Research. Included in the database are private firms, publicly traded enterprises, government enterprises and foreign-owned companies operating in Australia over the period 1983-1994 (see Dawkins, King and Harris, 1999, for details).

One important characteristic of the IBIS database is that the number of firms on which data have been collected has increased steadily over the sample period, with the inclusion of progressively smaller firms.[6] From the IBIS database, we draw two panels of manufacturing firms. The first panel is a balanced panel containing all manufacturing firms in the database for which data are available over the period 1984-1993.[7] This yields data on 2650 observations over 265 firms. The second panel adds a second shorter balanced panel on firms for which data are available for the period 1988-93, and increases the sample size to 3664 observations over 434 firms.

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[5] Rotemberg and Woodford (1999) review the theory and evidence on the cyclical movement of prices, costs and markups, arguing that observed procyclical movements in productivity and profits are consistent with countercyclical variations in markups.

[6] The authors have used firm-level data from the IBIS database in two papers on firm profitability, and these papers provide discussion of selection issues arising from the nature of the IBIS data collection. See McDonald (1999) and McDonald and Bloch (1999).

[7] We exclude 1983 since there are only a small number of firms in that year for which data are collected. We exclude 1994 due to the change in industrial classification between 1993 and 1994 when Australia switched from ASIC to ANZIC industrial classification systems.

The dependent variable is defined to be the log of annual gross labour productivity measured at the firm level, and it is computed as the ratio of real revenue to the number of employees.[8] The IBIS data do not contain any information on the cost of materials used in production, and the data on capital stock are both incomplete and likely to be measured with error. Thus, we are unable to include variables to measure the capital-to-labour ratio or materials-to-labour ratio. Instead, we use sample restrictions in the regression reported below to investigate the robustness of our results to this limitation.

Data on the independent variables are drawn from a variety of sources. From the IBIS database, information is available on the 2-digit industry in which the firm is most active. Using the industry codes, we then assign to each firm for each year the relevant 2-digit industry-level data, from published Australian Bureau of Statistics (ABS) data, on local share of the domestic market and the proportion of production exported. For diversified firms, weighted average values of local share (DS) and export share (XS) are calculated for each firm using weights derived from the contribution of business in each of the firm's 2-digit industry groups to firm total revenue.

To proxy for the domestic industry structure relevant to each firm, we construct a firm-specific average 4-digit industry concentration ratio (CR), where the average is weighted by the contribution of business in each 2-digit industry group to firm total revenue. We use concentration ratios at the 4-digit industry level to derive weighted 2-digit industry concentration ratios, where the weights reflect each 4-digit industry's revenue contribution to total 2-digit industry revenue.[9] We then assign the concentration ratios to the firm level data.

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[8] Firm revenue is deflated by a weighted 2-digit industry output price index, where the weights are based on the contribution by each of the firm's 2-digit industry groups to the firm's total revenue. This deflation corresponds to that shown in equation (3).

[9] 2-digit industry classifications are much broader than economically relevant markets, so that not all firms classified to a 2-digit industry compete in the same market. The concentration ratio for a 2-digit industry classification therefore tends to understate the level of concentration in the markets in which a firm competes. By taking a weighted average of 4-digit classification within each 2-digit industry, we expect to better approximate the average level of concentration of domestic sellers in the markets in which firms compete. Concentration data are not published for any classification scheme less aggregated than the 4-digit classification level. We do not have reliable data on the allocation of each firm's business across 4-digit industry classifications, so we use the industry aggregate measure to proxy for the allocation for individual firms. Finally, there is no adjustment to our concentration measure for import sales because the influence of

Concentration ratios at both the 4-digit and 2-digit levels are available from the ABS only for selected years. We use data for 1988, so that our measure of industry concentration is time invariant over the sample period. Finally, the aggregate annual unemployment rate (UE) is taken from ABS series.

Tables 1 and 2 present sample means of the log of labour productivity over time and across 2-digit industry groups, for both the 1984-93 panel and an expanded panel that includes firms for which data is only available for 1988-93.[10] Table 1 indicates the relatively steady increase in labour productivity over the sample period, increasing roughly 4% per year on average over the ten years from 1984 to 1993. The addition of firms from the shorter panel has little effect on the average labour productivity. Table 2 illustrates the marked differences in average labour productivity across firms from different 2-digit industry groups. For example, firms in Food, Beverages and Tobacco Products have an average labour productivity that is approximately 100% higher than firms in Fabricated Metal Products for the 1984-93 panel and approximately 75% higher for the expanded panel.[11] Table 2 also shows that the industry mix of the additional firms included in the shorter panel differs somewhat from the longer panel, and highlights the small sample sizes of some industry groups.

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import competition is examined separately through including a variable for the share of domestic market sales held by domestic producers.

[10] The expanded panel includes data from the 256 firms for the ten years as in 1984-93 panel plus data for six years on 178 other firms.

[11] Differences in average labour productivity may be partly explained by differences in the share of material inputs into production. Food, Beverages and Tobacco, Non-metallic Mineral Products and Basic Metal Manufacturing have the highest proportions of material inputs to turnover of any 2-digit industry group based on published Australian Bureau of Statistics data.

**Table 1: Log of Labour Productivity by Year (revenue per employee measured in $'000)**

| | 1984-83 Panel | | Expanded Panel | |
|---|---|---|---|---|
| | Mean | Std.Dev. | Mean | Std.Dev. |
| 1984 | 5.22 | 1.12 | 5.22 | 1.12 |
| 1985 | 5.34 | 1.11 | 5.34 | 1.11 |
| 1986 | 5.40 | 1.08 | 5.40 | 1.08 |
| 1987 | 5.48 | 1.09 | 5.48 | 1.09 |
| 1988 | 5.51 | 1.03 | 5.49 | 1.08 |
| 1989 | 5.54 | 0.95 | 5.55 | 1.02 |
| 1990 | 5.54 | 0.95 | 5.56 | 0.98 |
| 1991 | 5.49 | 0.93 | 5.49 | 0.96 |
| 1992 | 5.59 | 0.97 | 5.59 | 0.99 |
| 1993 | 5.62 | 0.99 | 5.60 | 1.00 |
| All years | 5.47 | 1.03 | 5.54 | 1.01 |
| Number of firms | 265 | | 434 | |

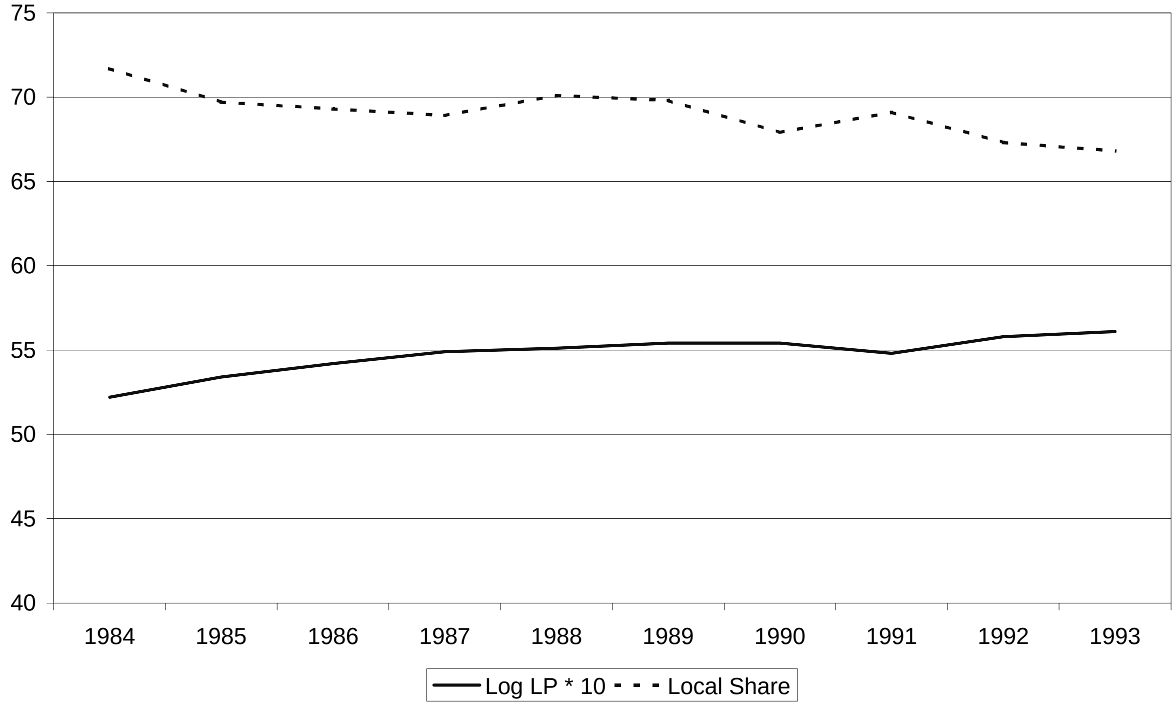
**Table 2: Log of Labour Productivity by Industry**

| | 1984-93 Panel | | | Expanded panel | | |
|---|---|---|---|---|---|---|
| 2 digit industry | Mean | Std. Dev. | Sample size | Mean | Std. Dev. | Sample size |
| Food, tobacco, beverages | 5.88 | 1.60 | 470 | 5.80 | 1.46 | 702 |
| Textiles | 5.75 | 0.77 | 50 | 6.42 | 1.30 | 80 |
| Clothing, Footwear | 4.85 | 0.36 | 30 | 4.82 | 0.58 | 64 |
| Wood, wood products | 5.29 | 1.59 | 100 | 5.33 | 1.46 | 130 |
| Paper, paper products | 4.95 | 0.54 | 140 | 5.07 | 0.69 | 240 |
| Chemical products | 5.64 | 0.68 | 510 | 5.68 | 0.79 | 686 |
| Non-metallic mineral prods | 5.21 | 0.55 | 110 | 5.23 | 0.54 | 162 |
| Basic metal manufacturing | 5.57 | 0.84 | 160 | 5.61 | 0.92 | 232 |
| Fabricated metal products | 4.90 | 0.60 | 110 | 4.91 | 0.56 | 140 |
| Transport and Equipment | 5.28 | 0.83 | 200 | 5.29 | 0.85 | 276 |
| Other metal products | 5.44 | 0.73 | 470 | 5.42 | 0.87 | 738 |
| Miscellaneous manufacturing | 5.10 | 0.75 | 130 | 5.28 | 0.78 | 214 |

Figure 1 plots movements over the period in average labour productivity and the average local share of the domestic industry for the long panel of firms. Increases in labour productivity are shown to have coincided with increases in international exposure (as reflected in declining local share of the domestic market). In particular, the high point of domestic share in 1984 corresponds to the low point of labour productivity, while the low point of domestic share in 1992-93 corresponds to the high point of labour productivity.

Identifying the contribution of changing international exposure to increasing labour productivity is the goal to which we now turn.

**Figure 1: Labour Productivity and Local Share of the Domestic Market**




## 5. Regression Results

We present two sets of regression results. The first set is based on estimation of a number of econometric specifications in levels of the main variables, for both the long panel and the combined panel of firms. The second set is based on estimation of specifications in first-difference form, in which the dependent variable measures the rate of change of labour productivity. Preliminary empirical investigation indicated that the determinants of labour productivity differ significantly by the degree of industry concentration. Thus, each table of results has two sections that correspond to estimates obtained after splitting the sample into relatively low and relatively high concentration firms and estimating the models separately for each sub-sample.[12]

[12] The separation of sub-samples of industries ranked by concentration has a long history in empirical studies of industrial organization (see Caves and Porter, 1978 for an early example applied to US manufacturing). Bloch and Olive (1996) find that pricing equations are significantly different in sub-samples of high and low concentration industries in Australian manufacturing, suggesting that the relationships determining firm behavior are systematically different in between industries in these sub-samples.

### *5.1. Econometric results from estimation in levels*

Table 3 presents four sets of results. Column 1 gives estimation results of a fixed-effects specification over the balanced panel of firms.[13] Note that concentration is omitted from the specification as it is time invariant, so its impact can't be separated in the fixed effects transformation. Since we do not include explicit controls for differences in capital intensity across firms, Column 2 gives results for a specification based on a subset of observations that omit firms with relatively high capital intensity. Similarly, Column 3 gives results after omitting firms in industries with relatively high materials intensity. Finally, Column 4 presents results using the combined sample of both the long and short panels.

Focusing first on the sub-sample of firms in industries with high concentration, results in Column 1 indicate that firm labour productivity is clearly affected by competition through a set of interactions of imports, industry concentration and the time trend. Note that the concentration ratio (CR) is an inverse measure of domestic competition, while the local share of the domestic market (DS) is an inverse measure of import competition. Labour productivity exhibits a significant positive trend over time, but the rate of increase is inversely related to the degree of industry concentration.[14] The impact on labour productivity of the local share of domestic market also depends on the level of industry concentration: the higher the concentration ratio, the larger the increase in labour productivity arising from a decline in the local share of domestic market. Thus, increases in international competition lead to relatively large improvements in labour productivity for those firms in industries with a relatively low degree of domestic competition. Overall, there is evidence supporting the argument that competitive pressure from at home and abroad leads to better productivity performance.[15]

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[13] A random effects model would permit inclusion of time invariant regressors in the estimating equation. However, estimation of a random effects model requires that the unobserved random effects are uncorrelated with the explanatory variables. This assumption that is unlikely to hold in practice. It turns out that results from random effects estimation are similar to those for the fixed effects model.

[14] An interaction of industry share of domestic market with the time trend was insignificantly different from zero and had a coefficient close to zero.

[15] There is a positive coefficient on domestic share in both panels of Table 1, suggesting that productivity is lower as import share, and hence foreign competition, is less. However, the negative coefficient on the interaction of domestic share and concentration means that productivity is actually increasing with import share for all concentration levels in the low concentration sub-sample and for all but the lowest concentration levels in the high concentration sub-sample. Also, the arguments in Section 2 suggest that measured

Results contained in the lower section of Table 3 are based on the sub-sample of firms in industries with relatively low industry concentration. There are both similarities and differences in results for the sub-sample of firms from high concentration industries. As with firms in industries with high concentration, competition is an important determinant of labour productivity in low concentration firms. Specifically, higher concentration ratios are associated with smaller rates of increase in labour productivity over time. However, the coefficient estimates on the trend and competition variables are uniformly smaller, and the terms involving local share of domestic market are no longer significant either individually or jointly.

There are also similarities and differences across sub-samples in the results for the unemployment and export share. Labour productivity is found to be procyclical for firms in industries with low concentration as is the case for firms in industries with high concentration, a result consistent the hypothesis that firms engage in labour hoarding so as to avoid the loss of skilled workers. However, only in the sub-sample of firms in industries with low concentration do firms with a higher share of domestic production exported overseas have higher levels of labour productivity.[16]

An F-test rejects the restriction that the determinants of labour productivity related to competition are equal between high and low concentration firms, with a p-value less than 0.0001. One interpretation of these results is that for firms in industries with relatively high levels of domestic competition, increases in international competition have a smaller effect on labour productivity compared with firms in industries with relatively low levels of domestic competition, since domestic competition requires domestic firms to be relatively efficient in order to survive in the marketplace.

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productivity is subject to upward bias when firms are protected from domestic or foreign competition and have market power. Thus, the estimated impact of import share on productivity is likely to be negatively biased, so our finding of a net positive influence is strong evidence in favor of a positive impact of foreign competition on productivity.

[16] When a set of concentration and trend interaction terms for export share is included, these variables are typically insignificant and the coefficient estimates are quite sensitive to the specification used.

**Table 3: Econometric Results - Estimation in Levels**

| High Concentration Firms [CR > .495] | Balanced panel | Capital intensity <.75 | Materials intensity <.62 | Expanded panel |
|---|---|---|---|---|
| Time Trend (TT) | .3073** | .2664** | .4305** | .3314** |
| | (.064) | (.058) | (.067) | (.062) |
| Industry Share of Domestic Market (DS) | .1554** | .1970** | .3136** | .1674** |
| | (.049) | (.046) | (.071) | (.044) |
| TT*Concentration Ratio (CR) | -.4858** | -.4175** | -.7124** | -.5301** |
| | (.118) | (.108) | (.125) | (.114) |
| DS*CR | -.2954** | -.3523** | -.5879** | -.3080** |
| | (.087) | (.083) | (.129) | (.078) |
| XS | -.2830 | .4987 | -.5648 | .1051 |
| | (.465) | (.390) | (.491) | (.411) |
| UE | -3.4793** | -4.6975** | -3.2761** | -4.4924** |
| | (.881) | (.781) | (.940) | (.797) |
| Constant | 6.4571** | 5.4885** | 5.9820** | 6.3011** |
| | (.476) | (.388) | (.445) | (.419) |
| Number of Observations | 1080 | 803 | 930 | 1404 |
| Number of Firms | 108 | 93 | 93 | 162 |

| Low Concentration Firms [CR < .495] | Balanced panel | Capital intensity <.75 | Materials intensity <.62 | Expanded panel |
|---|---|---|---|---|
| Time Trend (TT) | .1228** | .1577** | .1098** | .0933** |
| | (.027) | (.026) | (.032) | (.024) |
| Industry Share of Domestic Market (DS) | .0367 | .0622 | .0026 | .0796 |
| | (.067) | (.061) | (.069) | (.051) |
| TT*Concentration Ratio (CR) | -.2371** | -.3104** | -.1943** | -.1554** |
| | (.064) | (.060) | (.084) | (.056) |
| DS*CR | -.1246 | -.1807 | -.0322 | -.2337* |
| | (.173) | (.156) | (.182) | (.134) |
| XS | 2.0311** | .8838 | 2.0082** | 1.4012** |
| | (.655) | (.592) | (.782) | (.524) |
| UE | -3.6273** | -2.5353** | -4.2586** | -3.1013** |
| | (.911) | (.836) | (1.099) | (.708) |
| Constant | 6.3136** | 6.1990** | 5.7685** | 6.3625** |
| | (.694) | (.631) | (.558) | (.533) |
| Number of Observations | 1570 | 1315 | 1220 | 2260 |
| Number of Firms | 157 | 149 | 122 | 272 |

Notes: Robust standard errors are given in parentheses. A double (single) asterisk indicates that an estimated coefficient is significantly different from zero at the 5% (10%) level using a two-tailed t test.

Columns 2 through 4 of Table 3 present the results from three sensitivity checks of the main results: controlling for differences across firms in capital intensity, controlling for differences across industries in materials intensity, and including a larger number of firms in the sample. The first two are of particular interest given that both the capital-to-labour ratio and materials-to-labour ratio appear as determinants of labour productivity in equation (4). We adopt the approach of using proxy variables to identify various sub-samples of firms that are grouped by capital or materials intensity, and then re-estimating the specification on these sub-samples.

A rough proxy for capital intensity is available from the data, but it is likely to be measured with substantial error.[17] Plotting capital intensity across the sample reveals a high concentration of firms and observations with values between 0 and 1, and a long right tail with a small proportion of relatively high values of capital intensity. The results in Column 2 are based on omitting roughly the top 20% of the overall distribution from the sample as well as observations where imputed capital share is not available. There is no proxy for materials intensity available from firm-level data, but we construct weighted two-digit industry level ratios of the value of material inputs to total turnover and use this variable as a rough proxy for the unobserved firm-level measure. We experiment with a range of threshold points, and report results in Column 3 obtained by excluding approximately the top 20% of the overall sample by material share. Column 4 expands the estimating sample to include an additional set of firms for which data are available over the shorter period 1988-93.

While there is some variation in the magnitudes of the coefficient estimates across specifications, the key determinants of labour productivity are found to be qualitatively unchanged. In each case, the results point to the importance of domestic and international competition, and the effects of these variables on labour productivity is comparable. In addition, in each case an F-test of the restriction that the coefficients are equal for firms in industries with high and low concentration is rejected with a p-value of less than 0.0001. We now turn to an analysis of labour productivity that is based on estimation of a first-difference transformation of the model.

### *5.2. Econometric results from estimation in first differences*

Table 4 reports regression results obtained after a first-difference transformation of the specification in levels. As with the levels results, Column 1 of Table 4 gives the main results, while Columns 2 – 4 give the results of three sensitivity checks. Estimation is by OLS since the first-difference transformation removes the unobserved firm-specific effects. In addition, the time trend collapses to a constant and the time trend interacted with concentration collapses to the concentration ratio alone. Thus, the coefficients on the constant and

[17] Capital stock is approximated by the value of tangible assets minus current assets.

concentration are directly comparable to the coefficients in the levels specification for the time trend and the time trend times concentration, respectively.

Focusing first on Column 1 in the top half of Table 4, we find that all of the coefficient estimates are very similar to the estimates from the corresponding level results for relatively high concentration firms. The rate of change of labour productivity is positive but smaller in magnitude the larger is the degree of industry concentration. As well, the positive effect on labour productivity of a decrease in local share of domestic industry is larger for firms in industries with high concentration.

For firms in industries with relatively low concentration, the signs and magnitudes of the coefficient estimates are again comparable to the corresponding levels results from Table 3. However, the impact of concentration on the rate of change of labour productivity is no longer significant. Overall, as with the results contained in Table 3, it appears that the effects of domestic and international competition on labour productivity are significantly larger for firms in industries with high concentration. Results for the other covariates – the aggregate unemployment and export share – are also comparable to the levels results. Labour productivity growth is procyclical and labour productivity growth is positively related to positive changes in export share, with the latter result being unique to firms in industries with low concentration. An F-test rejects the hypothesis that the coefficients on the competition variables are the same across the concentration sub-samples of firms, with a p-value of 0.0132.[18]

Our results on the interaction of domestic concentration and import penetration parallel those found by MacDonald (1994) in estimates of influences on the first differences of labour productivity for US manufacturing industries. In both cases, improvements in productivity occur with increased import penetration only when domestic industry concentration is above some critical level. Also, the size of the productivity improvement rises substantially with the level of concentration. This suggests some generality to the proposition that exposure to import competition forces efficiency on producers who would otherwise be insulated from domestic competition. However, this finding has greater importance for understanding overall

[18] Again, this specification test allowed for separate coefficients on the other variables in the regression for both low and high concentration firms.

productivity performance in Australia than in the US, given the generally higher levels of industry concentration in a substantially smaller domestic market.

**Table 4: Econometric Results - Estimation in 1st Differences**

| High Concentration Firms [CR > .495] | Balanced panel | Capital intensity <.75 | Materials intensity <.62 | Expanded panel |
|---|---|---|---|---|
| Constant | .2991** | .1644 | .4466** | .3052** |
| | (.128) | (.106) | (.190) | (.118) |
| Δ(DS) | .1653** | .1782** | .2476** | .1385** |
| | (.068) | (.059) | (.092) | (.055) |
| CR | -.4508* | -.2011 | -.7261** | -.4696** |
| | (.240) | (.194) | (.357) | (.218) |
| ΔDS*CR | -.3231** | -.3317** | -.4779** | -.2714** |
| | (.129) | (.110) | (.174) | (.103) |
| ΔXS | -.6800 | -.3471 | -.8069 | -.1839 |
| | (.544) | (.549) | (.563) | (.443) |
| ΔUE | -3.4794** | -3.5467** | -2.8766** | -4.5112** |
| | (1.059) | (.949) | (1.120) | (1.037) |
| Number of Observations | 1080 | 803 | 930 | 1404 |
| Number of Firms | 108 | 93 | 93 | 162 |

| Low Concentration Firms [CR < .495] | Balanced panel | Capital intensity <.75 | Materials intensity <.62 | Expanded panel |
|---|---|---|---|---|
| Constant | .1335** | .1473** | .1187* | .0491 |
| | (.065) | (.062) | (.073) | (.051) |
| Δ(DS) | .0607 | .0156 | .0343 | .0599* |
| | (.048) | (.045) | (.047) | (.035) |
| CR | -.2543 | -.2494* | -.1988 | -.0339 |
| | (.161) | (.151) | (.187) | (.126) |
| ΔDS*CR | -.1783 | -.0613 | -.1060 | -.1690* |
| | (.125) | (.116) | (.123) | (.090) |
| ΔXS | 1.5095* | .6700 | 1.0868 | 1.5377** |
| | (.797) | (.744) | (.911) | (.618) |
| ΔUE | -2.6754** | -1.8269 | -3.0782** | -3.2841** |
| | (1.170) | (1.176) | (1.363) | (.916) |
| Number of Observations | 1570 | 1315 | 1220 | 2260 |
| Number of Firms | 157 | 149 | 122 | 272 |

Notes: Robust standard errors are given in parentheses. A double (single) asterisk indicates that an estimated coefficient is significantly different from zero at the 5% (10%) level using a two-tailed t test.

Columns 2 and 3 show that the key results are robust to the rough controls we employ for differences in capital intensity and in the ratio of material inputs to revenue. While again some sensitivity in the magnitudes of estimated coefficients to the sample specification is evident, the results are qualitatively similar to those reported in Column 1. This is also the case when the sample is expanded to include a short panel of firms over the period 1988-93. For each specification in Columns 2-4, F-tests reject the hypothesis that the coefficients on the competition variables are constant across sub-samples of firms, with p-values of 0.0401, 0.0107 and 0.0232, respectively.

In results not reported here, we also experiment with the inclusion of a lagged dependent variable to capture persistence in the rate of change of labour productivity. Since the lagged dependent variable is correlated with the transformed disturbance term, it needs to be instrumented in order to obtain consistent estimates. Suitable instruments include the levels and lags of the exogenous variables as well as log-labour productivity lagged two periods. (See Keane and Runkle, 1992 for further discussion.)

The coefficient on the lagged dependent variable is found to be positive and significant (with a coefficient around 0.6 for both sub-samples), indicating a degree of persistence in shocks to labour productivity. Other results are qualitatively unaffected, with two exceptions. First, the coefficient on concentration in the sample of firms with low concentration is markedly reduced in magnitude but retains its negative sign. Second, for firms in both low and high concentration industries the impact of the unemployment rate on labour productivity is no longer significant.

In order to better understand the estimated impacts of concentration and local share of industry, we use the results in Column 1 of Table 4 to predict the change in log-labour productivity (or the productivity growth rate) over the range of values of the explanatory variables present in the sample. These predictions are contained in Table 5a and 5b, for firms in high concentration industries and low concentration industries, respectively. Each cell of the table gives the predicted labour productivity growth rate for a given level of industry concentration and a given change in the local share of the domestic market. The final row and final column of each Table contain differences in the predicted change in log labour productivity across firms with different industry characteristics. Standard errors are given in parentheses.

**Table 5a: Predicted Log Labour Productivity–First Differences (high concentration industries)**

| Percentage Point Change in DS | | Concentration Ratio (1) 0.5 | (2) 0.55 | (3) 0.6 | (4) 0.65 | Difference between Col (4) and Col (1) |
|---|---|---|---|---|---|---|
| (1) | –3 | 0.0631** | 0.089** | 0.1149** | 0.1408** | 0.0777 |
| | | (.023) | (.018) | (.026) | (.040) | (.050) |
| (2) | -2 | 0.0666** | 0.07635** | 0.0861** | 0.09585** | 0.0293 |
| | | (.019) | (.015) | (.020) | (.029) | (.037) |
| (3) | -1 | 0.0701** | 0.0637** | 0.0573** | 0.0509** | -0.0192 |
| | | (.016) | (.013) | (.017) | (.025) | (.031) |
| (4) | 0 | 0.0736** | 0.05105** | 0.0285 | 0.00595 | -0.0677* |
| | | (.014) | (.012) | (.020) | (.030) | (.036) |
| (5) | +1 | 0.0771** | 0.0384** | -0.0003 | -0.039 | -0.1161** |
| | | (.015) | (.014) | (.027) | (.042) | (.049) |
| (6) | +2 | 0.0806** | 0.02575 | -0.0291 | -0.08395 | -0.1646** |
| | | (.017) | (.017) | (.035) | (.056) | (.065) |
| (7) | +3 | 0.0841** | 0.0131 | -0.0579 | -0.1289* | -0.2130** |
| | | (.020) | (.021) | (.045) | (.071) | (.082) |
| Difference between row (1) and row (4) | | -0.0105<br>(.016) | 0.0380**<br>(.015) | 0.0864**<br>(.031) | 0.1349**<br>(.049) | |

Notes: Standard errors are given in parentheses. A double (single) asterisk indicates that an estimated coefficient is significantly different from zero at the 5% (10%) level using a two-tailed t test.

**Table 5b: Predicted Log Labour Productivity–First Differences (low concentration industries)**

| Percentage Point Change in DS | | Concentration Ratio (1) 0.3 | (2): 0.35 | (3): 0.4 | (4) 0.45 | Difference between Col (4) and Col (1) |
|---|---|---|---|---|---|---|
| (1) | -3 | 0.0345 | 0.0485** | 0.0625** | 0.0765** | 0.0420 |
| | | (.033) | (.020) | (.017) | (.028) | (.052) |
| (2) | -2 | 0.0421* | 0.0472** | 0.0523** | 0.0574** | 0.0153 |
| | | (.024) | (.016) | (.014) | (.020) | (.035) |
| (3) | -1 | 0.0497** | 0.0459** | 0.0421** | 0.0383** | -0.0114 |
| | | (.019) | (.014) | (.012) | (.015) | (.024) |
| (4) | 0 | 0.0573** | 0.0446** | 0.0319** | 0.0192 | -0.0381 |
| | | (.021) | (.015) | (.013) | (.015) | (.024) |
| (5) | +1 | 0.0649** | 0.0433** | 0.0217 | 0.0001 | -0.0648* |
| | | (.027) | (.019) | (.016) | (.021) | (.035) |
| (6) | +2 | 0.0725** | 0.042* | 0.0115 | -0.019 | -0.0915* |
| | | (.036) | (.024) | (.020) | (.029) | (.052) |
| (7) | +3 | 0.0801* | 0.0407 | 0.0013 | -0.0381 | -0.1182* |
| | | (.047) | (.029) | (.025) | (.038) | (.069) |
| Difference between row (1) and row (4) | | -0.0228<br>(.035) | 0.0039<br>(.020) | 0.0306<br>(.030) | 0.0573*<br>(.030) | |

Notes: Standard errors are given in parentheses. A double (single) asterisk indicates that an estimated coefficient is significantly different from zero at the 5% (10%) level using a two-tailed t test.

Three main results are evident. First, holding local share of domestic market constant, firms in industries with higher industry concentration have lower rates of productivity growth, but this difference is significant only for firms in relatively highly concentrated industries. Second, declining local share of domestic market results in significant increases in the rate of growth in labour productivity for high concentration firms. Third, the larger the decline in the local share of domestic industry, the bigger the increase in labour productivity at firms in industries with high concentration. With industry concentration very low at 0.3, the bottom of the concentration distribution, productivity growth actually rises with increases in domestic market share, although the difference is not significant. Overall, we find that increased exposure to imports leads to faster productivity growth as long as concentration of domestic producers is above some minimal level. Further, the improvement in productivity growth is greater the higher is concentration.

## 6. Conclusions

Our key finding is that exposure to import competition interacts with domestic competition in influencing the productivity performance of manufacturing firms in Australia. In particular, labour productivity rises with increased exposure to imports, as long as the concentration of domestic production exceeds some minimal level. The higher is the concentration among domestic producers, the greater is the improvement in productivity associated with increased exposure to import competition. This finding is robust to the change in econometric specification from regressions for productivity levels to regressions for first-differences. It is also robust to changes in the sample of firms.

This finding suggests the existence of slack in Australian manufacturing firms that have been protected from domestic competition in the small domestic market with few producers and protected from foreign competition by high levels of border protection. Progressive reductions in border protection over the past three decades have increased import penetration, with domestic producers responding by reducing the slack that their previously protected positions had permitted. The resulting gains in productive efficiency are estimated to be substantial, providing a strong rationale for the pursuit of trade reform in industrialized countries with small domestic markets.

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