DISCUSSION PAPERS

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SCALE, OPENNESS AND PRODUCTIVITY
IN AUSTRALIAN MANUFACTURING INDUSTRIES

Richard E. Caves
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G.P.O. Box 4, Canberra 2601, Australia
SCALE, OPENNESS AND PRODUCTIVITY
IN AUSTRALIAN MANUFACTURING INDUSTRIES*

Richard E. Caves
Harvard University

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Australia's key concern about its manufacturing sector has long been the small operating scales that could be attained in small and isolated markets. The national market is limited to a population of 15 million, and even that is fragmented among far-flung capital cities dotted around the edges of a thinly populated continent. However, the nation's great distance from traditional exporters of manufactures (and potential customers for Australian exports) probably supplies enough natural protection to support a diversified, small-scale manufacturing industry. Therefore, the scale and composition of manufacturing industry to a significant degree result from natural forces.

But unnatural forces are present as well. Through much of their history Australians have embraced enough tariff protection to roughly double the isolating effects of international transport costs. Other policies have preserved regional fragmentation and promoted the decentralization of manufacturing industry. To appraise the effects of these policies, we need to determine how natural and artificial forces contribute to constraining the scales and productivity levels that can be attained in Australian manufacturing.

The prospect of booming exports of natural resources underlines the importance of these long-term constraints on productivity. Even if Australia can draw freely on international capital markets to finance these massive investments, they compete with manufacturing and the rural sector for the services of the Australian labor force. (They also compete for labor with the large services sector, but it is mostly sheltered from
international competition and hence likely to expand to serve demand increased by the nation's growing real income. The nation as a whole enjoys improved terms of trade, but these increase the force of international competition for parts of the manufacturing sector and frustrate hopes for export markets in other parts.

This chapter is built around a statistical analysis of productivity and scale in Australia's manufacturing industries. The ideal way to measure the effect of these forces is to compare total factor productivity in Australian manufacturing to world 'best practice' in an ideal economy not subject to scale constraints (or other impediments that may stem from Australian institutions). But that economic utopia reveals itself only imperfectly in the markets of other national economies. Therefore, repeating a research maneuver employed recently on Canada and Great Britain, we proceed as follows: Match as many Australian manufacturing industries as possible to their counterparts in the United States. For variables that indicate the productivity levels and operating scales of the Australian industries relative to their U.S. counterparts. Test hypotheses about influences on Australian productivity (or scale) by their association with variations in individual industries' relative performance levels. We first discuss the prevailing evidence on these hypotheses, then explain the details of the statistical design and report the results.

STRATEGIC INFLUENCES ON PRODUCTIVITY

The strangling limitation on productivity for Australian manufacturing lies in the difficulty of attaining economies of scale. Research in industrial organization finds increasing returns over some output range in essentially all manufacturing production functions. For most products these returns stop increasing at plant or firm sizes that are modest by standards of the United States market. But modesty in America is
extravagance in Australian: minimum efficient scales in cost manufacturing industries will count for large shares of the Australian market.\textsuperscript{2}

Likewise, the unit costs associated with operating at small (suboptimal) scales may be only slightly inflated in some industries while containing heavy penalties in others. Scale economies might seem to pose no problem for a small economy that is open to international trade. Activities are carried on either at efficient worldwide scales, with part of the output exported, or not at all. The problem arises for products which, if produced in Australia, are imperfect substitutes in the eyes of local buyers for goods produced elsewhere in the world. Imperfect substitutes can mean anything from nontraded goods—bricks and haircuts—to tradable homogeneous manufactured goods for which the local producer may enjoy some advantage in flexibility of delivery or the provision of auxiliary services.

Where Australian goods are imperfect substitutes for imports, Australian producers as a group face a downward-sloping demand curve. If the domestic producers' outputs are differentiated from each other (by product characteristics or location), each Australian producer faces a downward-sloping demand curve. If scale economies in production are significant, the plants scales selected by producers are unlikely to exhaust these. Advocates of tariff protection often acknowledge this problem but then leap to the conclusion that tariffs help to solve it: raising the delivered price of imports shifts outward the demand curves for Australian substitutes and increases their scales of production. That outcome is possible but not at all necessary. If the product is indeed differentiated, then excluding imports simply makes room for more domestic substitutes produced at small scale to replace varieties produced efficient
scales abroad. What deters efficient-scale production, then, is a combination of substantial scale economies, differentiation of domestic firms from foreign producers, and (artificial or natural) protection of domestic producers. We shall test the hypothesis in just that interactive form.

The evidence suggests that this model fits Australia's manufacturing sector comfortably. First, it implies a bias of the size distribution of manufacturing plants toward small scales. Data on plant-size distributions by employment are available for most countries, and Table I reports a comparison of Australia to the United States, United Kingdom and Canada.

It concentrates on 1977 but, because the published Australian data are severely aggregated in the upper tail, an unpublished tabulation for 1972-73 is also shown. The most interesting comparison is between Australia and similar-size Canada, which has 70.3 percent of its manufacturing employment in plants employing 100 or more, while Australia has only 61.9; comparable figures for Britain and America are 79.8 and 74.6. Industry mix and census definitions may account for part of the difference, but they are most unlikely to explain all of it. Conlon's investigation of matched Australian and Canadian industries confirms this difference. He found that small plants are significantly more prevalent in the Australian industries, along with other marks of small size and isolation such as higher ratios of wages and salaries to value added and of inventories to shipments.

One encounters the view that productivity in Australian manufacturing suffers not only from small size but also from excessive diversification and short production runs. Unfortunately, the detailed data necessary to compare the diversities of plants' outputs internationally are unavailable. Still, one analytical point almost suffices to confirm the proposition. Building a small plant and building a diversified plant are alternative
Table 1. Size Distributions of manufacturing establishments in Australia, Canada, Great Britain, and United States, by employment, various years (percentages)

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<tr>
<td>0 - 19</td>
<td>14.13</td>
<td>13.20</td>
<td>6.74</td>
<td>6.94</td>
<td>6.51</td>
</tr>
<tr>
<td>20 - 49</td>
<td>12.10</td>
<td>12.67</td>
<td>10.74</td>
<td>6.18</td>
<td>8.74</td>
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<tr>
<td>50 - 99</td>
<td>11.43</td>
<td>12.24</td>
<td>12.20</td>
<td>7.05</td>
<td>10.10</td>
</tr>
<tr>
<td>100 - 199</td>
<td>14.87</td>
<td>16.97</td>
<td>9.37</td>
<td>18.02</td>
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<tr>
<td>200 - 499</td>
<td>20.07</td>
<td>21.31</td>
<td>16.19</td>
<td>15.59</td>
<td></td>
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<tr>
<td>500 - 999</td>
<td>10.59</td>
<td>13.75</td>
<td>13.28</td>
<td>13.54</td>
<td></td>
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<tr>
<td>1,000 +</td>
<td>16.81</td>
<td>18.29</td>
<td>40.99</td>
<td>27.49</td>
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*The break in the United States distribution comes at 250 rather than 200.

ways to adapt to limited demand in a small market. If Australian plants of a given size are more diversified than similar-size plants elsewhere, that is because the alternative open to Australian managers is to make their plants more specialized but smaller still.5

Now we turn to some strategic influences on scale and productivity in Australian manufacturing. The first is the protection received by Australian manufacturing—both natural protection from transportation costs and artificial protection from trade restrictions. Although ocean transportation costs do not increase strongly with distance, Australia’s distance from major exporters of manufactured products is great indeed. In 1974 the median manufacturing industry received international transport-cost protection equivalent to a 14.4 percent tariff (the weighted mean was 18.6 percent). Australian exports are similarly constrained: transportation costs to the United States have been estimated to impose twice as large a barrier to Australian exports as do U.S. tariffs. The ad valorem tariff equivalents of transport costs tend to be lower on more highly fabricated goods. Therefore, in contrast the the typical tariff structure, effective rates of natural protection (that is, protection of Australian value added) are lower than nominal rates. The median (weighted mean) in 1974 was 10.3 (9.7) percent.6 Once more, a comparison to Canada is revealing: in 65 matched manufacturing industries, nominal and effective rates of transport-cost protection are both four times as high for the Australian industries.7 These rates of natural protection were, however, falling a bit in the 1970s, even with energy prices rising.8

Australia has chosen to heap artificial tariff protection atop this high natural protection. Comparative data for 1975 in Table 2 show that the weighted average and standard deviation of Australia’s nominal tariff
## Table 2. Imports - weighted averages and standard deviations of tariff rates on manufactures, Australia and selected countries, 1975 (percentages)

<table>
<thead>
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<th>Average MFN rate, weighted by country's imports</th>
<th>Standard deviation of MFN rates weighted by country's imports</th>
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<tbody>
<tr>
<td>Australia</td>
<td>13.4</td>
<td>20.6</td>
</tr>
<tr>
<td>Canada</td>
<td>7.5</td>
<td>8.2</td>
</tr>
<tr>
<td>European Community</td>
<td>7.5</td>
<td>5.9</td>
</tr>
<tr>
<td>Japan</td>
<td>11.0</td>
<td>18.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>5.4</td>
<td>4.5</td>
</tr>
<tr>
<td>United States</td>
<td>5.8</td>
<td>7.3</td>
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Source: Information from General Agreement on Tariffs and Trade compiled by Industries Assistance Commission, Annual Report 1977-78, Table 1.3.3.
rates both substantially exceeded those of the other countries shown (only Japan is close). The Australian tariff has generated a hill of evidence and a mountain of controversy; from these we extract a few traits that are important for the tariff’s effects on productivity. Until a decade ago, the country embraced the principle of made-to-measure protection, freely sheltering manufacturing industries with tariffs that would let some domestic producers cover their costs in competition with imports. That practice implies that a sector’s tariff rate should be higher, the less well suited for that activity is a thinly populated country rich in natural resources. Accordingly, studies of interindustry differences in protection have found that higher rates of assistance are given to low-skill, labor-intensive industries with simple technologies. High protection has gone to large industries, perhaps due to their weight in the political calculus.

When the Industries Assistance Commission replaced the Tariff Board in 1973, the government committed itself to making rates of duty both lower and less varied among industries (and thus reducing the interindustry misallocation of resources). A tariff cut of one-fourth across the board put the principle dramatically into practice. As the 1970’s proceeded and economic conditions deteriorated, Australia along with other countries slipped into providing distressed sectors with expedient protection by means of quantitative restrictions, allegedly temporary. Average effective rates of assistance (covering the gauntlet of tariffs, quotas, subsidies, etc.) did fall from 36 percent in 1968-69 to 26 percent in 1977-78. Without the replacement of tariffs by quotas, the fall would have been to 22 percent, with the majority of the 14-point decline due to the across-the-board reduction. Thus, the average level of protection has been
lowered somewhat, but stopgap measures have probably kept its variance from shrinking appreciably.\textsuperscript{12} International comparisons provide clinching evidence on the wide dispersion of Australian tariff rates: For other countries the correlations between tariff rates and import shares of domestic markets are typically positive, implying that the higher tariff rates only partially offset the comparative disadvantage of the most sheltered domestic producers. For Australia, however, the association runs the opposite direction: imports claim smaller shares in the most protected markets.\textsuperscript{13} Thus, made-to-measure protection has survived with a vengeance, so that high tariff rates do attain prohibitive levels. Even with the decline in average rates of assistance, the ratio of total trade to gross domestic product for Australia not only stands lower than for other OECD countries but also fell between 1960-62 and 1973-75 for Australia while rising for all the others.\textsuperscript{14}

The finishing twist to this tale of small size and restricted trade is the Australian market's regional fragmentation, which protects the various state-capital manufacturing centers from one another. Once again, a combination of natural and artificial forces is at work. The basic problem lies in the small population spread around the edges of the continent. However, policy choices have compounded it. Coastal shipping has suffered the high costs and cartelization that result from excluding international competition, and the railroad system has been balkanized under the control of the state governments.\textsuperscript{15} The transport system's inefficiencies have been partly sorted out, but their historical influence on industrial location will long persist. States' policies of subsidizing local industrial development have promoted branches of each industry in each manufacturing sector.\textsuperscript{16} As a consequence, Australia's manufacturing centers are surprisingly nonspecialized, and the typical industry is spread
rather evenly amongst them. These factors add another important deterrent to efficient scales of production.

Industrial Organization and Competition

Outside the nexus of small markets, differentiated products, and high protection, several other factors seem strategic for industries' productivity performance. Competitive conditions require a gingerly treatment in the Australian context, because they depend on the factors of size and openness already discussed. These factors limit both the numbers and absolute sizes of firms operating in Australian markets. Accordingly, producer concentration is higher than it would be in larger markets, such as the United States, although not nearly so much higher as it would be if average firm sizes in Australia and America were the same. For each of 120 industries used in the statistical analysis that follows, we calculated the ratio of the share of shipments originating by the four leading Australian producers to that originated by the four leaders in the U.S. counterpart industry. The mean of these ratios is 1.78, and that figure is biased downward.

The statistical evidence affirms that producer concentration depends on plant scale economies (relative to market size) and on import competition. However, contrary to what one might expect, plant scale economies do not account for much of the high levels of producer concentration found in Australia. The leading firms in many industries operate more than one plant, in part due to scale economies that extend to multiplant operation (that is, to the firm's nonproduction activities, and to multiplant coordination). Another empirical pattern reveals further consequences of scale economies: the more concentrated the industry, the smaller are the leading firms' plants relative to other
plants in the industry, and the smaller is the difference between the extents of leading firms' and other firms' multiplant operations. This pattern, also found in Canada, implies that the more concentrated the industry, the more likely do the leading firms and their smaller rivals operate similar numbers of similar-size plants. That is consistent with minimum firm size in the more concentrated industries being constrained more tightly by economies of scale to either plant or firm.

This pattern has several consequences. First, high producer concentration should exhibit at most a weak association with excess (monopoly) profits, because potential profits may be squeezed out between high costs (diseconomies of small scale) and demand rendered elastic by import competition. That prediction is consistent with the erratic statistical significance found for concentration in applications of the convention (large-economy) model of profit determinants to the Australian manufacturing sector. It is also consistent with the evidence that the intensity of international competition affects the process of price adjustment in the short run, after account is taken of the competitive structure of domestic sellers.

Nonetheless, producer concentration remains a potential influence on productivity, even if that influence is complex. On the one hand, given scale economies and other influences, high concentration implies that more efficient scales of production and higher productivity are being achieved. On the other, productivity can be affected adversely by patterns of market behavior to which highly concentrated producers are prone. Collusive price-fixing was largely free of legal restraint in Australia at least until 1974, and thus a history of easy access to price-fixing permeated the market conditions prevailing at the time chosen for our statistical
Agreements to fix prices and divide markets have been widespread. Such agreements can have many adverse effects on productivity. They include the entry of inefficiently small competitors beneath the fixed-price umbrella; the expansion of capacity in too-small increments or in the wrong locations; the retention of excess capacity to exploit collusively inflated price-cost margins; and various other resource-using forms of nonprice competition. In conclusion, many industries are concentrated enough to hold the potential for noncompetitive market behavior. And high concentration bears an uncertain relationship to relative productivity, because noncompetitive behavior in concentrated industries can impair productivity, while concentration as a response to a given state of scale economies can improve it.

Productivity may be affected by other aspects of business organization, such as the motives and qualities of business management. The balance of evidence from other countries favors the view that closer control of large enterprises by cohesive owners or groups leads to closer supervision of managers and less inefficiency through slippage in the "agency" relation. Because Australia’s leading firms are smaller and (apparently) less diversified than the largest enterprises in other industrial countries, one expects fewer of them to have escaped from effective control by their owners. Because of the prevalence of enterprises under overseas control, the published estimates cannot be compared to those for (say) the United States and Great Britain. Still, only 35 percent of 226 large companies were under managerial control in 1974-75, while 34.5 percent fell under minority or majority owner control and the remaining 30.5 were controlled by other corporations (foreign or domestic). In the United States, 82 percent of the 200 largest nonfinancial publicly held companies were under management control in 1974. Even without formal
control by owners, executive compensation schemes may serve to motivate business managers to maximize profits (minimize costs). These plans, however, seem less leveraged on the enterprise's profits in Australia than in the United States. Thus, managerial motives may or may not pose a problem for productivity.

The prevalence of multinational enterprises in Australia yields a similarly ambiguous influence. In 1975-76 foreign-controlled members of the largest 200 enterprise groups accounted for 22 percent of all value added in manufacturing, so their net effect on productivity is an important question. The favorable side is their documented ability to speed the transfer of overseas technology and diffusion of efficient methods of business operation. As we expect, the evidence confirms that technology reaches Australia more freely through intracorporate transfers than through the imperfect market for arm's length technology transfers. The unfavorable side lies in their very facility for operating at small scales behind the Australian tariff. Their presence is fostered by trade barriers that deter serving the market through exports, and their possession of proprietary intangibles (marketing skills, trademarks, technical knowledge) make them viable at smaller scales of operation than native firms would be. Because of that prowess, they might on balance lower productivity.

Research and Technology Transfer

The link between research and productivity in Australia runs beyond the multinational-company connection, just mentioned. Although a country's policies typically focus on research undertaken within its boundaries, the bulk of the technology used by most countries originates abroad. That pattern certainly holds for Australia, where more than nine-tenths of
patents issued and payments made for technical knowledge go to foreigners. No evidence suggests that Australia lags beyond other countries in the diffusion of innovations. Correspondingly, much of the research and development undertaken commercially in Australia serves to adapt technology from abroad, especially that secured from foreign affiliates. Some 70 percent of Australian R&D spending is on development, and independent firms undertake even less basic research than do foreign subsidiaries. Australia's national rate of R&D spending is typical of the small industrialized countries. That aggregate rate suggests no particular problems for the contribution of local research to productivity. However, a controversy circles around the extent to which R&D funds are government-provided and carried on in government laboratories. The dominant organization, Commonwealth Scientific and Industrial Research Organization, has been attacked for lacking a mechanism to interact with users of technology and spreading its resources thinly (agricultural research excepted) over a number of industrial areas. Thus, we do not expect Australian productivity to be especially deficient in high-research sectors, but it may nonetheless be true that national research outlays are not ideally allocated.

Labor Relations

A degenerate state of labor-management relations is a clear candidate for negative influence on productivity—one that has been confirmed statistically in the case of Britain. Observers familiar with the British scene have in turn suggested that Australia's labor-relations system may harbor some potential for impairing productivity in sectors subject to high levels of union membership. The highly unionized Australian manufacturing sector does not suffer from heavy wastage of
resources due to long strikes, but it does experience a lot of short
strikes, which (in Britain, at least) seems to impair productivity by
increasing the uncertainty of plant scheduling, inflating needed inventory
levels, and the like. Also, the fragmentation of Australia's unions
generates friction over jurisdictional issues. The arbitration system may
contribute to a productivity problem by putting wage determination in a
different sphere of decision-taking from non-wage questions, which have a
greater potential for affecting productivity. Wage determination is swept
up into the arbitration mechanism while the non-wage issues, often specific
to the workplace environment, are left aside. Thus, it seems
possible that troubled labor relations are associated with impaired
productivity in Australian industries.

Labor-market conditions are sometimes associated with another issue of
Australia's productivity performance—the ease with which resources can be
reallocated among sectors. An economy's allocation of resources among
sectors is efficient if rates of return to units of a given factor of
production are equalized in its various uses. In the short run, the rates
at which divergences are eliminated is subject to its own efficiency
conditions. If sticky resource misallocation persists, the blame can rest
on several doorsteps—labor, management, capital markets, or public policy.
The economy's ability to get resources into their best uses affects not
just the maximum real income the economy can attain at any one time but
also the rate at which it can grow, because the effective seizure of
expanding high-return opportunities then translates into high marginal
returns to increases in the economy's stock of factors of production.

Australian observers have appreciated this point and undertaken
some research on structural adjustment in the economy. By and large, it
turns up no specific malfunctions. True, the variability from year to year of the industry mix in the manufacturing sector seems to have shown a long-run decline, at least until 1973-74. And over the period 1963-73 the dispersion of the growth rates of ten major manufacturing sectors was smaller for Australia than for most other countries, although the conclusion ceases to hold if one moves the starting point back to 1950. To the extent an international difference in resource mobility exists, a sufficient explanation is Australia's high levels of natural and artificial protection, which force sectoral growth into closer alignment with the generally stable growth of domestic demand. It is not clear whether the decline in intersectoral movement over time is unique to Australia or typical of maturing industrial economies. In any case, research specifically addressed to the intersectoral movement of labor has established an apparently high level of interindustry mobility and one that is unrelated to industries' rates of assistance (tariffs, subsidies, etc.).

Our statistical analysis of productivity determinants accordingly will not develop this angle of adjustment capacity beyond the static role of tariff protection already outlined.

DETERMINANTS OF RELATIVE PRODUCTIVITY

The hypotheses raised above were tested by matching as many Australian manufacturing industries as possible to their U.S. counterparts and testing for the factors associated with good or poor relative performance. The two countries' standard industrial classifications match fairly well and provide a total of 158 paired industries, although missing data leave us many fewer usable observations. The determinants of their relative levels of labor productivity will be analyzed using data for 1973. Productivity is a relationship between output and the inputs producing it
when all are valued at their social opportunity costs. Conceptual problems arise for measuring productivity and testing its determinants within a consistent framework. The solutions that we employ are taken over from previous research and receive only a brief explanation here.

Research Design

The first problem that we face is how to value output at social opportunity cost when tariffs permit domestic prices to be inflated above the world prices. We assume (provisionally) that each domestic price in equilibrium equals the world price plus the nominal tariff for each output and purchased input. Then it can be shown that physical productivity per employee (with inputs and outputs valued at world prices) in the protected industry, $E_d$, physical productivity in some external "world industry," $E_w$, value added per employee as measured in the protected industry, $V_d$, and the protected industry's effective rate of tariff protection, $\tau_d$, are subject to the following simple relationships:

\[
\frac{e_d}{e_w} = \frac{V_d}{V_w (1 + \tau_d)}
\]

If the comparison is made not to value added per employee in some mythical world industry ($V_w$) but to a specific foreign country with its own tariff structure, then the relationship becomes the following $u$-subscripts indicating the foreign reference country:

\[
\frac{e_d}{e_u} = \frac{V_d (1 + \tau_d)}{V_u (1 + \tau_u)}
\]

The assumption that domestic producers always set prices equal to the world price plus the tariff is, of course, one that should be verified rather than taken on faith. Depending on the industry's comparative disadvantage, its competitiveness, and the elasticity of demand that it faces, the equilibrium domestic price may fall below this benchmark in
industries for which competing imports in equilibrium are in fact small. Two strategies are available for dealing with this problem. Some investigators have had access to actual market prices in the economy under study, allowing them to convert relative outputs directly into real terms. Others who lacked relative price data have constructed their basic dependent variable by the procedure just outlined but then tested the significance of explanatory variables indicating the degree that domestic sellers fail to price up to the world price plus the tariff (and therefore appear less productive than they really are). We follow the second strategy in this study. The dependent variable thus is the ratio of value added per employee in the Australian industry to that of its U.S. counterpart (converted to Australian dollars), and the effective protection rate used for Australia includes transportation costs and nontariff barriers (that for the United States includes only tariffs).

The other problem with the research design lies in reconciling the productivity measure of net output per unit labor input with the presence of other inputs in the production function. We expect producers to employ labor, capital, and other inputs so as to minimize the costs of whatever outputs they choose to produce. We need both to take other inputs into account and to reconcile the cross-section statistical analysis with the presumption that each industry has its own function. The solution developed by Davies and Caves is described here in general terms. Assume that each industry (Australian or American) operates on the same Cobb-Douglas production function, written in terms of net output, capital, and labor. Divide through by labor input, so that net output per unit of labor input is related to the capital-labor ratio. Control for the possibility that returns to scale in the plant are not constant (that is,
the output elasticities of the Cobb-Douglas function do not sum to one) by allowing net output per unit of labor input to depend on the size of the typical plant as well as the capital-labor ratio and the catch-all efficiency term. Now, divide the equation for the Australian industry by the corresponding one for its U.S. branch. For the \( j \)th industry in question, we have

\[
VPW_j = \left( \text{EFF}_j \right)^{\alpha} \left( \text{CAP}_j \right)^{\beta} \left( \text{TP}_j \right)^{\gamma} - 1
\]

where \( VPW_j \) indicates value added per employee in the Australian industry divided by value added per employee in the U.S. counterpart; \( \text{CAP}_j \) is assets per employee in the Australian industry divided by assets per employee in the counterpart; and \( TP_j \) is median plant size in the Australian industry divided by median plant size in the counterpart. \( \text{EFF}_j \) is the ratio of the two efficiency terms, and it accounts for all labor-productivity differences between the two countries that are not due to capital inputs or plant scales.

This equation provides an attractive starting point for the cross-section analysis of the determinants of relative productivity. The role of relative plant size, emphasized in the preceding discussion, enters in a natural way through \( TP_j \), and the term \( \text{EFF}_j \) can be expanded to include our other hypotheses about the determinants of relative efficiency. If we can justify applying the model to a sample of diverse industries, we need only add a disturbance term, take logarithms, and it is readily estimated statistically. However, as the equation makes clear, such a procedure amounts to assuming that all industries in both countries share a common production function. That assumption is quite dubious. We cannot abandon it totally, but we can relax it a good deal without much complicating the statistical procedure.

First, suppose that all Australian industries share the same Cobb-
The Douglas production function, as do all American industries, but the
Australian and American functions differ. We need only add two more terms
to the model—the values of $TF$ and $C_P$ for Australia alone, alongside the
ratios. Significant regression coefficients for the Australian terms will
indicate the differences between the Australian and American values of
$\alpha$ and $\delta$. Second, suppose that each industry's Australian and American
branches share the same production function, but some industries' coefficients differ from the common values of $\alpha$ and $\delta$. This difference can
be handled by adding slope shifts to the model for those industries thought
to differ from the typical patterns of factor intensity and returns to
scale. For example, we might draw on general knowledge to nominate one
group of sectors as especially labor-intensive and free of scale economies,
another as especially capital-intensive and prone to scale economies. Of
course, we cannot embrace the possibility that every industry's production
function differs from all others, because the cross-section model then
breaks down.

We have so far treated capital as the assets shown on the books of
producers—the basis for measuring the variable $C_P$. However, the basic
model neglects another element of capital in the form of human resources,
because it makes no allowance for differences among industries in employees' average skills of training or, for that matter, even the amount of time
they work. These factors can be incorporated in various ways. For
example, skills and training can be counted as intangible stocks of capital
by capitalizing their rents and adding them the physical asset stocks.
However, an alternative procedure employed by Davies and Caves seems more
attractive. The production function should really be written in terms of
effective labor $L^e$ rather than the body-count $L$. $L^e$ is a weighted sum of
types of labor with different skills or training. When we estimate the
model using the inappropriate \( L \) rather than \( L^* \), we can avoid bias by
including terms that recognize the different weights applied to different
labor groups when they are aggregated into \( L^* \). Suppose, for example, that
the distinction between production and nonproduction workers captures some
of the actual difference in the amounts of human capital that industries
employ. Then, it can be shown that the difference between the percentage
of nonproduction workers employed in the Australian industry and its U.S.
counterpart should be added to the model. We can treat any other binary
distinction between labor-groups in skill or quality the same way. 49

Although short supplies of human capital have not been recognized as a
drag on Australian productivity levels, they may in fact exert one. The
country does not invest heavily in secondary education, and the expansion
of higher education is quite recent. The Industries Assistance Commission,
comparing the growth of Australia's real gross domestic output per capita
to other OECD countries, found the nation ranked at about the bottom
quartile not because total output had grown slowly but because population
had grown fast. The increasingly large female and immigrant components of
the labor force may be lowering the average skill level. Parry's
investigation of interindustry differences in labor productivity found
positive influence for the proportions of technical and managerial
personnel and negative influences for the proportions of technical and
managerial personnel and negative influences for the proportions of female
employees and persons born overseas. 50 If Australia's stock of human
capital is on the low side relative to the United States and the shortfall
varies among industries, then skill/quality differentials should prove
significant in our basic model. The difference between the Australian and
American ratios of nonproduction workers to total employees, \( NPW \), should
take a positive coefficient.

Influences on Relative Efficiency

The preceding variables complete what we count as the core of the model for explaining relative productivity and bring us to the variables that should indicate relative efficiency (EFF in the basic model). The first of these, described in general terms previously, takes account of the interacting effects of scale economies, small market size, and tariff protection. A subtle interaction is required, because Australia's potential productivity disadvantage increases with minimum efficient scale and the disadvantage of suboptimal-capacity producers so long as tariff protection makes inefficient capacity viable. If protection is inadequate to shelter suboptimal-capacity producers, however, the relationship turns around, and "severe" disadvantages of small scale force any viable local producers to achieve efficient operating scales. A suitable form for this interaction, suggested by Saunders, is as follows:

\[ SCLA = (K - EFFA) \times MESU/CDMU \times (DDA/DDA) \]

where EFFA is the Australian sector's rate of effective protection, MESU is minimum efficient scale inferred from data for the U.S. counterpart industry, CDMU an (inverse) indicator of the disadvantages of suboptimal-scale production (also inferred from U.S. data), and DDA/DDA is the size of the Australian relative to the U.S. market (measured by domestic disappearance). 51 K is a constant that must be determined inductively; it implicitly determines the protection level at which inefficient-scale domestic production becomes viable for any given state of scale economies and market size. Saunders secured a significant coefficient for this variable (positive, as expected) and concluded that the best fit resulted
from $k = 0.3$ as a threshold for effective protection in Canada.

Appropriately, given Canada's geography, he did not consider transportation costs. The variable EffA includes natural as well as artificial protection. We searched for the value of $k$ that yields the most significant coefficient for EffA by starting with that mean and then raising it by small fractions.

In the preceding discussion we expressed skepticism about disentangling the complex influences of competitive conditions on efficiency. On the one hand, producer concentration in Australia is itself determined by forces (embodied in EffA) that should strongly affect efficiency. On the other, complete collusive bargains that can impair efficiency have been widely legal in Australia, and so their presence may be fairly independent of Australian producer concentration above a low threshold. If a drag on efficiency results from noncompetitive behavior, it should be evident in those industries where concentration is not only high but also above a minimum threshold determined by scale economies. We employed:

\[
\text{CONC} = \text{C4A} + \text{C8RU} \cdot \text{EFFA}
\]

C4RS = residuals from a logarithmic regression of C4A on MESU expressed as a fraction of U.S. industry shipments and C8RU, multiplied by EFFA.

In these definitions C4A is the share of turnover in Australia accounted for by the industry's four largest producers; MESU is the ratio of shipments by the median-size plant in the U.S. counterpart industry to total shipments by the U.S. industry (a proxy for minimum efficient scale); and C8RU is the ratio of net output per employee in U.S. plants smaller than the industry median to output per employee in larger plants (an inverse proxy for the cost disadvantage of suboptimal scale). Thus, the
value of CONC increases with Australian producer concentration and with the extent of tariff protection in Australia (EFFD) and decreases with increases in the apparent productivity disadvantage of small units. Its coefficient should be negative. So should that of the alternative variable CNRS, with which we try by another route to identify Australian industries that are unconcentrated relative to the floor imposed by scale economies apparent in the United States. CONC embodies the assumption that an Australian industry's concentration must be high relative to the scale-economies threshold before it permits collusion that is dysfunctional for efficiency; CNRS assumes that the problem may arise for any Australian industry that is less concentrated than a constraint based on U.S. scale economies would suggest. Because these terms reflect producer concentration, they must receive two-tail tests in recognition of another behavioral factor. The concentration ratio could correct for an error in our assumption that Australian industries price up to the world price plus tariff and transportation cost. A competitive industry with not too great a comparative disadvantage might set a lower price and as a result appear inefficient by the test of our dependent variable. A term reflecting the concentration ratio, if it corrects for this factor, would take a positive coefficient.

A number of other hypotheses about relative efficiency were tested. However, to anticipate the outcome, none of them proved statistically significant, and so the tests will be summarized briefly. Economic growth in Australia prior to 1977 should influence the distribution of plant scales existing in that year. Suppose that an enterprise cannot alter a plant scale efficiently, once it is built, and therefore chooses the plant's initial scale with an eye to how soon the market's growth will
allow it profitably to achieve full utilization. Then the faster the market has been growing, the less incentive has prevailed for putting suboptimal plants in place. This hypothesis was tested with negative results using the ratio of the absolute growth of the Australian market over 1969-77 to apparent minimum efficient scale. The available data restrict us to this shaky embodiment of the hypothesis, which covers too short a period and employs no control for the ease of enlarging established plants.

Several hypotheses address the role of multinational companies. They may exploit superior efficiency or transfer technology from abroad, earning rents that show up as higher relative productivity in Australia. Or they may exacerbate problems of inefficiently small scales, with the opposite result. In the event, no significant relationship emerged between relative productivity and the share of the Australian market accounted for by foreign subsidiaries (either that variable taken by itself, or interacted with the industry’s research intensity or rate of productivity growth). 53

Finally, we hoped to test the influence on Australian productivity of divisive labor relations. The absence of any appropriate data at the industry level forced us to omit this potentially important factor, inflicting left-out variable bias on the model. We made a crude attempt to approach the issue by inquiring whether relative productivity is lower in those Australian industries that are heavily unionized in the United States; this approach rests on the defensible assumption that the state of an industry’s labor relations depends heavily on its production technology, so an industry with divisive labor relations in one country is prone to the same problems elsewhere. However, the data offer no support.

We stress that the omission of these also-ran hypotheses has no substantial effects on the magnitudes and significance of the coefficients
reported. The assurance does not extend, however, to the untested hypothesis about the effect of labor relations on productivity.

Statistical Results

The data base containing the variables listed above was prepared as a cross-section of Australian and United States manufacturing industries centered on the year 1977 (1977-78 for Australia). Different years were tolerated for variables not collected in the reference year. Although most variables come from standard government statistical sources, missing observations proved to be a serious problem—the result of nondisclosure in the published source or difficulties of matching different statistical classifications. Because different industries tend to be missing for each variable, missing observations cumulatively reduce the number of degrees of freedom available to estimate our model. Hence, for a few important variables ad hoc procedures were used to plug these gaps, but this was not done across the board.

The most revealing results appear in the following equations:

\[
VFM = -0.659 + 0.099 \text{CAP} - 0.298 \text{CAPL} - 0.045 \text{CAPA} + 0.008 \text{TP} + 0.075 \text{TPA} \\
(1.58) \quad (1.48) \quad (0.35) \quad (0.25) \quad (0.24) \quad (2.23)
\]

\[+ 0.449 \text{NPW} + 0.923 \text{SCLA} + 0.174 \text{CNC} \]

\[0.67 \quad 3.27 \quad 1.14 \]

D.f. = 64; \( R^2 = 0.424 \)

\[
VFM = -0.574 + 0.086 \text{CAP} - 0.352 \text{CAPL} - 0.049 \text{CAPA} - 0.023 \text{TP} - 0.045 \text{TPA} \\
(1.51) \quad (1.30) \quad (4.55) \quad (0.25) \quad (0.56) \quad (2.04)
\]

\[+ 0.456 \text{NPW} + 0.764 \text{SCLA} + 0.194 \text{CNCR} \]

\[0.69 \quad 3.09 \quad 1.81 \]

D.f. = 64; \( R^2 = 0.441 \)

We consider first the neoclassical core of the model, which encompasses the ratios \( VFM, \text{CAP, TP} \) (expressed in logarithms), and the difference in homproduction worker shares, \( \text{NPW} \), already defined. It also
includes these slope-shift variables:

**CAPL** The logarithm of **CAP** entered again for a group of the more labor-intensive industries, to allow for a slope shift;

**CAPA** The logarithm of the capital-labor ratio for the Australian industries only, to allow for a systematic difference between Australian and U.S. production functions;

**TPA** The logarithm of the typical plant size for the Australian industries only, to allow for a systematic difference in revealed scale efficiency between Australia and the United States.

The estimated neoclassical core behaves in an undisputably peculiar fashion. **VPN**, relative labor productivity, is positively related to relative capital intensity (**CAP**), although the coefficient’s significance is weak. However, the coefficient of the slope shift that allows for different production technology in the more labor-intensive industries is negative, large, and highly significant. The coefficient of **CAPA** indicates that the output elasticity of capital is lower (that of labor is higher) in Australian industries than in their U.S. counterparts, although the difference is not statistically significant. Thus, these coefficients suggest strongly that the same Cobb-Douglas technology does not apply to labor-intensive industries as to other industries, and it weakly suggests that Australia obtains relatively higher labor (lower capital) productivity in the typical manufacturing industry.

A somewhat similar pattern arises for the variable indicating relative typical plant size (**TP**). It is quite insignificant, suggesting by itself no plant-level scale economies in the typical industry. However, the slope shift for typical plant size in the Australian industry (**TPA**) takes a significant negative coefficient. A possible interpretation is that, given
the constraint of operating in a small and protected market, Australian manufacturers have adapted so as to minimize their intrinsic productivity disadvantage in those industries best suited to small-scale and (perhaps) labor-intensive operations. NPW, indicating differential use of nonproduction workers, has the right sign but does not increase the model's explanatory power. If Australia underinvests in human capital, the effect does not show up in productivity differentials among manufacturing industries.

SCLA, indicating the combined influence of artificial and natural protection, minimum efficient scale, and market size, is highly significant in both equations. The value of the constant embedded in SCLA that yields the most significant regression coefficient is 0.30, which is approximately the mean of the rate of effective protection (natural plus artificial) for industries in the sample. That is, for any given incidence of scale economies, protection above the mean has a negative effect on productivity, and that effect grows larger, the more important are the scale economies. Saunders obtained similar results for Canada except for a slightly lower apparent threshold of 0.25 for protection's negative effect.

We tested the hypothesis, mentioned above, that SCLA's effect should be weaker in industries where product differentiation supplies some insulation for domestic producers. We calculated mean values of several variables indicating the intensity of differentiation of an industry's products and tested whether SCLA's coefficient is higher in industries with below-average differentiation. For a composite criterion reflecting structural differentiation (customization, importance of auxiliary services, infrequency of purchase), the hypothesis was supported, with SCLA's coefficient two-thirds larger in the less differentiated industries.
When the differentiation criterion is the importance of research and development, the hypothesis is again confirmed, and the difference in coefficients becomes fourfold. However, when the importance of media advertising becomes the differentiation criterion, SCLA's coefficient is two-thirds larger in the differentiated industries. That apparent exception, rather than undermining the hypothesis, may affirm the importance of scale economies of sales promotion in high-advertising industries.

The only other variable affecting relative efficiency to appear in these equations is the one representing the influence of producer concentration in Australia (CNRB or CNRS). Their coefficients would be negative if concentration leads to producer behavior that depresses productivity (after we have controlled for the lower bound that scale economies impose on producer concentration). A positive coefficient might be given the opposite interpretation. However, a still more attractive interpretation of a positive coefficient is that concentration increases the likelihood that Australian prices are pushed up to (or beyond) the level warranted by protection. The positive coefficients of this variable (significant at 10 percent in the second equation) incline us toward this hypothesis, which has previously been confirmed for Canada.

Our chief finding about what determines relative productivity is the interacting role of protection, scale economies, and product differentiation: Australia's average productivity disadvantage is greatest for industries market by substantial scale economies, large cost disadvantages of suboptimal-scale production, high protection (natural or artificial), and extensive structural product differentiation. With these factors controlled, we have weak evidence that concentrated industries in Australia are more likely to elevate their prices relative to the limit
set by international competition; put the other way around, we have fairly strong evidence that their potential rents are not all squandered in cost-increasing activities (nonprice competition, for example). These findings agree with similar research on the Canadian economy. We find no evidence that manufacturing productivity suffers from short supplies of nonproduction-labor skills or an inappropriate amount of foreign investment. Our confidence in these conclusions is limited by the peculiar behavior of the model's neoclassical core, which, however, suggests the plausible hypothesis that Australian industry has had some success adjusting its production technology to operate at small scales.

DETERMINANTS OF RELATIVE SCALE

The preceding model of relative productivity allowed for several types of shortfall. Those in the basic model are neoclassical sources associated with input combinations and scales of production. Those picked up in the efficiency term are more various—some related to scale, some to inefficiencies associated with the excess cost of producing Australia's level of output. Because the influence of the size of Australian production units is diffused through several variables, we append a direct investigation of what determines the scale of Australian production units relative to their counterparts in the United States. We are concerned here with plant scale economies, although scale economies also accrue to the multiplant firm. Australia's plant-size distribution can be measured and evaluated in various ways. A particularly attractive measure is the proportion of an industry's employment in plants larger than the median plant in the U.S. counterpart industry. The published data on Australian industries' plant-size distributions are too coarse to let us calculate this variable with any accuracy, but we do have data on the
companies classified to each Australian industry finally disaggregated by size class. We also know the extent of multiplant operation by the leading companies. Therefore, we calculate as our dependent variable the proportion of Australian employment in companies larger than the median U.S. plant size, and we control for the plant-company discrepancy by including as a regressor the number for plants per company for the four leading Australian firms. To indicate the notation, we shall be regressing RELS on MLTP and other variables to be explained.

Hypotheses About Relative Size

Much of the background to these hypotheses appeared previously, so we can set them forth briefly. The first of them concerns the viability of suboptimal scale production—the influences operating through RELA, the variable defined as a determinant of relative productivity. A similar variable suitable to explain relative size can take a slightly simpler form:

\[ SCB = RMSU * CPRU + EPCA \]

where RMSU is median plant size in the U.S. counterpart industry (i.e., MEDU) divided by U.S. industry shipments. CPRU and EPCA, defined previously, are the inverse indicator of small plants’ disadvantage (U.S. data) and the overall Australian rate of effective protection (natural or artificial). This variable’s predicted negative influence on RELS thus implies that Australian plants should be smaller (relative to the U.S. median) in industries with a large miniscule efficient scale in the United States but low drawbacks to suboptimal scale, and which receive high protection in Australia.

The market-size constraint on plant (or company) size of course assumes that the production unit is tied to a national (or smaller) market.
Any manufacturing industries that have attained significant exports should escaped the constraint and exhibit larger plant sizes—a hypothesis confirmed for Canada. Thus, we include

\[ \text{EIPA} = \text{ratio of exports to turnover for the Australian industry.} \]

It should obtain a positive coefficient. However, so few Australian industries attain significant exports that the prospects of EIPA are modest.

The presence of foreign subsidiaries is another potential influence on RELS:

\[ \text{FCTA} = \text{share of turnover in the Australian industry accounted for by foreign-controlled companies.} \]

The sign expected for its coefficient is ambiguous. If the proprietary assets of multinational companies help them to obtain large shares in Australian markets, then they will choose to build large plants, enlarging industries' typical plant sizes. However, the relation could go the other way where products are highly differentiated or multinationals serve the Australian market partly with imported articles, partly with goods produced locally. The first relationship may hold for some industries, the second for others, so that the absence of a significant relationship need not mean "no influence." One reason why multinationals' effect is ambiguous is differences in the degree to which nonproduction activities are integrated into plant operations. Such overhead activities may be more prevalent in the United States, enlarging American relative plant sizes. If technological and marketing knowledge is imported (via multinationals or otherwise) into Australia, local production units will be smaller as a result. Because nonproduction workers produce most of these intangibles, we can test the effect by including NPA, the difference between the
nonproduction-worker proportions of the Australian and U.S. labor forces. Its coefficient should be positive. Yet another version of this hypothesis, specified more narrowly, is that R&D is negatively related to

\[ R&D = \text{research and development outlays as a proportion of sales in the U.S. counterpart industry.} \]

We need to control for the regional fragmentation of many Australian manufacturing industries that confines some producers to local markets. The best way available to measure regional fragmentation is from data on the interstate dispersion of production among the Australian states. Specifically, for each industry we calculated

\[ REGH = \text{Herfindahl index of concentration of the industry's employment among the states.} \]

The lower is \( REGH \), the more evenly is an industry's employment dispersed among regions. Therefore, we presume, the more localized are markets, and the smaller should plant sizes be.

**Statistical Results**

The data base employed to estimate this model is the same as that used in the previous section to explain relative productivity, but missing values in this case leave a smaller number of observations. Also, multicollinearity proved a more severe problem, rendering the model somewhat sensitive to small changes in specification. The hypotheses about \( R&D \) were tested (in the first instance) in a linear additive model; no formal framework offers itself comparable to the neoclassical core determinants of \( VPN \). The three versions reported in Table 3 embody some interactions that will be explained along with the results.

First of all, the coefficient of export activity (\( EXPA \)) takes a
<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Equation (1)</th>
<th>Equation (2)</th>
<th>Equation (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLTP</td>
<td>0.010</td>
<td>0.011</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(2.22)</td>
<td>(2.60)</td>
<td></td>
</tr>
<tr>
<td>SCIR</td>
<td>-0.205</td>
<td>-0.217</td>
<td>-0.223</td>
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<td></td>
<td>(1.59)</td>
<td>(1.75)</td>
<td>(1.72)</td>
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<tr>
<td>NFW</td>
<td>1.438</td>
<td>1.686</td>
<td>1.819</td>
</tr>
<tr>
<td></td>
<td>(1.69)</td>
<td>(2.54)</td>
<td>(2.63)</td>
</tr>
<tr>
<td>REGH^2</td>
<td>-1.847</td>
<td>-1.923</td>
<td>-2.412</td>
</tr>
<tr>
<td></td>
<td>(1.72)</td>
<td>(1.89)</td>
<td>(2.33)</td>
</tr>
<tr>
<td>REGHNF</td>
<td>2.292</td>
<td>2.471</td>
<td>2.623</td>
</tr>
<tr>
<td></td>
<td>(1.99)</td>
<td>(2.29)</td>
<td>(2.34)</td>
</tr>
<tr>
<td>FCTA</td>
<td>0.285</td>
<td>0.300</td>
<td>0.321</td>
</tr>
<tr>
<td></td>
<td>(3.30)</td>
<td>(1.70)</td>
<td>(3.82)</td>
</tr>
<tr>
<td>FCTRD</td>
<td>-0.273</td>
<td>-0.287</td>
<td>-0.309</td>
</tr>
<tr>
<td></td>
<td>(3.27)</td>
<td>(3.65)</td>
<td>(3.79)</td>
</tr>
<tr>
<td>EXPACK</td>
<td>-0.304</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXPAL</td>
<td>-0.653</td>
<td>--</td>
<td>--</td>
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<tr>
<td></td>
<td>(0.65)</td>
<td></td>
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<tr>
<td>KD</td>
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<td>--</td>
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<tr>
<td></td>
<td>(0.35)</td>
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<tr>
<td>Constant</td>
<td>0.194</td>
<td>0.137</td>
<td>-0.047</td>
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<tr>
<td></td>
<td>91.11</td>
<td>(0.94)</td>
<td>(0.38)</td>
</tr>
<tr>
<td>D.f.</td>
<td>36</td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>R^2</td>
<td>0.302</td>
<td>0.343</td>
<td>0.251</td>
</tr>
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</table>

Table 3. Determinants of sizes of Australian production units relative to United States midpoint plant size (NEILS)
pervasive sign but is quite insignificant—no surprise in view of the small share of output exported by most Australian manufacturing industries. We wondered if the expected effect might turn up in the more capital-intensive resource-processing sectors, and accordingly allowed the coefficient of EXP to take different slopes in the capital-intensive (EXPa) and labor-intensive (EXPb) industries (the sample industries were split around mean capital-intensity; b0 is an intercept shift for capital-intensity). As equation (1) shows, this maneuver failed to alter the negative results. We concluded that export markets have yet to influence the structures of Australia's manufacturing industries (contrary to their Canadian counterparts), and EXP was dropped from the model. Its removal had no substantial effect on other coefficients, as equation (2) shows.

The term combining the influence of scale economies and the tariff, DELT, takes the appropriate negative coefficient but is only marginally significant in a one-tail test. The relative prevalence of nonproduction workers in Australian plants (SPWP) is positive and significant. The regional-dispersion variable, REGM, when entered in its original form, took a perverse negative coefficient that was nearly significant statistically. To explore this anomaly, we first squared the variable in order to give more dispersion to the highly fragmented industries—a move that only ameliorated the perversity. Then we tested the hypothesis that regional dispersion is associated with smaller scales more strongly in those industries with above-average levels of foreign investment (REGMMP allows a slope-shift for REGMMP in those industries). As Table 3 shows, regional dispersion is significantly more associated with small scale in those industries, although the basic perverse results (negative coefficient of REGM2) remains unexplained. Foreign investment itself has a significant positive influence (two-tail test), while RNDU when entered as an additive
regressor yields a significant negative one. However, a positive correlation between ETA and RNU proved to be an important source of multicollinearity in the model. In Table 3 RNU is entered interactively with ETA by means of the variable ECR, which is defined as ETA (1 + RNU).

Finally, the extent of multiplant operation in Australian industries (MLP) took the significant positive coefficient expected for cleaning up the mismeasurement of relative plant size. Because multiplant operation may be associated behaviorally with other variables in the model (notably SHEP), we were concerned that its inclusion not affect the interpretation of other variables. Therefore, in equation (3) we suppressed its interaction with the other regressors by first regressing REL on it, then taking the residuals from this regression as the dependent variable in equation (3); as the table shows, this change in fact has little effect on the magnitudes and significance levels of the other regression coefficients.

We made one supplemental inquiry into the determinants of relative plant size, motivated by the less than ideal nature of the statistical proxies for scale economies that enter into REL. We know from a body of research on industrial structures in other countries that substantial scale economies tend to compress the variance of plant sizes in an industry by forcing all viable producers to attain minimum efficient scale. Conversely, if the cost disadvantage of suboptimal scale is small, plant sizes may be diverse even if minimum efficient scale is large. These patterns suggest the following hypothesis: the smaller the dispersion of plant sizes in Australia, the greater should be Australian relative plant size. We calculated a Gini coefficient over the Australian plant-size distributions and computed a correlation between it and the dependent
variable. We did obtain the negative coefficient predicted by the hypothesis (−0.117), but it is not statistically significant (t = 1.06).

To recapitulate these conclusions, tariff protection does increase the viability of small-scale production to the degree that scale economies permit. Tariffs, and also inducements that encourage multinational companies to disperse their plant locations, are flagged as policies aggravating the economy's problem of small-scale operation. But Australian plants are small partly because they forego in-plant non-production activities, or because they import the services of nonproduction workers (the negative influence of U.S. research and development). Foreign investment itself is associated with larger plant sizes, but this influence has strong negative offsets in research-oriented industries (here, product differentiation is surely at work) and those subject to geographic fragmenation. While this interpretation has a satisfying coherence, it needs to be discounted for the multicollinearity of the regressors and the amount of manipulation that followed upon the initial results.

Our two dependent variables, VFM and DELS, are different measures of the same general phenomenon—the displacement of scale and productivity by structural conditions and policies prevailing in Australia. The two variables are only seemingly unrelated, and therefore should be estimated by generalized least squares for greater efficiency. The results of this maneuver proved unhelpful because of the problem of missing observations, which yielded somewhat fewer degrees of freedom for DELS and many fewer for RP than in the ordinary least squares equations reported above. Because the qualitative interpretation of the significance of key variables remained unchanged, we do not report the results.
CONCLUSIONS

The most important normative question about Australian industrial organization, we submit, is the degree to which its efficiency and productivity are constrained by serving small and isolated markets, and the degree to which public policy has worsened this problem—or could relieve it. The strategy used in this paper has been not to study the relevant policies directly but to dig into the underlying question of how important these constraints are. With that known, quantified estimates of the effects of tariff protection and other relevant policies can come into reach. This paper has attempted a first step at this quantification by applying a coherent framework to analyze the productivity of Australian manufacturing industries relative to their counterparts in the United States. The analysis covers outright differences in average productivity and also differences in scale of operation. The statistical findings suggest the following conclusions for economic policy and its factual surround:

1. Small market size and isolation do constrain both the overall productivity and the scale efficiency of Australian manufacturing industries. This problem will be mitigated by long-run economic growth. It may be exacerbated by the general-equilibrium adjustment of an expanding resources sector, insofar as it makes suboptimal scale of operation more attractive in some industries.

2. High levels of tariff protection impose an economic cost that consists importantly of making suboptimal scale production feasible. In doing so, Australian protection acts like amplified international transportation costs.

3. Australian manufacturers have apparently made the best of the opportunities open to them, in the sense that their “revealed” production function claims a relative productivity advantage in activities that are small-scale and not capital-intensive. This behavioral finding may have
implications for the best direction of investments in developing and adapting production technology.

4. Previous research has indicated many other public policies that account for geographic fragmentation of manufacturing industries, notably a fragmented transportation system and plant-location inducements by the states. Our results are consistent with states' policies having contributed to geographic dispersion and small scale in industries where foreign subsidiaries are prevalent, suggesting that these inducements may frequently have aimed at the multinationals.

5. This study has not directly addressed competition policy in Australia, but it does provide some relevant conclusions. First, we do find some evidence that concentrated industries with only moderate comparative disadvantages (in international trade) are more likely to "price up to the tariff." This in turn implies some cost of allocative inefficiency. Second, the conclusions we reach about scale and productivity are highly cautionary about the technical inefficiency (lower productivity) that might occur as a result of any attempt to improve allocative efficiency by fragmenting production. Third, these results by no means rule out the possibility that collusive agreements and practices in concentrated industries impose efficiency costs, but they do suggest (weakly) that not all the monopoly rents claimed by more concentrated industries are dissipated in this fashion.
FOOTNOTES


2. "Minimum efficient scale" refers to the smallest output at which average unit cost reaches its minimum value. The evidence on scale economies devolves from various research techniques (engineering estimates, various statistical approaches to *ex post* data); the findings differ somewhat on particular industries but agree fully in the conclusions just stated. For a survey see Donald A. Hay and Derek J. Morris, *Industrial Economics: Theory and Evidence* (Oxford: Oxford University Press, 1979), chap. 3.


similar results; see Pat Brown and Helen Hughes, "The Market Structure of
Australian Manufacturing Industry, 1914 to 1962-4," Australian Economic
Development in the Twentieth Century, ed. Colin Forster (London: Allen &
Unwin, 1970), pp. 193-5. They showed that plant concentration did not
change much in Australian manufacturing over a half-century, implying that
sizes of plants and markets increased at similar rates.

5. P. H. Karsel and Maureen Brunt, The Structure of the Australian Economy
this trade-off in Canada appears in R. E. Caves, Diversification, Foreign
Investment, and Scale in North American Manufacturing Industries (Ottawa:

6. R. M. Conlon, Transport Costs as Barriers to Australian Trade, Centre for
Applied Economic Research, Paper No. 8 (Kensington: University of New South
Wales, 1979), esp. p. 27. Also see Gary P. Sappson and Alexander J. Yeats,
"Tariff and Transport Barriers Facing Australian Exports," Journal of

7. Conlon, "International Transport Costs and Tariffs," Table 7.5. These
differences apply to the median and the weighted or unweighted mean
figures.

8. A. E. G. Walker and K. M. Schneider, "Transport Costs and Australia's
International Trade in the 1980's," unpublished ms., Industries Assistance
Commission, 1980. The containerization revolution has recently affected
most of Australia's manufactured imports, greatly changing the
interindustry pattern of rates of transport-cost protection.

9. A convenient brief review is provided by R. G. Gregory and J. J. Pincus,
"Industrial Assistance," Industrial Economics: Australian Studies, ed. L.

11. Gregory and Pincus, p. 138 (data from Industries Assistance Commission). The decline stopped in 1977-78; exact figures on a comparable production-weighted basis are not available for later years.

12. Indeed, the coefficient of variation rose from 0.83 in 1968-69 to 1.31 in 1977-78.


18. Because each Australian industry is typically matched to several U.S. industries, whose concentration ratios were weighted and averaged to make the comparison. The average will typically exceed a concentration ratio calculated directly for leading-firm shipments in the combined market.

19. David K. Round, "Plant Size, Scale Economies and 'Optimum' Concentration Levels in Australian Manufacturing Industries," *Weltwirtschaftliches Archiv*, vol. 116 (No. 2, 1980), pp. 341-52. He compared actual four-firm concentration ratios in 139 industries to the minimum ratios that would prevail if each leading firm operated only one plant equal in size to the average of leading firms' plants. The median concentration ratio then would be around 20 percent, while the actual median is about 45 percent.


25. Karvel and Brunt, pp. 94-100.

26. Karvel and Brunt (pp. 98-99) confirmed the prevalence of excess capacity in moderately concentrated Australian oligopolies.

27. These tendencies should not be entirely collinear. Suppose that scale economies and market size interact to allow room for only a few producers in Australia, but constrain them to a Chamberlin-type monopolistic-competition equilibrium with their overseas competitors. Then they have no room for disfunctional noncompetitive behavior. Conversely, as the minimum-scale constraint is relaxed and potential excess profits come available, the scope for strategic behavior expands.


It does appear that the market for corporate control has some effect on managerial performance in management-controlled Australian firms, but this discipline grows less effective as firm size increases. See M. L. Lawriwsky, "Some Tests of the Influence of Control Type on the Market for Corporate Control in Australia," *Journal of Industrial Economics*, vol. 32 (March 1984), pp. 277-91.


32. Suggestive evidence appears in Brash, chap. 5 and pp. 162, 165; studies of productivity in Canada and Britain have leaned toward ascribing a negative effect to multinationals.


38. These points are discussed in Chapter 00 (Mitchell).


40. R. Dixon, "Variations in the Composition of Manufacturing Employment in the
Australian Economy, Australia Economic Review, No. 59 (Third Quarter 1982), pp. 33-42.

41. These conclusions are based on coefficients of variation calculated among growth rates presented in Industries Assistance Commission, Structural Change in Australia, pp. 14, 65, 67, 69.

42. Ibid., pp. 40-55; also David H. Robertson, *Australia's Growth Performance: An Assessment*, Kasper and Parry, chap. 4.

43. Typically an Australian industry is matched to several U.S. industries at the four-digit level of the U.S. standard industrial classification. Industry shipments were used throughout as the weighting variable for constructing weighted averages. Details of the procedure and of definitions and sources of variables appears in Appendix B.

44. See Caves, Porter, and Spence, chap. 10; Saunders.

45. For Canada it was found that the degree to which domestic producers price up to the tariff can be explained by the industry's market structure. See Tia Hazeldine, *Testing Two Models of Pricing and Protection with Canada/United States Data,* Journal of Industrial Economics, vol. 29 (December 1980), pp. 145-54. Another problem without a ready solution is that differentiated goods may be priced above the world price plus tariff.

46. Davies and Caves, Appendix A. The derivation is reported in Appendix A.

47. We follow the usual procedure of netting out purchased materials inputs. This can be justified either if there is no substitution between these and primary factor inputs to the production process, or if they are perfect substitutes.

48. Monetary values are expressed in a common currency. Typical plant size, here measured in terms of employment, summarizes the size distribution of plants in an industry. Davies and Caves showed that a suitable
approximation is midpoint plant size—the scale of the plant accounting for the 50th percentile of output when plants are ranked from the largest to the smallest.

49. As a method of incorporating human capital this strategy offers several advantages. It permits us to assume that workers of different qualities may be good substitutes for one another (although not one-for-one), while human capital and physical capital may be relatively poor substitutes. Also, it avoids the problem of measuring human capital directly.

50. Negative influences for these latter groups are expected, we stress, on the basis of less extensive training and (in the case of females) a larger proportion working part-time. See Industries Assistance Commission, Annual Report, 1981-82, pp. 13-18, and Thomas G. Parry, "Structure and Performance in Australian Manufacturing, With Special Reference to Foreign-Owned Subsidiaries," Kasper and Parry, pp. 183-9. Parry's design resembles that employed in this chapter, but he did not utilize an international comparison for control or a consistent production-function framework.

51. Saunders, pp. 172-4. For the United States we substituted industry shipments for domestic disappearance in order to avoid a large number of missing observations.

52. The logic of this statement follows from the justification for the variable $SFLA$. Saunders employed a variable constructed like $CONC$ in his study of the efficiency of Canadian industry and failed to confirm the hypothesis.

53. Bernhardt found a positive influence for foreign investment interacted with research intensity for Canada, Saunders a negative influence mitigated in research-intensive sectors.

54. Compare Caves, Porter, and Spence, pp. 31-34.

55. We experimented with a variable analogous to $CAPL$ to serve as a slope shift
In capital-intensive industries. However, missing data cost us many industries in the highly capital-intensive sectors, and perhaps for that reason the variable proved completely insignificant.

56. Saunders adjusted the relative weight of the tariff and scale-economy terms whose product is $\text{SCLA}$ by attaching an exponent to the former. Our experimentation indicated that, for Australia, the best fit results with that exponent set equal to one. Appendix C contains descriptive information on industries with high and low values of $\text{SCLA}$.

57. This variable was analyzed for Canada by Caves, Porter, and Spence, pp. 270-3.

58. A more sophisticated correction could be obtained for some industries by fitting some functional form to the published data on multipoint operation by several size-classes of leading firms. We did not expect that the gain would be worthwhile.

59. We assume that the exports/shipments ratio for the U.S. counterpart industry may be neglected because of the U.S. market's large size.

60. The Herfindahl index is calculated by squaring the fraction of national employment in each state and summing the fractions. It can range from 0.167 (even distribution) to 1.0 (all in one state). Its sample mean is 0.33.

61. Ideally, it should also incorporate what we customarily call "technical inefficiency," the degree to which productivity levels in individual plants and companies in each country fall short of the frontier obtainable within that country's economic structure. Research of this type is under way in both countries.
Appendix A -- PRODUCTION-FUNCTION FRAMEWORK FOR ANALYZING RELATIVE PRODUCTIVITY

This appendix reports a model that allows the analysis of relative productivity to be undertaken within the framework of explicit production functions for the industries in question. It gives rise to the estimation form employed for the analysis of the productivity of Australian industries relative to their U.S. counterparts in the text of this paper. 1

Consider a given industry of N plants in Australia. Suppose that each plant operates along a Cobb-Douglas production function; so if Y, K and L denote net output, capital and labor respectively, then for plant i:

\[ Y_i = AK_i^\alpha L_i^\beta \quad \text{for } i = 1 \ldots N \]  

(A.1)

Recall that, for the Cobb-Douglas production function, A is an efficiency parameter, and \( \alpha + \beta \) indicate the extent of returns to scale with \( \alpha + \beta < 1 \), \( \alpha + \beta > 1 \) denoting respectively decreasing, constant, and increasing returns to scale. We assume initially, and quite unrealistically, that the N plants are of equal size with identical capital-labor ratios: \( K_i = \bar{K}, \ L_i = \bar{L} \) for all i, with \( \bar{K} \) and \( \bar{L} \) standing for arithmetic means.

This assumption allows us to aggregate easily to the industry level. Substituting into (A.1) and summing over the N plants and dividing by aggregate L yields the following expression for the industry's labor productivity:

\[ \frac{Y}{L} = \frac{N\bar{K}^\alpha\bar{L}^\beta}{\bar{L}} = A\bar{K}^\alpha \bar{L}^{\alpha+\beta-1} \]  

(A.2)

where \( Y, K \) and \( L \) denote industry aggregates over the \( N \) identical plants.

---

1. It was initially set forth in S. M. Davies and R. E. Caves, "Inter-Industry Analysis of United Kingdom-United States Productivity Differences," National Institute of Economic and Social Research, Discussion Paper No. 61 (1983), Appendix A.
Thus, the industry's labor productivity depends on "efficiency" (A), capital intensity \( \frac{K}{L} \), and average plant size (\( L \)), the exponent of the last indicating the extent of scale economies.

We now assume, more realistically, that the N plants differ in size (that is, the \( K_i \) and \( L_i \) differ), although we retain for the assumption that all share the same capital intensity, i.e., \( \frac{K_i}{L_i} = \frac{K}{L} \) for all \( i \).

Substituting this weaker assumption into (A.1), summing over the N plants and dividing by \( L \), aggregate labor productivity can now be written:

\[
\frac{Y}{L} = \frac{A \left( \frac{K}{L} \right)^\alpha \left( \frac{L}{L_i} \right)^{\alpha + \beta}}{L} = A \left( \frac{K}{L} \right)^\alpha \left( \frac{L}{L_i} \right)^{\alpha + \beta} \sum_{i=1}^{N} \frac{L_i}{L} \tag{A.3}
\]

It is convenient to employ the following definition:

\[
P = L \left( \sum_{i=1}^{N} \frac{L_i}{L} \right)^{\alpha + \beta - 1} \tag{A.4}
\]

which enables us to rewrite A.3 as:

\[
\frac{Y}{L} = A \left( \frac{K}{L} \right)^\alpha P^{\alpha + \beta - 1} \tag{A.5}
\]

Comparison of (A.5) and (A.2) reveals the only difference to be the replacement of \( L \) by \( P \). Because we shall argue that \( P \) is an alternative measure of "typical" plant size, better suited to typical empirical patterns of unequal-size plants, we interpret (A.5) as a confirmation of the relationship between productivity and capital intensity and typical plant size.

Thus far we have considered a single Australian industry, whereas our goal is to undertake a multi-industry comparative study. We have a sample of \( r \) industries \( (i \ldots j \ldots r) \) and wish to investigate the variations among these industries in the ratio of labor productivity in Australia (AU) to that in the United States (US). We introduce the following definitions:
\[
\begin{align*}
VPW_j &= \left(\frac{Y/L}{Y/L}\right)_{AU} / \left(\frac{Y/L}{Y/L}\right)_{US} \right)_{j} \\
EFF_j &= \left(\frac{L}{L}\right)_{AU} / \left(\frac{L}{L}\right)_{US} \right)_{j} \\
CAP_j &= \left(\frac{K/L}{K/L}\right)_{AU} / \left(\frac{K/L}{K/L}\right)_{US} \right)_{j} \\
TP_j &= \left(\frac{K}{K}\right)_{AU} / \left(\frac{K}{K}\right)_{US} \right)_{j} \\
CAPA_j &= \left(\frac{K/L}{K/L}\right)_{AU} \\
TPA_j &= \left(\frac{K/L}{K/L}\right)_{AU}
\end{align*}
\]

These terms refer respectively to comparative labor productivity, comparative efficiency, comparative capital intensity, comparative typical plant size, capital intensity in Australia, and typical plant size in Australia.

We can now consider how to deal with similarities and differences among the production functions of the \( r \) industries. We start with:

1. \( \alpha \) and \( \beta \) are the same for all industries in both countries.

If this simplifying assumption holds, we have a very convenient result. From (A.5), assumed to hold for industry \( j \) in both countries, we can write:

\[
VPW_j = \left(\frac{EFF_j}{CAP_j}\right)^\alpha \left(\frac{TP_j}{TP_j}\right)^{\alpha + \beta - 1} \quad \text{for all } j \tag{A.6}
\]

This is the basis for the fundamental estimating equation quoted in the text (with \( i \) subscripts substituted for \( j \)). With logarithms taken, we have a linear relationship between comparative productivity and comparative efficiency, comparative capital intensity, and comparative plant size. Each variable except \( EFF_j \) is observable, and an estimated regression equation in this form gives us estimates of \( \alpha \) and \( (\alpha + \beta - 1) \). \( EFF_j \) is essentially unobservable, because it reflects all other influences on productivity; we assume it to be determined by a number of observable influences that are discussed in the text.

2. \( \alpha \) and \( \beta \) differ between Australia and the United States, but are constant for all industries in each country.

In this case, taking the ratio of (A.5) for Australia to (A.5) for the United States gives:
\[ V_{PK} = (\text{EFF}) (\text{CAP})^\alpha \text{US} \left( \frac{\text{TP}_{ij}}{\text{TP}} \right)^\beta \text{US}^{-1} (\text{CAPA})^\alpha \text{AU}^{-\gamma} \text{US} (\text{TPA})^\alpha \text{AU}^\beta \text{US}^{\gamma} \text{US} \]  

(A.7)

Because the \( \alpha \) and \( \beta \) are assumed the same for all \( j \) in each country, this should hold true for all \( r \) observations. In terms of our original regression equation, this means the addition of two extra variables—capital intensity and typical plant size in Australia.

3. \( \alpha \) and \( \beta \) differ between industries in each country.

In the limit, with every industry's coefficients different from every other one's, there is no scope for cross-industry regression analysis. Let us suppose, however, that \( \alpha \) and \( \beta \) are the same for all industries within broad sectors but differ among these broad sectors. Econometrically, this situation can be handled by including dummy slope variables for each (but one) of the sectors for which different \( \alpha \) and \( \beta \) values are suspected. In a complete model with additional explanatory variables included, this procedure has the implication that the marginal effects of these other variables are the same for all industries, while allowing for intersector differences in the impact of capital intensity and plant size.

The last problem addressed in this appendix is the justification for using \( P \) (equation A.4) as a measure of typical plant size, and its empirical embodiment. The concentration of production units in different markets is complicated by the fact that the industries concerned may have very different size distributions of plants or firms (i.e., differing in both numbers and dispersion). One solution flowing from the Herfindahl measure of concentration is to translate each size distribution into the equivalent number of equal-size units, and then to record as more concentrated the market with fewer equivalent units. The larger units are commonly weighted more heavily, and a convenient
way to do this (based on the generalized Herfindahl index) is:

\[ N(a) = \left( \sum_{i} s_i^v \right)^{1/(1 - v)} \]  \hspace{1cm} (A.8)

where \( s_i \) is the market share of firm \( i \) and \( v \) is a parameter chosen by the researcher, with the weight attached to large units in translating the size distribution into an equivalent number of equal-size units increasing with \( v \).

If we then divide aggregate market size by \( N(a) \) we have a measure of average effective unit size. Where actual unit sizes are unequal and theory indicates that the larger units are more important, this is a reasonable way to represent typical size.

The reason for introducing this consideration from the measurement of concentration is apparent when (A.8) is compared to (A.4). Measuring the size of plant by employment, \( s_i = l_i / L \), \( P \) is the average effective unit size just set forth, with the parameter \( v = \alpha + \beta \), the extent of returns to scale.

A problem arises when we turn to the measurement of \( P \), in that \( \alpha \) and \( \beta \) must be known in order to compute the variable. This information is not generally available, and so we must resort to a measurable proxy. As it happens, there exists an excellent candidate, a measure widely used in many studies of "typical" plant size. This is the median of the first-moment plant size distribution, i.e. the mid-point plant size in the sense that 50 percent of industry employment is accounted for by plants of less than that size. Intuitively, this can be justified by the fact that the mid-point will typically represent the sizes attained by the larger plants and be insensitive to the number of very small plants operating in the industry. More formally, it can be shown that, if we assume the plant size distribution is approximately lognormal, the deviation of the mid-point plant size from \( P \) depends on the difference between unity and \((\alpha + \beta - 1)^2\), which is likely to be very small. That is our justification for using mid-point plant size as the basis for measuring \( \bar{T}_1 \).
Appendix B -- SOURCES OF DATA AND CONSTRUCTION OF VARIABLES

The establishment of the data base for this project began with the decision that Australian manufacturing industries would be matched to their United States counterparts, and that 1977-1978 for Australia would be the year for effecting the match and centering the data. The year 1977 was attractive for being as "normal" as once can find in the 1970s, and for being a year when the Census of Manufactures was taken in the United States. The Australian standard industrial classification (ASIC) was revised in 1978; where it was necessary to employ data on the 1978 classification, we matched to industries defined in the previous (1976) classification using Australian Bureau of Statistics, Key Between the 1978 and 1969 Editions of ASIC, Catalogue No. 1209.0. The same standard industrial classification scheme was employed by the United States through the 1970s. United States four-digit manufacturing industries were matched to Australian four-digit industries judgmentally using the document just mentioned and U.S. Office of Management and Budget, Standard Industrial Classification Manual, 1972. The 1969 and 1978 Australian industries can be matched quite precisely; where discrepancies were tolerated in matched industries, they were quite small. The match between Australian and U.S. industries is less precise, and we estimate that discrepancies in coverage or 10 - 15 percent were tolerated not infrequently. Also, even when the product coverage of the two industries is conceptually identical, their actual output sizes may differ greatly. As these things go, the Australian and U.S. classifications match reasonably well; only one two-digit sector, plastic products, was lost entirely. Because the U.S. classification is finer than the Australian, variables observed for U.S. industries had to be weighted by shipments and aggregated to the level of their Australian counterparts. A sampling of 137 matched industries were available.

For the analysis of relative productivity, the dependent variable (VPQ) was calculated, following the equation derived in the text, from these sources: Values added per employee for Australia, ABS; Manufacturing Operations: Details of Operation by Industry Class, Australia 1977-78, Catalogue No. 0205.0; for the U.S.: U.S. Bureau of the Census, 1977 Census of Manufactures public user tape; Rates of effective protection for Australia: Industries Assistance Commission, public user tape; for U.S.: Bureau of the Census, U.S. Commodity Exports and Imports as Related to Output, 1977. It was necessary to use nominal tariff rates based on realized tariff revenue for the United States, because there is no satisfactory set of effective rates available at the four-digit SIC level. Effective rate of natural protection through transport costs for Australian ratios of c.i.f. value of imports to v.i.d. (value for duty) for 1974-75, supplied by Industries Assistance Commission. Transport-cost protection was not included for U.S. industries, partly because of a lack of satisfactory data, partly from the expectation that many U.S. industries prices would lie below the reference point defined by the world price plus natural and artificial protection. Because the tariff and transport-cost variables are all subject to substantial measurement errors, we experimented with the alternative use of nominal and effective rates for Australia and with the inclusion and exclusion of the transport-cost term. Happily, the best statistical results emerged from the theoretically superior specification, involving the effective rate of protection and including transport costs. The dependent variable takes that form for all
results reported in the text. U.S. dollar values were converted to
Australian dollars using the exchange prevailing between the beginning of
1977 and mid-1978 (from International Monetary Fund).

The dependent variable for the analysis is relative plant size (REL),
starts from the United States distribution of plants by employment-size
classes (Bureau of the Census, 1977 Census of Manufacturers, public user
tape). We first delete the smallest size-class of plants (less than 10
employees). Then we count down the size classes, starting with the
largest, until we arrive at the one containing the 50th percentile of
industry shipments. We then use an interpolation formula to identify
within that size class the employment size of the plant accounting for the
50th percentile of industry shipments (net of shipments shipped to plants
employing less than 10). We then proceed to a tape supplied by Australian
Bureau of Statistics (Enterprise Statistics, 1977) giving for each
Australian counterpart industry a variety of data on companies classified
to each industry ranked from the largest in terms of employment; these data
are provided for successive groups of four companies, making it possible to
determine with considerable accuracy the proportion of the Australian
industry's employment in companies employing more than the median-size U.S.
plant. The decision to use the Australian company (rather than plant) size
distribution was pragmatic. Because the published data for 1977-78
aggregate all plants employing 100 or more persons, they are useless for
the purpose at hand. A manual tabulation of plant sizes disaggregating the
larger size classes is available for 1977-78, but the nonconformity of the
data plus the still-high level of aggregation caused us to prefer the
company data.

We now proceed to the sources of the exogenous variables used in the
analysis, presenting these in alphabetical order of the symbols:

CAP—assets per employee in the Australian industry, 1977-78, divided
by assets per employee in the United States counterpart, 1977 (expressed in
Australian dollars). For Australia, fixed tangible assets are taken from
the public user tape of the Enterprise Statistics, 1977, employees from
Details of Operations by Industry Class. For the United States fixed
assets (total assets less inventories) case from Bureau of the Census,
Annual Survey of Manufacturers, 1976, public user tape (a 1977 figure is not
available); employees are from 1977 Census of Manufacturers, public user
tape.

CAPA—fixed assets per employee in the Australian industry, 1977-78.
Source: see entry for CAP.

CAPL—the value of CAP for ASIC Industries 23, 24, 341. Source: see
CAP.

CMS-border specific from a regression of producer concentration in
Australia on MESU/DDU and CONC/EFFRA. For sources of these variables, see
entries for CONC and SCLA.

CONC—producer concentration in Australia (turnover accounted for by
largest four companies), interacted with effective protection in Australia
(EFFRA) and the cost disadvantage ratio in the United States. Producer
concentration is taken from Enterprise Statistics, 1977, public user tape.
For the sources of CDRU and EFFA, see entry for SCLA.

EXPA--ratio of exports to turnover for the Australian industry, 1977-78. Source: Industries Assistance Commission public tape user.

FTAI--share of turnover in the Australian industry accounted for by foreign-controlled companies. Source: ABS, Foreign Ownership and Control in Manufacturing Industry, 1972-73, Catalogue No. 5312.0. We did not use the later (1975-76) data, because they were reported on a more aggregated basis.

MLTP--number of plants per company, four largest companies classified to the Australian industry, 1977-78. Source: ABS, Enterprise Statistics, 1977, public user tape.

NPC--nonproduction employees expressed as a fraction of total employees, Australia, 1977-78, minus the same ratio for the United States, 1977. Source: BLS, National Establishment Time Accounts, 1977, Table 1.

REDB--Herfindahl index of concentration of the Australian industry's employment among states, 1979-80. For each industry we expressed employment in each state as a fraction of total employment in Australia, squared the fractions, and summed them. Source: ABS, Census of Manufactures, 1979, Table 6, Series 80, Table 6, Series 80.


RNB--company-financed research and development outlays expressed as a fraction of total company sales, 1976. Source: U.S. Federal Trade Commission, Annual Survey of Manufacturing, 1976. We used 1976 because 1977 data had not been released at the time the research was completed. FTC data are preferred to those of the National Science Foundation for being reported on a less aggregated basis.

SCLA--interactive variable calculated (using the formula given in the text) from these components: (1) EFFA-effective rate of natural and artificial protection for the Australian industry, 1977-78 (see sources given for construction of the dependent variable in the analysis of relative productivity). (2) MESU--shipments by the midpoint-size plant in the U.S. industry expressed in Australian dollars, 1977 (calculated from U.S. Bureau of the Census, 1977 Census of Manufactures, public user tape). (3) CDRU--"cost advantage ratio" for the U.S. counterpart industry, value added per employee for plants in size-classes smaller than the one containing midpoint plant size divided by value added per employee for plants in size-classes larger than the one containing mid-point plant size (source: same as MESU). (4) DDA--domestic disappearance in the Australian industry, domestic shipments minus exports plus imports (calculated from the IAC public user tape). (5) DDU--domestic disappearance in the U.S. counterpart industry (calculated from U.S. Bureau of the Census, U.S.).
Commodity Exports and Imports as Related to Output, 1977.

SCLD—calculated by the formula RMSU*CDRU*EFFA. Sources: see entries for RMSU and SCLA.

TP—midpoint plant size (employment) for the Australian industry divided by midpoint plant size for the U.S. counterpart. The Australian figure is calculated from ABS, Manufacturing Establishments: Selected Items of Data Classified by Industry and Employment Size, Australia, 1977-78, Catalogue No. 8204.0. The U.S. variable is the one calculated for the dependent variable in the analysis of relative size (see above) from the U.S. Bureau of the Census, 1977 Census of Manufactures, public user tape.

These variables and numerous other data on Australian and United States industrial organization were put in machine-readable form through the Project for Industry and Company Analysis, Harvard Business School. We are grateful to the School for its support of this data-base project.
Appendix C -- Industries with Extreme Values of Scale/efficiency Indicators

Our analyses of both relative productivity and relative plant scale turn on one complex interactive variable, SCLA and SCLB respectively. Because their values are unfamiliar empirically and hard to grasp intuitively, it may prove helpful to readers to see a list of industries taking extreme values for each.

SCLA embodies the hypothesis that industries subject to important scale economies (as revealed from U.S. data) and given low protection in Australia will contain in Australia only industries with relatively efficient-scale production units, to the extent that Australian production is viable at all. Conversely, industries with substantial scale economies but given high protection in Australia afford room for a lot of capacity that is viable but inefficient. Industries with minor scale economies should be in the middle of the distribution, except to the extent that their rates of effective protection are either extremely high or extremely low (negative).

We first list the ten industries ranked from the highest values of SCLA, indicating that high scale economies and/or low protection impel them to scale efficiency:

1. 3224 Aircraft building and repair
2. 3311 Photographic equipment and supplies, optical instruments, and film processing
3. 2921 Smelting and refining of copper
4. 2927 Rolling, drawing, and extruding of aluminum
5. 3321 Shipbuilding and repair
6. 2828 Rolling, drawing, and extruding of nonferrous metals n.e.c.
7. 3312 Measuring apparatus and professional and scientific equipment and supplies, n.a.o.
8. 3321 Television sets, radios, communication and other electronic equipment
9. 2723 Pharmaceutical and veterinary products
10. 2621 Publishing

Now, the ten industries ranked from the lowest (high protection plus scale economies create considerable room for scale-inefficiency):

1. 2730 Petroleum refining
2. 2192 Beer
3. 3336 Commercial and industrial space heating and air-conditioning equipment
4. 2152 Starch, gluten and starch sugars
5. 2713 Plastics materials, synthetic resins and synthetic rubber
6. 3322 Refrigerators and household appliances
7. 2195 Alcoholic beverages n.e.c.
8. 2711 Chemical fertilizers
9. 3121 Metal cans, cannisters and containers
10. 2181 Confectionery, chocolate and cocoa
The variable SCIM identifies those industries in which small production units tend to be viable in Australia because of a combination of high tariffs, large scale economies inferred from U.S. data, but small cost disadvantages of suboptimal-scale producers. The following list gives the ten industries with the highest values of this variable (ranked from the highest observed value):

1. 3322 Refrigerators and household appliances
2. 2721 Ammunition, explosives and fireworks
3. 2210 Tobacco products
4. 3446 Writing and marking equipment
5. 2321 Textile finishing
6. 2332 Felt and felt products
7. 2181 Confectionery, chocolate and cocoa
8. 3225 Transport equipment n.e.c.
9. 3325 Batteries
10. 3221 Shipbuilding and repairing

The industries with the lowest values for this variable need not be listed, because they are entirely dominated by low rates of effective protection.