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TRADE LIBERALISATION AND PRODUCTIVITY GROWTH: TIME-SERIES EVIDENCE FROM AUSTRALIAN MANUFACTURING

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Trade Liberalisation and Productivity Growth: Time-Series Evidence from Australian Manufacturing*

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Abstract

This paper uses historical annual data for 27 years from 1968-9 on eight two-digit ANZSIC industries to assess the impact of the changes in industry assistance on economic efficiency. The empirical analysis shows that a one percent decline in the nominal rate of assistance leads to between 0.18 and 0.56 percent gain in multi-factor productivity, the latter our measure of economic efficiency. This finding has strong policy ramifications for the future of tariff reform in the manufacturing sector.

Note: This is work in progress. The data used for the analysis is drawn from unpublished IC sources. As such, the paper shall not be quoted without prior permission of the author and the Industry Commission.

* The analysis for this paper was undertaken at the Canberra office of the Industry Commission, support with data by Commission staff is acknowledged.

1 Introduction

Protection of the domestic manufacturing sector in Australia has had a long history. The subject has generated considerable debate recently following the decision by the Government to freeze car tariffs at 15 percent from the year 2000 to 2004 followed by a step down in 2005 to 10 percent. The initial rationale for protection of industry was to enable the establishment of a viable domestic manufacturing sector; this was then considered to be a social good on self-sufficiency arguments and in that it was perceived to provide diversity in employment opportunities such that Australians were not considered as "hewers of wood and drawers of water" (Brigden 1929: 5).[1] These infant industry arguments for protection imply that assistance was meant to be short-term and provided only until the industry established itself. The more recent arguments, particularly those pertaining to the tariff freeze for the automotive sector, are based on arguments of saving jobs; an important concern in the current climate of high unemployment. Even though some protection to manufacturing has been accepted since federation, policy makers have been explicit in ensuring transparency in magnitude of assistance afforded to industry and monitoring of the cost, in terms of economic efficiency, of such assistance. These two responsibilities constitute the statutory obligations of a politically independent body in the form of the Industry Commission.

This paper focuses on the second obligation of the Commission. The long policy experiment in respect of assistance provision to the domestic manufacturing sector now enables us to draw on this experience to gauge the impact of assistance provision on economic efficiency. This efficiency is quantified in terms of multi-factor productivity (MFP). The data used in this analysis is drawn from Commission database and Australian Bureau of Statistics (ABS) publications and is for 2-digit ANZSIC manufacturing sectors for the 1967-8 to 1994-5 period. The time series analysis for eight industries over the 27 year period reveals that assistance withdrawal is statistically significantly associated with productivity gains; our most conservative estimates show that a one percent reduction in the nominal rate of assistance afforded to the industry leads to a MFP gain of 0.18 percent. This link between trade liberalisation and productivity growth have implications for competitiveness of industry in the context of free regional trade in the year 2010; an APEC commitment that we assume is non-negotiable.

Here we concentrate on the manufacturing sector for three reasons. First, manufacturing has gone through a gradual process of assistance reduction, but this has neither been monotonic nor uniform across the sub-sectors. This variability in assistance is valuable in any quantitative analysis. Second, the tradeable nature of the sector allows us, at a conceptual level, to translate industry value-added from domestic to border prices that are free of domestic distortions to enable the analysis of the impact of distortions on "distortion-free" output. This is an important consideration given that assistance to the sector was provided with the view to providing shelter to domestic suppliers from complete exposure to world trade. Given the small size of the Australian manufacturing sector relative to world output, there is little basis for protection on terms-of-trade arguments. Third, data is available for 25 years beginning 1968-9 for eight industries providing sufficient degrees of freedom

[1] Hillman (1977) notes that one motive for protection to manufacturing was to encourage immigration.

for econometric analysis.[2] This data has received more consistent treatment within as against across large industry aggregates as manufacturing and agriculture. For example, valuation of output and incorporation of the various forms of assistance provided to industry has been given uniform treatment across individual manufacturing sectors, this uniformity is not present between manufacturing and agriculture.

The rest of the paper is organised as follows. Section 2 provides an overview of assistance provided to the manufacturing sector over the period of study. Section 3 presents a brief survey of the link between trade policy and growth. Section 4 presents evidence in support of the claim of this paper, that is reductions in industry assistance has improved MFP. Some policy implications of this finding is presented in section 5. Conclusion follows.

2 Overview of assistance to the manufacturing sector

The manufacturing sector in the period 1968-9 to 1994-5 has undergone a process of assistance withdrawal.[3] As shown by Figure 1a, both the effective and nominal rates of assistance has declined for the aggregate sector, but this trend has not been uniform across the sub-sectors of manufacturing. Figure 1b shows that protection to textiles, clothing, and footwear (TCF), transport equipment (TEQ), and food, beverages, and tobacco (FBT) has varied considerably over time. The significant changes on assistance to manufacturing over the last twenty-seven years has included: a 25 percent across the board tariff cut in July 1973; introduction of quota assistance

[2] ERP and NRA data for 1993-4 and 1994-5 is not yet available.
[3] Source for this and the next paragraph is Industry Commission (1995).

following pressures for assistance due to the down-turn in economic activity in 1974; tariff reductions introduced in January 1977 followed by reductions in the duty rates following the devaluation of the Australian dollar and multilateral trade negotiations; increased use of export incentives from 1977-8; and announcement in the economic statement of May 1988 of general tariff reductions and the continuation of this program since. The schedule announced in this statement has a target of an effective rate of assistance (ERA) of 5 percent for most industries. In terms of quantitative controls, import licensing were abolished in 1960 but quantitative controls remained on TEQ and TCF sectors until April 1988 and March 1993, respectively.

[Figures 1a; NRA and ERA for Total Manufacturing]

[Figure 1b: NRA and ERA in three sectors]

In terms of assistance to manufacturing, tariffs constitute the bulk and have increased in importance over time. For example, in 1983/4, tariffs accounted for over 80 percent of total measured assistance to manufacturing while in 1990 this figure had increased to 90 percent. The significant disparities in assistance to sectors <u>within</u> manufacturing has serious resource allocation effects. For example, in 1970-1 29 percent of total manufacturing output received a nominal rate of assistance of less than five percent; this figure is projected to rise to 85 percent by the year 2000-1. Analogously, 9 percent of total manufacturing value-added received an effective rate of assistance less than five percent, this figure is projected to increase to 55 percent by the year 2000-2001.

The variability amongst manufacturing industries in respect of assistance provided has increased over time while the general level of assistance to the sector in aggregate has declined. Figure 2 below shows that the ratio of assistance to FBT, TCF, and TEQ relative to the manufacturing average were 0.44, 2.69, and 1.39, respectively, in 1968-9; these figures changed to 0.33, 6.08, and 2.42 in 1992-3. Hence, the distorting effects on resource allocation within manufacturing as a result of the differential treatment between the sub-sectors must have increased over the years.

[Figure 2: Ratio of ERA relative to mean for manufacturing]

[DN: Plan for the future of tariff reform - one paragraph only]

3. Trade liberalisation and productivity growth

The link between trade policy and growth is a tenuous one. Here we provide a brief overview.[4] The impact of trade liberalisation on productivity is unresolved. The theoretical literature does not yield an unambiguous prediction on the direction of change, the onus therefore rests on empirical studies to establish any such effects.[5] Empirical studies, in turn, have failed to show an unambiguous association between trade policy and growth. A number of studies, principally for developing countries with industry and firm level data, have failed to establish an unequivocal positive relationship between trade reforms and productivity growth.[6] Moreover, most of these studies have been plagued by both empirical and conceptual shortcomings. First, these studies rarely posit an explicit theoretical mechanism linking trade policy with

[4] For a detailed theoretical treatment on the link between trade and growth see Grossman and Helpman (1991).
[5] See surveys by Rodrik (1988 and 1992) and Tybout (1992).
[6] See surveys by Havrylshyn (1990), Nishimizu and Page (1990), and Rodrik (1995).

productivity growth.[7] As Rodrik (1995: 2935) notes, " since the conceptual issues are rarely sorted out as a prelude to empirical analysis, the hypothesised cause-and-effect are difficult to interpret". Here we use the production function augmented with variables from "new growth theory" to establish directions of causality between trade policy and productivity growth.

A second limitation of this literature is empirical in that data limitations, particularly in respect of changes in trade policy, have been very limited in supply both across industries and countries and over time.[8] A few studies have taken advantage of sudden and drastic policy changes through use of dummy variables in econometric studies to discern any association between changes in trade regime and productivity growth.[9] Such occurrences are few and in these studies causality is inferred from association alone. More importantly, use of such "before-and-after" analysis implicitly assumes that a) the trade reform process was an once and for all event, and b) that it was complete; neither of these impositions are likely to hold in most cases of reform. In the cases where the reform process is gradual and non-monotonic, the dummy variable technique is of limited value.

Australian manufacturing is different in many respects to the above qualifications. First, the reform process has been gradual and non-monotonic. Second, data on nominal as well as effective rates of protection are available since 1968/9 to 1994/5. Third, data on factor inputs and industry output in terms of value-added is available in published form. The relatively long time series provides us with sufficient degrees of

[7] Causation was often inferred from association. eg If productivity rose after as against before reforms, then the reforms were credited for the gains.

freedom to carry out econometric estimates of the association between productivity growth and trade liberalisation.

4 Model and Results

The Conceptual Framework

Let the production function be given by

$$Y = AF(BK, CL) \qquad (1)$$

where Y, K, and L are value-added, physical capital, and labour, respectively; and A, B, and C denote productivity indices with the first being neutral with respect to the two factors of production while the last two are factor biased. Each of these productivity indices, in turn, are functions of further variables as given below.

$$A = A(t), \qquad (2)$$

$$B = B(M, R) \qquad (3)$$

$$C = C(\tau) \qquad (4)$$

Technological progress is driven by technology that results from progress in time alone.[10] Capital productivity is a positive function of the extent of imports of intermediate inputs and domestic research and development activity; the first is a

[8] See Edwards (1993).
[9] See Harrison (1994).

channel via which foreign best practice and a wide array of intermediate inputs enter the production function, the second proxies for indigenous productivity enhancing activity.[11] Labour input is a negative function of the level of protection via the standard X-inefficiency argument, reductions in protection raises effort through the standard "cold-shower" effect of trade liberalisation.[12] Substituting equations (2) to (4) into equation (1) and then differentiating the resulting expression gives

$$\hat{Y} = \alpha_0 + \alpha_1 \hat{K} + \alpha_2 \hat{L} + \alpha_3 \hat{M} + \alpha_4 \hat{R} + \alpha_5 \hat{\tau} \qquad (5),$$

where a caret over the variable represents its growth rate. Equations (1) and (5) form the basis of the empirics that follows, but first we provide a brief description of the data.

Data

The data used is as recent and comprehensive as available and is drawn from the Industry Commission data base. This (annual) data up to 1992/3 year together with a detailed description of sources and methods of collection is provided in Industry Commission (1995), hence we provide a brief description of variables employed in this study. The time period covered is from 1968/9 to 1994/5 for eight two-digit ANZIC manufacturing industries (see Appendix I for industry descriptions).

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[10] This is a simplification given foreign direct investment and foreign R&D could also impact on A.

[11] See Romer (1986) for a theoretical justification for these arguments.

[12] See Horn, Lang and Lundgren (1996) on the first and Vousden (1993) on the second.

Value-added is in 1989/90 constant domestic prices.[13] Unassisted value added, interpreted as value-added in border prices, is computed by deflating value-added in domestic prices by the effective rate of assistance (ERA). The ERA encompasses effective rate of protection (ERP) as well as non-border interventions in the form of production subsidies, input taxes and subsidies, special credit facilities, special depreciation allowances and tax provisions, and the provision of industry-specific infrastructure. As such, the ERA provides a measure of the relative incentives afforded to industry for domestic value adding activity. In the case of manufacturing, assistance estimates are derived using import parity as the appropriate benchmark; this being the case because of the import-substituting nature of domestic production.[14] In contrast, the nominal rate of assistance (NRA) ignores the input distortions and hence is analogous to nominal tariffs but it encompasses quantitative controls at the final product level. Capital input is measured by the quantity of capital services provided, capital being distinguished between machinery and equipment (M&E) and non-residential construction (NRC). Capital stock data, available from the Commission database, has been used to compute capital intensity in the estimate of the intensive-form of equation (1). Labour input is measured as number of workers weighted by an index of hours worked as per sector and year. R&D stocks and index of intra-industry trade from Industry Commission (1997) are used as the measures of R and M, respectively.

Results

[13] See Appendix II for justification for use of unassisted value-added for this analysis.

[14] See Appendix Table A3 for data on share of exports in total output for the sectors covered in this study.

First a Cobb-Douglas representation of equation (1) with constant returns to scale assumption imposed, as the most restricted form of the model, is estimated in levels.[15] Time effects are included to control for economy wide demand effects as those arising from business cycles. Thus, the equation estimated is of the form

$$\ln y = a_0 + a_1 \ln k + a_3 \ln M + a_4 \ln R + a_5 \ln(\tau) + T_t + \upsilon \qquad (6)$$

where small letters denote per-capita values of the respective variables, T is year dummy for period t and v is the error term which is assumed *iid*. The coefficient estimates are given in table 1. The coefficient estimates reported in column (i) are obtained with both time and fixed effects in place. With the exception of the coefficient on R, all coefficients have the expected sign and are statistically significantly different from zero at the 95 percent confidence level. The point estimate of the coefficient on R is not statistically different from zero at the 95 percent confidence level. Lack of R&D data for the eight years preceding 1978/9 has been responsible for the loss of 64 degree of freedom. Given this penalty and the fact that the coefficient on R is insignificant, equation (6) was re-estimated but without R. Column (ii) reports results when fixed effects were omitted while the case where both time and fixed effects are included is reported in column (iii) of table 1.

The magnitude of the capital elasticity coefficient (a_1) is sensitive to inclusion as against exclusion of fixed effects. This is also true of the elasticity of changes in protection to value-added. In all the three estimates, the estimate of a_1 is plausible relative to capital's share in value-added. One robust finding from all of these

[15] The CRS assumption implies $a_2 = 1 - a_1$ in equation (6).

estimates is that increases in nominal rates of assistance have a negative and statistically significant impact on TFP. The point estimate of a_5 reported in column (i) of Table 1, where the complete model in equation (6) is estimated with time and industry dummies, suggests that a one percent drop in the nominal rate of protection leads to, on average, 0.18 percent rise in TFP. Given the inclusion of fixed effects, this must be interpreted as deviations of the respective variables from their means for the overall time period as per industry. Also note that this is the most conservative of the estimates of a_5 amongst all the estimates reported in Tables 1 and 2.

The adjusted coefficient of variation at 87 percent is high, particularly for panel regressions which tend to have values lower than 50 percent. One reason for this high R^2 may be because the regressions are carried out in levels, this is particularly true when variables tend to have strong trend components in them.[16] One obvious remedy is to de-trend the data, but this is what the model in equation (5) does. Furthermore, the specification in equation (5) has the added strength of having a strong theoretical basis for use of the differenced model. Hence, equation (5) which is analogous to estimating (6) but now in differenced form and without the CRS restriction, is estimated next. If we let the growth rate of variable V be represented by the first log-difference of the variable, ie

$$\hat{V} = \frac{V_t - V_{t-1}}{V_{t-1}} \approx \ln V_t - \ln V_{t-1} \equiv \Delta \ln V$$ [17]

[16] The high coefficient of variation may be due to spurious correlations, this effect is likely if the variables are non-stationary.

[17] From now on we use $\hat{V}$ and $\Delta \ln V$ inter-changeably.

then equation (5) has an analogous representation as

$$\Delta \ln Y = a_0 + a_1 \Delta \ln K + a_2 \Delta \ln L + a_3 \ln \Delta M + a_4 \ln \Delta R + a_5 \ln \Delta(\tau) + T_t + \upsilon \quad (7).$$

[Table 2 about here]

where time effects and an error term have been included. The results of the estimate of equation (7) is provided in table 2. The estimate in column (iv) is the implementation of the standard growth accounting identity. Three observations can be made from these estimates: first, growth in labour is the only significant determinant of output growth; second fixed effects are important; and third, the model has very low predictive power given the low coefficient of variation statistic. Columns (v) and (vi) report the estimate of the model given in equation (7) with and without the R&D variable, respectively.[18] The coefficient on growth in non-residential construction has negative and statistically insignificant coefficient. This result may be a statistical outcome given the low variance in the observations pertaining to this variable (see summary statistics reported in Appendix I, Table A2). The insignificant coefficient can be rationalised on economic considerations as well given that non-residential construction, which includes factory buildings in bulk, is not expected to be highly responsive to changes in annual output. The lack of statistical significance on growth in machinery and equipment variable can be due to the above factors as well, though here it is important to note that the point estimate of

[18] Another estimate with both the level and growth of R&D stocks was estimated to account for the possibility that it is both the level and change in indigenous capacity that impacts on TFP growth. The results from this estimate were not statistically and qualitatively different to that reported in column (ii) of table 1.

this coefficient is comparable to that obtained with the level estimates reported in column (iii) of Table 1. Again the robust finding is the negative coefficient on the protection variable.

Last, we incorporate the first lags of the error terms from equation (6) as an additional variable (EC_{t-1}) in equation (7) which now gives an error correction form (ECM) of (7).[19] The rationale for doing this was to discern any short and long-run relationships between changes in nominal rates of assistance with TFP growth in the manufacturing sector.

$$\Delta \ln Y = a_0 + a_1 \Delta \ln K + a_2 \Delta \ln L + a_3 \ln \Delta M + a_4 \ln \Delta R + a_5 \ln \Delta(\tau) + bEC_{t-1} + T_t + \upsilon \quad (8)$$

The result of this estimate is reported in column (vii) of table 2. The positive and statistically significant coefficient on the error correction terms does not suggest any stable relationship between protection and output. There is no theoretical reason to expect a long-run steady-state relationship between productivity and protection; furthermore, should such a relationship exist, our short time series would not be able to pick this up. The finding of relevance to this paper is the fact that the qualitative as well as quantitative impact of protection on TFP growth remains robust in all of these estimates.

Sensitivity tests

[19] The estimates from column (iii) in table 1 is used given the comparability to the estimate in (vii).

There are two concerns from the above estimates of a_5, the elasticity of TFP with respect to protection. The first is whether the coefficients are homogeneous across sectors. The second and related concern is whether the estimate of a_5 is stable across time and industries. We attend to these concerns next.

The test for homogeneity of slope coefficients in estimates reported in columns (v) to (vii) in Table 2 is restricted due to lack of sufficient degrees of freedom. Inclusion of time effects, shown to be important from the earlier estimates, is the principal reason for this lack of degrees of freedom. Time effects in our estimates are included to control for economy-wide effects as those arising from business cycles. Given that production in manufacturing is principally for the domestic market (see table 4), the time effects capture shifts in demand for manufactures. An alternative means of capturing these time specific shifts in demand is through a capacity utilisation variable. This variable, caputl, is created as the (log) deviation of aggregate GDP from a trend fitted value.[20] Caputl provides the percentage deviation of actual output from the trend-fitted value.

Figure 3 provides a time plot of GDP and Caputl, the latter picks the troughs and peaks of the business cycle that is in accord with data on unemployment. Incorporation of caputl in place of time effects frees up the necessary degrees of freedom to carry out the homogeneity tests. Table 3 reports these results. We carry out tests on functional form on the model without time and fixed effects, the most restrictive form of the model estimated so far. The RESET test rejects the functional form employed, a plot of the residuals shows that the error terms from the FBT sector over-shoot the 95 percent confidence bands. Dropping this sector from the data results in the acceptance of the functional forms by both the RESET tests at the 5 percent significance level. Most importantly, the qualitative and quantitative findings with respect to a_5, the parameter of interest to this study, remains robust to all of the above qualifications.

[Figure 3: GDP and Capacity Utilisation]

[Table 3 about here]

The second concern is on the stability of a_5. We test this by carrying out OLS recursively and following the estimates obtained from addition of variables from the 7th to the last (192nd) observation. The negative and statistically significant coefficient is present through out. The coefficient estimates are stable, particularly after the 73rd observation.

[Figure 3: Stability of a_5 based on recursive residuals]

In summary, the results provide strong support to the hypothesis that reductions in nominal rates of assistance to Australian manufacturing has raised TFP growth in the sector. Our analysis for eight two digit manufacturing ANZSIC sectors shows that a one percent reduction in the nominal rate of assistance afforded to these sectors leads

[20] Australian GDP over the 1968-9 to 1994-5 period grew at 3 percent per annum; this figure was obtained by regressing log GDP on a constant and time trend. Caputl is the residual from this

to approximately half a percent rise in TFP growth. Here we have relied on the estimates emanating from the estimate of the model given in equation (7), the preference being due to the fewer restrictions placed on the estimates — *vis-a-vis* model given in equation (6) — and the fact that it has a strong theoretical basis.[21]

5 Three Policy Implications

Time series evidence in this paper shows that reductions in the nominal rates of assistance has raised MFP, we extrapolate on this association to draw some policy inferences. Given the above, the ramifications for the future of productivity growth, competitiveness of industry, and success in exports from future tariff reform is serious. Three specific issues are taken on board; first, the implications for productivity growth emanating out of a gradual *vis-a-vis* step-reduction in tariffs come the year 2010 is considered; second, the issue of endogenous protection where "free-trade" by the year 2010 is subject to lobby-group pressure is discussed; and third, we consider the issue of employment creation in manufacturing via stalling the liberalisation process in the interim period.

In a world of perfect information, perfect foresight, and credible policy with infinitely lived agents, announcements of phasing-out of assistance is sufficient to produce the productivity gains regardless of the actual timing of such policy actions. If these conditions held for the past policy changes then the data would reveal structural breaks in respect of the elasticity of MFP to announcements of changes in policy of

regression.

[21] See Granger (1997) and Pesaran (1997) on modeling the long-run and the role of theory in such modelling.

protection. The econometrics does not reveal any such breaks.[22] Absence of such structural breaks suggests failure of one or more of the assumptions listed in the first sentence of this paragraph. Hence, gradualism is likely to deliver in terms of efficiency gains relative to a one-step reduction come the year of free-trade.

Next we consider the case of lack of policy credibility, where an early failure on future liberalisation could stall the liberalisation process altogether. Suppose that the time taken to liberalise a sector is proportional to the magnitude of rent-generating resources displaced by such liberalisation. Now gradualism makes sense in that it is the only practical option. This is true even if it is desirable, on static welfare considerations, to liberalise all at once; the political economy disallows such large discrete jumps. The argument here draws on bicycle-theory in that if one does not continue forward, then falling-off is inevitable.[23]

Last, 'saving-jobs' in the interim through a freeze on the liberalisation process could stall job-creation in manufacturing in the longer run. Though there is no evidence in support of the claim that protection creates jobs, suppose this was true.[24] Much of manufacturing output in Australia is for the domestic market. If the gradualism argument of the preceding paragraph were true, then a phased reductions in tariffs would usher the industry into a position to compete under free-trade in the year 2010. Should such productivity gains enable success in the export markets, little reason to expect otherwise, then permanent gains in employment in manufacturing would arise

[22] These structural breaks are 'eye-balled' by viewing plots of the CUSUM, CUSUMSQ, and coefficient estimates obtained from recursive OLS.
[23] Staiger (1995) argues that stalling the liberalisation process could lead to back-peddling as well.

from production for the export markets. Contrast this with protection now to save a few jobs but at a cost of productivity gains that could disadvantage the industry in future. An objective assessment of the value of short-term protection to save jobs now requires full knowledge of the gains now versus the losses in the future and the discount rate; issues beyond the purview of this paper.

6 Conclusion

Australians in general have been concerned ever since federation over the need to establish a viable and an efficient manufacturing sector. Some of these concerns were based on national security considerations, arguments for infant industry protection, and the need to generate variety in employment opportunities. Industry assistance via protection and direct subsidies have been used to support industry, but the government and the informed public has been conscious of the need to keep such assistance transparent and be able to gauge the impact of these assistance on economic efficiency.

Past policy actions have produced sufficient data to test if reductions in protection has raised economic efficiency, the latter quantified in terms of raising MFP growth. The answer using readily available Australian Bureau of Statistics and Commission data is in the affirmative. We find that one percent reduction in the nominal rate of assistance afforded to manufacturing leads to, on average, from 0.18 to a half a percent increase in TFP growth. The ramifications of the above finding on viability of

[24] Our preliminary and on-going work using this same data set suggests that there is no evidence in support of this claim. For example, the sectors that have been protected more than the manufacturing average have also tended to shed more jobs relative to the manufacturing average.

the manufacturing sector under free regional trade is serious; the message being that failure to liberalise now may put the sector at a disadvantage later.

Table 1: Regression in levels (equation 6).

Coefficient	Variable	(i)	(ii)	(iii)
a_0	constant	–	0.19	–
			(0.22)	
a_1	ln k	0.49	0.35	0.50
		(4.51)	(4.76)	(3.50)
a_3	ln M	0.19	0.0029	0.0061
		(3.16)	(0.97)	(2.53)
a_4	ln R	-0.094	-	-
		(-0.82)		
a_5	ln (τ)	-0.18	-1.11	-0.63
		(-3.17)	(-19.33)	(-8.91)
Time effects		yes	yes	yes
Fixed effects		yes	no	yes
# obs.		128	192	192
Standard error		0.1379	0.4010	0.227
R^2		0.91	0.89	0.88
R^2 adjusted		0.89	0.88	0.85

Pooled data for 8 two-digit ANZIC manufacturing industries over 24 years used in the estimates. The dependent variable is per-worker value-added. k is capital stock per worker. t-ratios given in parenthesis. R&D data available since 1976/7, hence the smaller number of observations in model estimate (i).

Table 2: Growth regression results (equation 7).

Coefficient	Variable	(iv)	(v)	(vi)	vii
a_0	constant	–	–	–	
a_1	Δln K1	0.13	0.55	0.40	0.40
		(0.44)	(1.61)	(1.47)	(1.48)
a_1	Δln K2	0.0026	-0.031	-0.015	-0.010
		(0.04)	(-0.36)	(-0.21)	(-0.13)
a_2	Δln L	0.45	0.32	0.51	0.53
		(3.58)	(1.61)	(3.40)	(3.55)
a_3	Δln M		0.14	0.075	0.071
			(1.86)	(1.35)	(1.28)
a_4	Δln R		0.0092	–	
			(0.041)		
a_5	Δln (τ)		-0.46	-0.51	-0.56
			(-4.27)	(-5.65)	(-5.93)
b	EC_{t-1}	–	–	–	0.11
					(2.92)
Time effects		no	yes	yes	yes
Fixed effects		yes	yes	yes	yes
# obs.		192	128	192	192
Standard error		0.1538	0.1367	0.1252	0.1243
R^2		0.068	0.35	0.47	0.49
R^2 adjusted		0.017	0.16	0.35	0.38
F-Statistic		0.92^{++}	–	0.59^{+}	1.64^{+}
		[0.57]		[0.76]	[0.13]

Pooled data for 8 two-digit ANZIC manufacturing industries over 24 years. The dependent variable is growth in aggregate value-added (Y). Notes: $^{+}$ denotes test for intercept homogeneity while $^{++}$ indicates test for intercept and slope homogeneity. [p-values given in brackets].

Table 3: Growth regression results (Diagnostic tests).

Coefficient	Variable	(iix)	(ix)
a_0	constant	0.047	0.042
		(3.40)	
a_1	Δln K1	0.16	0.22
		(0.71)	(1.06)
a_1	Δln K2	0.04	0.024
		(0.77)	(0.46)
a_2	Δln L	0.47	0.51
		(4.43)	(5.03)
a_3	Δln M	0.082	0.057
		(1.56)	(1.16)
a_5	Δln (τ)	-0.65	-0.72
		(-8.12)	(-8.43)
caputl		yes	yes
Fixed effects		no	no
# obs.		192	168^{+}
Standard error		0.1307	0.1200
R^2		0.34	0.39
R^2 adjusted		0.32	0.37
F-Statistic		1.36^{++}	1.29*
		[0.085]	[0.259]
χ^2 statistic		8.89*	1.35*
		[0.003]	[0.245]

Pooled data for 8 two-digit ANZIC manufacturing industries over 24 years. The dependent variable is growth in aggregate value-added (Y). Notes: $^{+}$ 24 observations for FBT excluded. $^{++}$ indicates test for intercept and slope homogeneity. * indicates RESET test for functional form. [p-values given in brackets].

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APPENDIX I

Table A1: Industry descriptions

ANZSIC CODE	DESCRIPTION
21	Food, beverages and tobacco
22	Textiles, clothing, footwear and leather
24	Printing, publishing and recorded media
25	Petroleum, coal, chemicals and associated products
271,273	Basic metal products
274, 5,6	Structural, sheet and fabricated metal products
281,282	Transport equipment
29	Other manufacturing

Table A2: Correlation Matrix and Summary Statistics

	Δln Y	Δln K1	Δln K2	Δln L	Δln ERP	Δln NRP	Δln M
Δln Y	1						
Δln K1	-0.022	1					
Δln K2	0.014	0.00052	1				
Δln L	0.68	0.041	-0.13	1			
Δln ERP	0.033	-0.064	0.025	-0.068	1		
Δln NRP	0.00014	0.024	0.030	-0.00054	0.50	1	
Δln M	-0.038	-0.010	-0.14	0.031	-0.15	-0.020	1
Summary Statistics							
Mean	0.018	0.041	0.037	-0.019	-0.039	-0.040	0.022
Stnd. dev.	0.041	0.043	0.18	0.092	0.13	0.12	0.18

Table A3: Export share in total output

ANZSIC CODE	Industry Description	1968-9	1992-3
21	Food, beverages and tobacco	0.19	0.22
22	Textiles, clothing, footwear and leather	0.06	0.18
24	Printing, publishing and recorded media	0.01	0.01
25	Petroleum, coal, chemicals and associated products	0.03	0.14
271,273	Basic metal products	0.08	0.16[a]
274, 5,6	Structural, sheet and fabricated metal products	0.03	0.07[a]
281,282	Transport equipment	0.03	0.11
29	Other manufacturing	0.04	0.08

Notes: Exports includes re-exports; [a] denotes data for 1991-2 financial year, the most recent available, used.

APPENDIX II

Why the "wrong" results of the past?

Several attempts to show a negative link between productivity growth and increases in protection have failed, here we show that it has been due to use of domestic prices for valuation of output and value-added.[25] For pedagogic purposes, assume a small open economy (Australia) that produces two tradeables Cloth (C) and Food (F). Let the only restriction on trade be via tariffs on C such that the domestic price of C relative to F is given by

$$p = (1+\tau)p^* \qquad \text{(A2.1)}$$

where p denotes domestic relative price while p* denotes the world relative price. Suppose that all of the existing resources are employed such that the economy is on its production possibilities frontier, the marginal rate of transformation between C and F is shown in Figure A2 below. The initial steady state equilibrium is given by E_0 where at given domestic prices, C_0 and F_0 quantities of cloth and food are produced. In terms of domestic price of F, the GDP of manufacturing at this equilibrium is Y_0.

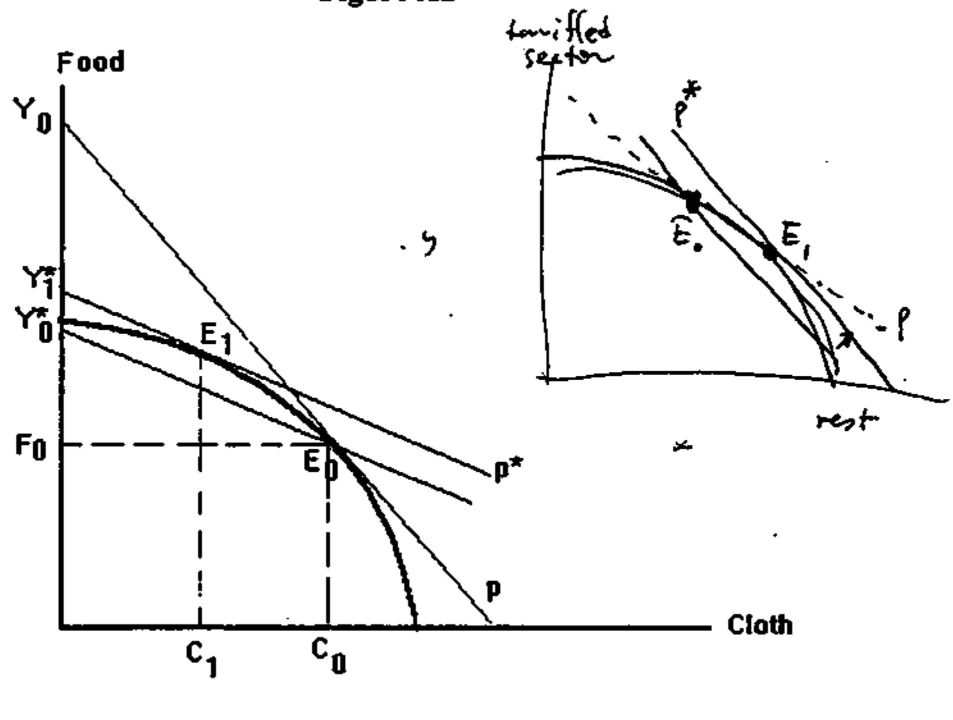
Now suppose τ is reduced gradually such that the price line pivots pushing the equilibrium towards E_1. In terms of F, GDP declines as the tariff is lowered. In terms of C, GDP rises. If quantity weights are used to derive the aggregate price deflator, then an intermediate result prevails depending on the initial pattern of production and

[25] This result can be seen if the Commission estimates of MFP change is regressed on change in any of the two measures of protection, ERA or NRA. Furthermore, a growth accounting estimate using value-added and factor input data from the Commission database gives negative and statistically significant coefficient estimates on capital as well as a positive coefficient on the variable measuring change in protection.

the quantity responses between the two sectors as a result of the price change. In this framework, a reduction in tariffs may accompany a reduction in GDP because output of the protected sector is falling and so is its domestic price.

The problem here is with valuation, if output is measured in p*, then the move from E_0 to E_1 brings about an unambiguous rise in GDP regardless of which commodity is used as the numeraire.

Figure A2

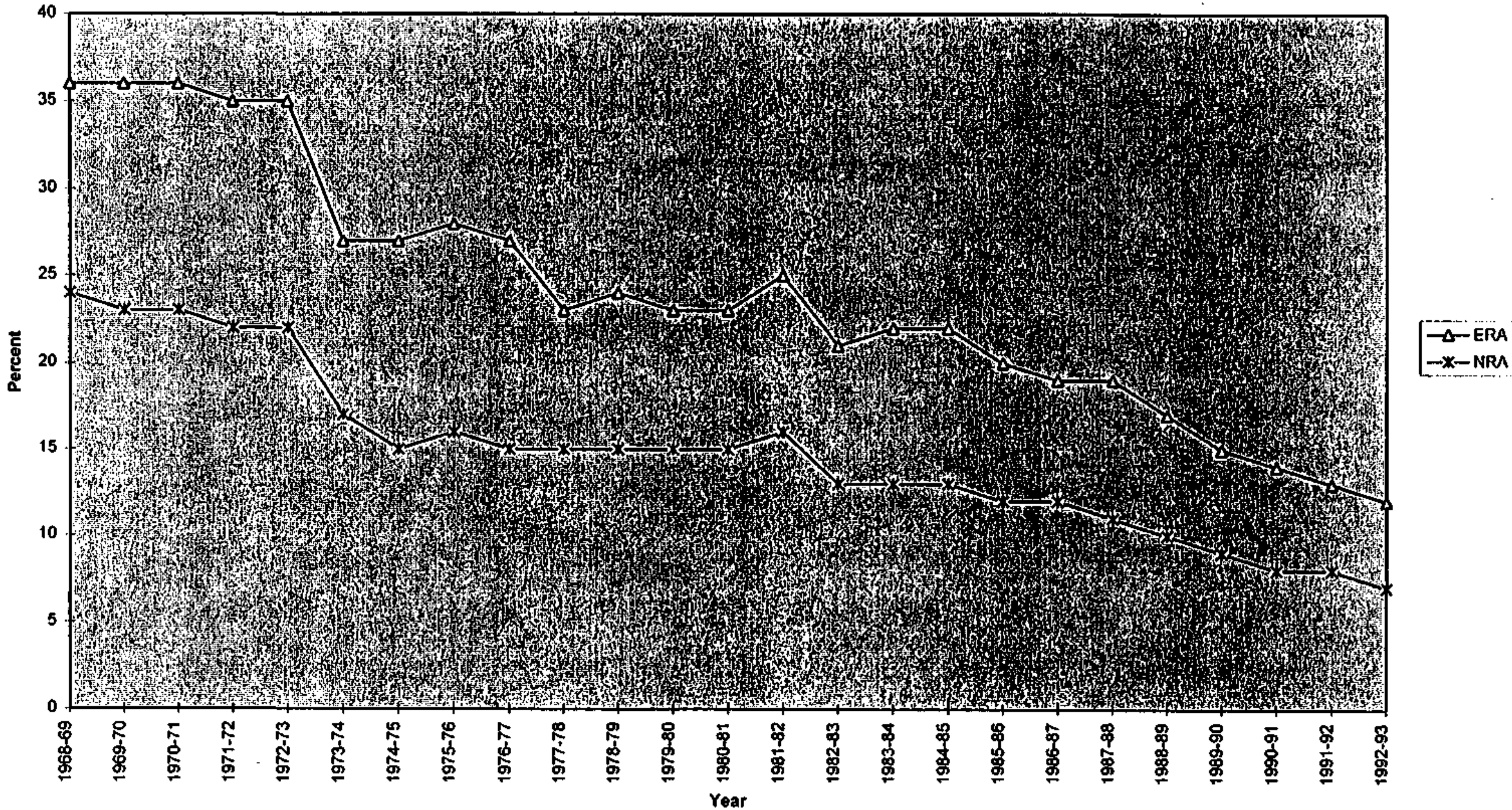


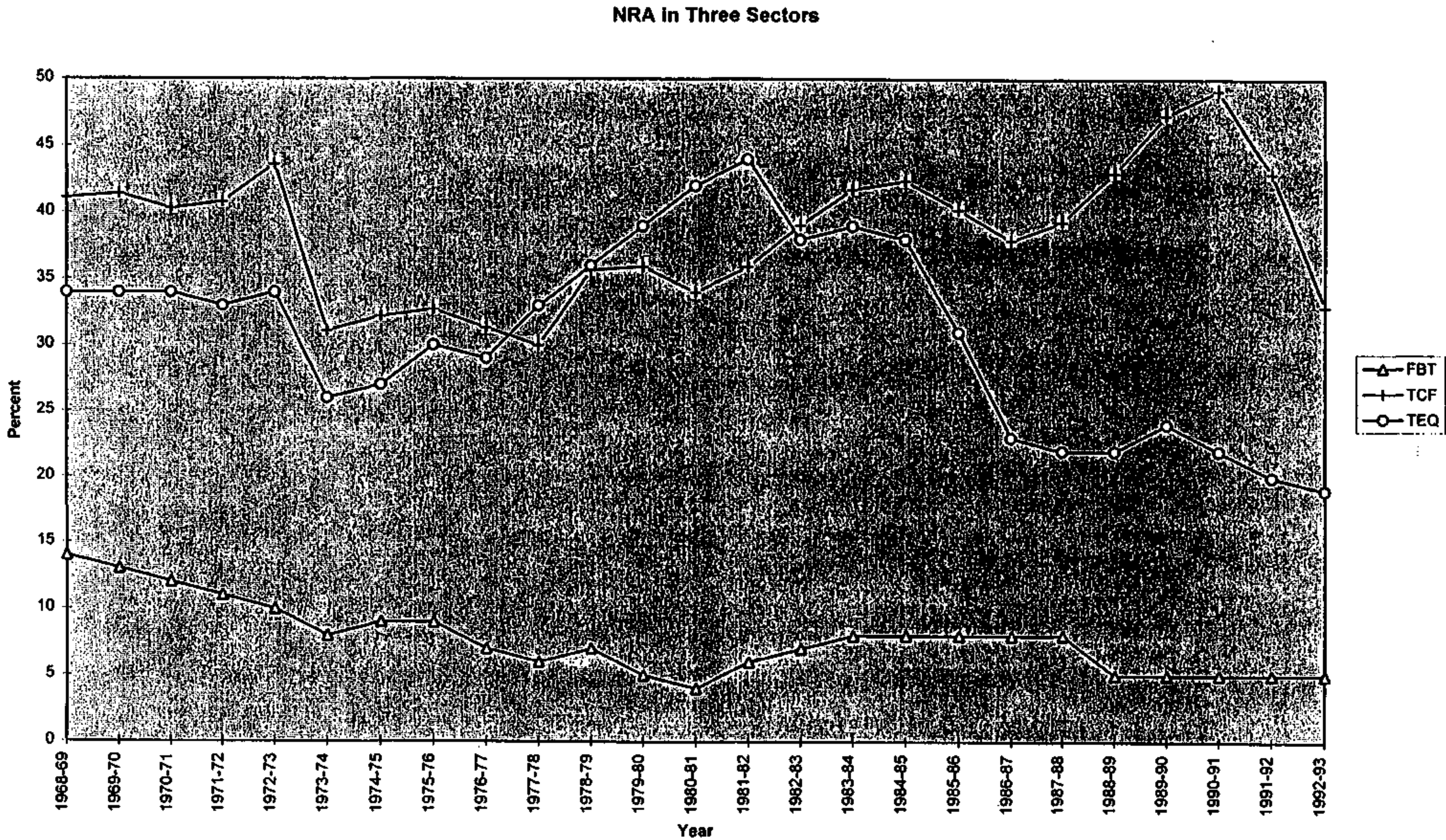
$P_y y + P_x x = I$

$y = \frac{I}{P_y} - \frac{P_x}{P_y} x$

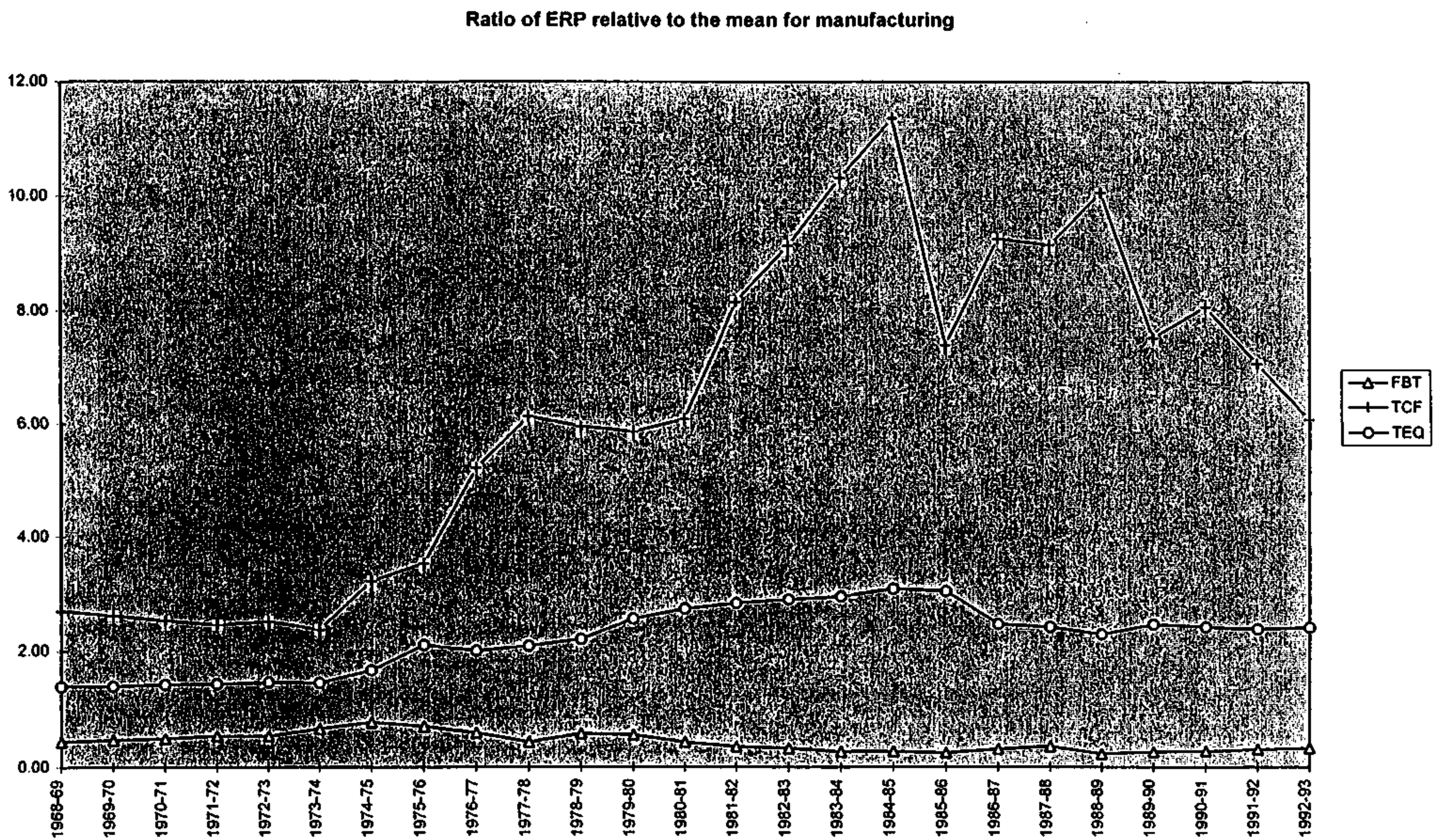
The transition between the two equilibriums, particularly with regards to changes in TFP in the presence of factor market rigidity, is non-monotonic. The fall in protection will create pressures for inter-sectoral movement of labour and capital. The standard Stolper-Samuelson result of a fall in the returns to the intensive factor in the protected sector as a result of a fall in protection will prevail in the new steady state. Should there be, within the short-run, impediments to movement of factors of production, then the declining industry will not be able to fully shed the factors in employment resulting in a drop in TFP with the drop in protection. In the figure above, this would be akin to having a short-run MRT that is enveloped between $F_0E_0C_0$ and the MRT drawn. Hence at the instant of the drop in domestic prices from p to p*, output of the industry drops from Y_0 to Y_0^*. In the long-run when all factors are mobile between sectors, E_1 prevails where Y_1* of income is realised.

NRA and ERA for Total Manufacturing





NRA in Three Sectors
Percent
Year
50
45
40
35
30
25
20
15
10
5
0
1968-69
1969-70
1970-71
1971-72
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
1980-81
1981-82
1982-83
1983-84
1984-85
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
FBT
TCF
TEQ


Ratio of ERP relative to the mean for manufacturing
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1968-69
1969-70
1970-71
1971-72
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
1980-81
1981-82
1982-83
1983-84
1984-85
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
FBT
TCF
TEQ

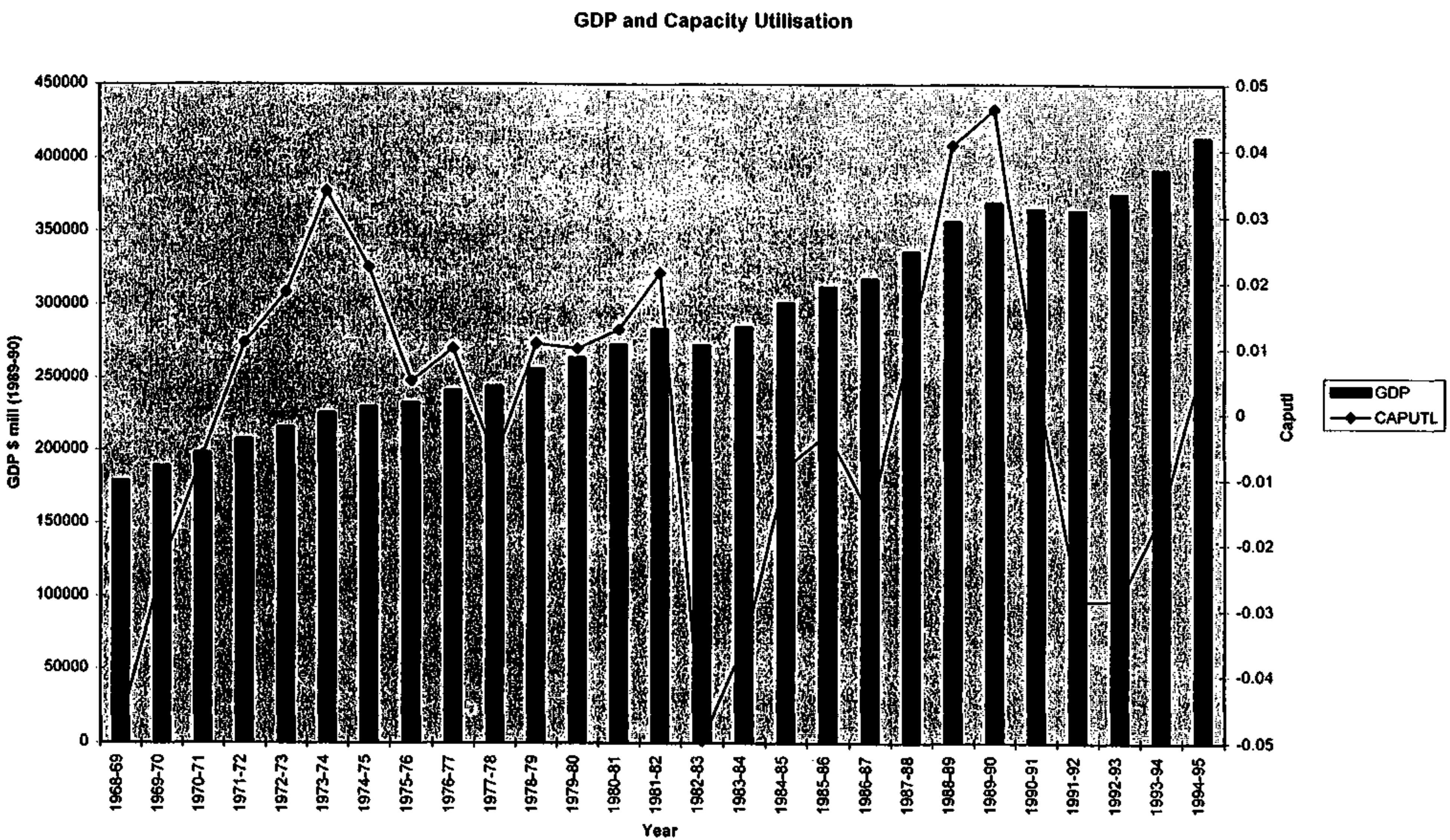
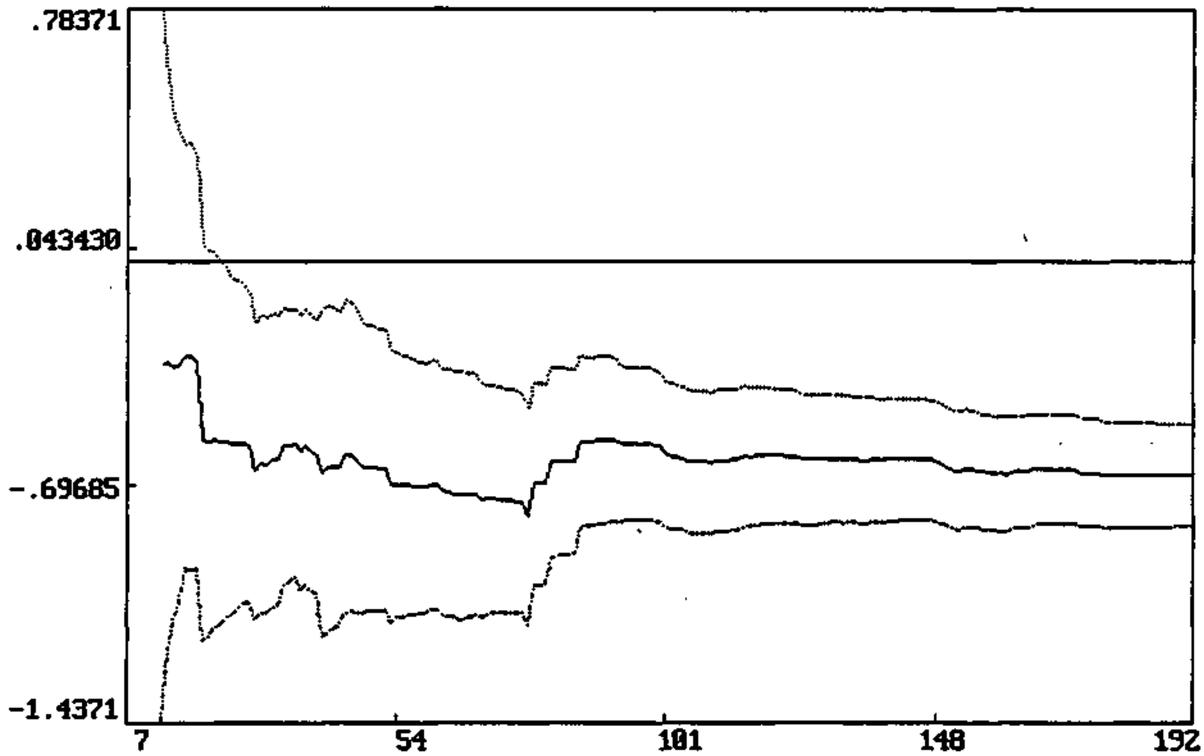

GDP and Capacity Utilisation
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
GDP $ mill (1989-90)
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
Caputl
GDP
CAPUTL
1968-69
1969-70
1970-71
1971-72
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
1980-81
1981-82
1982-83
1983-84
1984-85
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
Year

Figure A1: Coef. of a5 and its 2 S.E. bands based on recursive OLS



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