Thai Journal of Development Administration Vol. 27, No. 2, April 1987

TOTAL FACTOR PRODUCTIVITY GROWTH AT THE FIRM LEVEL IN THAILAND: A CHALLENGE FOR THE FUTURE

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1. Introduction

The importance of the efficient use of resources in an economy's industrialization process is becoming increasingly recognized. While high growth rates of manufacturing output can be attained for some time by simply increasing the allocation of inputs to that sector, this process cannot continue indefinitely. In a major comparative study, Chenery (1986) indicates conclusively that countries with relatively efficient growth processes are those which are able to realize relatively higher aggregate output growth rates from a given growth of factor inputs. In particular, he shows that this phenomenon tends to occur in countries which exhibit high total factor productivity (TFP) growth rates[1].

It is now generally accepted that the rapid economic growth of Thailand's manufacturing sector in the 1960's and 1970's, frequently behind significant protective barriers, was not necessarily achieved in the most efficient ways. The reaching of the limits of the manufacturing sector's growth possibilities from simply reallocating resources is indicated to some extent by the dramatic decline of manufacturing growth rates across the board as the industrial sector entered the 1980's (see Table 1). It is clear that to realize rapid growth in the future, considerable efforts will have to be concentrated on increasing the component of output growth accounted for by the growth of TFP.

Indeed, in numerous policy statements, and the recently released Sixth National Economic and Social Development Plan, issues relating to the "quality" and "efficiency" of national development form one of the main focal points for policy efforts during the Sixth Plan period. The appropriate role of the government in creating an economic environment in which the private sector can operate in the most effective manner, unhindered by bureaucratic red tape and distortionary policies, is now being seriously re-evaluated in the light of the Sixth Plan guidelines.

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Table 1

Growth of manufacturing GDP at 1972 Prices – Selected Sectors

Sector	Compound Annual Growth Rates				
	1960–65	1965–70	1970–75	1975–80	1980–85
Textiles	28.7%	7.2%	18.6%	11.8%	6.2%
Wearing Apparel	3.4%	6.8%	19.8%	15.6%	10.3%
Paper & Paper Products	24.6%	27.4%	13.3%	24.6%	4.2%
Chemicals & Chem. Products	8.1%	12.0%	6.1%	20.5%	6.7%
Rubber & Rubber Products	15.4%	31.8%	19.3%	12.3%	-2.7%
Electrical Machinery	18.5%	22.1%	8.5%	20.9%	4.6%
Transport Equipment	13.6%	7.1%	15.1%	14.7%	5.2%
Total Manufacturing	11.5%	10.3%	9.6%	10.5%	5.4%

Source: National Economic and Social Development Board.

Despite the recent shift of emphasis in policy rhetoric, there have been few studies either at the sectoral or at the firm level that attempt to shed more light on the efficiency aspects of Thailand's industrialization process. In particular, the effect of government policies on the decision-making process of entrepreneurs in the private sector, and the resulting impacts on productivity growth, both at the firm and sector level has received very little attention. Paitoon (1982) and a recent World Bank research project provide some calculations of sectoral TFP growth rates using data from the National Statistical Office of the Thai government but do not really explain differences in TFP growth rates between sectors. The former indicates that exporting industries consistently out performed import competing industries, particularly in the 1970s. The latter results suggest strongly that overall TFP growth rates fell substantially in the 1970's as compared to the 1960's. Both results are perhaps explained to some extent by the fact that levels of protection from foreign competition rose sharply in the latter period. Nishimizu and Page (1986), using the World Bank data, provide further support for this thesis by showing that sectors with greater exposure to foreign competition tended to have higher TFP growth rates and to manifest improvements in international competitiveness.

This paper represents a preliminary attempt[2] to define and examine TFP growth issues at the firm level based on a detailed study of firms in seven manufacturing subsectors, namely: spinning and weaving, synthetic fibre, garments, electrical goods, paper and pulp, rubber products, and automotive parts. In particular, a recently developed methodology is applied to decompose firm level TFP growth into one component resulting from technological progress and another resulting from changes in the efficiency in the use of existing technology and resources. Statistical techniques are used to identify the importance of a set of firm and sector specific variables in explaining firm differences in TFP growth rates. The time series data covering the operations of 139 firms from 1975 to 1983 that is used in the analysis was collected from August 1984 to February 1985. Statistics were obtained both from personal firm contacts and from government sources such as the Board of Investment and the Commercial Registration Department. Details regarding the numbers of firms and various characteristics by sector are presented for reference purposes in Annex Table 1.[3]

The paper is structured as follows: section two presents a brief methodological discussion of the measurement of TFP growth rates and the decomposition of TFP; section three describes and summarizes the results of the statistical calculations; section four presents an econometric examination of firm level differences in TFP growth rates; and section five presents a summary and policy recommendations.

2. The Theoretical Framework

2.1 The Measurement of TFP Growth Rates[4]

The analysis and measurement of TFP growth rates have generally been carried out within the framework provided by the economic theory of production. The fundamental basis of this theory is that there exists a well-defined relationship between some maximum level of output and the levels of a set of inputs that are used in the production process. The relationship is permitted to change over time, thus allowing for shifts in the production function as improved technology becomes available.

The following general form of the production function is used as the starting point for the analysis:

(1) $Q(t) = F[K(t), L(t), M(t), T]$,

where $Q(t)$ = real output of the relevant unit at time t,

$K(t)$ = real capital input at time t,

$L(t)$ = labour input at time t,

M(t) = real intermediate input at time t, and

T = a shift parameter representing time.

Differentiating this function with respect to time, letting "∧" represent the rate of change of variables over time, yields the following equation:

$$(2)\ Q(t)/\hat{Q}(t) = a(t)\hat{K}(t)/K(t) + b(t)\hat{L}(t)/L(t) + c(t)\hat{M}(t)/M(t) + V(t)$$

where the weights, a(t), b(t), and c(t), of the proportional growth rates of the inputs represent the output elasticities of these inputs and the last term, V(t), represents the rate of change of TFP which corresponds to the rate of growth of output with respect to time, holding all inputs constant.

If it is further assumed that production is taking place under constant returns to scale and producer equilibrium is attained, with each factor receiving its marginal product, then the output elasticities in equation (2) are equivalent to input shares and sum to one. The TFP growth rate calculated from observed factor shares can then be defined simply as the difference between the growth rate of real output and the growth rates of real inputs weighted by their shares in output:

$$(3)\ V(t) = \hat{Q}(t)/Q(t) - a(t)\hat{K}(t)/K(t) - b(t)\hat{L}(t)/L(t) - c(t)\hat{M}(t)/M(t),$$
$$\text{where } a(t) + b(t) + c(t) = 1.$$

In order to estimate the growth of TFP from firm or industry data, the following discrete approximation to the continuous-time (Divisia) index in equation (3) is used:

$$\begin{aligned}(4)\ [\ln V(t) - \ln V(t-1)] = {} & [\ln Q(t) - \ln Q(t-1)] \\ & -1/2\,[a(t)+a(t-1)]\,[\ln K(t) - \ln K(t-1)] \\ & -1/2\,[b(t)+b(t-1)]\,[\ln L(t) - \ln L(t-1)] \\ & -1/2\,[c(t)+c(t-1)]\,[\ln M(t) - \ln M(t-1)]\end{aligned}$$

This approach enables a measurement of TFP growth without actually having to estimate econometrically a specific functional form of the production (or cost) function itself and provides a useful measure of the economic performance of the unit being considered even when one does not have enough observations to support the econometric estimation. However, in order to measure static levels of efficiency at the firm level and obtain the decomposition of the observed levels of TFP growth as measured by equation (4) into technological progress and changes in levels of technical efficiency, the "best-practice" production frontier as it changes over time must be specified.

2.2 Frontier Estimation and the Decomposition of TFP Growth[5]

The estimation of a specific frontier enables the recovery both of a set of firm or industry specific Farrell-type[6] indices of technical efficiency for each point in time, from which rates of change can be calculated, and of the magnitude of the shift in the overall "best-practice" production frontier due to technological progress. Changes in technical efficiency basically correspond to all changes in productivity not accounted for by technological progress, and include the effects of the more efficient use of existing inputs including capital stock (i.e. better capacity utilization), of improved managerial practices, of diffusion of technological knowledge that is already available in the economy, and of "learning by doing." The static indices of technical efficiency essentially represent a measure of the distance from the observed input/output point to the best-practice frontier.

The functional form that is used is the Translog Production Function, a function that has been widely utilized in recent empirical studies of production[7] and which, due to its flexible nature, imposes fewer a priori restrictions on the production structure than less flexible functional forms such as the Cobb-Douglas or CES Production Functions. The Translog Production Function, which is a second-order Taylor series approximation to a well-behaved arbitrary production function, such as equation (1), can be represented as follows (see Christensen et al, 1971, 1973):

$$(5)\quad \ln Q(s,t) = a_o(s,t) + \sum_m a_m(s,t)\ln z_m(s,t) + 1/2\sum_m\sum_n b_{mn}\ln z_m(s,t)\ln z_n(s,t),$$

where $a_o(s,t) = a_o(s) + a_t(s)t + 1/2b_{tt}(s)t$,

$a_m(s,t) = a_m(s) + b_{mt}(s)t$,

s = a firm or sector index, and

z = input levels.

In order to estimate the parameters of the function, conditions of constant returns to scale, monotonicity, and concavity are imposed and the function is constrained to lie on or outside all the observed input-output points. Linear programming estimation procedures are used, and the changes of technological progress and technical efficiency are calculated; the former by combining the actual input-output values for each year with the estimated production function parameters, and the latter by using the values of the slack variables from the constraint mentioned above and taking log-differences over time.[8]

It should be noted that the TFP growth estimate calculated from observed factor shares will not in general be equal to the sum of the change in technical efficency and the change in technological progress calculated from the "best-practice" frontier coefficients. The following equation summarizes in words the components of the decomposition of TFP growth described above (see Nishimizu and Page (1982) for a mathematical derivation):

(6) TFP Growth = Technological Progress
+ Change in the Level of Technical Efficiency
+ Residual due to Differences between Frontier Output Elasticities and Observed Factor Shares

In practice, since the residuals depend on the differences between the observed factor shares (which represent interior output elasticities in equation 3) and the estimated frontier elasticities, they are likely to be greater, the greater are the factor market distortions in the economy under study and the greater the levels of inefficiency of the firms or sectors.

3. The TFP Growth Estimates[9]

Prior to carrying out a statistical examination of causes of differences in TFP growth rates among firms, the results of the TFP growth estimates, a breakdown of the sectoral sources of growth, and the decomposition of TFP growth estimates into the components discussed above will be presented. It should be emphasized that the thrust of the analysis deals with firm level issues and the data are not therefore ideally suited to aggregation at the sectoral level, both because the firm coverage is not always complete and because the firm data are not always available for identical periods. However while the sectoral summaries should be interpreted with care, they do provide a good indication of the kind of analysis that can be carried out, and yield insights which pave the way for the more detailed firm analysis in the next section.

3.1 TFP and the Sources of Output Growth

Table 2 presents a sectoral breakdown of the standard sources of growth analysis where real output growth is accounted for by appropriately weighted input growth rates (of labor, capital, and intermediate inputs) and TFP growth. In order to reflect more accurately the overall picture in each sector all the growth rates are weighted by real output at the firm level.

The average real output growth rate of the sample firms of almost 10% appears to correspond reasonably well to the growth rates of GDP presented in Table 1. Overall, some 60% of this output growth was accounted for by growth of inputs, while the remaining 40% was accounted for by TFP growth of almost 4%. As would be expected, the bulk of the former was due to growth of intermediate inputs (48.7%), while capital growth (10.8%) and especially labor growth (0.7%) contributed relatively little. While there are no other sources of growth estimates for the same time period, it should be noted that the TFP shares of this study are considerably higher than those found by Paitoon (1982) for sectoral data from 1970-1976. For the firms covered by this study, TFP growth actually played a much more important role than previously thought.

At the sectoral level, the growth rates and contributions of the various sources of growth varied considerably. In terms of the contribution of TFP growth

Table 2. Sectoral Sources of Growth -- 1975 to 1983

(Growth Rates)[1]

Sector	Output	Total Inputs	of which: Labour	Capital	Interm	TFP
	(1)	(2)	(3)	(4)	(5)	(6)
Spinning, Weaving & Knitting	8.38	4.58	-0.06	0.81	3.83	3.80
	100.0%	54.7%	-0.7%	9.7%	45.7%	45.3%
Synthetic Fibre	8.02	3.02	-0.19	0.64	2.57	5.00
	100.0%	37.7%	-2.4%	8.0%	32.0%	62.3%
Garments and Other Textiles	6.36	4.96	0.12	0.38	4.46	1.39
	100.0%	78.0%	1.9%	6.0%	70.1%	21.9%
Electrical Goods	27.41	20.48	0.46	1.81	18.21	6.93
	100.0%	74.7%	1.7%	6.6%	66.4%	25.3%
Paper and Pulp	8.97	7.53	0.32	2.60	4.61	1.45
	100.0%	83.9%	3.6%	29.0%	51.4%	16.2%
Rubber Products	2.67	3.27	0.06	0.91	2.30	-0.60
	100.0%	122.5%	2.2%	34.1%	86.1%	-22.5%
Automotive Parts	11.53	3.91	0.26	1.04	2.61	7.62
	100.0%	33.9%	2.3%	9.0%	22.6%	66.1%
All Sectors	9.67	5.82	0.07	1.04	4.71	3.86
	100.0%	60.2%	0.7%	10.8%	48.7%	39.9%

Notes: [1]Average annual sectoral growth rates from 139 firms weighted at the firm level by real gross output. Percentages represent the contributions of each component to output growth.

The growth rates in columns 1, 3, 4, 5, and 6 correspond to the various expressions in equation 4 in the text, where the input growth rates are weighted by their respective shares in output.

to output growth, the surveyed firms in the automotive parts and synthetic fibre sectors performed well above average while the paper and pulp and rubber sectors showed rather weak results. In the latter sector, where the four major firms were included in the sample, the poor performance was due largely to capacity underutilization resulting from the general decline in domestic demand as reflected in the GDP growth figures in Table 1. In fact, it was noticeable in the rubber sector that the smaller, and generally younger companies, performed much better than the larger companies over the period. However, the opposite was the case in the synthetic fibre industry.

3.2 The Components of TFP Growth

An important first step towards understanding the nature of TFP growth concerns its decomposition into the components discussed in section 2 and illustrated in equation 6. The sectoral results for the 139 firms covered by the sample are shown in Table 3, where the first half of the table presents unweighted averages and standard deviations while the second presents averages weighted by real output and percentage contributions of each component to TFP growth. The major implications of the results will be discussed according to the various components.

Technological Progress. Given the definition of the component of observed TFP growth resulting from technological progress, it is hardly surprising that the contribution of technological progress is in all cases non-negative.[10] Synthetic fibre, automotive parts, and electrical goods are sectors where the "best-practice" frontier was moving relatively rapidly, while the rubber products and paper and pulp sectors experienced little or no technological progress over the period.

The main implication relating to this component is that while technological progress dominates both the overall average with a share of more than 75% and the sectoral results with the most significant positive contribution in all cases except paper and pulp, the distribution of growth rates of technological progress among firms within the same sector is relatively constant (see the standard deviations in Table 3).

Technical Efficiency. The most striking result concerning changes in technical efficiency is that overall, such changes actually made a negative contribution of 1.3% to TFP growth. While seemingly small, this average masks much more worrying trends at the sector level. Indeed, five of the seven sectors experienced declines in levels of technical efficiency over the period, implying that the firms either became absolutely more inefficient or failed to keep up with "best-practice" production techniques.[11] This deterioration occurred most significantly in the rubber and garments sectors where negative changes in technical efficiency, of 2.21% and 1.64% respectively, dominated TFP growth. The picture was less worrying but still of concern in the remaining three sectors. Furthermore, as evidenced by the standard deviations, the variability of changes in technical efficiency between firms in the same sector is relatively high.

When combined with the observations in the previous section dealing with techological progress, this implies to some extent that the major constraint to efficient growth at the firm level is concerned more with the problem that firms use the existing "best-practice" technology inefficiently than the more general

Table 3. Decomposition of TFP Growth Rates — 1975 TO 1983

(Growth Rates)

	TFP (1)		of which: TPROG (2)		TEFF (3)		OUTEL (4)	
Unweighted[1]								
Spinning, Weaving and Knitting	3.74	(6.03)	2.15	(0.68)	1.39	(5.61)	0.20	(1.46)
Synthetic Fibre	2.67	(5.75)	4.23	(0.37)	-2.24	(6.03)	0.68	(1.01)
Garments and Other Textiles	2.60	(3.30)	3.64	(0.89)	-1.35	(3.13)	0.32	(1.25)
Electrical Goods	9.38	(9.27)	6.21	(0.78)	0.92	(6.12)	2.24	(4.81)
Paper and Pulp	1.58	(6.54)	0.00	(0.00)	0.05	(6.64)	1.54	(5.94)
Rubber Products	3.36	(5.88)	0.45	(0.25)	1.47	(6.18)	1.44	(2.48)
Automotive Parts	8.91	(4.64)	6.65	(1.57)	1.70	(5.98)	0.55	(2.76)
All Sectors	4.90	(6.53)	3.38	(2.45)	0.73	(5.65)	0.79	(2.93)
Weighted[2]								
Spinning, Weaving and Knitting	3.80		1.87	49.2%	1.08	28.4%	0.85	22.4%
Synthetic Fibre	5.00		4.41	88.2%	-0.12	-2.4%	0.71	14.2%
Garments and Other Textiles	1.39		3.18	228.8%	-1.64	-118.0%	-0.15	-10.8%
Electrical Goods	6.93		6.01	86.7%	-1.22	-17.6%	2.14	30.9%
Paper and Pulp	1.45		0.00	0.0%	1.45	100.0%	0.00	0.0%
Rubber Products	-0.60		0.28	-46.7%	-2.21	368.3%	1.33	-221.7%
Automotive Parts	7.62		6.70	87.9%	-0.53	-7.6%	1.49	19.6%
All Sectors	3.86		2.96	76.7%	-0.05	-1.3%	0.95	24.6%

Notes: [1]Unweighted average annual sectoral growth rates from 139 firms.
Numbers in parentheses represent standard deviations.
[2]Average annual sectoral growth rates from 139 firms weighted by real gross output.
Percentages represent the contributions of each component to TFP growth.
Columns 1 to 4 correspond to the various elements of equation 6 in the text where : TPROG – Technological Progress;
TEFF – Change in Technical Efficiency;
OUTEL – Residual due to differences between frontier elasticities and observed factor shares.

Table 4. Correlations between the Various Components of Productivity Change

Sector			TFP	CHTFP	TEFF	TPROG	LTEFF
Spinning Weaving and Knitting	TFP	--	1.00				
	CHTFP	--	0.97	1.00			
	TEFF	--	0.96	0.99	1.00		
	TPROG	--	0.22	0.23	0.11	1.00	
	LTEFF	--	0.02	0.01	-0.03	0.29	1.00
Synthetic Fibre	TFP	--	1.00				
	CHTFP	--	0.99	1.00			
	TEFF	--	0.98	1.00	1.00		
	TPROG	--	0.01	-0.04	-0.10	1.00	
	LTEFF	--	0.85	0.92	0.93	-0.14	1.00
Garments and Other Textiles	TFP	--	1.00				
	CHTFP	--	0.93	1.00			
	TEFF	--	0.88	0.96	1.00		
	TPROG	--	0.23	0.22	-0.06	1.00	
	LTEFF	--	-0.18	-0.22	-0.23	0.03	1.00
Electrical Goods	TFP	--	1.00				
	CHTFP	--	0.88	1.00			
	TEFF	--	0.86	0.99	1.00		
	TPROG	--	0.30	0.23	0.11	1.00	
	LTEFF	--	0.22	-0.25	-0.20	-0.43	1.00
Paper and Pulp	TFP	--	1.00				
	CHTFP	--	0.59	1.00			
	TEFF	--	0.59	1.00	1.00		
	TPROG	--	0.00	0.00	0.00	0.00	
	LTEFF	--	-0.35	0.26	0.26	0.00	1.00
Rubber Products	TFP	--	1.00				
	CHTFP	--	0.92	1.00			
	TEFF	--	0.91	1.00	1.00		
	TPROG	--	0.27	0.12	0.08	1.00	
	LTEFF	--	-0.27	-0.28	-0.29	0.13	1.00
Automotive Parts	TFP	--	1.00				
	CHTFP	--	0.92	1.00			
	TEFF	--	0.94	0.97	1.00		
	TPROG	--	0.19	0.37	0.13	1.00	
	LTEFF	--	-0.26	-0.22	-0.24	0.00	1.00
All Sectors	TFP	--	1.00				
	CHTFP	--	0.90	1.00			
	TEFF	--	0.81	0.92	1.00		
	TPROG	--	0.40	0.42	0.03	1.00	
	LTEFF	--	-0.07	-0.05	-0.10	0.10	1.00

Notes: Simple correlation coefficients from the mean values for 139 firms. TFP, TEFF, and TPROG as defined in Table 3.
CHTFP = TEFF + TPROG.
LTEFF = Static level of technical efficiency.

problem of slow rates of technological progress. This point is further amplified in Table 4 which shows that the correlation between the growth of TFP and the change in technical efficiency is remarkably high in all sectors while that between TFP growth and technological progress is similarly low across the board.

The Residuals. The last main point concerning Table 3 involves the residual term resulting from differences between frontier easticities and observed factor shares. In general, both the size and contribution of the residual term is relatively insignificant and in no sector does it cause the sum of technological progress and change in technical efficiency to take the opposite sign from that of observed TFP growth. This result is also confirmed by the very high correlation coefficients between the two variables (CHTFP and TFP) in Table 4. This observation contrasts sharply with Nishimizu and Page (1982)'s sectoral results from Yugoslavia where 9 of 26 sectors from 1965 – 78 experienced sign differences of this nature. A likely explanation is that, since factor markets in Thailand were generally less subject to state interference than those in Yugoslavia, the observed factor shares reflected more accurately frontier output elasticities.

4. Factors Influencing Firm Level TFP Growth

In this section, the approach that will be adopted to test a set of hypotheses concerning the determinants of productivity growth at the firm level will be to use the estimates of TFP growth, rates of technological progress, and changes in technical efficiency as dependent variables in multiple regression equations with parameters representing the possible determinants as the explanatory variables. The hypotheses to be tested are drawn from the literature on the various aspects of industrial development and trade and industrial policy in developing countries and from a consideration of issues that are important and of current relevance in the Thai context.

The following regressions need to be interpreted in light of the implications of the previous section regarding technological progress and changes in technical efficiency. In particular, to the extent that these components of TFP growth depend on different factors, the regressions explaining TFP growth itself may be somewhat compromised This may well explain some of the difficulties faced by earlier attempts to explain TFP growth. The presentation of three regression equations in each instance will enable this issue to be addressed.

A further point concerns the issue of whether to use static or dynamic variables as explanatory variables, for example foreign ownership share or the change in foreign ownership share. An initial set of regressions were run using static variables with generally abysmal results. Accordingly, where possible and where the hypothesis does not specifically involve a static concept, the explanatory variables that are used represent changes or growth rates of the basic static variables that were originally obtained in the firm survey. Several variables that were used to test hypotheses regarding the influence of government policy, including the effective rate of protection, and whether or not the firm received promotion from the Board of Investment, were not amenable to being transformed into a dynamic form, and it can be concluded that these variables do not contribute significantly to explaining TFP growth.

4.1 Age of Firm

One of the assertions that often underlies the infant industry argument for government intervention in the industrial sector is that new firms experience higher TFP growth rates than older ones. Previous firm level studies using cross-section data were clearly unable to consider these dynamic aspects of the infant industry argument. The variables that are introduced to test this hypothesis include the age of the firm (AGE), the age of the firm squared (AGESQ), and the average age of firms in the sector (SAGE). The expectation would be that AGE should have a negative coefficient, while AGESQ should be positive, implying that younger firms experience higher TFP growth but at a decreasing rate.

The results are presented in regression equations 1 to 3 of Table 5 and tell a somewhat mixed story. On the one hand, the coefficients of AGE and AGESQ are of the anticipated sign in all equations but statistically significant at the 99% level only in the equations explaining TFP growth and technological progress. On the other hand, the overall explanatory power is very low in all the equations, although somewhat higher in equation 3. Accordingly, the results offer some support, albeit rather weak, to the stated hypothesis. The SAGE variable is significant only in equation 3, implying that sectors with a preponderance of new firms experience more rapid movement forward of the "best-practice" frontier.

4.2 Sectoral Differences

A set of regressions, numbers 4 to 6, were run to examine whether or not sectoral differences play an important role in influencing the respective variables. The results are very informative, indicating strongly that technological progress is most definitely a sectoral rather than a firm level phenomenon while changes in technical efficiency are not influenced at all by sectoral considerations. Indeed, some 68% of the firm level differences in technological progress are explained by sectoral factors, and all but one of the sector dummies are significant at the 99% level. As in equations 1 to 3, the TFP growth regression carries the signs and significance levels of the technological progress equation but has very little explanatory power (R-squared = .04).

4.3 Firm-Level Differences

Equations 7 to 9 of Table 5 show the most informative equations that were found using the following firm-level characteristics as explanatory variables:

(a) Foreign-ownership (CHFSH). The evidence is mixed with regard to hypotheses regarding the influence of this variable--on the one hand, foreign firms may be expected to have more technical expertise, better marketing contacts, and better access to finance, while on the other hand, they do not have the local contacts and experience of domestic entrepreneurs which may be crucial if the policy environment is at all bureaucratic or if the domestic factor endowment differs greatly from that in the foreign company's home country.

(b) Export to revenue ratio (CHEXPRR). The hypothesis that exporting firms or industries are more efficient than those producing primarily for the domestic market has found much support in the literature. It derives from the idea that in the process of exporting certain benefits are conferred on the exporter such as access to technological advice from buyers and general exposure to product markets and competition in other countries.

(c) Energy to output ratio (GRENGYR), real average wage proxying for skilled labor (GRRAWAGE), capital to labor ratio (GRTKLR), and local raw material ratio (CHLRMATR). These variables will be used to test the hypothesis that firms that use technology or inputs that are more suited to the local endowments will grow more efficiently than those which do not. The expected signs would be GRENGYR (-), GRRAWAGE (+), GRTKLR (-), and CHLRMATR (+).

(d) Profit to revenue ratio (CHPROFRR). This will be used ostensibly to test the hypothesis that firms in competitive markets develop more efficiently than those in more concentrated markets [12]. The underlying concept is that monopoly breeds inefficiency and has been subjected to much testing by Industrial Organization economists mainly in the context of the developed countries. Another related hypothesis, also derived from Industrial Organization theory, is that there exists a positive relationship between profit levels and concentration levels. This raises an interesting question concerning the relationship between TFP growth and profit rates, especially since many studies use the profit rate as an indicator of entrepreneurial success. The inverse correlation between profitability and efficiency that is implied by the two hypotheses dealing with the structure of the market would imply that this use of a financial success indicator as a proxy for success may be severely misleading when trying to identify entrepreneurial characteristics that one may want to encourage with a view to increasing economic efficiency.

(e) Inventory to revenue ratio (CHINVENTRR). This variable is included partly to capture upswings and downswings in market conditions and partly to capture one aspect of management efficiency. To the extent that it does act as a

Table 5. Results of Selected Overall Regression Models - Pooled Time - Series Cross - Section Data.

Regression No.	1		2		3		4		5		6	
	COEFF	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT
Dependent Var.	TFP		TEFF		TPROG		TFP		TEFF		TPROG	
CONSTANT	8.98*	2.25	-2.43	-0.64	10.20**	11.51	7.78**	7.24	0.51	0.50	6.48**	45.43
AGE	-1.11**	-3.74	-0.68*	-2.41	-0.28**	-4.25						
AGESQ	0.03**	2.85	0.02	1.08	0.01**	3.87						
SAGE	0.20	0.51	0.69	1.88	-0.54**	-6.25						
S 1							-4.08**	-3.05	0.83	0.65	-4.31**	-24.26
S 2							-4.55*	-2.14	-1.86	-0.92	-2.25**	-7.96
S 3							-5.04**	-3.20	-1.91	-1.26	-2.94**	-14.07
S 4							-0.78	-0.46	-0.62	-0.39	-0.44	-1.95
S 5							-6.35**	-3.45	-0.07	-0.04	-6.48**	-26.53
S 6							-5.75**	-3.05	0.39	0.22	-6.08**	-24.31
R-Squared	0.03		0.02		0.09		0.04		0.01		0.68	
S.E.of Reg.	11.48		10.91		2.55		11.48		10.98		2.67	

Notes : ** - Coefficient significantly different from O at the 99% level.
* - Coefficient significantly different from O at the 95% level.

Number of observations in all regressions - 651.

TFP -- TFP growth rate
TEFF -- Change in level of technical efficiency
TPROG -- Growth rate of technological progress
AGE -- Age of the firm since start-up.
AGESQ -- Age of the firm squared.
SAGE -- Average age of firms in each sector as of 1980.
S1 -- Dummy = 1 if firm is in Spinning, Weaving, & Knitting sector.
S2 -- Dummy = 1 if firm is in Synthetic Fibre sector.
S3 -- Dummy = 1 if firm is in Garments & Other Textiles sector.
S4 -- Dummy = 1 if firm is in Electrical Goods sector.
S5 -- Dummy = 1 if firm is in Paper & Pulp sector.
S6 -- Dummy = 1 if firm is in Rubber Products sector.

Table 5. Results of Selected Overall Regression Models Pooled Time-Series Cross-Section Data.

Regression No.	7		8		9	
	COEFF.	T-STAT	COEFF.	T-STAT	COEFF.	T-STAT
Dependent Var.	TFP		TEFF		TPROG	
CONSTANT	2.77**	9.30	-0.84**	-2.77	3.26**	29.63
CHFSH	16.82**	2.68	8.53	1.34	0.16	0.07
CHEXPRR	3.42	1.00	1.82	0.53	1.94	1.54
GRENGYR	-5.20**	-4.90	-3.09**	-2.87	-0.86*	-2.20
GRRAWAGE	10.50**	5.99	11.17**	6.28	1.69**	2.60
GRTKLR	-3.89**	-2.65	-8.19**	-5.51	-0.57	-1.06
CHLRMATR	-0.31	-0.12	-8.34**	-3.08	0.37	0.37
CHPROFRR	76.41**	26.33	73.53**	25.00	0.75	0.70
CHINVENTRR	-8.79**	-4.19	2.54	1.20	0.20	0.26
R-Squared	0.62		0.57		0.03	
S.E. of Reg.	7.17		7.27		2.65	

Notes : ** – Coefficient significantly different from O at the 99% level.
* – Coefficient significantly different from O at the 95% level.
Number of observations in all regressions – 651.

TFP -- TFP growth rate
TEFF -- Change in level of technical efficiency.
TPROG -- Growth rate of technological progress.
FSH -- Share of foreign reg. capital in total reg. capital.
EXPRR -- Ratio of exports to total sales.
ENGYR -- Ratio of real energy input to output.
RAWAGE -- Real average wage.
TKLR -- Ratio of total capital stock to labour.
LRMATR -- Ratio of local material inputs to output.
PROFRR -- Ratio of net profits to total revenue.
INVENTRR -- Ratio of value of inventories to total revenue.
GR in front of a variable denotes the continuous growth rate.
CH in front of a variable denotes the change in value.

barometer for market conditions, a significant negative coefficient would provide some support to the idea that capacity underutilization in bad times leads to falling TFP growth.

The equations for TFP growth and change in technical efficiency exhibit very satisfactory explanatory power given that firm data is being used, while that for technological progress has an R-squared of only .30, further fueling the notion that technological progress is only a sectoral phenomenon. As a result equation 9 offers little scope for further interpretation. In equations 7 nnd 8, however, it is interesting to note that all the variables exhibit the same signs with the exception of CHINVENTRR. This again indicates the importance of changes in technical efficiency as the crucial component of TFP growth differences at the firm level.

The foreign ownership variable is positive and significant in explaining TFP growth while positive and not significant in explaining changes in technical efficiency. It would appear that the positive aspects of foreign ownership dominate the negative ones, but not through their influence on the process of improving levels of efficiency.

In the case of the export variable, the coefficient, while positive is not at all significant in any of the equations. Several explanations offer themselves for this counter-intuitive result : firstly, exporting firms may already be very efficient and not have much scope for further improvements; and secondly, due to quota systems (in textiles and garments) and "easy" or "windfall" export markets in certain sectors, the export variable may not be adequately proxying for the positive attributes outlined above.

The appropriate factor mix variables generally take the expected signs and are all highly significant with the exception of the local material usage variable. Firms which succeeded in reducing real energy input, which used higher levels of skilled labor, and which increased the labor content of the production process relative to capital experienced higher TFP growth rates and improved levels of technical efficiency. With regard to local material usage, the negative coefficient is perhaps explained by the fact that several sectors faced government policies which enforced minimum local content requirements directly (automotive parts and electrical goods) or indirectly via tariff raiff regardless of the economic or technical suitability of local materials. Furthermore, it is conceivable that some firms attempted to cut costs using local raw materials but failed to anticipate the productivity problems resulting from lower quality and/or unreliable supply.

The most consistent variable, both in term of its positive sign and its level of significance, is the profit variable. Given that TFP growth essentially measures reductions in real unit costs it was not too surprising to find the profit variable so significantly positive although one could have doubted the reliability of such sensitive data. The significance of the variable in explaining changes in levels of efficiency calculated from dynamic production frontiers is much more interesting, however. It implies that the simple profit to revenue ratio, or rather changes in it, does actually proxy very well for improvents in entrepreneurial efficiency and contradicts the simple industrial organization hypothesis linking high profit rates to high levels of concentration and hence inefficiency.

The inventory ratio variable performs as expected in a significant way in the TFP growth equation, but surprisingly is insignificantly positive in the technical efficiency equation. Preliminary results following a methodology developed by Bruton (1967) do indicate that changes in capacity utilization in the sample firms due to local or world market recessions did significantly influence TFP growth during certain periods.

5. Summary and Policy Implications

There is no doubt that explanation of TFP growth rate differences at the firm or sector level presents a thorny problem. Nevertheless, in this paper, by using an original and unique set of firm level data and applying economically sound and innovative measurement techniques, certain aspects of the problem have been elucidated. A main conclusion is that when analyzing firm or sector level TFP growth rates, one must be careful to distinguish between technological progess, which tends to be largely determined by sectoral characteristics, and changes in levels of technical efficiency which are very firm specific in nature. In particular, regression equations using TFP growth as the dependent variable may present confusing results since the coefficients may be picking up the influences of conflicting signals.

The regression analysis provided some mild support for the well known infant industry argument, but did not indicate that exporting on its own had a significant positive influence or TFP growth. In general, production in line with domestic resource availability was shown to be conducive to efficient growth, and the bottom line measure of the profit to revenue ratio was seen to be closely related to efforts to improve efficiency. However, given the importance of firm specific variables in explaining TFP growth, it would be useful to examine in more detail the real firm level practices that influence TFP growth. This would provide more substance to the somewhat mechanistic regression analysis presented above using a set of variables that only proxy for the characteristics that one would like to identify. Such an analysis, on the basis of 49 firm interviews is carried out in Brimble (1986) where most of the insights in this paper are confirmed in a more qualitative, and sometimes more satisfying manner.

From a policy point of view, the results have several major implications : firstly, there would appear to be more scope to improve industrial performance at the firm level by improving the use of existing technology than by encouraging the rapid adoption of new technologies. The large firm level differences in changes in technical efficiency indicate that this could perhaps be addressed by carefully planned programs to ensure the better diffusion of information between firms in similar activities; secondly, the traditionally supportive policy of the Thai government towards foreign investment would seem to be vindicated and any efforts to restrict capital inflows should be very carefully considered on efficiency grounds: and thirdly, given the strong link between efficient growth and appropriate input usage, government should carefully reconsider policies that distort product or factor prices. Prime candidates for early reform would be the market distortions that result from the tariff structure, the business tax system, and the investment promotion system.

Footnotes

[1]TFP growth is generally defined as the difference between the growth rate of output and the sum of input growth rates weighted by their respective elasticities with respect to output. The studies cited by Chenery (1986) calculate TFP growth rates using value added and primary inputs. Many studies, including this one, use value of gross output and all inputs in the calculation of TFP. See Nishimizu (1979) for a discussion of this issue.

[2]Preliminary in two senses of the word: firstly, insofar as existing studies attempting to explain TFP and efficiency growth at the firm level are very rare. In a recent survey, Pack (1987) concludes that "the forces conducive to productivity growth in manufacturing are not as well understood as is sometimes supposed."; and secondly, insofar as this paper analyses in detail only the data concerning TFP growth. Future work will entail an analysis integrating the TFP growth estimates with the static technical efficiency estimates. This integration will enable a firm level consideration of the point made by Krueger and Tuncer (1980) that studies of TFP growth alone provide little indication of actual efficiency levels.

[3]Due to space limitations, no comprehensive examination of the seven sectors will be undertaken. When certain sectoral characteristics appear to be important in explaining firm differences in TFP growth rates they will be mentioned at that time.

[4]The presentation in this part follows closely that by Gollup and Jorgenson (1980) and is by now relatively standardized.

[5]The frontier estimation and subsequent decomposition used in this analysis closely follows Nishimizu and Page (1982).

[6]See the seminal work by Farrell (1957) and a useful recent survey by Forsund, Lovell, and Schmidt (1980).

[7]See Chakrabarty (1983) for a survey.

[8]See Nishimizu and Page (1982) for a discussion and application of the methodology to time series sectoral data from Yugoslavia, Handoussa, Nisnimizu and Page (1984) for an application to time series public sector firm data from Egypt, and Page (1984) for a static application of translog frontiers to cross-section firm data from India.

[9]The firm level data used in the estimation process was carefully checked for consistency and accuracy at all stages of the calculations. Real values of gross output

and intermediate inputs were adjusted to 1975 prices using appropriate price indices from the Ministry of Commerce. The number of workers was used as labour input. The growth of capital serices was proxied by the growth of real undepreciated capital stock calculated in a perpetual inventory fashion. Input shares were calculated as the ratio of current price input expenditures to value of gross output in current prices. In order to avoid the problem of negative expenditures on capital services, such expenditures were calculated from total capital stock estimates on a cost recovery basis for the share calculations.

[10] In the estimation of the "best-practice" frontier, it was assumed that technological knowledge was never lost over time, so the frontier was constrained to move forwards.

[11] Indeed, there is some evidence that those sectors with relatively rapid growth in technological progress tended to contain more firms that had fallen behind than sectors with lower rates of technological progress.

[12] In fact, in the absence of any good studies on market structure in Thailand, and faced with a problem of devising satisfactory measures of the "contestability" of markets, this hypothesis was more carefully examined in a more subjective way in Brimble (1986).

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Annex Table 1. Selected Sectoral Characteristics of Firms Surveyed

Sector	No. of Firms	AGE (YRS)	EXPRR	ENGYR	TKLR	LRMATR	CAPST ('000B)	EMPLOY (NOs)	OUT ('OOOB)	PROFRR	RAWAGE ('OOO B)
Spinning, Weaving & Knitting	46	10.01	0.215	0.069	309	0.398	429,992	1,234	204,558	-0.004	15.52
(Standard Deviation)		(5.42)	(0.212)	(0.035)	(162)	(0.181)	(593,699)	(129.3)	(250,093)	(0.099)	(4.97)
Synthetic Fibre	7	6.00	0.079	0.066	1,413	0.106	1,046,590	708	454,856	0.003	31.16
(Standard Deviation)		(3.62)	(0.098)	(0.017)	(648)	(0.228)	(1,082,514)	(434)	(376,001)	(0.113)	(9.11)
Garments and Other Textiles	19	8.68	0.451	0.043	200	0.377	104,960	713	95,268	-0.010	15.51
(Standard Deviation)		(4.29)	(0.427)	(0.039)	(148)	(0.178)	(103,050)	(980)	(122,917)	(0.083)	(5.97)
Electrical Goods	17	10.50	0.085	0.016	422	0.275	140,763	378	129,969	0.001	22.83
(Standard Deviation)		(6.86)	(0.243)	(0.014)	(284)	(0.232)	(149,808)	(343)	(136,369)	(0.083)	(9.72)
Paper and Pulp	11	9.27	0.035	0.097	848	0.282	397,562	417	185,166	-0.120	27.55
(Standard Deviation)		(3.76)	(0.072)	(0.037)	(721)	(0.143)	(461,750)	(353)	(201,428)	(0.394)	(11.12)
Rubber Products	15	10.43	0.234	0.046	498	0.331	222,286	388	195,571	0.040	27.10
(Standard Deviation)		(5.89)	(0.312)	(0.045)	(400)	(0.201)	(316,481)	(285)	(250,090)	(0.075)	(24.93)
Automotive Parts	24	8.50	0.055	0.019	460	0.196	120,075	236	139,374	0.036	26.29
(Standard Deviation)		(4.79)	(0.113)	(0.016)	(274)	(0.142)	(194,650)	(218)	(259,356)	(0.088)	(9.70)
All Sectors	139	9.41	0.185	0.050	453	0.314	302,750	703	179,343	-0.002	21.26
(Standard Deviation)		(5.25)	(0.274)	(0.040)	(425)	(0.200)	(501,105)	(938)	(238,349)	(0.142)	(12.13)

Notes : All variables are unweighted means calculated from the data for 139 firms

AGE -- Age of the firm since start-up.
EXPRR -- Ratio of exports to total sales.
ENGYR -- Ratio of real energy input to real output.
TKLR -- Ratio of total capital stock to labour.
LRMATR -- Ratio of local material inputs to output.
CAPST -- Real value of total capital stock.
EMPLOY -- Number of employees.
OUT -- Real value of output.
PROFRR -- Ratio of net profits to total revenue.
RAWAGE -- Real average wage.

I am especially grateful to Mieko Nishimizu and John Page of the World Bank for their support at all stages of the research project from which this paper derives. Unfortunately, due to time constraints, they were unable to read and comment on the paper. I gratefully acknowledge both logistical and informational assistance from the Board of Investment and the Industrial Management Company during the fieldwork. Atchaka Sibunruang read and constructively commented on all parts of the paper. Finally, I would like to express my thanks to the team in Thailand that helped me gather the firm level data, Khun Ruchadaporn, Khun Sunee, Khun Suree, Khun Kittichoke, Acharn Karnchana, Acharn Sunee, and Acharn Piyawadee, and Debbie Bateman who helped immensely with the programming and data processing in Washington D.C. Needless to say, I alone am responsible for any remaining errors and the views expressed in the paper are mine and do not necessarily represent those of any affiliated institutions.