Economic Reform and Allocative Efficiency in China's State-Owned Industry

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ABSTRACT

This empirical study of China's state-owned industry demonstrates that during the period of industrial reform total factor productivity has been increasing rapidly in 20 enterprises surveyed by the World Bank. This productivity performance stands in sharp contrast to the pre-reform period, during which Chinese industry was notorious for its stagnant total factor productivity. There is also evidence that allocative efficiency improved markedly between 1978 and 1982. Furthermore, efficiency gains across firms have a strong, positive correlation with the share of enterprise profits retained by workers and management, suggesting that the introduction of material incentives has been an important source of these productivity gains.

1. Introduction

Beginning in late 1978, the People's Republic of China introduced sweeping reforms into its management of state-owned industry. Before reform, the allocation of labor, capital, and materials to industrial enterprises was carried out administratively, at the central or regional level, and output was typically sold to the state at controlled prices. This planned system succeeded in channeling capital and labor into industry and raising industrial output, but there is considerable evidence that allocative efficiency has been poor in this planned sector. Total factor productivity (TFP) was at best stagnant in Chinese industry from 1957-78, and may have actually declined over that period.[1]

Decisions made by the Central Committee of the Chinese Communist Party at its Third Plenum in December 1978 led to the development of a reform program for the Chinese economic system. Concrete plans for reform started to be annouced by the State Council in mid-1979. The centerpiece of reform has been the devolution of economic control to the enterprise level. In the agricultural sector, this meant breaking up the communes and introducing the "Family Responsibility System," providing individual peasant families considerable freedom to choose inputs and outputs, sell a large share of output on "free markets," and retain the profits. Agricultural output grew rapidly in the years following reform, and there is a growing body of evidence that resource use has become more efficient in Chinese agriculture.[2]

There have been analogous attempts to reform state-owned

industry in China, which consists of 87,000 enterprises and accounts for three-quarters of the country's industrial output. The reforms have provided enterprises with more freedom in hiring or purchasing inputs, including capital and materials, but rarely labor. Enterprises now have limited ability to alter their product line and introduce new products, and typically self-market a significant share of their output at prices largely free of government control. Most importantly, enterprises are permitted to retain a large share of profits on self-marketed output, ranging from 40-100 percent. (The exact profit retention rate is negotiated between the enterprise and the state.) Enterprises typically pay out some of the retained profits as bonuses to workers and managers, and invest the balance in new productive activities of the firm.[3]

These reforms have clearly created some incentive for enterprises to economize on the use of resources and to produce products for which there is demand from consumers and other firms. On the other hand, who actually is the residual claimant for the earnings of state-owned enterprises, especially future earnings, is often uncertain and a matter of intense negotiation. Hence it is not clear how strong these incentives for allocative efficiency actually are, nor whether they are uniform across Chinese industry. In assessing the first few years of industrial reform, scholars are quite divided on the question of whether or not the reforms have led to greater efficiency. Chen, Wang, et al. (1987), for instance, conclude that "initial reform in industry has been very successful," while Christine Wong (1986) argues that "Reforms in Chinese state-owned industry can be judged a failure through the first 5

years..." Those who argue that the reforms have not been successful point to the fact that industrial output has risen rapidly, but that growth rates have also been high for capital stock and material inputs. The World Bank (1985) finds no increase in total factor productivity in the state-owned industrial sector during the first few years of economic reform.

In this paper I use data gathered by the World Bank on 20 state-owned enterprises in China to investigate whether total factor productivity at the enterprise level has risen during the reform period and whether there is evidence that allocative efficiency has increased. The main result of the study is that for these 20 firms TFP has grown rapidly, at an average rate of 4.7 percent per annum. Furthermore, the dispersion across firms in the level of TFP declined markedly between 1978 and 1982, which is consistent with an improvement in allocative efficiency. Finally, across enterprises, TFP growth is positively correlated with the share of output self-marketed and the share of profits retained by the firm, which supports the hypothesis that the economic reforms have been the source of this increase in allocative efficiency.

Interpretation of these results requires some caution: the 20 enterprises surveyed by the World Bank are not a representative sample of Chinese state-owned industry, in that no money-losers were included in the study. The results presented here suggest that, among enterprises that were already doing relatively well, economic reform has spurred greater efficiency. One of the criticisms of the reforms is that firms with poor economic results are still not allowed by the state to go

bankrupt.[4] Since no such firms are covered by this study, the results do not necessarily contradict the finding that for the state-owned sector as a whole TFP has not increased during the reform period. Nevertheless, the results presented here suggest that industrial reform in China, in particular the creation of material incentives for workers and managers, must be judged at least partially successful in its stated goal of improving allocative efficiency.

2. Measuring Allocative Efficiency, 1978 and 1982

The World Bank survey of 20 Chinese state-owned enterprises, reported in *China's Industrial Reform* (Tidrick and Chen, 1987), provides data on inputs and outputs for the period 1975-82, as well as a wealth of background information on these firms. In measuring allocative efficiency pre- and post-reform I assume that the objective of state-owned industry is to maximize the value added produced by capital and labor, given input and output prices. It should be emphasized that if input and/or output prices are distorted, maximizing industry value added is not necessarily socially optimal. Furthermore, especially in the pre-reform period, it is not at all obvious that output maximization has been the goal of state-owned industry. Nevertheless, this is an appropriate analytical framework: the reform is clearly aimed at maximizing the value of output produced by the resources in industry, and applying the same framework to pre-reform data is necessary in order to measure the extent to which this goal has been achieved.

Maximizing the value of output requires that the marginal revenue product of capital be the same in each firm, and that the

marginal revenue product of labor also be equalized across enterprises; these can be regarded as necessary conditions for efficient resource allocation.[5] The twenty firms in this sample produce different products, presumably with different technologies, so that optimally they will employ different capital-labor ratios. The efficiency conditions imply that labor productivity (value added per worker) will have a positive relationship to input of capital per worker. The relationship will not typically be linear, even in logarithms. In order to measure how well the sample data from a particular year meet these efficiency conditions, I estimate the following cross-section equation:

$$(1) \qquad Ln(Y_i/L_i) = \alpha + \beta_1 ln(K_i/L_i) + \beta_2 [ln(K_i/L_i)]^2,$$

where, for each firm i, Y is net value of output, K is productive assets, and L is number of workers. This exercise is equivalent to fitting a Translog production function with constant returns to scale to the data; if the quadratic term is dropped, a Cobb-Douglas function remains.[6]

The efficiency conditions do not imply that data from different firms should fit a Translog production function exactly; furthermore, there are other factors, notably human capital, omitted from the analysis. For these reasons, it would be difficult to interpret the results from this exercise if carried out for a single year. It is another matter, however, to compare how well, in different years, data from the same enterprises fit a production function. Variation across firms in the amount of human capital per worker, which may lead to devitations from equation (1), is unlikely to change significantly

within a few years--especially in China, where labor mobility is very limited. A large change in the extent to which firm-level data fit a production function can thus reasonably be interpreted as evidence of a change in allocative efficiency.[7]

There are, unfortunately, many missing data points for the years 1975-77, so that 1978 is the first year for which equation (1) can be estimated with any reasonable number of degrees of freedom. (Data for 1978 cover 17 of the 20 firms.) In estimating equation (1) the quadratic term turns out to be insignificant. Regression results with the quadratic term omitted are presented in Table 1. The coefficient on the capital-labor ratio is positive, but not significantly different from zero. The data and the regression line are plotted in Figure 1: the R^2 for this equation is .06. Hence data from the pre-reform year of 1978 appear to confirm that allocative efficiency has been poor in China's state-owned industry: there is essentially no relationship between output per worker and capital input per worker.

Equation (1) was also estimated across the data for 1982, covering 20 firms. Again, the quadratic term is insignificant. Table 1 presents the regression for 1982: the R^2 has increased to .27. The coefficient on the capital-labor ratio has increased to .38 and is now significant at the .01 level. The data and regression line are plotted in Figure 2, where it can be seen that the fit is much tighter than in 1978.

From this admittedly small sample, it does appear that state-owned enterprises have moved closer to meeting the conditions associated with efficient production. There remains the question of how important,

in quantitative terms, this development is. One answer to this question is provided by the following counterfactual experiment: Use the residuals from the estimated production functions to define an index of total factor productivity (TFP):

$$(2) \qquad TFP_i = \exp[\ln(Y_i/L_i) - \ln(\hat{Y_i/L_i})],$$

where $(\hat{Y_i/L_i})$ is the labor productivity for enterprise i predicted by the regression equation, given the firm's capital-labor ratio. A firm that lies on the regression line will have TFP=1; TFP will increase (decrease) with the vertical distance above (below) the regression line. This index indicates how much value, compared to other firms, an enterprise produces with a given bundle of capital and labor. Use this index to divide the 1978 sample into the 8 most efficient firms and the 9 least efficient firms; fit a regression line to the most efficient firms (reported in Table 1); finally, use the coefficients from that regression to calculate the increase in output that would result if the 9 least efficient firms had the average level of efficiency of the most efficient firms.

The result of this experiment is that output for the least efficient firms would rise by 319 percent in 1978 if they had the average efficiency of the most efficient firms (holding capital and labor input constant). Obviously, there were tremendous potential gains in 1978 to be reaped by shifting capital and labor to more productive uses. A similar experiment conducted for 1982 yields the result that output for the 10 least efficient firms would increase by 99 percent if they achieved the average efficiency of the 10 most efficient firms from

that year. This result suggests that allocative efficiency increased markedly between 1978 and 1982, at least among these 20 firms; there remain, however, considerable gains to be reaped by further improvements in resource allocation.

Finally, it should be emphasized again that the changes documented here represent an improvement in allocative efficiency from the point of view of the whole Chinese economy only to the extent that output prices reflect social utility and input prices reflect relative scarcities. Hence a strict interpretation of the results is that there is evidence here that the industrial reform would lead to improved allocative efficiency *as long as it is combined with significant price reform*. Many industrial prices have been decontrolled, but some key prices, such as that of electricity, remain fixed and obviously distorted. These price distortions need to be eliminated before the full potential benefit of industrial reform can be realized.

3. Economic Reform and TFP Growth, 1975-1982

Data from the World Bank sample can also be used to estimate the growth of TFP at the enterprise level during the reform period. For this purpose a pooled, cross-sectional regression of equation (1) was carried out across the 20 firms and 8 years. For the pooled regression, output data were first converted to constant prices.[8] The results of this pooled regression are reported in Table 2 (after dropping, once again, the insignificant quadratic term).

The errors from this regression can be used to calculate an index of TFP, both across firms and over time:

$$(3) \qquad TFP_{it} = \exp[\ln(Y_{it}/L_{it}) - \ln(Y_{it}/\hat{L}_{it})].$$

For 1975-78, the average level of this index is 1.04, with a coefficient of variation of .59. During the years of reform, 1979-82, the average level is 1.24, with a coefficient of variation of .47. The reduced dispersion in TFP across firms, between the pre- and post-reform periods, is consistent with the results presented in Section 2. The increase in average TFP level indicates that TFP has increased during the reform.[9]

The TFP index can be used to calculate the average rate of TFP growth for each enterprise. Table 3 lists the 20 enterprises in the sample, the years covered by their data, and average rates of growth of labor productivity, capital per worker, and TFP. For these enterprises the average TFP growth rate is 4.7 percent per year, very high by Chinese historical standards. Furthermore, TFP growth during this period appears to be the main source of labor productivity growth, which averaged 5.3 percent per annum. The average growth rate of capital per worker has been only 2.1 percent.[10]

The final question that remains is whether there is any evidence linking the increase in TFP documented here with the economic reform program. The World Bank survey provides some information which can be interpreted as evidence of the extent to which the incentives faced by enterprise management have been altered by the reform: for instance, the share of output self-marketed by the firm, and the share of total profit retained by the firm for distribution to workers and for reinvestment. The latter measure, in particular, gives a good indication of the extent to which an enterprise has been cut free from the planned system.

Table 4 presents the correlation, across firms, of TFP growth with these indicators of changed incentives and management system. (Rank correlations are used to minimize the impact of outliers, which could be substantial in such a small sample.) TFP growth has a positive correlation of .27 with the share of output self-marketed, and an even stronger positive correlation (.46) with the share of profits retained by the firm. The profit retention rate would seem to be a good indicator of the strength of the incentive faced by workers and management to improve efficiency; if so, the positive correlation with TFP growth found here is evidence that the reform program has in fact led to greater allocative efficiency.

There is also a strong, negative correlation between TFP growth and TFP level in 1978, indicating that enterprises that were poor performers at the beginning of the period have realized the greatest efficiency gains. This makes sense, since the inefficient producers by definition were making the poorest use of their resources and had the potential to make large gains quickly. Presumably this is the source of the observed decrease, between 1978 and 1982, in the dispersion of TFP levels across firms.[11]

4. Conclusions

The main finding of this empirical study is that during the period of Chinese industrial reform total factor productivity has been increasing rapidly in 20 state-owned enterprises surveyed by the World Bank. This productivity performance stands in sharp contrast to the pre-reform period, during which Chinese industry was notorious for its

stagnant total factor productivity. There is also evidence that allocative efficiency improved markedly between 1978 and 1982. Furthermore, efficiency gains across firms have a strong, positive correlation with the share of enterprise profits retained by workers and management, suggesting that the introduction of material incentives has been an important source of these productivity gains.

Data on Chinese enterprises and industries remain quite limited, and in some cases unreliable. Consequently, empirical work on China, including that presented here, should be interpreted cautiously; much more information will be needed to definitively assess the success or failure of industrial reform in China. Nevertheless, the results presented here provide a preliminary indication that the reform has met with some success. In theory, the reform program, by forcing enterprises to stand on their own without state support, offers firms both a carrot and a stick to encourage greater productivity. Many of the enterprises covered by this study have responded to the carrot, and there is evidence that the larger the carrot, the greater the productivity gains.

What cannot fully be addressed by this study is whether the industrial reform program in China really carries any stick: all of the enterprises in the World Bank survey were profitable in the pre-reform period and have remained profitable. Many state-owned enterprises, however, persistently lose money, and there is no evidence to date that the state will allow these firms to fail. It may be that the carrot is working, but that the absence of a stick will limit the extent to which increased efficiency spreads throughout China's state-owned industry.

Notes

1. Perkins (1988) estimates TFP growth for Chinese agriculture and industry combined to be -1.41 percent per annum in 1957-65, and 0.62 percent per annum in 1965-76. Tidrick (1986) estimates TFP growth for state-owned industry and finds, between 1957 and 1978, an annual growth rate either slightly below or slightly above zero, depending on the weights chosen for capital and labor.

2. See Lin (1987) and Johnson (1988).

3. For details of China's planned economy and the specific reforms that have been introduced since 1978, see Byrd and Tidrick (1987), Chow (1985), Perkins (1988), Reynolds (1987), and World Bank (1985).

4. See, for instance, Wong (1986, 1987).

5. It is possible, of course, that a particular firm may have low marginal revenue products of both capital and labor, relative to other firms. This would be evidence of X inefficiency, rather than resource misallocation, at the firm level. Nevertheless, from the point of view of Chinese industry this still represents resource misallocation, since the resources misused by this firm could be better utilized elsewhere.

6. Estimating a Translog production function with variable returns to scale across this data set finds no evidence of economies or diseconomies of scale.

7. A different approach to measuring the extent of resource misallocation is to estimate the marginal rate of technical substitution

between capital and labor in each industry or sector and compute the resource saving that could be realized by equating these rates across sectors. Desai and Martin (1983) apply this approach to Soviet industry. The data set on Chinese enterprises provided by the World Bank survey is not large enough to permit this approach.

8. The World Bank survey provides data on gross output in constant and current prices, yielding an implicit price deflator for gross output; this deflator was then used to convert value added into constant prices.

9. Table 2 also presents the results of estimating pooled, cross-sectional production functions for 1975-78 and 1979-82 separately. The increase in the constant term is another indication that average TFP has increased.

10. No effort was made to convert capital stock data into constant prices, since no appropriate deflator was available. Given the modest inflation occurring in China during this period, the rate of growth of capital stock is likely to be slightly overestimated. Consequently, TFP growth is likely to be underestimated.

11. Table 4 also reports the correlation between a firm's TFP growth and its capital-labor ratio, which would provide evidence of whether the economic reform has tended to favor light or heavy industries. The correlation is virtually zero, indicating that in this small sample there is no evidence of any such bias.

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Table 1

Cross-Sectional Estimates of Production Functions for Chinese Enterprises, 1978 and 1982

Dependant Variable: Value Added per Worker, Current Prices

Year	Number of Firms	Constant	Capital-Labor Ratio	R^2
1978	17	1.15	.22 (.95)	.06
1978	8 most efficient	1.81	.17 (1.00)	.14
1982	20	.93	.38 (2.59)	.27
1982	10 most efficient	1.04	.51 (4.85)	.75

Note: Dependant and independant variables have been entered as logarithms. Figures in parentheses are t-statistics.

Table 2

Pooled, Cross-Sectional Estimates of Production Functions for Chinese Enterprises, 1975-1982

Dependant Variable: Value Added per Worker, 1982 Prices

Years	Number of Observations	Constant	Capital-Labor Ratio	R^2
1975-82	124	1.13	.27 (3.71)	.10
1975-78	46	1.02	.25 (1.90)	.08
1979-82	78	1.21	.27 (3.23)	.12

Note: Dependant and independant variables have been entered as logarithms. Figures in parentheses are t-statistics.

Table 3

Rates of Growth of Labor Productivity, Capital Intensity, and Total Factor Productivity for 20 Chinese Enterprises, 1975-1982

Enterprise	Years Covered	Average Annual Rate of Growth (percent): Value Added per Worker (1982 prices)	Productive Assets per Worker	TFP
Anshan Iron and Steel	1976-82	4.9	5.3	3.5
Baoji Nitrogen Fertilizer	1975-82	13.3	-3.6	14.3
Chengdu Locomotive and Rolling Stock	1977-82	-6.7	1.8	-7.2
Chongqing Clock and Watch	1979-82	23.3	10.3	20.5
Jiangmen Nanfang Foodstuff	1975-82	9.1	7.4	7.1
Jinling Petrochemical	1981-82	a	a	a
Mindong Electrical Machinery	1979-82	-16.2	2.5	-16.9
Nanning Silk and Linen Textile Mill	1975-82	10.1	3.3	9.2
North China Petroleum	1976-82	-7.5	5.2	-8.9
Northwest #1 Cotton Mill	1977-82	0.9	-7.7	3.0
#2 Automobile Plant	1978-82	43.9	5.2	42.5
Qingdao Forging Machinery	1977-82	-8.9	-0.4	-8.8
Qinghe Woolen Textile Mill	1975-82	0.1	5.9	-1.5
Qingyuan County Economic Commission	1975-82	9.2	3.3	8.3
Sanchazi Forestry Bureau	1975-82	3.2	4.2	2.1
Shanghai #17 Cotton Mill	1977-82	3.7	-3.3	4.6
Shanghai High-Pressure Oil Pump Factory	1978-82	4.0	-6.2	5.7
Shenyang Smelting	1976-82	2.5	3.2	1.6
Tianjin Color Textile	1978-82	2.9	3.5	1.9
Xiangxiang Cement	1977-82	8.9	-0.6	8.9
Unweighted Average		5.3	2.1	4.7

[a]Since data for this enterprise cover only two years, growth rates are not presented.

Table 4

Correlation of TFP Growth with Other Variables for 17 Chinese Enterprises, 1975-1982

Rank Correlation Coefficients

	TFP Growth	*Self-Marketed*	*Retained Profits*	*TFP Level*	*Capital-Labor*
TFP Growth					
Share of Output Self-Marketed, 1980-82	*.27*				
Share of Profits Retained by Firm, 1980-82	*.46*	*.33*			
TFP Level, 1978	*-.52*	*-.50*	*-.70*		
Capital-Labor Ratio, 1982	*-.01*	*-.07*	*-.35*	*.08*	

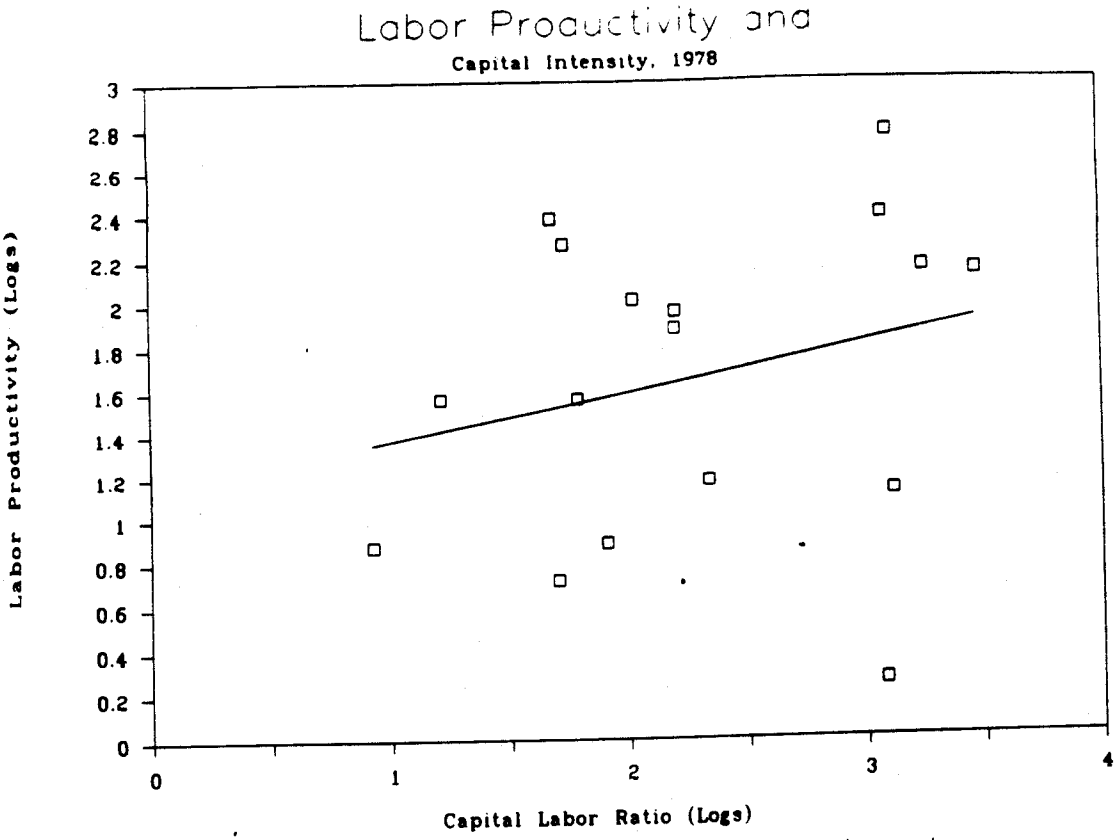

Figure 1

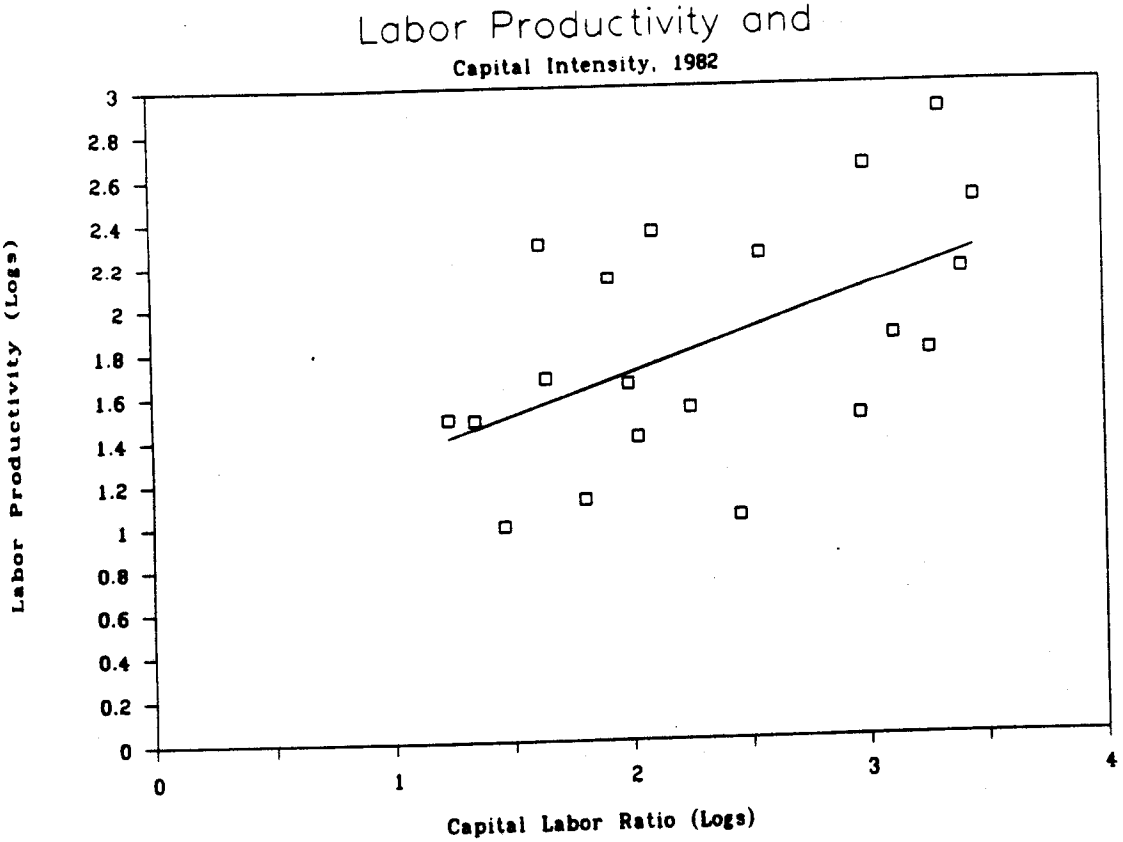

Figure 2