Imported Technology and Employment: Evidence from Panel Data on Indian Manufacturing Firms

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Abstract

This paper examines the effect of the ratio of imported capital to domestic capital on the ratio of labor to value-added that is, labor required per unit value of output, using firm level data in eight manufacturing industries over the period from 1991-92 to 2001-02. The empirical results indicate that given the ratio of labour to capital, any increase in the ratio of foreign to domestic capital stock lowers the labor to value added ratio. The rapid upward trend in the ratio of foreign to domestic capital stock since the early 1990s is also evident from the data set. Based on these findings, we conclude that In India higher dependency on foreign capital imports resulted in weak absorption of labor, despite the rapid growth of Indian manufacturing sector in the reform period.

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1. Introduction

It is often argued that developing countries import technology from developed countries, resulting in a mismatch between the technological requirements of the former and the available technology (for instance, Pack and Todaro 1969). Technology innovated in the developed world is mainly of labour-saving and skill-intensive type as it has to suit the situation of developed economies. On the other hand, developing countries are mainly labour surplus and skill scarce economies and hence, the objective of employment growth along with economic growth gets defeated when technology is largely imported from abroad. India, especially the manufacturing sector, has achieved rapid economic growth since the 1990s. However, the absorption of labor has not been impressive in comparison to the output growth. In this study we examine whether import of technology affects the utilization of labor in Indian manufacturing firms.

As Azeez (2006) points out distinctly, a new technology gets embodied in capital goods, and therefore, import of capital goods is often considered as import of technology. Once imported capital good is put into operation, the technological progress realized in the country of origin will be incorporated into the production process (UNIDO, 2005). Hence, the debate relating to the nature of technology gets shifted to the import of capital goods. The overall effect of the import of technology or capital on developing economies needs to be assessed, based at least on its effect on productivity enhancement and labor absorption.

Though the import of technology from developed countries may be expected to raise the productivity of developing countries, there are plausible doubts about this effect. Chakravarty (1987) noted that with imports of capital goods on a significant scale, domestic costs of production are unlikely to come down if the imports and domestic production involve substitutability. Developing countries might be importing expensive capital goods that could be produced in their own countries. Chandrasekhar (1992) argued further that in the Indian context imports of capital goods have acted as substitutes for domestic production of capital goods, imposing a social cost in the form of unutilized capacity. And this made the domestic firms operate at high unit cost of production. However, Azeez's (2006) work on non-electrical machinery sector shows that the capital goods imports in the eighties shifted away from a substitute to a complementary one, which in turn enhanced the domestic capacity utilization in the nineties. Hasan (2002) presents evidence from panel data on Indian manufacturing firms, suggesting that imported technologies have a significant effect on productivity. In a very exhaustive study using data on 33 Indian manufacturing industries for the period from 1992 through 2001 Pandit and Siddharthan (2006) show that technology imports through joint ventures and MNE participation influence employment positively. They noted that employment growth, production of differentiated products, skill intensity of the work force and technological up-gradation go hand in hand.

Another line of argument asserts that the adoption and adaptation of these international technologies are indeed costly because of tacit knowledge and circumstantial sensitivity of technology (Evenson and Westphal 1995). It is argued that unless an importing country has significant technological capability, it cannot fully utilize imported technology. But the counter view is that countries further from the frontier have lower R&D returns, implying that the cost of innovation is more in a poor country than in a rich country. Hence, it is still cheaper for a latecomer to buy the technology already invented by others than to re-invent the wheel though it is widely noted that international technology does not come cheap (UNIDO, 2005). Hasan (2002) in this respect noted that productivity-enhancing effects of domestic capital goods appear to owe more to the disembodied technologies imported by producers of domestic capital goods than the R& D they conduct.

But imported technology may require more skilled workers than unskilled workers while developing countries are usually abundant in the latter. Acemoglu and Zilibotti (2001) argue that due to the difference in skill scarcity, technology in developed countries tends to be skill intensive and is inappropriate for developing countries. Thus the potential productivity of imported technology cannot be realized in developing countries. Berman and Machin (2000) show that actually the skill-bias of technological change is occurring, especially in middle-income countries. Their results also indicate that developing countries follow the pattern of skill upgrading that happened earlier in developed countries. This mismatch between labor requirement of the imported technology and the endowment of types of work forces may leave unskilled workers unemployed. For these reasons it is not obvious that the import of technology may enhance productivity of importing countries.

If the import of technology enhances productivity as well as promotes employment, the choice is absolutely desirable. And such a possibility can exist at least theoretically: for example, technological progress can bring in upward shift in the production frontier, which would mean higher levels of output for the given levels of inputs. In such a situation even if the new technology becomes more labour intensive, the rise in value added can still be more than the rise in employment, and hence, labour productivity will increase. However, when output is fixed, the shift in technology from a capital intensive to a labour intensive one would result in deterioration in labour productivity. Conversely, if the new technology dampens employment and improves productivity by capital-deepening process, the gains in productivity and losses in employment are to be compared to assess the net outcomes. Mitra (2006) argues that over time productivity growth in Indian manufacturing industry has been much faster than the employment growth, possibly because of capital deepening process and the unsuitability of the imported technology to the requirements of the domestic economy. Thus, whether the new technology affects employment adversely or fastens labour absorption is one of the central questions that need a thorough investigation. Pandit and Siddharthan (2006) have quite clearly pointed out that import of technology through joint ventures and MNE participation has shown positive effects on employment. Hence, our hunch is that if these conditions are not met mere increase in import of technology may not allow firms to use it effectively and thus draw benefits in relation to employment.

The objective of the present study is to examine the effect of the import composition of capital, i.e., the ratio of imported capital to domestic capital, on the ratio of labor to output (value-added), namely, the amount of labor input required to produce unit value of output.[1] We made panel data estimation using firm level data in eight manufacturing industries over the period from 1991-92 to 2001-02, the period that is characterized by rapid globalization and is believed to have fastened the process of diffusion of knowledge. The estimation has been carried out for all industries combined and for each industry separately corresponding to the following groups: basic metals, non-metallic mineral products, chemicals, plastics and rubbers, non-electrical machinery, electrical machinery, electronics and transport equipment.

The empirical results indicate that as the ratio of foreign to domestic capital stock increases, the ratio of labor to value added tends to be lower, with the ratio of labor to total capital being controlled for. We also show the rapid upward trend in the ratio of foreign to domestic capital stock since the early 1990s. These findings combined, we conclude that higher dependence on foreign capital imports resulted in weak absorption of labor, despite the rapid growth of Indian manufacturing sector since the 1990s.

The rest of the paper is organized as follows. We explain the methodology in section 2. Data and construction of variables, as well as summary statistics, are presented in section 3. Section 4 discusses the estimated results. We conclude in section 5.

2. Estimation methodology

The specification of our model is as follows.

$$\ln\left(\frac{L}{Q}\right) = \alpha + \beta \ln\left(\frac{L}{K}\right) + \gamma \ln\left(\frac{L}{K}\right) * PD + \delta \ln\left(\frac{IK}{DK}\right) + \theta \ln\left(\frac{IK}{DK}\right) * PD$$

[1] Thus our analysis is only partial in this context.

where L indicates labor, K total capital stock, IK imported capital stock, DK domestic capital stock and Q output (value added). PD is a period dummy that takes zero if the observation belongs to the period from 1991-92 to 1995-96 and one if it is from 1996-97 to 2001-02. It is argued that drastic deregulation since 1991 took effect only after a couple of years since its implementation. The period dummy is expected to capture this effect. As argued above, if technological progress (upward shift of the production frontier) is accompanied by a rise in labour-capital ratio it may still lead to a situation where value added may grow faster than labour and hence, one may expect a decline in labour to value added ratio. On the other hand, if technological progress brings in a rise in capital-labour ratio (a fall in labour-capital ratio) then labour-value added ratio would obviously decline (or labour productivity would shoot up). A similar situation may arise again when capital deepening process takes place. In other words, on a priori basis there is no definite relationship between labour-value added ratio and labour-capital ratio. Given the labour-capital ratio any tilt in favour of the imported content of capital may cause deterioration in the labour requirement per unit value of value added of the firm if the imported technology is of labour saving type.

3. Data, variable construction, description of data

Data

In this paper we focus on the firms operating in the following eight industries: chemicals, plastics and rubbers, non-metallic mineral products, basic metals, non-electrical machinery, electrical machinery, electronics, and transport equipment.

Our data set covers the period from 1991-1992 through 2001-2002. The primary source of data is *PROWESS*, compiled by Center for Monitoring Indian Economy (CMIE). Other data sources are mentioned below.

Variable construction

Period Dummy

As mentioned above, period dummy variable takes zero if the observation belongs to the period from 1991-92 to 1995-96, and one if it belongs to the period from 1996-97 to 2001-02.

Output

We constructed deflated gross value added as a measure of output. The deflator applied to value added of firm i is:

$$DEF_i = \sum_{k=1}^{n_{ik}} s_{ik} \times DEF_k \ ,$$

where k indicates a two digit level industry in which firm i operates and s_{ik} is the percentage share of sales in industry k in firm i's total sales and n_{ik} is the index of industries in which firm i operates. DEF_k is the wholesale price index of industry k.

Labor

PROWESS contains the data on wages and salaries. We divide this number by average wage of each firm. First, the average wage of each industry is obtained by dividing the total emoluments of the industry by total mandays employed in the industry, the data of which are available from Annual Surveys of Industries. Since we do not have data on how many workers are employed for each product, the average wage of firm i is calculated as weighted average of each industry's average wage, with weights being the percentage sales in each industry in firm i's total sales.

Capital

To a large extent the study followed the method used by Srivastava (2000), which is explained in Appendix. The main differences between Srivastava's method and that used in this study are as follows. First, although Srivastava (2000) uses a balanced data set, we use an unbalanced data set, in which companies differ in the initial year. We calculate the estimated real capital stock in the initial year of each firm in our data set based on the method that Srivastava (2000) used to obtain the capital stock for the base year in his study. Second, although Srivastava (2000) divided the capital into plant and machinery, buildings and other capital, we did not split capital into different categories at this stage.

Foreign Capital and Domestic Capital

The data on foreign capital goods are also available from PROWESS, termed as forex spendings capital goods. This covers the value of imported capital goods like plant and machinery. To obtain real stock value of foreign capital, we make the following assumptions:

1. No foreign capital goods existed before 1991.
2. Missing values means zero investment in foreign capital goods in that year.

We apply perpetual inventory method to the data on foreign capital goods. We do not have appropriate deflator for foreign capital goods, which depends on the exchange rate between Indian rupees and the currency of an exporting country. Thus, we simply apply the deflator for domestic capital goods.

Finally, we obtain domestic capital stock simply by subtracting foreign capital stock from total capital stock.

Descriptive statistics

In this paper we focus on the observations that meet the following conditions: Gross value added >0, Labor>0, Total Capital Stock >0, and 10>Capital Output Ratio>0. Correlations between variables are shown in Table 1. Notice that total capital and domestic capital show a higher correlation than that between total capital and foreign capital. Summary statistics are presented in Table 2. Note that both labor-gross value added ratio and labor-capital ratio take extreme maximum-values. Therefore, for estimation purposes we deleted the observations whose values for these two ratios are greater than the mean value plus two times its standard deviation.

Table 1: Correlation between Variables

	Gross Value Added	Labor	Total Capital	Foreign Capital	Domestic Capital
Gross Value Added	1				
Labor	0.78	1			
Total Capital	0.84	0.78	1		
Foreign Capital	0.83	0.52	0.74	1	
Domestic Capital	0.75	0.78	0.97	0.57	1

Source: *PROWESS*, compiled by Center for Monitoring Indian Economy (CMIE).

Table 2: Summary Statistics

	Mean	Std Dev	Minimum	Maximum
Gross Value Added	51.867	179.538	0.007	5945.951
Labor	1019756.3	3020993.0	985.0	5.09150D+07
Total Capital	85.6	322.2	0.0	6656.3
Foreign Capital	17.4	90.3	0.0	2633.4
Domestic Capital	68.3	262.4	0.0	4669.0
Labor-GVA ratio	36252.6	227711.0	1198.2	1.38940D+07
Labor-Capital ratio	2391397.2	1.31947D+08	417.1	8.58396D+09
Foreign-Domestic Capital Ratio	0.5	3.1	0.0	123.4

Source: See Table 1.

Figure 1 shows the time trend of the annual mean of total, domestic and foreign capital stock. Total capital stock tends to move upward, though the change is not monotonic. Foreign capital stock continuously increases except for 1998. Conversely, domestic capital stock remains the same or decreases slightly, especially in 2000 and 2001. Figure 2 shows the trend of the ratio of foreign capital stock to domestic capital stock. This ratio drastically increases throughout the 1990s, from less than 0.1 to more than 0.9 in 2001. Lastly, Figure 3 shows the time trends of labor to gross value added ratio and labor to total capital stock ratio. Both ratios decreased concurrently in the early part of the 1990s. Since 1996 the ratio of labor to value added ratio increased again, while the ratio of labor to capital ratio remained the same.

Figure 1: Trends of Capital

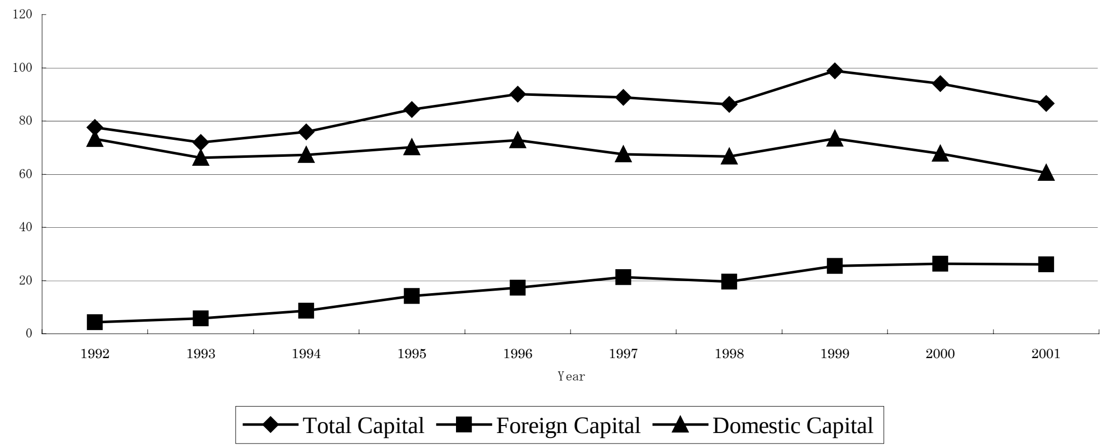


Figure 2: Foreign to Deomestic Capital Ratio

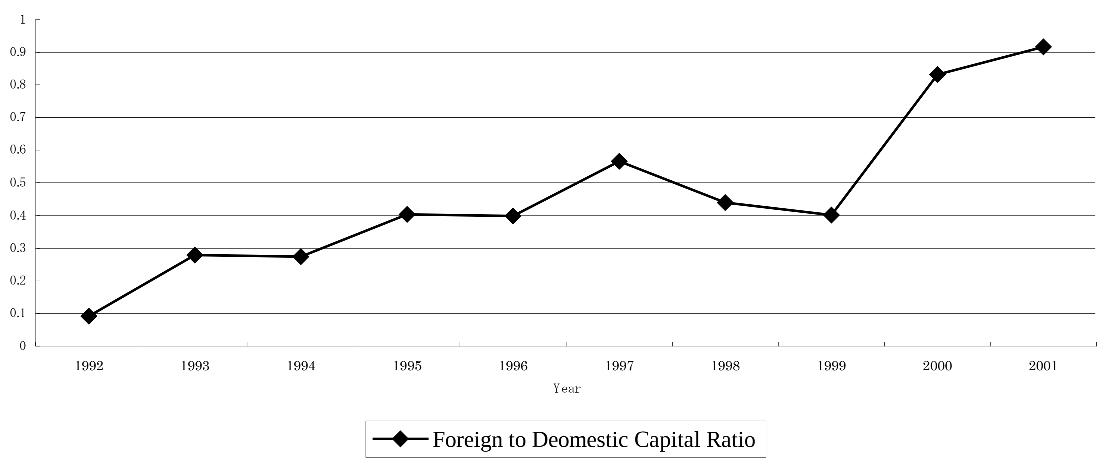
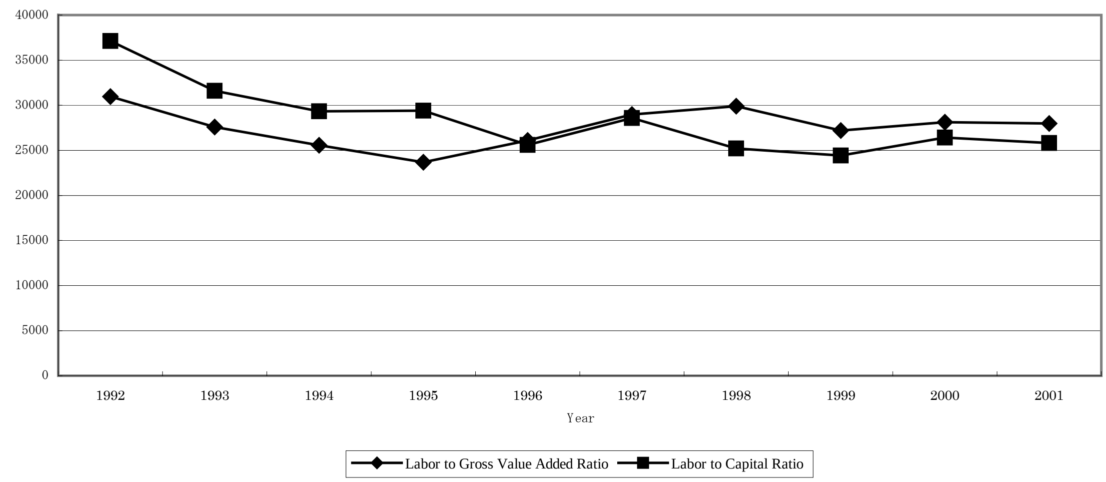


Figure 3: Trends of Labor to Gross Value Added and Capital Ratio



4. Estimation results

A firm is designated to a specific industry if more than 50 per cent of the total sales of the firm correspond to that industry. Thus, it is possible that a particular firm is included in a specific industry in a certain year but in another industry in some other year.

Tables 3 and 4 show our estimation results. Table 3 first presents the results based on all observations- pooled across industries. The estimation results clearly indicate that the ratio of labor to value added tends to be smaller for firms with a larger ratio of foreign to domestic capital stock. Moreover, this effect is stronger in the latter part of the sample period.

Table 3: Estimation Based on Entire Sample: All Industries, All Firms and All Time Points

Dependent Variable: ln(Labor/Value Added)

	All Sample	
Fixed Effect	Coefficient	t-statistic
ln(Labor/Capital)	0.287	12.393**
ln(Labor/Capital)*(period dummy)	0.002	0.649
ln(imported capital/domestic capital)	-0.020	-2.591**
ln(imported capital/domestic capital)*(period dummy)	-0.018	-2.341*
R^2	0.768	
adj R^2	0.726	
Random Effect	Coefficient	t-statistic
ln(Labor/Capital)	0.317	22.410
ln(Labor/Capital)*(period dummy)	0.004	1.775
ln(imported capital/domestic capital)	-0.031	-4.402

ln(imported capital/domestic capital)*(period dummy)	-0.012	-1.573
R^2	0.308	
adj R^2	0.307	
Hausman(p-value)	35.232 [.0000]	
Selected Model	FE	
No. of observations	3960	

Notes: Period dummy = 1 if the observation is in 1996-2001, = 0 if in 1991-1995; ** and * indicate 1 and 5 per cent significance level respectively.

The estimation results based on separate sample groups for each industry present mixed findings (Tables 4). In basic metals and transport equipments the negative effect of the ratio of foreign to domestic capital stock is significant but the effect is not stronger in the latter part of the sample period. In non-metallic mineral products and electronics the negative effect is not statistically significant in the first part though in the latter part of the sample period it turns out to be significant. In the rest of the sample industries we do not observe any statistically significant effect of the ratio of imported capital to total capital. In the absence of any positive effect of this variable on employment the statistically significant results are taken to indicate that as the ratio of foreign to domestic capital stock increases, firms tend to use less labor per one unit of output, after controlling for labor/capital ratio. Moreover, in Figure 2 we saw a drastic increase in the foreign to domestic capital stock ratio during the sample period. Therefore, we conclude that higher dependence on the import of foreign capital in the 1990s at least partially explains weak absorption of labor in manufacturing sectors in spite of its rapid growth.

Table 4: Industry-Specific Estimation Results

Dependent Variable: ln(Labor/Value Added)

	Basic Metals		**Chemicals**	
Fixed Effect	Coeff.	t-statistic	Coeff.	t-statistic
Ln(Labor/Capital)	0.046	0.421	0.150	1.652
Ln(Labor/Capital)*(period dummy)	0.035	2.472*	0.029	2.878**
Ln(imported capital/domestic capital)	-0.054	-1.020	0.009	0.284
Ln(imported capital/domestic capital)*(period dummy)	0.084	2.053*	-0.016	-0.533
R^2	0.683		0.672	
adj R^2	0.594		0.593	
Random Effect	Coeff.	t-statistic	Coeff.	t-statistic

Ln(Labor/Capital)	0.306	5.429**	0.279	5.487**
Ln(Labor/Capital)*(period dummy)	0.031	2.433*	0.038	3.951**
Ln(imported capital/domestic capital)	-0.087	-2.404*	-0.039	-1.499
Ln(imported capital/domestic capital)*(period dummy)	0.078	2.155*	0.009	0.342
R^2	0.238		0.297	
adj R^2	0.229		0.286	
Hausman(p-value)	8.7818 [.0668]		15.534 [.0037]	
Selected Model	RE		FE	
No. of observation	339		278	

Non-metallic Products		**Non-electrical Machinery**		**Electrical Machinery**	
Coeff.	t-statistic	Coeff.	t-statistic	Coeff.	t-statistic
0.342	3.232**	0.231	2.796**	0.574	3.234**
-0.025	-2.075*	0.015	1.886	-0.004	-0.367
0.045	1.267	-0.037	-1.223	-0.009	-0.263
-0.115	-3.390**	0.049	1.666	-0.003	-0.076
0.667		0.696		0.816844	
0.597		0.633		0.774472	
Coeff.	t-statistic	Coeff.	t-statistic	Coefficient	t-statistic
0.211	4.045**	0.213	4.206**	0.472	6.453**
-0.024	-2.071*	0.014	1.868	-0.003	-0.273
0.047	1.471	-0.036	-1.331	-0.012	-0.378
-0.107	-3.284**	0.044	1.534	0.013	0.334
0.115		0.139		0.490	
0.105		0.128		0.478	
5.0788 [.2793]		2.4959 [.6454]		1.5746 [.8133]	
RE		RE		RE	
368		324		166	

Electronics		**Plastics and Rubbers**		**Transport Equipments**	
Coeff.	t-statistic	Coeff.	t-statistic	Coeff.	t-statistic
0.442	2.967**	0.434	3.724**	0.528	8.294**
-0.004	-0.252	-0.001	-0.109	-0.001	-0.255
-0.036	-0.726	0.007	0.345	-0.052	-3.140**
-0.148	-2.446*	0.025	0.785	-0.003	-0.132
0.715264		0.796453		0.782003	
0.622289		0.752595		0.745585	
Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
0.086	0.972	0.400	8.437**	0.438	12.307**
0.001	0.047	0.002	0.272	-0.001	-0.241
-0.004	-0.096	0.000	0.019	-0.054	-3.420**
-0.109	-2.002*	0.028	0.958	-0.001	-0.059
0.088		0.567		0.484	
0.059		0.559		0.480	
13.500 [.0091]		4.5865 [.3324]		4.1042 [.3921]	
FE		RE		RE	
131		221		497	

Notes: Period dummy = 1 if the observation is in 1996-2001, = 0 if in 1991-1995; ** and * indicate 1 and 5 per cent significance level.

As regards the labour-capital ratio**,** it is seen to have a positive effect on the labour-value added ratio in most of the industry groups, suggesting that capital-deepening process has been raising labour productivity. This is not necessarily an outcome of technological progress because as mentioned above, technological progress perceived as larger returns in terms of output to the same magnitude of inputs leads to larger value added growth than employment, thus resulting in a rise in labour productivity even when capital-labour ratio may actually decline.

5. Conclusion

In this paper we examined the effect of the ratio of foreign to domestic capital stock on the ratio of labor to value added ratio. Our findings show a negative relationship between these two. Namely, as the ratio of foreign to domestic capital increases, the ratio of labor to value added tends to decline. We also show that the annual mean of the ratio of foreign to domestic capital stock increased drastically during the 1990s. These two results together explain at least partially that higher dependence on the import of foreign capital in the 1990s has led to sluggish absorption of labor in the manufacturing sector in spite of its rapid growth. Since a mere increase in the capital-labour ratio is not adequate to reflect technological progress we conclude that with liberalization there is a growing tendency to import capital in the name of technological progress without of course realizing its effectiveness. All this raises labour productivity and creates the illusion of technological progress though actually it could be the result of capital deepening process. As pointed out clearly by the study conducted by Pandit and Siddharthan (2006) import of capital goods impacts on employment positively only when there is scope for joint ventures and MNE participation. Without meeting some of these important pre-conditions, which enhance the knowledge relating to the mechanisms of exploiting the new technology acquired from abroad, a mere import in technology would mean rising unutilized capacity. Therefore, it is not appropriate to pose the question whether globalization per se that promotes import of technology has positive or negative effects on employment. Rather it is important to examine whether the spirit of globalization is being followed to reap the advantages in terms of improvements in technical know-how and knowledge-sharing so that all this assimilates concurrently with the domestic process and helps fulfill the objectives of pro-poor growth in the technology-importing country.

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Appendix

Real Capital Series

With a few differences we follow the method taken by Srivastava (2000). The replacement cost of the capital stock is calculated as,

$$P_{t+1}^{i}K_{t+1}^{i} = \frac{P_{t+1}^{i}}{P_{t}^{i}}(1-\delta)P_{t}^{i}K_{t}^{i} + P_{t+1}^{i}I_{t+1}^{i} ,$$

where δ is the depreciation rate, P is the price of capital, K is capital stock and I is investment. Although Srivastava divided capital into plant and machinery, buildings and other capital, we did not do so at this stage.

Implicit deflators for total capital formation are obtained from the National Account Statistics, in which a series are available for private sector capital formation at current and base year (1993-94) prices.

To obtain capital at replacement cost for the base year, Srivastava made three assumptions. We modified his assumptions to our setups as follows.

Assumption 1: No firm has any capital in 1991-1992 of a vintage earlier than 1976-1977. For firms incorporated after 1977 it is assumed that the earliest vintage of capital in their capital mix dates to the year of incorporation.

Assumption 2: The price of capital has changed at a constant rate at $\Pi = P_t/P_{t-1} - 1$ from 15 years before the initial year in the data or the date of incorporation of the firm up to 1991-1992 (or the initial year in the data). Values of Π were obtained by constructing capital formation price indices from the series for gross fixed capital formation in the National Accounts Statistics.

Assumption 3

Investment has increased at a constant rate for all firms and the rate of growth of investment $g = I_t/I_{t-1} - 1$. Here the rate of growth of gross capital formation at 1993-1994 prices is assumed to apply to all firms. Again, different average rates are obtained for firms established after 1977.

Under these assumptions, if the capital stock of the earliest vintage is τ periods old, then the revaluation factor for gross fixed assets (R^G) is:

$$R^G = \frac{\left\{(1+g)^{\tau+1} - 1\right\}(1+\Pi)\left\{(1+g)(1+\Pi) - 1\right\}}{g\left\{(1+g)(1+\Pi)\right\}^{\tau+1} - 1} .$$

Similarly, the revaluation factor for net fixed assets (R^N) is:

$$R^N = \frac{\left\{(1+g)^{\tau+1} - (1-\delta)^{\tau+1}\right\}(1+\Pi)^{\tau}\left\{(1+g)(1+\Pi) - (1-d)\right\}(1-\delta)}{(g+\delta)\left\{(1+g)^{\tau+1}(1+\Pi)^{\tau+1} - (1-d)^{\tau+1}\right\}(1-d)} ,$$

where d is the rate of accounting depreciation and δ is the economic rate of depreciation. As in Srivastava (1996) we used 7.1 per cent for δ. We calculate the average accounting depreciation rate for each firm for d.

We apply these revaluation factors to the initial net fixed asset data in our data set, to obtain our estimated initial capital stock. After that we obtain the series of capital stock at replacement cost by the perpetual inventory method, mentioned above.