Working Paper No. 626

Technical Change in India's Organized Manufacturing Sector*

by

Jesus Felipe
Utsav Kumar
Asian Development Bank, Manila, Philippines

October 2010

* This paper represents the views of the authors and not those of the Asian Development Bank, its executive directors, or the member countries they represent. Contacts: jfelipe@adb.org (corresponding author); ukumar.consultant@adb.org.

Levy Economics Institute
P.O. Box 5000
Annandale-on-Hudson, NY 12504-5000
http://www.levyinstitute.org

ABSTRACT

We use the real wage–profit rate schedule to examine the direction of technical change in India's organized manufacturing sector during 1980–2007. We find that technical change was Marx biased (i.e., declining capital productivity with increasing labor productivity) through the 1980s and 1990s; and Hicks neutral (increasing both capital and labor productivity) post-2000. The historical experience suggests that Hicks-neutral technical change may only be a passing phase before we see a return to the long-term trend of Marx-biased technical change. We also find that the real profit rate has increased from about 30 percent to a very high 45 percent, that the real wage rate increased marginally, and that the share of capital in value added doubled. Overall, technical change in India's organized manufacturing sector during 1980–2007 favored capital.

Keywords: Hicks-neutral Technical Change; India; Marx-biased Technical Change; Real Wage–Profit Rate Schedule

JEL Classifications: E10, O40, O47

1. INTRODUCTION

In this paper we study the direction (i.e., bias) of technical progress in India's organized manufacturing sector during 1980–2007. A country's rate of economic growth ultimately depends on the growth of its productive population, its stock of accumulated capital goods, and on technical progress.

The direction of technical change can be studied within the framework of the neoclassical model by assuming that there exists a well-behaved aggregate production function that summarizes the possibilities of substitution of capital for labor in a sector or economy (see Ferguson [1968]). While this is the standard approach and it has merits, it is not exempt of problems, in particular those raised during the Cambridge debates (Cohen and Harcourt 2003) and those concerning the proper aggregation conditions (Felipe and Fisher 2003 and 2006). The Cambridge debates delved into the idea that "capital," as used in aggregate production function studies, is simply the market value of a huge range of different "physical capital goods." However, as the wage rate changes, the prices of all these goods can undergo any pattern of change, depending on the exact structure of their costs of production. This means that there is no guarantee that a lower wager rate will lead to a lower value of capital per worker or more employment, for a given stock of the capital value, as the neoclassical analysis predicts.[1]

The aggregation problem refers to the conditions under which microeconomic production functions can be aggregated to yield a neoclassical aggregate production function. The results of this body of work unequivocally lead to the conclusion that the conditions are so stringent that, for all practical purposes, one can think that aggregate production functions *do not exist*. A brief summary of the aggregation conditions is as follows (Felipe and Fisher 2003 and 2006): (i) except under constant returns, aggregate production functions are unlikely to exist at all; (ii) even under constant returns, the

[1] There are two extremely damaging problems: (i) **reswitching**: It refers to the violation of the supposedly inverse relation between capital intensity and the profit rate. It leads to the possibility of a non-negative relationship between the profit rate and the capital-labor ratio; (ii) **reverse capital deepening**: It occurs when the value of capital moves in the same associated direction as the rate of profit. In this case, the most profitable project is the one with a less capital-intensive technique.

conditions for aggregation are so very stringent as to make the existence of aggregate production functions in real economies a non-event. This is true not only for the existence of an aggregate capital stock, but also for the existence of such constructs as aggregate labor or even aggregate output; (iii) one cannot escape the force of these results by arguing that aggregate production functions are only approximations. While over some restricted range of the data approximations may appear to fit, good approximations to the true underlying technical relations require close approximation to the stringent aggregation conditions, and this is not a sensible thing to suppose.

Instead, we use the real wage–profit rate schedule (Sraffa 1960), a flexible tool consistent with neoclassical and non-neoclassical models. The real wage–profit rate schedule allows us to analyze technical change through changes in the productivity parameters, labor and capital productivity, and in the factor rewards (real) wage and profit rates.

The rest of the paper is structured as follows. In section 2, we derive the real wage–profit rate schedule and discuss the different types of technical change. In section 3 we show India's wage–profit rate schedule at different points in time and study technical progress in India's organized manufacturing sector. Section 4 offers some conclusions.

2. METHODOLOGICAL FRAMEWORK: THE WAGE–PROFIT RATE SCHEDULE

We start with the income accounting identity that states that total (net) value added (Y_n) equals the sum of total nominal wage bill/total compensation of employees (W_n), plus total profits/operating surplus (Π_n).[2] This identity can be written as follows:

$$Y_n \equiv W_n + \prod_n \equiv w_n L + r_n K \qquad (1)$$

[2] This holds at any level of aggregation—national, sector, industry, or firm. It does not involve any assumption about the production structure or the nature of markets.

Total labor compensation (W_n) can be expressed as the product of the nominal wage rate (w_n) times the number of workers (L). Similarly, profits can be written as ex-post nominal profit rate (r_n) times the constant price value of the stock of capital (K). In real terms, equation 1 becomes:

$$Y_r \equiv W_r + \prod_r \equiv w_r L + r_r K \tag{2}$$

where W_r (w_r) is the real wage bill (real wage rate) and is obtained by dividing the nominal wage bill (nominal wage rate) by the consumer price index ($W_r=W_n/P_w$, $w_r=w_n/P_w$); Π_r (r_r) is the real operating surplus (real profit rate) and is equal to the nominal operating surplus (nominal profit rate) divided by an appropriate price index ($\Pi_r=\Pi_n/P_s$, $r_r=r_n/P_s$). For the purposes of this paper we take real value added (Y_r) as the sum of the real wage bill and real operating surplus.[3]

Expressed as per worker, equation (2) can be written as:

$$y \equiv w_r + r_r k \tag{3}$$

where $y=Y/L$ is labor productivity and $k=K/L$ is the capital-labor ratio. Using $\theta=Y/K$ (i.e., capital productivity), equation 3 can be written as:

$$y \equiv w_r + r_r k \equiv w_r + r_r \frac{K}{L} \equiv w_r + r_r \frac{K * Y}{L * Y} \equiv w_r + r_r \frac{(Y / L)}{(Y / K)} \equiv w_r + r_r \frac{y}{\theta} \tag{4}$$

or

$$w_r \equiv y\left[1 - \frac{r_r}{\theta}\right] \tag{5}$$

[3] Alternatively, one can have a common deflator for value added, total wage bill, and operating surplus.

Equation (5) is known as the *real wage–profit rate schedule* (Foley and Michl 1999). The real wage–profit rate schedule shows that, given labor and capital productivity, there is a trade-off between real wage rates and real profit rates. This schedule allows us to analyze the direction of technical change.

In the real wage rate and real profit rate (*w,r*) space, if the real profit rate is equal to zero, the real wage rate equals labor productivity. Similarly, if the real wage rate equals zero, the real profit rate is equal to capital productivity. The slope of the real wage–profit rate schedule is the negative of the ratio of labor productivity to capital productivity, $\partial w / \partial r = -y / \theta = -k$, that is, the capital-labor ratio. A change in the slope of the real wage–profit rate schedule or a shift in the schedule is an indicator of the direction of technical change.

Technical change can be decomposed into a combination of labor-saving and capital-using (or saving). Technical change is labor-saving if $\hat{y} > 0$ (i.e., if labor productivity increases). It is said to be capital-saving (using) if $\hat{\theta} > 0$ ($\hat{\theta} < 0$) (i.e., capital productivity increases (decreases)). Accordingly, technical change can be classified into one of the following four categories:

i. *Harrod-neutral technical change*: labor-saving and neither capital-saving nor capital-using— $\hat{y} > 0$ and $\hat{\theta} = 0$ (the real wage–profit rate schedule becomes steeper, the vertical intercept shifts outwards, and horizontal intercept remains unchanged).

ii. *Hicks-neutral technical change*: equally labor- and capital-saving— $\hat{y} = \hat{\theta}$ (the slope of the real–wage profit rate schedule remains unchanged, and both vertical and horizontal intercepts shift outwards).

iii. *Solow-neutral technical change*: neither labor-saving nor labor-using and capital-saving— $\hat{y} = 0$ and $\hat{\theta} > 0$ (the real wage–profit rate schedule becomes flatter, the vertical intercept is unchanged, and the horizontal intercept moves inwards).

iv. *Marx-biased technical change*: labor-saving and capital-using— $\hat{y} > 0$ and $\hat{\theta} < 0$ (the real wage–profit rate schedule becomes steeper, the vertical intercept shifts outwards, and the horizontal intercept shifts inwards).

3. TECHNICAL CHANGE IN INDIA'S ORGANIZED MANUFACTURING SECTOR

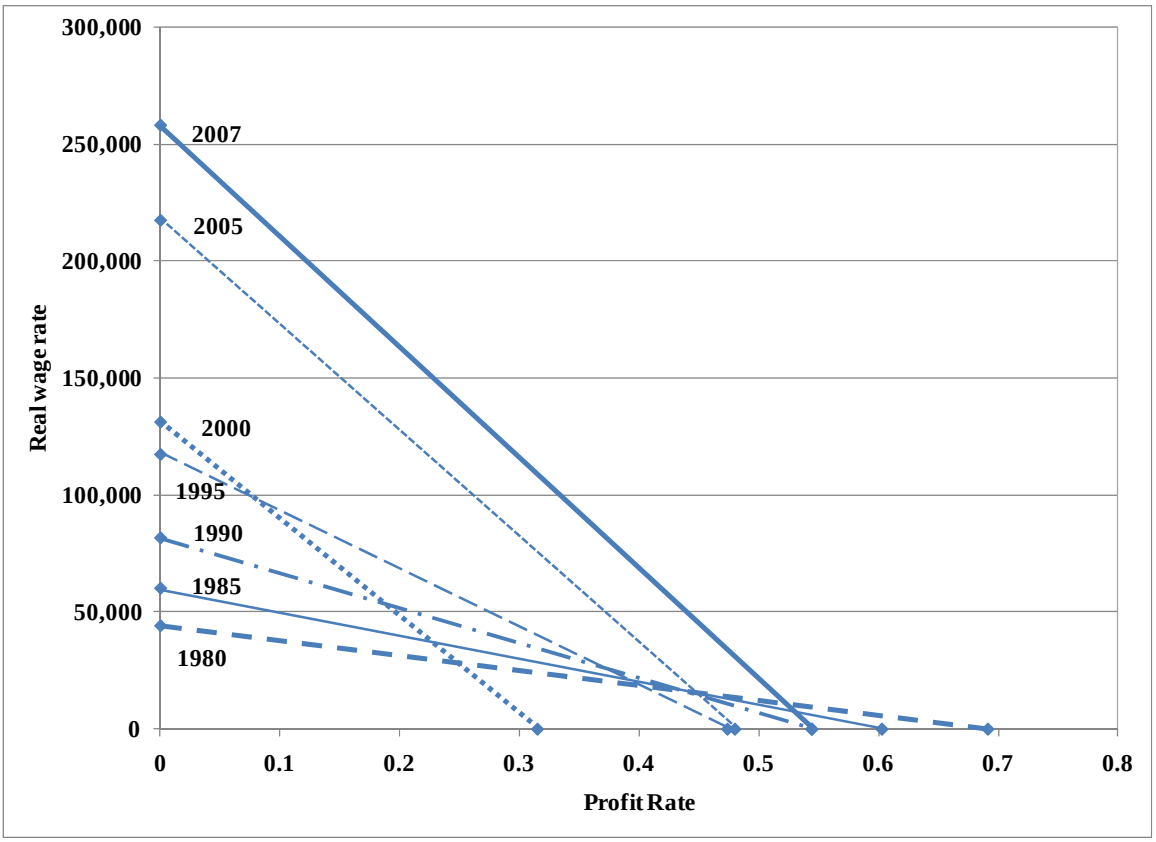
Using data for India's organized manufacturing sector during the period 1980–2007, we examine the bias of technical change. The definition of the variables used in our analysis is provided in table 1.

Table 1: Data Definition and Sources

Variable	Definition
Nominal output/value added (Y_n)	Net value added. This is arrived at by subtracting total input costs and depreciation from the value of total output. **Source:** Annual Survey of Industries (ASI)
Total number of workers (L)	Total number of employees (includes production workers employed directly or through contractors and all other employees). **Source:** ASI
Nominal labor compensation/total wage bill (W_n)	This is defined as the sum of wages and salaries, employers' contribution (such as the provident fund and other funds), and workmen and staff welfare expenses. **Source:** ASI
Consumer price index (P_w)	Consumer price index for industrial workers (index series for different base years, spliced and rebased to 1993–94). **Source:** Reserve Bank of India
Nominal wage rate (w_n)	Nominal labor compensation divided by total number of workers ($w_n=W_n/L$)
Real wage rate (w_r)	Nominal wage rate deflated by P_w ($w_r=w_n/P_w$)
Nominal operating surplus/profits (Π_n)	Value added net of total labor compensation ($\Pi_n=Y_n-W_n$)
Deflator for capital stock and operating surplus (P_s)	Wholesale price index for machinery and equipment (1993–94=100). **Source:** Reserve Bank of India
Real capital stock (K)	Book value of fixed capital, deflated by P_s ($K=$*Fixed Capital*$/P_s$). Fixed capital stock is obtained from ASI and is defined as the depreciated value of fixed assets owned by the factory as on the closing day of the accounting year. Fixed assets are those that have a normal productive life of more than one year. Fixed capital includes land, including lease-hold land, buildings, plant and machinery, furniture and fixtures, transport equipment, water system and roadways, and other fixed assets such as hospitals, schools, etc. used for the benefit of the factory personnel.
Nominal ex-post profit rate (r_n)	Nominal operating surplus divided by real capital stock ($r_n=\Pi_n/K$)
Real operating surplus (Π_r)	Nominal operating surplus deflated by P_s ($\Pi_r=\Pi_n/P_s$)
Real ex-post profit rate (r_r)	Nominal ex-post profit rate deflated by P_s ($r_r=r_n/P_s$)
Real value added (Y_r)	Compute as the sum of real wages and real operating surplus ($Y_r=W_n/P_w+\Pi_n/P_s$)
Price deflator for value added (P)	Implicit price deflator backed out from the computed real value added and nominal value added ($P=Y_n/Y_r$)
Labor productivity (y)	Real value added divided by total number of workers ($y=Y_r/L$)
Share of the real wage-bill (labor compensation) in real output (value added)/labor share (s_l^r)	$s_l^r=\left(w_r L/Y_r\right)$
Capital productivity (θ)	Real value added divided by real capital stock ($\theta=Y_r/K$)
Share of capital in real output (value added)/capital share (s_k^r)	$s_k^r=\left(r_r K/Y_r\right)=\left(\prod_r/Y_r\right)$

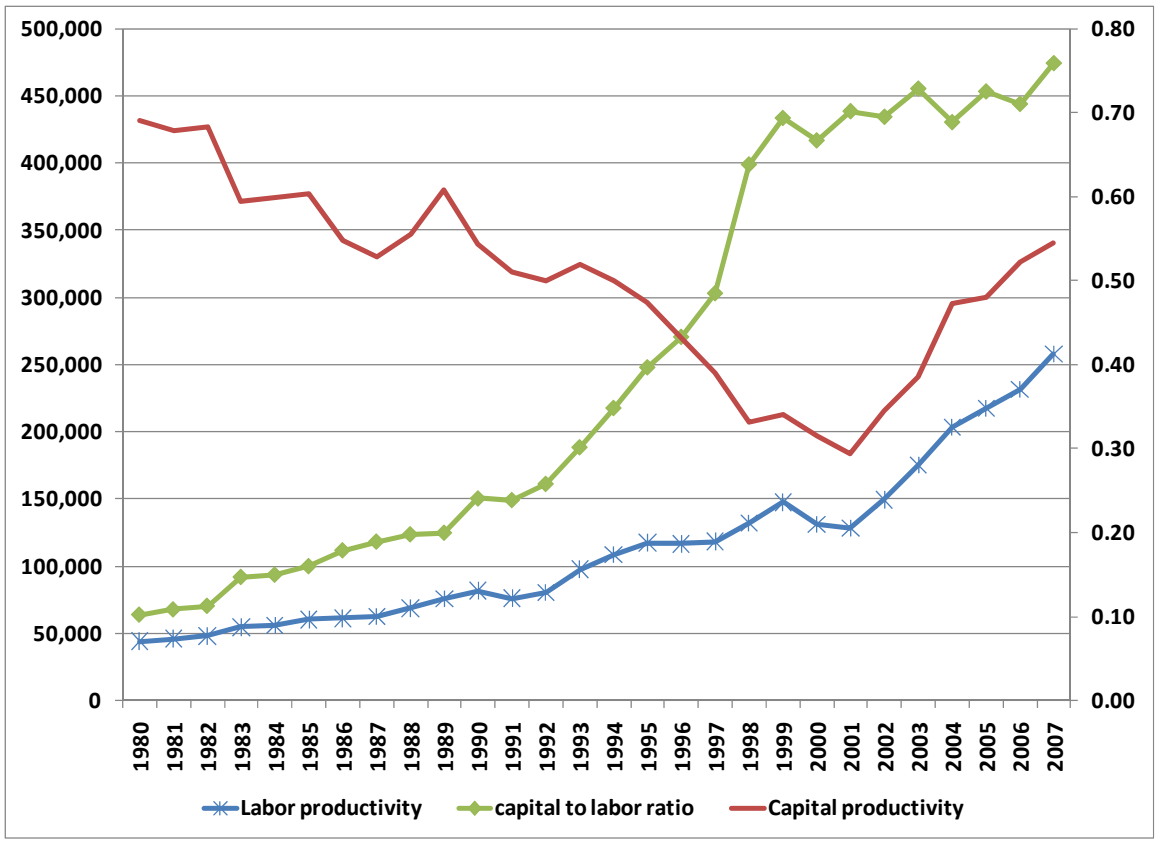
The real wage–profit rate schedules of India's organized manufacturing sector for the years 1980, 1985, 1990, 1995, 2000, 2005, and 2007 are shown in figure 1. The figure shows the trade-off between real wage and profit rates. Between 1980 and 2000, the horizontal intercept of the real wage–profit rate schedule shifted inwards, i.e., capital productivity fell ($\hat{\theta} < 0$). At the same time, the vertical intercept of the real wage–profit rate shifted upwards i.e., labor productivity increased ($\hat{y} > 0$). In other words, the technical change was capital-using and labor-saving (i.e., it was a Marx-biased). However, after 2000, both the vertical and horizontal intercepts shifted outwards (i.e., both labor and capital productivity increased). Though they did not increase by the same proportion, technical change after 2000 is Hicks-neutral.

Figure 1: Real Wage–Profit Rate Schedule for India's Organized Manufacturing Sector



As shown above, the slope of the real wage–profit rate schedule, $\partial w / \partial r = -y / \theta = -k$, gives the direction of technical change. This indicates that the direction of technical change is the result of a combination of changes in labor productivity (y), capital productivity (θ), and in the capital-labor ratio (k). Figure 2 shows the three variables: *y, k, and* θ. We know that between 1980 and 2000, labor productivity increased, while capital productivity declined (Marx-biased technical change). This means that the increase in labor productivity was entirely the result of an increasing capital labor-ratio. After 2000, both capital productivity and the capital-labor ratio increased, and therefore both contributed to the increase in labor productivity. Post-1999, the capital-labor ratio has remained almost constant, with both labor and capital productivity increasing. This is reflected in figure 1 in a near-parallel outward shift in the real wage–profit schedule (Hicks-neutral technical change).

Figure 2: Labor Productivity, Capital Productivity, and Capital-to-Labor Ratio



It is useful to compare the type of technical change of India's organized manufacturing sector with that of other countries. Many researchers (see, for example, Foley and Michl [1999] and Marquetti [2003]) have documented that capital productivity falls and labor productivity rises (i.e., an increasing capital-labor ratio) across both developed and developing economies. The empirical evidence provided by Marquetti (2003) shows that Marx-biased technical change in the form of declining capital productivity and increasing labor productivity seems to be the unavoidable development path. Marquetti (2003) further noted that while the long-term pattern of technical change in industrialized societies is Marx-biased, it is interrupted by periods in which both labor productivity and capital productivity increase (i.e., technical change during this period is Hicks-neutral).

With the caveat that the pattern of technical change shown by Marquetti (2003) is for the whole economy and for a long period, the nature of technical change in the Indian manufacturing sector over the period 1980–2007 seems to conform to the international norm.[4] If this is indeed the general pattern, the worldwide experience would suggest that Hicks-neutral technical change is a temporary phase that is part of a long trend of Marx-biased technical change.

The long-term pattern of technical change, as shown in an increasing labor productivity and a falling capital productivity, can be explained using two alternative hypotheses. The first is based on the neoclassical growth model, which explains this pattern as the result of a stable production function, the movements along which can explain the inverse relationship between capital and labor productivity. The second is the classical-Marxian view, which argues that these changes reflect a bias in the technical change, which, in turn, is caused by the incentive structure inherent in a capitalist economy, driven by profitability.

According to the classical view, profit rates, through their impact on investment and capital accumulation, play a crucial role in determining the growth rate of an economy. In order to earn higher profit rates, firms try to introduce technical changes that lower production costs at the existing level of real wages, and that lead to high profits. These technical changes are in turn brought about by increasing capital accumulation. However, once the technical innovation becomes widespread, prices are driven down and profit rates fall. Capital accumulation and the need to innovate, which comes with the drive to increase profit rates, therefore ultimately cause a fall in the profit rate. Note that the rate of profit could be falling even if the share of profits (or operating surplus) in total value added increased. This would happen if capital productivity fell. To see this consider the following relationship:

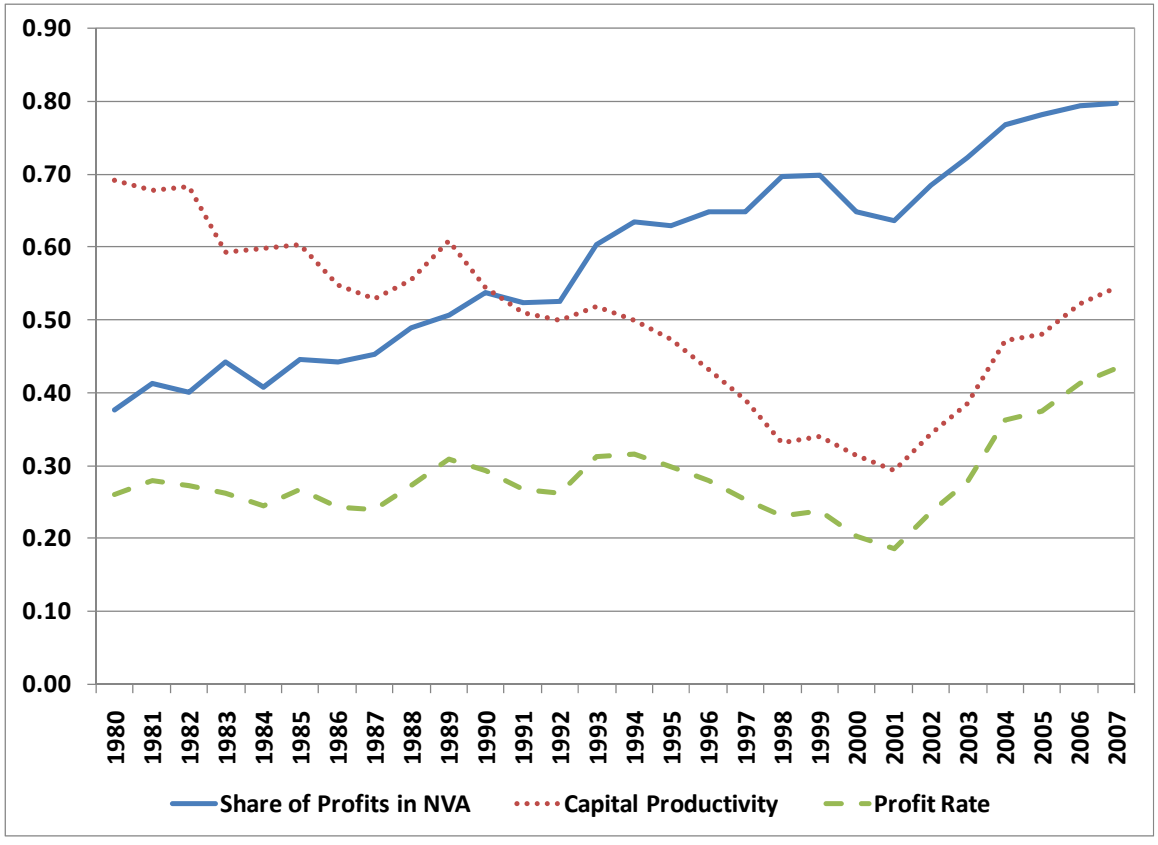
[4] For the total economy for the period 1978–2000, Felipe, Laviña, and Fan (2008) find that both labor productivity and capital productivity are increasing, but not in the same proportion, and technical change is "better characterized by something that resembles Hicks-neutral technical change."

$$r_r = \frac{\prod_r}{K} \equiv \frac{\prod_r}{Y_r} * \frac{Y_r}{K} \equiv s_k * \theta \qquad (6)$$

where, s_k^r is the share of real operating surplus in real value added (i.e., the capital share).

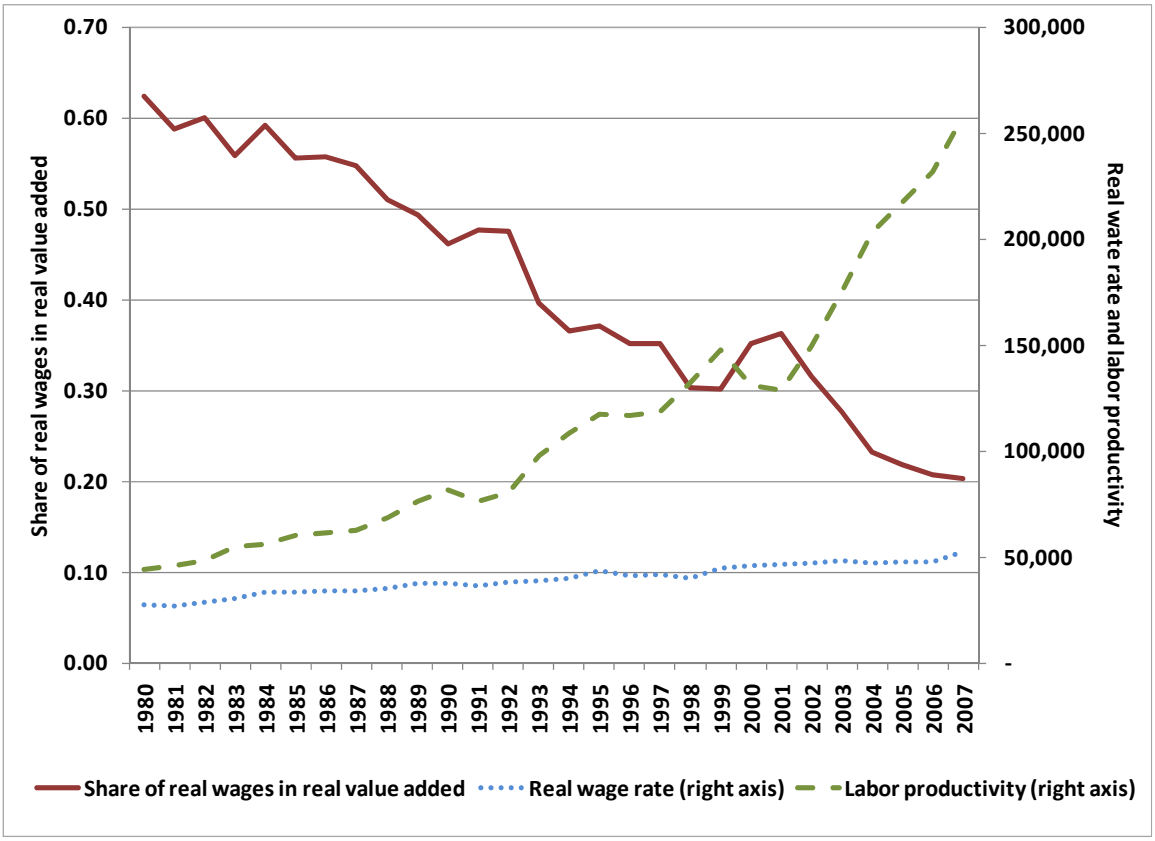
We decompose the profit rate as shown in equation (6) for India's organized manufacturing sector. This is shown in figure 3. We see that the share of profits in real value added increased over the period 1980–2007, while capital productivity (shown earlier) declined, except during the post-2000 period. The real profit rate remained stable between 1980 and the mid-1990s at close to 30%; it declined afterwards and increased again after 2001 to about a very high 45%. This makes India's organized manufacturing a very profitable sector.

Figure 3: Real Profit Rate, Share of Profits in NVA, and Capital Productivity



While the profit rate of India's organized manufacturing sector has increased, the real wage rate has barely increased and was outpaced by the gains in labor productivity (figure 4). Commensurate with an increase in the share of profits in value added is the decline in the labor share (i.e., the real wage bill as a share of real value added); see Felipe and Kumar (2010) for a further discussion of a declining labor share in India's organized manufacturing sector.

Figure 4: Labor Share, Real Wage Rate, and Labor Productivity



4. CONCLUSIONS

Using the real wage–profit rate schedule, we have examined the direction of technical change in India's organized manufacturing sector during 1980–2007. We have found that technical change was of a Marx-biased nature until 2000, and Hicks-neutral afterwards.

This implies that labor productivity increased and capital productivity declined during 1980s and 1990s, while both labor and capital productivity increased post-2000. The historical experience, however, suggests that Hicks-neutral technical change may only be a passing phase before we see a return to the long-term trend of Marx-biased technical change.

The puzzling aspect of India's pattern of technical change is that it has not entered yet a phase of steady decline of the profit rate, as seems to be the historical experience of many other countries. Indeed, in most countries, rapid capital accumulation has led to a steady decline in the profit rate. This is not the case of India's manufacturing sector, where the profit rate is about 45%**,** significantly higher than in 1980. On the other hand, the real wage rate has only increased marginally during this the period analyzed, and the distribution of income has clearly tiled toward capital, whose share doubled during 1980–2007. The conclusion of our analysis is that technical change in India's organized manufacturing sector during 1980–2007 has favored capital.

REFERENCES

Annual Survey of Industries (ASI). Ministry of Statistics and Programme Implementation. Government of India. 1980–2007.

Cohen, A., and G. Harcourt. 2003. "Whatever Happened to the Cambridge Capital Controversies?" *Journal of Economic Perspectives* 17(1): 199–214.

Felipe, J. and F.M. Fisher. 2003. "Aggregation in Production Functions: What Applied Economists Should Know." *Metroeconomica* 54(2–3): 208–262.

————. 2006. "Aggregate Production Functions, Neoclassical Growth Models and the Aggregation Problem." *Estudios de Economía Aplicada* 24-1(April): 127–163.

Felipe, J., E. Laviña, and E.X. Fan. 2008. "The Diverging Patterns of Profitability, Investment and Growth of China and India, 1980–2003." *World Development* 36(3): 741–774.

Felipe, J., and U. Kumar. 2010. "A Reassessment of the use of Unit Labor Costs as a Tool for Competitiveness Analysis and Policy in India." Working Paper 624. Annandale-on-Hudson, NY: Levy Institute of Bard College.

Ferguson, C.E. 1968. "Neoclassical Theory of Technical Progress and Relative Factor Shares." *Southern Economic Journal* 34(4): 490–504.

Foley, D., and T. Michl. 1999. *Growth and Distribution*. Cambridge, MA and London: Harvard University Press.

Marquetti, A. 2003. "Analyzing Historical and Regional Patterns of Technical Change from a Classical-Marxian Perspective." *Journal of Economic Behavior and Organization* 52(2): 191–200.

Sraffa. P. 1960. *Production of Commodities by Means of Commodities*. Cambridge, UK: Cambridge University Press.