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Analyzing historical and regional patterns of technical change from a classical-Marxian perspective

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Abstract

This paper analyzes whether technical change follows the labor-saving, capital-using Marx-biased pattern. This form of technical innovation underlies Marx's explanation of the falling rate of profit. Long-term data for industrialized societies reveal such pattern punctuated by a phase in which both inputs present an increase in productivity. Regional data from the Penn World Table supplemented by our standardized net capital stock estimate reveals that most of the world regions have followed the Marx-biased technical change over the period 1964–1990. However, the non-Marx-biased pattern appears in some world regions in the 1980s.

JEL classification: E11; O40

Keywords: Technical change; Labor productivity; Capital productivity

1. Introduction

Economists have long recognized the basic tendency for labor productivity to rise and capital productivity to fall, and have explained it from a variety of perspectives. The two broad approaches are the classical-Marxian interpretation represented in this symposium, that sees these movements as reflecting a bias in the adoption of technical changes that systematic incentives in the capitalist economy cause. The other is the neoclassical interpretation, that sees these movements as occurring along a historically stable production function.

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The classical-Marxian interpretation argues that the major force driving technical change is profitability. Individual capitalists would adopt technical changes that lowered costs of production at current levels of real wages (called viable technical changes) in order to obtain “super-profits” by continuing to sell their output at prices determined by the higher costs of their less technically advanced competitors. In the dispute between capitalist and labor over the value added Marx saw a systematic incentive to technical change following a bias toward labor-saving and capital-using pattern. Mechanization emerges as the typical pattern of technical innovation in capitalist economies. Thus, in contrast to Harrod-neutral technical change, which is labor-saving but neither capital-saving nor capital-using, and to Hicks-neutral technical change, which is equally labor and capital-saving, what we might call Marx-biased technical change is labor-saving and capital-using.

The purpose of this paper is to investigate the existence of patterns of Marx-biased technical change in economic growth. We analyze the evidence of biased technical change by looking at historical data on real labor productivity and output-capital ratio, which we will refer to as capital productivity, for the US, the UK, Japan, The Netherlands, Germany, and France (Maddison, 1991, 1995a,b). We investigate the evidence of biased technical change from regional data for the USA and Canada, Latin America, North Africa, Sub-Saharan Africa, East Asia, Southern Asia, Western Europe, South Europe, Eastern Europe, and Oceania (Summers and Heston, 1991).

The data used are the aggregated national output measures based on the market valuation of outputs, aggregated labor inputs, and aggregated capital measures based on the market valuation of different capital goods. We employ a single measure of output, labor and capital. There are important issues of aggregation to be addressed in the use of each of these measures. For example, they implicitly neglect changes in labor skills and the composition of labor inputs by skill. They also cannot distinguish between changes in capital measure due to changes in price and composition of the stock of capital goods from changes due to uniform changes in the quantity of capital goods of each type, an issue raised sharply in the Cambridge Capital Debates (Harcourt, 1972). Other relevant questions will not be addressed, except to point out here that the existence of a pervasive pattern in the aggregate data poses a problem of explanation for any theoretical approach.

2. Historical patterns of technical change

Maddison (1991, 1995a,b) and his associates have compiled a standardized data set that allows us to study the long-term pattern of technical change for six developed economies. For the US and the UK there are aggregated statistics from 1820 to 1992, for Japan from 1890 to 1992, for Germany from 1938 to 1992, for France from 1950 to 1992, and for The Netherlands from 1913 to 1992. The data on gross stock of fixed non-residential capital for The Netherlands were obtained in Groote et al. (1996). The set of statistics includes estimates of the real value of output, total hours worked per year for few specific years, and the real value of gross stock of fixed non-residential capital. Despite the constraint on labor productivity information, the data set allows us to investigate both the historical pattern and phases in the evolution of technical change in these countries.

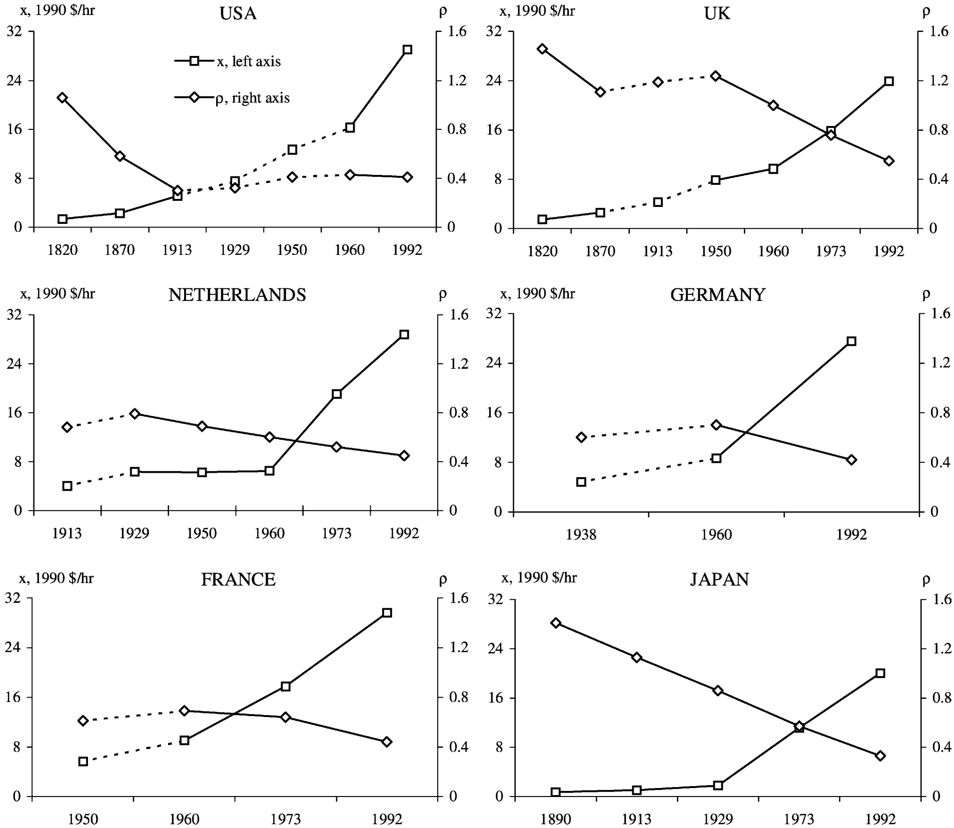

Fig. 1. The evolution of labor and capital productivity, respectively, x and ρ, for six developed countries, 1820–1992 (Maddison data). There is a predominance of Marx-biased pattern of technical change, punctuated by an intermediary period in which both inputs present an increase in productivity (dotted line). Japan is the only country that shows a Marx-biased pattern in the entire period.

A criticism of the analysis of the technical change evolution here presented is that no systematic attempt is made to separate trend and cycle. In fact, the only attempt made was to use benchmark years that reflect normal business cycle conditions.

Fig. 1 shows the evolution of labor productivity, x, and capital productivity, ρ, for these six countries. The pattern of technical change in the US economy is consistent with the capital-using, labor-saving Marx-bias for the period 1820–1992. However, the Marx-biased pattern is not uniformly present in the entire period. In fact, the evolution of technical change can be broken up into three phases. First, from 1820 to the early 20th century, the technical change followed the Marx-bias pattern. Second, from the early 20th century until the 1950s, the technical progress followed a path in which the growth rate of labor and capital productivity were greater than zero, a pattern which we call input-augmenting. Third, from the 1960s onwards, the Marx-bias is again the dominant pattern of technical change.

Duménil and Lévy (1995) interpret the path of technical innovation in the US over the period 1869–1992 based on a classical-Marxian evolutionary model of technical change where innovation is a random local process and labor costs are exogenous. Variations in the conditions of innovation reproduce the historical trend of labor and capital productivity. The conditions of innovation were difficult, easy, and difficult again.

The data for the UK in the period 1820–1992 confirm the Marx-bias as the long-term pattern of technical change. Again there was a tendency for capital productivity to fall in the long-term. The three phases of technical change are also present, but they have a different time frame. The first phase, covering the period 1820–1870, followed a Marx-biased pattern. The second phase, the period 1870–1950, presented an input-augmenting technical change. The third phase, from the 1950s onwards, represents a return to Marx-bias pattern of technical change. The path of technical change in the UK was similar to the US economy. The conditions of innovation in the UK were also difficult, easy, and then difficult again.

For The Netherlands the Marx-biased technical change is the dominant pattern in the period 1913–1992. The data present the second and third stages of technical change and it is consistent with the US and the UK experience. The period 1913–1929 exhibits an input-augmenting technical change while the period 1929–1989 shows a Marx-biased pattern of technical change. Germany in the period 1938–1992 and France in the period 1950–1992 present the Marx-biased technical change as the dominant pattern. The phases of technical change in both countries appear to be consistent with the experience of the US, the UK, and The Netherlands. An input-augmenting technical change is followed by a Marx-biased pattern. The data show that The Netherlands, Germany, and France presented the second and third stages of technical change that characterized the experience of the US and the UK.

The experience of these five countries reveals that there is a long-term tendency for technical change to follow the capital-using, labor-saving Marx-bias pattern. Although there was a tendency for capital productivity to fall in the long-term, the evolution of technical change is characterized by the presence of three stages which shows that the Marx-bias pattern is not uniform for the whole period of modern capitalist development. The path of innovation in capitalism was difficult, easy, and then difficult. The results in this paper confirm the hypothesis about the variation of the difficulty-to-innovate pointed out by Duménil and Lévy.

The evolution of the technical change raises the question of what forces could have been behind the increase of the capital productivity, the main difference between the three stages, in these five western developed countries from the turn of the 20th century until the 1950s. Duménil and Lévy answer this question saying that the increase in capital productivity was due to the managerial revolution in late nineteenth century and early 20th century.

Japan displays the Marx-biased pattern as the only form of technical change in the period 1890–1992. It reflects the significant effort of capital formation to overcome the relative backwardness of the Japanese economy. Japan is the most successful country in terms of catching-up with the developed western economies. It seems that the process of catching-up involves the transfer of capital intensive technology from the leader to the follower countries through capital accumulation. As we will see in the next section, this strong Marx-biased technical change characterizes the evolution of the backward economies.

3. World patterns of economic growth

The remarkable comprehensiveness of the Penn World Table data allows us to examine the world patterns of technical change. The Penn World Table, Mark 5.6, presents data on labor productivity expressed in 1985 purchasing power parity and measured as real GDP per worker. The net standardized stock of fixed capital is obtained by the perpetual inventory method using the investment series computed from the variable real investment share of GDP presented in the PWT. The net standardized stock of fixed capital was estimated following Hulten and Wykoff (1981), employing the total residential plus non-residential investment, a geometric depreciation form, and a depreciation rate of 7.5 percent. For a comparison between our estimated net standardized stock of fixed capital and other estimates, see Marquetti (1997).

If a labor-saving, capital-using Marx bias is typical of capitalist economic development, we would expect to see a strong downward-sloping relation between x and ρ over the whole world economy. Fig. 2 plots (ρ, x) observations for all 126 countries and years for which data is available for any part of the period 1964–1990. The data is fitted using a robust non-parametric method (Cleveland, 1993) called "local regression". The local regression technique calculates a weighted least-squares fit to the data at each point on a grid, with weights that decline sharply with the distance of the data point from the grid point. The local regression fit is made robust by calculating robustness weights that decline sharply with the size of the residual for each data point from the local regression fit, and then iterating the local regression fit with these robustness weights.

The existence of a pervasive pattern of negative correlation between capital productivity and labor productivity in the course of economic development is unmistakable in this data. There are some exceptions represented by the sprinkling of data points to the northeast of the main cluster; these outliers are observations from the oil export countries. It is equally clear that there are substantial variations in the exact paths that national economies follow in the course of economic development, as shown by the wide scattering of the points around the sharp turning point of the fitted curve. But the dramatic clustering of the points around the

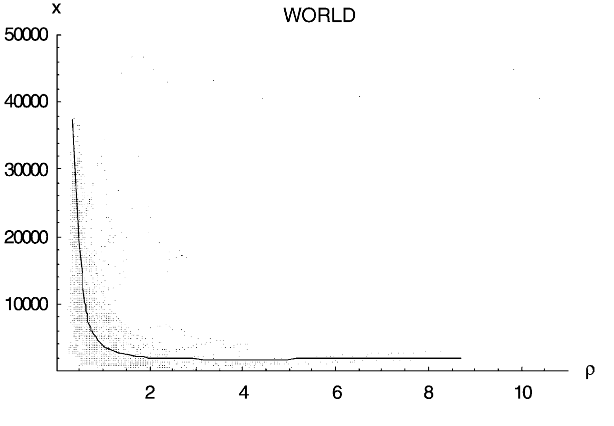

Fig. 2. Full sample of (ρ, x) points, 1964–1990 (Penn World Table data and my estimates of national capital stock).

pattern of negative tradeoff and the sharp identification of the monotonic relation between ρ and x by the robust local regression fit leave little doubt that there is a tendency for national economies to follow a path of declining capital productivity and rising labor productivity in the course of economic development. Poor countries are characterized by low labor and high capital productivity while rich countries have high labor and low capital productivity.

We will briefly mention two hypotheses which have been put forward in the economics literature to explain the downward-sloping relation between x and ρ. The enormous literature on the neoclassical growth model (running from Solow, 1970, through Mankiw et al., 1992) attempts to interpret this pattern as arising at least partially from the existence of a stable production–function relationship between capital and labor inputs. The much smaller literature putting forward a classical-Marxian alternative to the neoclassical production function represented in this symposium suggests that these patterns result from biases in technical change rather than movements along a stable production function isoquant. The Marx-bias pattern of technical change is expressed in the difficulty-to-innovate in both inputs.

4. Regional patterns of technical change

The evidence we have presented up to this point supports the hypothesis that capitalist economic development typically, but not universally, follows a pattern of combined labor-saving and capital-using technical change. In this section we look at the data directly on rates of change in labor productivity and capital productivity, respectively, l and c.

Fig. 3 plots (c, l) observations for world regions in our sample. The data for the world regions were obtained, first, by summing the GDP, capital stock, and number of worker for the countries in the region and, then, computing x and ρ. The Middle-East was not considered due to the effect of oil prices in GDP. Local regression was employed to remove the cyclical movement of the data, then the growth rates were computed.

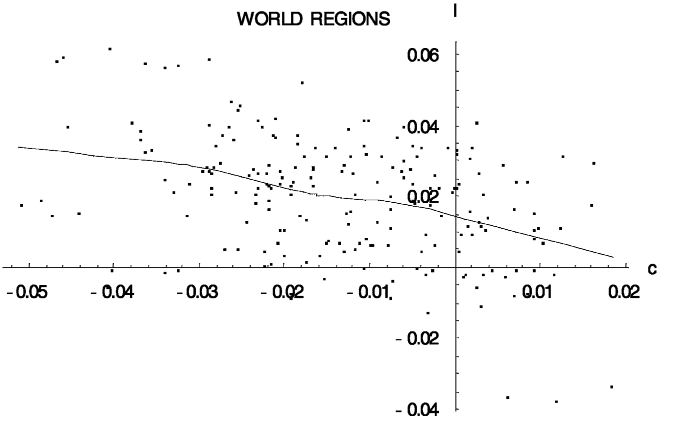

Fig. 3. The (c, l) points for world regions, 1965–1990 (Penn World Table data and my estimates of national capital stock).

Table 1
Mean and standard deviation for regional sample of (c, l) observations, 1965–1990 (Penn World Table data and my estimates of national capital stock)

	c	l
Mean	−1.158	1.861
S.D.	1.268	1.157

Table 2
Frequency of sign patterns for regional sample of (c, l) observations, 1965–1990 (Penn World Table data and my estimates of national capital stock)

	$c < 0$	$c > 0$
$l > 0$	0.6968	0.1489
$l < 0$	0.0745	0.0798

There is, as we would expect, a strong tendency for the points to cluster in the northwest quadrant, corresponding to negative c and positive l, though there is a scattering of points in all the quadrants. The local regression curve fitted to the data reveals a negative correlation between c and l, indicating a correlation between the magnitude of changes in c and the corresponding period's changes in l. This is also consistent with the hypothesis of a stable production function along which national economies are moving, since such an isoquant from such production function would introduce some negative correlation between c and l.

The mean and standard deviation of the c and l data are presented in Table 1. The means confirm the general hypothesis of Marx-biased technical change, but the wide scattering of the points makes the standard deviations large relative to the means.

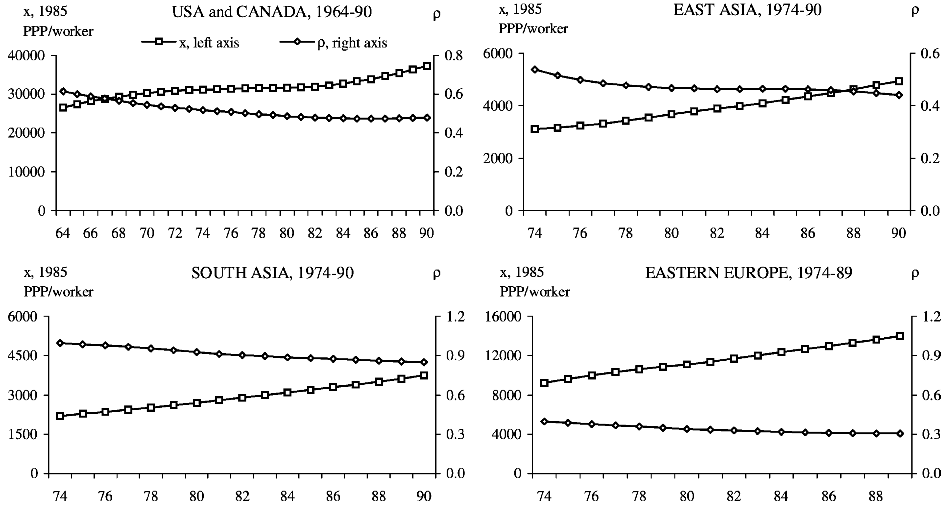

Fig. 4. The evolution of labor and capital productivity in world regions with Marx-biased pattern in the period with available data (Penn World Table data and my estimates of national capital stock).

Table 2 presents the distribution of the sign patterns of c and l. There is a large predominance of the Marx-biased technical change.

An important question to investigate is what world regions presented the non-Marx-biased technical change over the period in study. Fig. 4 shows the evolution of labor and capital productivity for the world regions that presented Marx-biased technical change over the period 1964–1990 or 1974–1990. The Marx-biased technical change is presented over the whole period 1964–1990 for the US and Canada and for the period 1974–1990 for East Asia, South Asia, and Eastern Europe. East and South Asia were the world regions with highest growth rates in the years 1974–1990 and presented a strong Marx-bias. It seems that mechanization is the basic form for poor countries to overcome their relative backwardness. The increase in labor productivity is obtained through the reduction in capital productivity.

Fig. 5 displays the path of labor and capital productivity for the world regions that presented the non-Marx-biased technical change during part of the period 1964–1990 or 1974–1990. Technical change for Western and Southern Europe in the period 1964–1990 and for Oceania in the period 1974–1990 displays the Marx-biased pattern for the period as a whole. But there are two sub-periods in the evolution of the technical innovation. First,

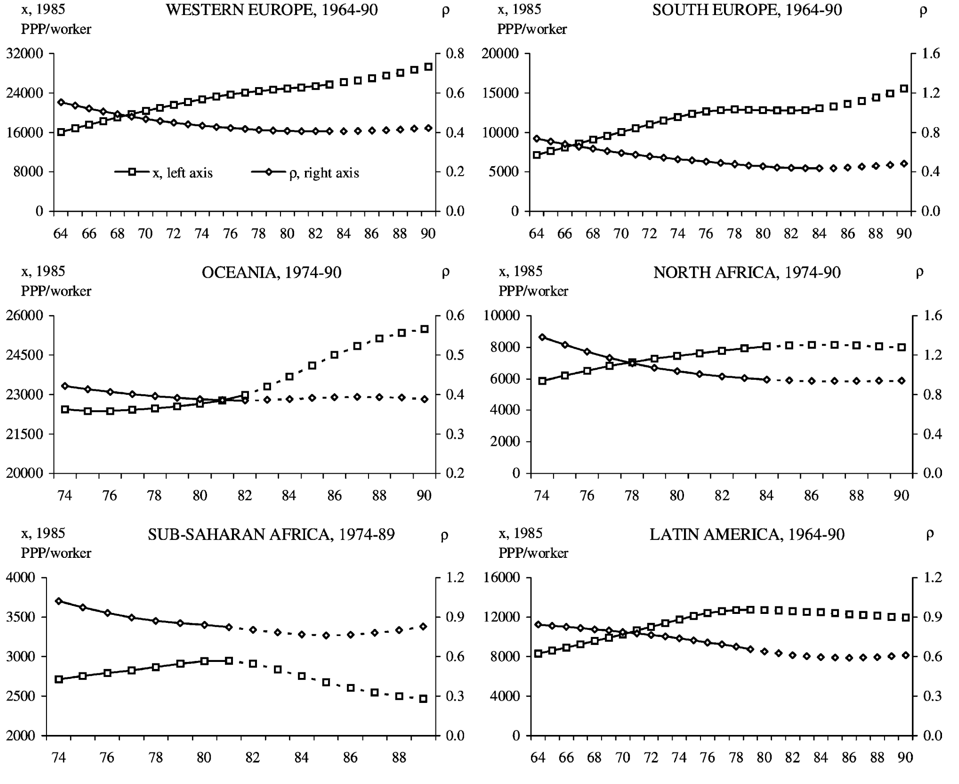

Fig. 5. The evolution of labor and capital productivity in world regions with phases of non-Marx-biased technical change (dotted line) (Penn World Table data and my estimates of national capital stock). For Western Europe, South Europe, Oceania, Latin America and North Africa, the Marx-biased is the predominant pattern of technical change for the period as a whole.

from the beginning of the period until the early 1980s, the technical change followed the Marx-biased pattern. Second, between the early 1980s until 1990, there was an expansion in labor and capital productivity, a pattern we call input-augmenting technical change.

North Africa also displays a Marx-biased pattern of technical change in the period 1974–1990, but in the second half of the 1980s there was a stagnation of technical progress. Sub-Saharan Africa in the period 1974–1989 had a decline in both labor and capital productivity. However, the evolution of technical change during this period presented two phases. First, from 1974 to 1982, the pattern of technical change followed the capital-using, labor-saving Marx bias. Second, after 1982, capital productivity was relatively constant and labor productivity declined.

As in the Sub-Saharan case, the 1980s were a period of poor performance for Latin America. In fact, after 1979 there was a rupture in the Marx-bias pattern. The period 1964–1990 as a whole followed the Marx-bias pattern, but during the 1980s there was a technical stagnation. Thus, the analysis of the regional pattern of technical change also shows the Marx-biased pattern as the dominant one, but reveals the important presence of other cases.

5. Conclusion

Marx associated the tendency for the rate of profit to fall with capital accumulation, first identified by the classical political economists and accepted by him, with a bias in the patterns of technical change toward labor-saving and capital-using technologies. We have dubbed this pattern Marx-biased technical change.

The analysis of long-term data for six developed countries reveals the Marx-bias as the dominating pattern of technical change. Three phases of technical innovation were identified. The first and third phases followed the Marx-biased pattern, while both labor and capital productivity increased in the second one. Duménil and Lévy explain the historical path of technical change in the US economy based on a classical-Marxian evolutionary model of technical change where the conditions of innovation were relatively difficult, easy, and difficult again. Allowing for change in the conditions of innovation in this model helps to explain the historical path of both labor and capital productivity.

An exploration of the evidence for Marx-bias in the patterns of technical change in regional data in the period 1964–1990 confirms the predominance of the Marx-biased pattern, but reveals a substantial number of cases with other patterns of technical change. The data show the existence of negative correlation between capital productivity and labor productivity in the course of economic development. This pattern is also consistent with the neoclassical literature that interprets it as arising from the existence of a stable production function.

These preliminary findings suggest a number of avenues for further research. It would be useful to categorize further the non-Marx-biased instances to identify other economic forces as well as those political and social factors that might explain their anomalous status or to study the empirical dependency of the degree of labor-saving and capital-using technical change on other factors, such as the size of national economies and openness of the economy. Such studies could lead to a deeper understanding of the technical change path in the process of economic development.

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