

Technical Progress: Hicks, Harrods and beyond

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1. Introduction

Technical progress is a continuing process that increases the efficiency of the production process over time, allowing more output to be produced from the same quantities of factor inputs, capital (K) and labour (L).

Impact of technical progress in the production process:

There are three possibilities:

- technology may be **labour-saving**, allowing output to be produced with less labour input
- technology may be **capital-saving**, using less capital input
- technology may save both capital and labour.

Three different concepts of neutral technical progress have been proposed in the literature by

- ✓ Hicks (1932)
- ✓ Harrod (1942)
- ✓ Solow (1969)



2. Hicks-neutral

According to Hicks (1932), neutrality is

“An invention which raises the marginal productivity of labour and capital in same proportion”.

Thus, a technological innovation to be neutral (Hicks-neutral) if the ratio of the marginal products remains unchanged for a given capital-labour ratio.

The Hicks-neutral production function can be written as

$$Y = T(t) \cdot F(K, L)$$

where $T(t)$ is the index of the state of the technology.

It can be seen that the ratio of factor marginal products

$$\frac{\frac{dY}{dK}}{\frac{dY}{dL}} = \frac{T(t)F_K}{T(t)F_L} = \frac{F_K}{F_L}$$

does not depend on T .



3. Harrod-neutral

According to Harrod (1942), “*neutral technical progress is one which leaves capital output ratio unchanged, provided that rate of profit remains constant*”.

Harrod defined a technological innovation to be neutral (Harrod-neutral) if the relative input shares

$$\frac{K F_K}{L F_L}$$

are unchanged for a given capital-output ratio.

The Harrod-neutral production function can be written as

$$Y = F [K, L \cdot T(t)]$$

(Notice that the technology factor, $T(t)$, appears in the production function as a multiple of L .)

This form of technical progress is called labour-augmenting because it acts to increase output in the same way as an increase in the stock of labour.



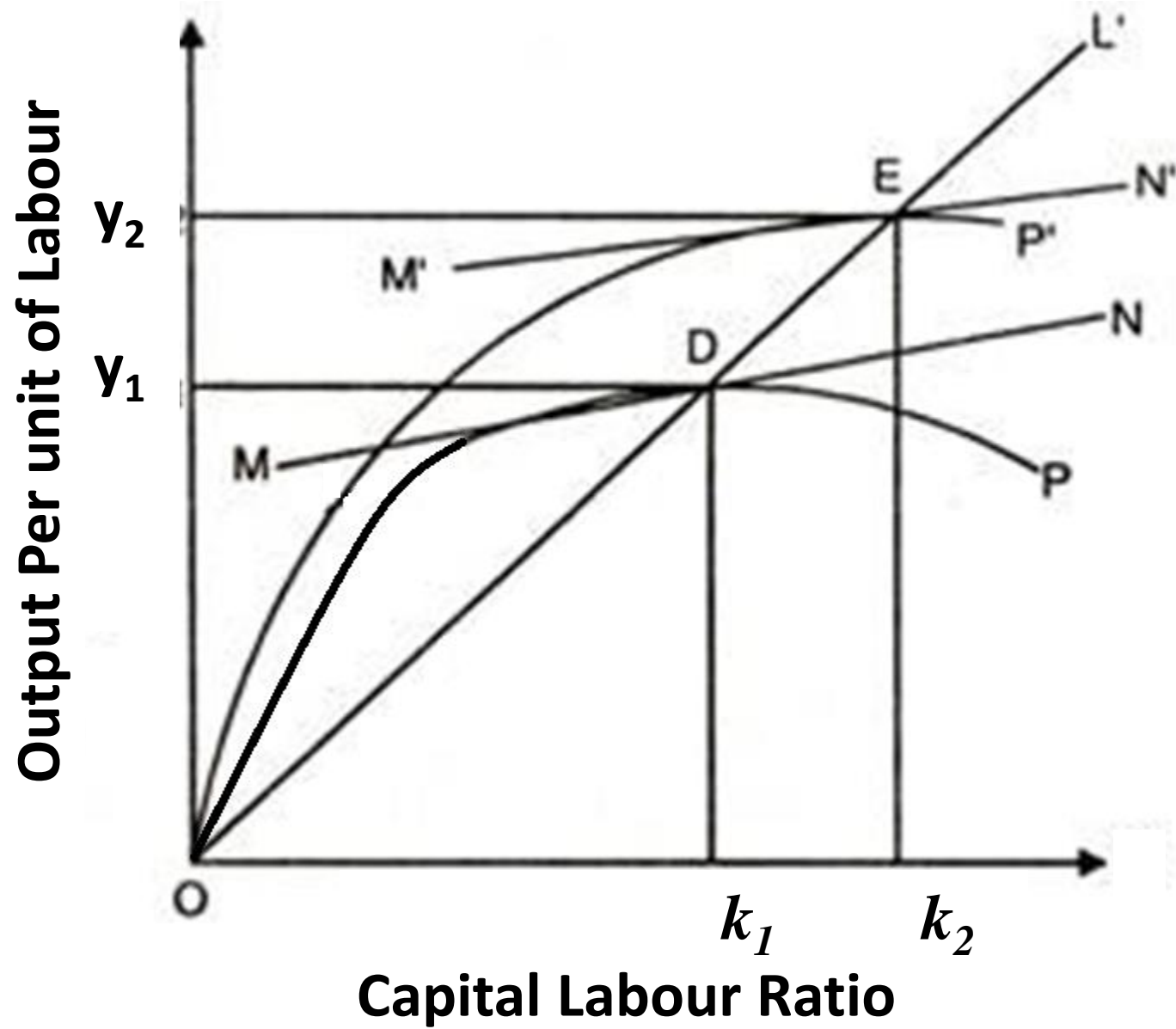


Figure 1



In Figure 1, the capital per labour (k) is measured along X-axis and output per labour (y) is along Y-axis. OP is the production function before the technical change and OP' is after technical change.

Since the ray OL passes through both points D and E, the capital output ratios are equal. That is ,

$$\frac{Ok_1}{Oy_1} = \frac{Ok_2}{Oy_2}$$

which implies that $\frac{OK_1}{OY_1} = \frac{OK_2}{OY_2}$ (i.e., capital output ratios)

Harrod's neutrality also requires that the rate of profit must remain constant along with a constant capital output ratio after technical progress.

This implies that the marginal productivity of capital must be same at both points of D and E .

That is the slope at point D must be equal to the slope at point E. In other words, the tangents at D and E must be parallel to each other (i.e., $MN \parallel M'N'$)



4. Harrod-neutral v/s Hicks-neutral

- Harrod's definition of neutral technical progress is superior to that of Hicks. Reasons are as follows:
 - it is applicable to a dynamic situation rather than a static situation.
 - It forms a most significant part of the theory of economic growth because it uses the concept of capital output ratio which is indispensable in modern growth analysis.
- In Harrod neutral technical change, there is no direct reference to labour as it is entirely based on the relationship between capital and output but capital labour ratio and output labour ratio may change without technical change.
- Therefore, in Harrod's neutrality, the rise in output per machine would be in the same proportion as the rise in the output per man.



5. Solow-neutral Technical Progress

Solow (1969) defined a technological innovation to be neutral (Solow-neutral) if the relative input shares

$$\frac{K F_k}{L F_L}$$

remain unchanged for a given labour-output ratio.

The Solow-neutral production function can be written as

$$Y = F [T(t) \cdot K , L]$$

This form of technical progress is called *capital-augmenting* because it acts to increase output in the same way as an increase in the stock of capital.

(N.B.: Solow model of technical progress will be discussed latter)



6. Arrow: Learning-by-doing

Arrow (1962) constructed models in which ideas were unintended by-products of production or investment, a mechanism described as learning by doing.

- In these models, each person's discoveries immediately spill over to the entire economy, an instantaneous diffusion process that might be technically feasible because knowledge is non-rival.
- **Learning-by-doing** is a concept in economic theory by which productivity is achieved through practice, self-perfection and minor innovations.
- The concept of learning-by-doing has been used by Kenneth Arrow in his design of *endogenous growth theory* to explain effects of innovation and technical change.



7. Endogenous growth models: No technological change

- The recent contributions determine the long-run growth rate within the model; hence, the designation endogenous growth models.
- The initial wave of the new research—Romer (1986), Lucas (1988), Rebelo (1991)—built on the work of Arrow(1962), Sheshinski(1967), and Uzawa(1965) and did not really introduce a theory of technological change.
- In these models, growth may go on indefinitely because the returns to investment in a broad class of capital goods—which includes human capital—do not necessarily diminish as economies develop.



Assignment

1. What do you mean by technical progress? (2)
2. What are the impacts of technical progress in the production process? (2)
3. Illustrate the impact of technology on production function. (2)
4. State and explain Hicks-neutral technical progress. (2+2)
5. What do you mean by labour augmenting technical progress? Does it differ from labour saving technical progress? (2)
6. State and illustrate Hicks-neutral technical progress. (2+4)
7. Distinguish between Harrod-neutral and Hicks-neutral. (2)
8. Make a clear distinction between Solow-neutral and Hicks-neutral. (4)
9. State the salient features of learning-by-doing of Arrow. (3)
10. How does the theory of technological progress related with endogenous growth models? (2)



Reference:

Robert J. Barro Xavier Sala-i-Martin (2004), ***Economic Growth*** , 2nd Edition, The MIT Press

Thanks

