

## A Critique of the Marginal Productivity Theory of the Price of Capital

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The most important question in a theory of capitalism is the question of *profit* – where does profit come from, and what determines its magnitude? Profit is the main motive and overriding purpose of capitalist production, and the main determinant of the dynamics of capital accumulation. When profits are high, then the rate of capital accumulation will be strong, unemployment will fall, and the overall condition of the economy will be good (a period of prosperity). On the other hand, when profits are low or insufficient, then the rate of capital accumulation will be weak, unemployment will rise, and the overall condition of the economy will be bad (a period of crisis and recession or depression).

In addition, the question of the origin of profit is also important for an ideological or ethical reason. If the source of profit is the work and effort of capitalists, then the receipt of profit by capitalists is just and fair and equitable. On the other hand, if the source of profit is the labor of workers, then the receipt of profit by capitalists is exploitation, and capitalism is inherently an unjust and unfair economic system.

The question of profit is the main question in Marx's theory of capitalism. Most of Volume 1 of *Capital* is about this all-important question, and all the main conclusions of Marx's theory follow from the basic theory of profit. (The question of profit was also emphasized by the classical economists, especially Ricardo.) In contrast, the question of profit is given much less attention in neoclassical economics. As we shall see below, the return to capital is redefined in marginal productivity theory as the "price of capital". In marginal productivity theory, capital and the return to capital have always received much less attention than labor and wages, and in recent decades the former have been almost entirely ignored. Nonetheless, marginal productivity theory remains the most widely accepted theory of the return to capital by neoclassical economists and is widely used in empirical work.

The marginal productivity theory of distribution was developed in the late 19<sup>th</sup> century by J.B. Clark (US) and Philip Wicksteed (UK) and others. The variables determined in the modern versions of this theory are the prices of the factors of production – the price of labor (wages), the *price of capital* (more on this key variable below), and the price of land (I will ignore land in what follows). According to this theory, the prices of the factors of production are determined by the supply and the demand for these factors.

The demand functions for labor and capital are derived in essentially the same way, from given production functions  $[Q = f(K, L)]$  and the firm's profit-maximizing condition that the price of each factor should be equal to the marginal product of each factor.<sup>2</sup> The marginal product of each factor is the extra output that is produced if that factor is increased by one

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<sup>1</sup> I wish to express thanks to my many students over the years who have helped me to develop this critique through our discussions. I am eager to hear from readers - please send me comments at [fmoseley@mtholyoke.edu](mailto:fmoseley@mtholyoke.edu).

<sup>2</sup> More precisely, the firm's profit-maximizing condition is that the price of each factor should be equal to its marginal *revenue* product, which is its marginal physical product multiplied times the unit price of the output. This complication will be ignored in what follows, because the key issue is the existence or non-existence of the physical marginal products.

unit, and *all other factors remain constant*. Mathematically, the marginal product of each factor is the partial derivative of output with respect to that factor; e.g. the marginal product of capital is the partial derivative with respect to capital:  $[MPK = \partial Q/\partial K]$ .

The supply functions of labor and capital are derived in different ways. The supply of labor is derived from the utility function of individuals and the assumption that each individual chooses the number of hours she wishes to work on the basis of a “labor-leisure” trade-off in order to maximize her utility. This totally unrealistic assumption does not apply to capitalist economies, in which workers are wage-laborers, who generally cannot choose the number of hours they want to work, but instead whose hours of work are determined by the buyers of their labor-power.<sup>3</sup> The supply of capital is even more problematic and has not yet received a definitive treatment, and will be discussed further below.

Marginal productivity theory comes to the harmonious conclusion that in equilibrium the price of each factor is equal to its marginal product, which is widely interpreted to mean that each factor of production is paid what it contributes to the production of the output. In what follows, I will focus attention on marginal productivity theory of capital and the price of capital.

## 1. “Aggregation problem”

A serious problem in the marginal productivity theory of capital is the so-called “*aggregation problem*”, i.e. the difficulty of adding together different kinds of capital goods to obtain a single quantity of capital in production functions, even for individual firms, and especially for aggregate production functions (Joan Robinson was the first to make this criticism in the 1950s). Capital is defined in terms of *physical goods*, as the quantity of capital goods (machines, buildings, equipment, etc.) utilized in production. But it is impossible to conceive of a common unit of measure in terms of which all the different kinds of capital goods could be reasonably added together.<sup>4</sup>

Therefore, marginal productivity theory does not provide a macroeconomic theory of the distribution of income between the classes of society, in contrast to Marx’s theory and Ricardo’s theory which do provide macro theories of the class distribution of income.

## 2. Demand for capital – marginal product is not a legitimate concept

There is an even more serious problem in the derivation of the demand for capital – the derivation of the demand for capital is based on the fundamental concept of the marginal productivity, and the marginal product of capital *is not a legitimate concept*. The existence of raw materials in the production process (and intermediate goods in general) contradicts the

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<sup>3</sup> There is also a fundamental logical contradiction between the  $L^s$  and  $L^d$  curves, because  $L^s$  is defined in units of *hours*, whereas  $L^d$  is defined in units of *workers* (the marginal product of labor is the extra output that results from adding one *worker* to a given capital). This contradiction makes the labor market analysis incoherent.

<sup>4</sup> The absence of a satisfactory method of aggregating capital means that the “aggregate production function” in growth models in macroeconomics is not a valid theoretical concept, despite its widespread use. Two other areas of economics in which theoretically illegitimate aggregate production functions are still widely used in empirical applications are economic history and economic development.

Marx’s theory does not have an “aggregation problem” because Marx’s concept of capital is defined in terms of money, which can be easily aggregated.

concept of the marginal productivity of capital. Raw materials are inputs to production that cannot be held constant as output increases. In order for output in goods-producing industries to increase, the quantity of raw materials used to produce the output *must also be increased* (e.g. more cloth to produce another shirt, or more tires to produce another car). However, the concept of the marginal product of capital (i.e. the partial derivative of output with respect to capital) requires that the input of capital is increased by one unit, *all other inputs must be held constant*. But it is *not possible to hold the raw material inputs constant* and produce more output. Therefore, the concept of the marginal product of capital is self-contradictory when raw materials are included in the production function, as they should be (this fundamental problem also applies to the marginal product of labor and the derivation of the demand for labor).

Furthermore, if raw materials are included as a factor in production functions, as they should be, then the price of raw materials would presumably be determined in the same way as the other factors, by equating price of raw materials with the marginal product of raw materials. But what is the meaning of the “marginal product of raw materials”? The concept of the marginal product of raw materials requires that output could be increased by increasing raw materials by one unit and *holding all other inputs constant*. But how is it possible to increase output if both labor and capital are held constant – by magic? Therefore, the concept of the marginal product of raw materials is also invalid, and raw materials cannot be reasonably incorporated into marginal productivity theory.

One way that neoclassical economists have tried to deal with the problem of raw materials – especially in empirical work – has been *assume raw materials away*, i.e. to assume that the production functions are “*value added* production functions”, without raw materials (and intermediate goods in general) as inputs. However, this solution does not work, because a production function is a *physical* concept – which consists of physical quantities of inputs and outputs – and value added is a *nominal* concept – the difference between the price of the output and the prices of intermediate goods. One can subtract the price of intermediate goods from the price of the output to calculate value added, because both prices are nominal terms which are commensurable. However, one cannot subtract the physical quantity of intermediate goods from the physical quantity of output, because intermediate goods and the output produced are different kinds of physical goods which are incommensurable. There is no common unit of measure in terms of which this subtraction could be made. Therefore, a “value added production function” is an oxymoron.<sup>5</sup>

### **3. Supply of capital – no theory**

In addition to this insurmountable problem in the demand for capital and the marginal product of capital, there is also the additional problem that there is *no theory of the supply of capital* at all. It is generally assumed that capital goods are *rented* by producing firms, rather than purchased, and thus the supply of capital goods is assumed to be provided by capital goods

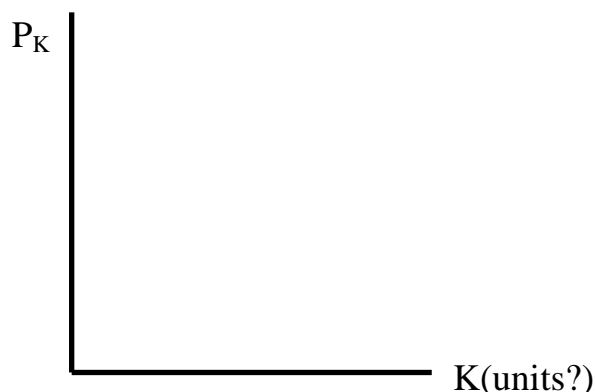
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<sup>5</sup> If raw materials are not included in production functions, then they would not be included in the cost functions in the theory of the firm (i.e. the theory of the supply of output). In this case, the profit-maximizing condition for firms (price = marginal cost) would be erroneous because marginal cost would not include the cost of raw materials. Thus if firms based their supply decision on marginal costs without raw materials, their decision would not maximize profits. They would produce a greater than profit-maximizing quantity of output, which would result in losses.

rental firms.<sup>6</sup> Since it is assumed that capital goods are not produced in the current period, there is no production function and no cost function from which to derive the supply of capital goods by rental firms in the usual way.

So in addition to “no legitimate  $K^d$  curve”, there is no  $K^s$  curve at all, and thus no theory of the price of capital as determined by  $K^d$  and  $K^s$ .

The resulting graph of the capital market looks like this:



This empty graph is not a printer error. The theory is empty.

#### 4. Price of capital – determined by costs

Instead, what is sometimes presented (if any theory of the price of capital is presented at all, which is rare) is a theory of the *long-run equilibrium price of capital*, as determined by the *costs* of the rental firms (because in the long-run, competition and the mobility of capital across industries will eliminate any “economic profit” or “economic loss” for the rental firms). The *costs of the rental firms* consists of two components: an explicit *depreciation* component (this period’s cost of the capital goods) and an implicit *interest* component, which is the “opportunity cost” of investing in these capital goods, rather than in alternative investments. The depreciation component is equal to the product of the price of the capital goods when purchased ( $P_G$ ) and the depreciation rate of these capital goods ( $d$ ), and the interest component (the “opportunity cost”) is equal to the product of the price of the capital goods when purchased and the prevailing rate of interest or average rate of profit in the economy ( $r$ ). Algebraically:

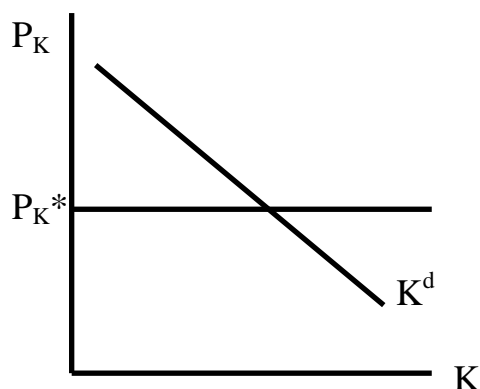
$$P_K = dP_G + rP_G$$

Thus we can see that the price of capital is not an actual market price, but is instead a hypothetical price constructed with the assumption of an implicit “opportunity cost”. It is not clear why anyone would want to explain this unreal price, which one never observes in capitalist economies.

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<sup>6</sup> Gregory Mankiw, in his best-selling intermediate macro textbook *Macroeconomics*, assumes that firms rent capital goods from *households*. But, as one student said, poking fun at this ludicrous assumption, “my household doesn’t own any capital goods”. Mankiw’s presentation of the marginal productivity theory of capital will be examined in detail in a sequel to this paper.

We can also see that, even if we implausibly assume that the demand for capital could somehow be derived, *it would play no role* in the determination of the long-run equilibrium price of capital. The long-run equilibrium price of capital is determined solely by these costs. The graph of the capital market would look like this:



The  $K^d$  curve (even if it could be constructed) plays no role in the determination of the long-run equilibrium price of capital goods. The  $K^d$  curve would jointly determine (along with the  $P_K^*$  curve) the long-run equilibrium *quantity* of capital goods, but it would have no effect on the long-run equilibrium *price* of capital goods.

Thus the claim of marginal productivity theory that the price of capital is determined by the marginal product of capital is doubly fallacious: the marginal product of capital is an illegitimate concept, and even if it were legitimate, it would play no role in the determination of the price of capital.

## 5. Opportunity costs taken as given

But it gets even worse. In this theory of the long-run equilibrium price of capital, the “opportunity cost” of the rental firms (i.e. the prevailing rate of interest *times* the capital investment), which provides the “return to capital” of the rental firms, is *taken as given*, and not explained. The rate of interest is not determined by the marginal product of capital, nor by anything else in this theory. The rate of interest is taken as given as an exogenous implicit “cost”, like the explicit depreciation cost. Thus the “return to capital” – what Marx and the classical economists called “profit”, and defined as the excess of price over cost – is redefined by marginal productivity theory as a “cost”, and this “cost” is taken as given in the determination of the long-run equilibrium price of capital goods. Therefore, marginal productivity theory ultimately takes as given what is supposed to be explained – the return to capital. This theory is completely empty and provides no explanation whatsoever of the magnitude of this return to capital. The return to capital is a presupposition of the theory, not something that is explained by the theory.

I suppose that this is the reason why it is assumed in this theory that capital goods are rented by producing firms – because in that case, the producing firms would actually have to pay an rental cost to the rental firms. Then the rental cost would be a real cost, and it would seem reasonable to take this cost as given, similar to the actual depreciation cost. However, this unrealistic assumption does not really make the “opportunity cost” a real cost; and, most

importantly, this unrealistic assumption does not explain what determines the magnitude of this “opportunity cost”, which continues to be taken as given.<sup>7</sup>

It is argued by proponents of marginal productivity theory that this unrealistic assumption (that firms rent their capital goods) “makes no difference” in the conclusions of the theory, i.e. in the derivation of the long-run equilibrium price of capital. If the producing firms owned their own capital goods, *they would charge themselves the same implicit “opportunity cost”*, instead of actually paying this “opportunity cost” to rental firms. It is argued that the “opportunity cost” applies to the producing firms who own their own capital goods, as it does to the rental firms.

However, I argue that this more realistic assumption (that firms own their capital goods) also “makes no difference” in the *fundamental deficiency* of the theory – this theory still does not provide an explanation of the average return to capital, but instead takes this all-important variable as given, and uses this given to explain the “price of capital”, a variable which is not an actual price and is of no theoretical interest.

## Conclusion

In conclusion, it is clear that the marginal productivity theory of capital and the price of capital is a horrible theory, that is logically contradictory and empty at the core. And yet it continues to be widely accepted by almost all mainstream economists, especially in empirical work. Why is that?

I think the reasons are pretty clear:

(1) Marginal productivity theory provides crucial ideological support for capitalism, in that it justifies the profit of capitalists, by arguing that profit is produced by the capital goods owned by capitalists. All is fair in capitalism. There is no exploitation of workers. In general, everyone receives an income that is equal to their contribution to production.

(2) The main alternative theory of profit is Marx’s theory, and the conclusions of Marx’s theory (exploitation of workers, fundamental conflicts between workers and capitalists, recurring depressions, etc.) are too subversive to be acceptable by the mainstream.

But these are *ideological* reasons, not scientific reasons. If the choice between Marx’s theory and marginal productivity theory were made strictly on the basis of the standard scientific criteria of logical consistency and empirical explanatory power, Marx’s theory would win *hands down*. Marx’s theory is a rigorous logical deduction from the labor theory of value, and it has very impressive explanatory power (conflicts over wages, the length of the working day, and the intensity of labor; inherent technological change, increasing inequality, recurring depressions, etc.) Marginal productivity theory by contrast is a contradictory theory with no explanatory power.

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<sup>7</sup> This unrealistic assumption also results in the following bizarre conclusion: if the producing firms actually paid the average return to capital to the rental firms as rent, then in the long-run the producing firms would make no profit. But why would capitalist firms continue to rent capital goods and produce output, if they make no profit in the long-run?

We should challenge and criticize marginal productivity theory on every occasion that presents itself, and we should teach and further develop Marx's theory, as a much better alternative theory of profit.

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