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Matter Matters: Productivity, Resources, and Prices

Egmont Kakarot-Handtke*

Abstract

Tastes and technology are the ultimate givens of standard economics. Their interaction is mediated by the marginal principle. This approach is unsuitable to explain the nature and magnitude of overall profits and their distribution within the business sector. The present paper therefore takes a quite different analytical route. The standard behavioral axioms are replaced by objective structural axioms and the standard production function is replaced by a sequential production function. From this new formal basis two exemplary factor prices, the product price, and the real wage are derived under the conditions of market clearing and equal profit ratios.

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Keywords New framework of concepts, Structure-centric, Axiom set, Factors of production, Substitution, Profit redistribution, Bargaining margin, Equal profit ratios, Metachoice

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Thousands upon thousands of scholars, as well as thousands of statesmen and men of affairs, have contributed their efforts to the attempt to understand the course of events of the economic world. And today this field of investigation is being cultivated more extensively, than ever before. How is it, then, that in all these years, and with all the undoubted talent that has been lavished upon it, the subject of economics has advanced so little? (Schoeffler, 1955, p. 2)

This can be explained.

Economics is a strange sort of discipline. The booby traps I mentioned often make it sound as it is all just a matter of opinion. That is not so. . . . There are always differences of opinion at the cutting edge of a science, But they last longer in economics . . . and there are reasons for that. As already mentioned, rival theories cannot be put to an experimental test. All there is to observe is history, and history does not conduct experiments: too many things are always happening at once. The inferences that can be made from history are always uncertain, always disputable, You can't even count on a long and undisturbed run of history, because the "laws" of behavior change and evolve. Excuses, excuses. But the point is not to provide excuses. (Solow, 1998, pp. x-xi)

The point is, in the first place, not to provide self-contradictory excuses. It was the core argument of the Historical School that the scientific method as exemplified by the natural sciences, i.e. the hypothetico-deductive method, is not applicable in the economic realm. But, beware, if economics is historical then it is not a science.

That is why Descartes said that history was not a science – because there were no general laws which could be applied to history. (Berlin, 2002, p. 76)

Hence Solow's often heard explanation amounts to the denial of the very foundation of standard economics.

The science of Economics, however, is in some degree peculiar, owing to the fact ... that its ultimate laws are known to us immediately by intuition, or, at any rate, they are furnished to us ready made by other mental or physical sciences. That every person will choose the greater apparent good; that human wants are more or less quickly satiated; that prolonged labor becomes more and more painful; are a few of the simple inductions on which we can proceed to reason deductively with great confidence. From these axioms we can deduce the laws of supply and demand, the laws of that difficult conception, value, and all the intricate results of commerce, so far as data are available. (Jevons, 1911, p. 18)

Faithfully following Jevons, general equilibrium theory rests on a set of behavioral axioms (Arrow and Hahn, 1991, p. v). When a theory does not yield satisfactory results this is, in the last instance, due to the self-chosen foundational assumptions.

Much of economic theory is based on three questionable assumptions: (1) the world is deterministic; (2) decision makers act as if they know the values of all relevant parameters; and (3) consumers and firms respectively, act as if they were maximizing utility and profit. (Stigum, 1991, p. 29)

Accordingly, the standard set of behavioral axioms is in the present paper at first replaced by objective structural axioms. As Solow correctly observed ‘the “laws” of behavior change and evolve’ and this is why they are not suited as axioms. The second foundational assumption that has to be replaced is the “law” of diminishing returns which is embodied in the standard production function. This function is convenient for the application of the profit maximization hypothesis and Euler’s theorem but is only superficially related to real world production- and market conditions (cf. Mandler, 1999, p. 37-46; Lavoie, 1992, pp. 27-36; Shaik, 1980; Robinson, 1953; Hicks, 1939, p. 84; Sraffa, 1926).

We proceed as follows. The formal frame that constitutes the pure consumption economy is set up in section 1. Profit is defined in section 2. For perfect analytical transparency we then move from the production conditions in the elementary state of nature, section 3, to the initial economy. This transition effects a productivity increase which is captured by the sequential production function in section 4. The purely organizational effect is then complemented by the formal inclusion of all resources that are necessary for the production of the consumption good output. In section 5 the prices of the two exemplary resources raw material and energy are derived for the simple zero profit case. It turns out that relative resource prices are inverse to the productivities of the respective firms and that the real wage is directly proportional to the productivity in the consumption good producing firm and its relative size. In section 6 the relation between the price of the final product and the resource prices are derived for the general case of positive profits under the conditions of market clearing and equal profit ratios. Section 7 concludes.

1 Axioms

The first three structural axioms relate to income, production, and expenditures in a period of arbitrary length. For the remainder of this inquiry the period length is conveniently assumed to be the calendar year. Simplicity demands that we have at first one world economy, one firm, and one product.

Total income of the household sector Y is the sum of wage income, i.e. the product of wage rate W and working hours L , and distributed profit, i.e. the product of dividend D and the number of shares N .

$$Y = WL + DN \quad |t \quad (1)$$

Output of the business sector O is the product of productivity R and working hours.

$$O = RL \quad |t \quad (2)$$

Consumption expenditures C of the household sector is the product of price P and quantity bought X .

$$C = PX \quad |t \quad (3)$$

The axioms represent the pure consumption economy, that is, no investment expenditures, no foreign trade, and no taxes or any other government activity.

2 Profit

The business sector's financial profit in period t is defined with (4) as the difference between the sales revenues – for the economy as a whole identical with consumption expenditures C – and costs – here identical with wage income Y_W :

$$Q_{fi} \equiv C - Y_W \quad |t \quad (4)$$

In explicit form, after the substitution of (3), this definition is identical with that of the theory of the firm:

$$Q_{fi} \equiv PX - WL \quad \Leftarrow \quad Y_W \equiv WL \quad |t \quad (5)$$

With (6) the expenditure ratio ρ_E , the sales ratio ρ_X , and the distributed profit ratio ρ_D is added for formal convenience as:

$$\rho_E \equiv \frac{C}{Y} \quad \rho_X \equiv \frac{X}{O} \quad \rho_D \equiv \frac{Y_D}{Y_W} \quad \Leftarrow \quad Y_D \equiv DN \quad |t \quad (6)$$

Definitions add no new content to the set of axioms but determine the logical context of concepts (Stigum, 1991, pp. 35-36). An expenditure ratio $\rho_E = 1$ indicates that total consumption expenditures are equal to total income, or, in other words, that the household sector's budget is balanced; a value of $\rho_X = 1$ of the sales ratio means that the quantities produced and sold are equal in period t or, in other words, that the product market is cleared.

Using the first axiom (1) in combination with (6) one gets from (4) the relation between financial profit and the key ratios:

$$Q_{fi} \equiv C - Y + Y_D \quad \Rightarrow \quad Q_{fi} \equiv \left(\rho_E - \frac{1}{1 + \rho_D} \right) Y \quad \text{cond.} \quad \rho_X = 1 \quad |t \quad (7)$$

In the pure consumption economy financial profit is greater than zero if the expenditure ratio ρ_E is >1 or the distributed profit ratio ρ_D is >0 , or both. If distributed profit Y_D is set to zero, then profit or loss of the business sector is determined solely by the expenditure ratio. For the business sector as a whole to make a profit consumption expenditures C have in the simplest case to be greater than wage income Y_W . So that financial profit comes into existence in the consumption economy the household sector must run a deficit at least in one period. This in turn makes the inclusion of the financial sector mandatory (for details see 2011b).

The determinants of profit look essentially different depending on the perspective. For the firm price P , quantity X , wage rate W , and employment L in (5) seem to be all important; under the broader perspective of (7) these variables play no role at all. Both views are formally equivalent.

Equation (5) can, under the condition of market clearing $\rho_X = 1$, be rewritten as:

$$Q_{fi} \equiv PRL - WL \quad \text{if } \rho_X = 1 \quad |t \quad (8)$$

A higher productivity R obviously leads to a higher profit (all other things equal). This conforms to common sense and the experience of a *single* firm. Equation (7) on the other hand indicates that productivity is irrelevant for *overall* profits. Both views are correct. A productivity increase in one firm leads to a *redistribution* of profits within the business sector. It is a simple, nevertheless frequent, logical mistake to generalize the experience of a single firm.¹ For the economy as a whole there exists no relation between productivity and profit.

Axioms and definitions, to be sure, are not the sole ingredients of a theory.

The usefulness of the analytical models that represent similes of actual processes (divested, however, of any qualitative change) cannot be denied. But what matters most in the case of evolutionary structures is the emergence of novelties, of qualitative changes. For these aspects we have no other solution than that of a dialectical approach, involving in particular structural changes. This means to use words, instead of numbers, for truly qualitative changes cannot be represented by an arithmomorphic model. (Georgescu-Roegen, 1971, p. 325)

Therefore, we have to clarify first what the economy to which the axioms refer looks like. This yields the *logical* points of entry of notions like choice, work, market etc. To suspend the complexities of reality, Hobbes's synthetic method of reconstructing the social order is used. This method, which has been absorbed by Bentham, James Mill, Ricardo, and other political economists, is – hardly surprising – no other than the axiomatic method (Halévy, 1960, pp. 493-494). Likewise an account is supplemented of how the initial economy, which is given by the axiom set, comes into being by rational economic choice.

¹ "Nicht richtig ist es aber, wenn die Wissenschaft diesen Horizont der Einzelunternehmer sich zu eigen macht. Ihre Aufgabe ist es ja gerade, die gesamtwirtschaftlichen Zusammenhänge aufzudecken." (Eucken, 1989, p. 143)

3 From the state of nature to the initial economy

The specification of the state of nature is required as a well-arranged reference point for the initial economy. To start with a perfectly symmetric geography it is assumed that natural men/women live on hexagonal estates of equal size.² Natural man/woman needs for his subsistence exactly 16 units per day of a general purpose good GPG that satisfies all his/her needs. Both, one unit more or less of GPG would be fatal.

The time budget of natural man/woman is split up into 22 hours which are devoted to activities that are essential for subsistence and two hours of free time as itemized in Table 1.

Transformation	10 h
Regeneration	10 h
Relocation/Maintenance	2 h
Free time	2 h

Table 1: The time budget of natural man/woman

Natural man/woman is endowed with resources that consist of a stock of raw materials and free energy. All resources are available on the estate. There is no scarcity, on the contrary, only a small portion of resources disposable in period t is actually used and the number of available estates exceeds the number of individuals. Natural man/woman transforms the raw materials into a form suitable for physical consumption. Boiled down to the essentials, all that takes place in the process of physical transformation and consumption is dissipation of energy which, however, is restored by Nature. The physical metabolism of Hexagonland is ruled by the Second Law of Thermodynamics:

... a living organism is a *steady going concern* which maintains its highly ordered structure by sucking low entropy from the environment so as to compensate for the entropic degradation to which it is continuously subject. (Georgescu-Roegen, 1971, pp. 192-192), original emphasis; see also (Khalil, 2004), (Weissmahr, 1992), (Brooks and Wiley, 1986), (Prigogine, 1980), (Boulding, 1970, pp. 23-25)

With the assumption that Nature restores the requisite natural resources all questions that arise from the depletion of given stocks are at this point deliberately suspended. The process of physical transformation takes 10 hours per day and yields 16 units of GPG.

Political Economy, therefore, presupposes all the physical sciences; it takes for granted all such of the truths of those sciences as are concerned

² "In theory, property is not incompatible with equal portions of the land distributed among aspirant farmers. Equality of land distribution was enshrined in early Roman agrarian law but, noted Smith, subsequent (very human) events undid its prospects ..." (Kennedy, 2009, p. 248)

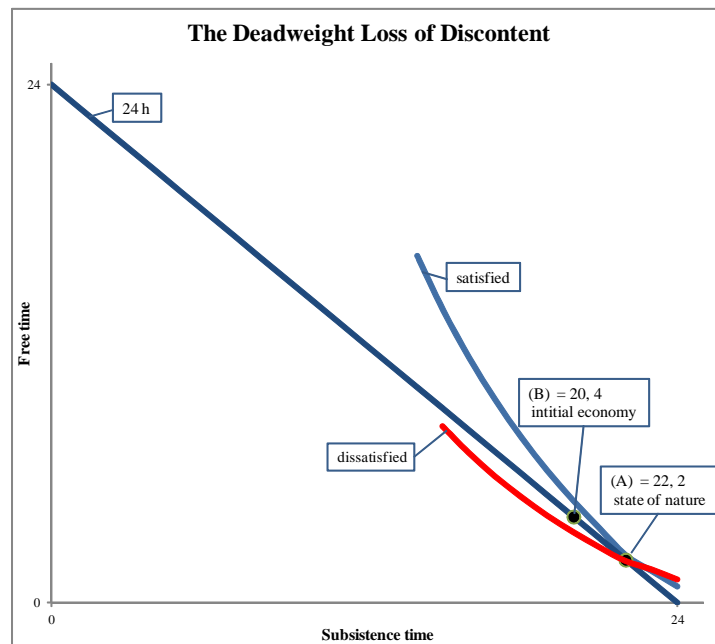


Figure 1: Time budget and satisfaction–dissatisfaction with the state of nature

in the production of the objects demanded by the wants of mankind; or at least it takes for granted that the physical part of the process takes place somehow. (Mill, 2004, p. 102)

This entails, at the very least, that a production function must not contradict known physical laws.

The main activities of natural man/women in his/her free time are communication, consumption/wellness, and speculation. The speculative character reflects out of idle curiosity and tries to make sense of men/women, Nature and all that. According to Veblen, idle curiosity generates novelty in an ongoing manner (Hodgson, 1996, p. 127).

One source of novelty is a man named Smith who is keenly interested in the process of transformation and in how the actual living conditions are appreciated by his neighbors (Elsner, 1989, p. 189). To abstractly clarify the current state of affairs he first draws the immutable time budget constraint that is reproduced in Figure 1.

Since some inhabitants of Hexagonland are perfectly satisfied with how things are and some are not, two representative sets of indifference curves are needed. The normal way to make an optimal choice by moving along the indifference curve or by moving to a higher indifference curve is ruled out. One way for the discontents to establish Pareto optimality in the state of nature is to change their preference structure. The second alternative is to change reality.

As it happens, Mr. Smith eventually propounds a proposal to improve conditions. He reckons that exactly $n=100$ participants are needed to make his plan work. The

main idea consists of an elaborated organizational scheme for the division of labor (Groenewegen, 2008, p. 3). A provisional calculation shows that all participants together could produce 1.600 units of GPG in 8 hours instead of 10 in the state of nature. The new organization of the transformation process would raise productivity R from 1.6 to 2.0 units per hour. Every participant would have to bring the resources with them, so there would at first be no difference with regard to resource input compared to the state of nature.

Mr. Smith points to the fact that his scheme would make 100 dissatisfied inhabitants of Hexagonland better off and adds the disclaimer that the future participants would have to accept as given fact that the quality of work is different from the quality of transformation. Complaints about estrangement, he adds, should therefore be left to political economists.

The proposal concludes with a scheme for the introduction of money with the following specifications: the wage rate is set at 1 € per hour and is equal for all participants. With an input of 800 hours per day and a productivity of 2 units per hour the price of one unit of GPG is calculated to be 0.50 €. With a daily income of 8 € the participants could therefore buy the 16 units of GPG that are needed for subsistence exactly as in the state of nature. The proposal is implemented and thereby the household and the business sector as well as the product and labor market come into existence. Quite intuitively Mr. Smith applied the structural axioms with distributed profits set to zero.

The welfare gain consists of leisure multiplied with the number of participants. With this metachoice Hexagonland enters history, or, as Veblen put it:

All economic change is a change in the economic community, – a change in the community’s methods of turning material things to account. The change is always in the last resort a change in habits of thought. (Veblen, 1961, p. 75)

4 The sequential production function

The productivity increase in the initial economy stems alone from the reorganization of the labor input L . This can be formally expressed as:

$$O = r(L_1 \oplus L_2 \oplus \dots \oplus L_i \oplus \dots \oplus L_n) \quad \text{with} \quad \sum_{i=1}^n L_i = L \quad |t \quad (9)$$

Mr. Smith’s organizational novelty is embodied in equation (9) which covers, as a limiting case, the different stages of a production process with labor as the sole input. The sequential operator \oplus signifies a succession of distinct tasks, that is, the different labor inputs L_1, L_2, L_i are *not* commutative (cf. Georgescu-Roegen, 1971, pp. 236-238). It is not necessary to consider here the case of a parallel execution of tasks.

In the general case a lot of diverse inputs other than labor are necessary to produce a consumption good, e.g., raw materials, the service of tools and machines, energy in various forms, bacteria, catalysts, and so on. These physical resources, too, are applied together with labor, in a certain sequence. The production process can be stated in an explicit and elementary form as production recipe with F_j enumerating the quantities of *all* necessary physical inputs regardless of whether they have a price or not:³

$$O = r(L_1 \oplus F_1 \oplus F_2 \oplus L_2 \oplus \dots \oplus L_i \oplus F_j \oplus \dots \oplus F_m \oplus L_n) \quad |t \quad (10)$$

Input, and by consequence output, gradually undergo a qualitative change, if, for example, input F_j consists of wood and is replaced by steel as it happened progressively during the Industrial Revolution (Rosenberg and Birdzell, 1986, p. 146). If necessary this qualitative change can be roughly captured by indexing the output according to identifiable vintages $O^I, O^{II}, O^{III} \dots$

The labor input ratio is defined as:

$$\rho_{Li} \equiv \frac{L_i}{L} \quad |t \quad (11)$$

The resource input ratio is defined as:

$$\rho_{Fj} \equiv \frac{F_j}{L} \quad |t \quad (12)$$

Applying (11) and (12) the sequential production function (10) then reads:

$$O = r(\rho_{L1} \oplus \rho_{F1} \oplus \rho_{F2} \oplus \rho_{L2} \oplus \dots \oplus \rho_{Li} \oplus \rho_{Fj} \oplus \dots \oplus \rho_{Ln} \oplus \rho_{Fm})L \quad |t \quad (13)$$

This reduces formally to the 2nd axiom:

$$O = [r(\bullet)]L = RL \quad |t \quad (14)$$

The productivity R varies in a non-continuous fashion with changes of the labor and resource input ratios and the reorganization of the production process. The Industrial Revolution made it plain that large scale transformation of energy into mechanical work by machines is one crucial determinant of productivity (Rosenberg and Birdzell, 1986, p. 146). For productivity changes, which depend to a great extent on the technical development, knowledge and human capital (Mokyr, 1990, p. 239-244), no general formula can be given. History shows that the different stages of the production process are at different points in time supported or fully replaced by energy consuming machines and these partial substitutions require successive reorganizations (Winter, 2005). A continuous and reversible substitution of labor, raw material, capital or energy is ruled out by (13). There is no such thing as a marginal factor product.

³ For an illuminating critique of the notion of a factor of production see (Fraser, 1937, pp. 198-218)

Once established the sequential production process is repeated for an indefinite time. Moderate or transitory changes of input prices have no immediate effect. Only after some time adaptations are considered. The new sequential production function then embodies the adaptations that reflect changing technologies, materials, and input prices. The change process is discontinuous and normally entails investments in new buildings and machines. Scarcely more can be said about the production process in general. Productivity changes, therefore, have to be taken as random in the first round of analysis.

Given the period consumption of resources as determined by (13) the change of the stock of a renewable resource $\Delta\bar{F}_{jt}$ can be defined as:

$$\Delta\bar{F}_j \equiv F_j^+ - F_j \quad |t \quad (15)$$

If the resource is not renewable F_j^+ is zero. The remaining stock of a resource in period t is given by:

$$\bar{F}_{jt} \equiv \bar{F}_{j0} - \sum_{t=1}^t \Delta\bar{F}_{jt} \quad (16)$$

However, since the initial stock \bar{F}_{j0} is not known with great precision the remaining stock \bar{F}_{jt} is guesswork. This applies *a fortiori* to projections (Jevons, 1865), (Meadows et al., 1972). The real scarcity of a resource at a given point in time is mostly unknown.

The initial economy is now prepared for further extensions. The obvious next step is to discard the assumption of a fixed demand for the GPG and the assumption of free resources.

5 Resource prices in the zero-profit case

The business sector is composed of three firms. Firm A produces the final consumption good, firm M the raw material and firm E supplies the energy (in the specific form of coal, oil, electricity etc.). The production of investment goods is not considered here (for details see 2011c). From (2) follows for the output of the three firms:

$$\begin{aligned} O_A &= R_A L_A \\ O_M &= R_M L_M \quad |t \\ O_E &= R_E L_E \end{aligned} \quad (17)$$

The respective productivities are formally determined by the sequential production function (13).

The given overall labor input L is allocated between the firms:

$$\begin{aligned} L &\equiv L_A + L_M + L_E \quad |t \\ 1 &\equiv \rho_{LA} + \rho_{LM} + \rho_{LE} \end{aligned} \quad (18)$$

Firm M sells raw material to firm A . According to (5) its profit is given by:

$$Q_{fiM} \equiv H_M F_M - W_M L_M \quad |t \quad (19)$$

Firm E sells energy to firm A and makes a period profit of:

$$Q_{fiE} \equiv H_E F_E - W_E L_E \quad |t \quad (20)$$

The revenues of the suppliers M and E reappear as costs in the profit equation of the producer of the final output:

$$Q_{fiA} \equiv P_A X_A - H_M F_M - H_E F_E - W_A L_A \quad |t \quad (21)$$

Firm A sells the quantity X to the household sector at price P . Its costs consist of the price H_M and quantity F_M of the raw material input, the price H_E and quantity F_E of energy input, and its own wage costs. Taken all three profit equations together the resource revenues and costs cancel out. Total profit is independent of the prices and quantities of resources.

For all firms it is at first assumed that profits are zero and that the product market and the resource markets are cleared, i.e. $X = O, F = O \rightarrow \rho_X = 1$ for all markets.

From (20) and (17) then follows:

$$H_E = \frac{W_E}{R_E} \quad \text{if } Q_{fiE} = 0; \rho_{XE} = 1 \quad |t \quad (22)$$

The market clearing energy price is equal to unit wage costs of firm E .

From (19) and (17) follows:

$$H_M = \frac{W_M}{R_M} \quad \text{if } Q_{fiM} = 0; \rho_{XM} = 1 \quad |t \quad (23)$$

The market clearing raw material price is equal to unit wage costs of firm M .

If the wage rates in both industries are equal relative resource prices depend solely on the inverse productivities:

$$\frac{H_M}{H_E} = \frac{W_M R_E}{W_E R_M} \Rightarrow \frac{H_M}{H_E} = \frac{R_E}{R_M} \quad \text{if } W_M = W_E \quad |t \quad (24)$$

Partial wage rate changes affect relative input prices, general changes do not and therefore do not give rise to a substitution of resource inputs.

From (21) and the zero-profit condition follows the price of the consumption good:

$$P_A = \frac{1}{X_A} (H_M F_M + H_E F_E + W_A L_A) \quad \text{if } Q_{fiA} = 0 \quad |t \quad (25)$$

Substituting (22) and (23) gives:

$$P_A = \frac{W_A}{R_A} \left(\frac{W_M}{W_A} \frac{L_M}{L_A} + \frac{W_E}{W_A} \frac{L_E}{L_A} + 1 \right) \quad \text{if } \rho_{XA} = 1 \quad |t \quad (26)$$

The market clearing price of the final output depends on unit wage costs of the consumption good producer and on relative labor costs of the three firms. Under the condition of equal wage rates in all firms this reduces with the help of (18) to:

$$P_A = \frac{W}{R_A} \left(\frac{L_M}{L_A} + \frac{L_E}{L_A} + 1 \right) \Rightarrow P_A = \frac{W}{R_A} \frac{L}{L_A} \quad \text{if } W_A = W_M = W_E = W \quad |t \quad (27)$$

Generally speaking, the price of the final output depends on unit wage costs in the consumption good producing firm and the relative size of the three firms measured in labor input. All relative prices depend on the real magnitudes productivity and labor input if (average) wage rates are equal for all firms. All variables are measurable.

The real wage follows from (27) as:

$$\frac{W}{P_A} = R_A \frac{L}{L_A} \quad |t \quad (28)$$

The real wage is directly proportional to the productivity of the consumption good producing firm A and its relative size. The productivity in turn depends on the organization of the resource- and labor inputs as expressed by the sequential production function (13). The real wage does not depend on marginal productivity.

6 Resource prices in the general case

A positive profit for the economy as a whole according to (7) leads to the indeterminacy that is observable in the real world and opens the opportunity for profit redistribution among firms. The energy producer is here taken as a case in point. Under the condition of market clearing his minimum selling price follows from (20) and the zero-profit condition as:

$$H_E^{min} = \frac{W_E}{R_E} \quad \text{if } Q_{fiE} = 0; \rho_{XE} = 1 \quad |t \quad (29)$$

The maximum selling price follows correspondingly from the profit equation of firm A (21) and the zero-profit condition:

$$H_E^{max} = \underbrace{\frac{H_E^{min}}{W_E L_E}}_{\text{firm E}} \left(\underbrace{L_A (P_A R_A - W_A)}_{\text{firm A}} - \underbrace{L_M H_M R_M}_{\text{firm M}} \right) \quad \text{if } Q_{fiA} = 0; \rho_{XA} = 1 \quad |t \quad (30)$$

The maximum selling price of the energy producer depends on the respective selling prices of the other firms and the cost conditions of all firms. The difference between the maximum and minimum energy price constitutes the objective margin for bargaining which, although calculable in principle, is most probably not known

with any precision by real world agents. The outcome of the bargaining is a unique historical event. No behavioral theory, game theory included, is able to predict the outcome.⁴ What is indeed predictable is that the consumption good producing firm will get in serious troubles if the energy price happens to be higher than that given by (30). The bargaining outcome determines the distribution of profits within the business sector according to (19), (20), (21).

In order to eliminate all subjective elements and to determine the resource prices analytically as a benchmark an additional assumption is required. The most suitable condition is profit ratio equalization. The overall profit ratio follows from (7) as:

$$\rho_Q \equiv \frac{Q_{fi}}{WL} \Rightarrow \rho_Q \equiv \rho_E(1 + \rho_D) - 1 \quad |t \quad (31)$$

The overall profit ratio ρ_Q is positive if the expenditure ratio ρ_E is >1 or the distributed profit ratio ρ_D is >0 , or both.

The profit ratio of the raw material producing firm M follows from (19) and is defined as:

$$\rho_{QM} \equiv \frac{H_M F_M}{W_M L_M} - 1 \quad |t \quad (32)$$

The profit ratio of the energy producing firm E follows from (20) and is defined as:

$$\rho_{QE} \equiv \frac{H_E F_E}{W_E L_E} - 1 \quad |t \quad (33)$$

The profit ratio of the consumption goods producing firm A follows from (21) and is defined as:

$$\rho_{QA} \equiv \frac{P_A X_A}{H_M F_M + H_E F_E + W_A L_A} - 1 \quad |t \quad (34)$$

Under the condition of market clearing the profit ratios change to:

$$\rho_{QM} \equiv \frac{H_M R_M}{W_M} - 1 \quad \text{if } \rho_{XM} = 1 \quad |t \quad (35)$$

$$\rho_{QE} \equiv \frac{H_E R_E}{W_E} - 1 \quad \text{if } \rho_{XE} = 1 \quad |t \quad (36)$$

$$\rho_{QA} \equiv \frac{P_A R_A L_A}{H_M R_M L_M + H_E R_E L_E + W_A L_A} - 1 \quad \text{if } \rho_{XA} = 1 \quad |t \quad (37)$$

Under the conditions of equal profit ratios, i.e. $\rho_{QM} = \rho_{QE} = \rho_{QA}$, and equal wage rates, i.e. $W_M = W_E = W_A = W$, and with the help of (18) the raw material price follows as:

⁴ "Postwar theory therefore does not adequately explain how competitive factor markets function." (Mandler, 1999, p. 49), see also (Blaug, 2002, p. 52, n. 10)

$$H_M = \frac{1}{R_M} \left(\sqrt{P_A \frac{W R_A}{L_A} - 1 + \left(\frac{W}{2 \left(\frac{L}{L_A} - 1 \right)} \right)^2} - \frac{W}{2 \left(\frac{L}{L_A} - 1 \right)} \right) \quad |t \quad (38)$$

The raw material price depends on the price of the final product P_A and on variables that refer to labor costs and the relative size of firm A given the productivity of firm M . Given the structural variables of firm A the raw material price moves with the square root of the price of the final product under the conditions of market clearing and equal profit ratios.

Accordingly the energy price is given by:

$$H_E = \frac{1}{R_E} \left(\sqrt{P_A \frac{W R_A}{L_A} - 1 + \left(\frac{W}{2 \left(\frac{L}{L_A} - 1 \right)} \right)^2} - \frac{W}{2 \left(\frac{L}{L_A} - 1 \right)} \right) \quad |t \quad (39)$$

The energy price likewise depends on selling price and the structural variables of firm A given the productivity of the energy producer. Relative resource prices therefore depend under the condition of market clearing and equal wage rates solely on the inverse productivity ratio, that is, on real variables.

$$\frac{H_M}{H_E} = \frac{R_E}{R_M} \quad |t \quad (40)$$

This relationship is the same as in the zero-profit case (24).

What remains to be determined is the price for the final product. Consumption expenditures go entirely to firm A :

$$C = P_A X_A \quad |t \quad (41)$$

From the axiom set and (6) then follows under the condition of market clearing:

$$P_A = \rho_E (1 + \rho_D) \frac{W}{R_A} \frac{L}{L_A} \quad \text{if } \rho_{XA} = 1 \quad |t \quad (42)$$

The price of the final product depends on the expenditure ratio ρ_E , the distributed profit ratio ρ_D , unit factor costs, and the relative size of the consumption good producing firm. The expenditure ratio is here equal for wage income and distributed profit (for different expenditures ratios see 2011a). The assumption of market clearing makes it that a higher overall profit is redistributed via the changes of the resource prices according to (38) and (39) between the firms. Relative prices remain unchanged because they depend solely on the productivities in the three firms. There is no incentive for the substitution of resources.

The analytical determination of resource prices presupposes equal profit ratios. If this equalization does not take place in the real world the resource prices will be found between their lower and upper limits as determined by the zero profit conditions. Negative profits can only persist over a limited time span and are conducive to sudden structural changes within the business sector.

The real wage follows from (42) as:

$$\frac{W}{P_A} = \frac{R_A}{\rho_E(1 + \rho_D)} \frac{L_A}{L} \quad \text{if } \rho_{XA} = 1 \quad |t \quad (43)$$

The determinants of the real wage as given for the zero profit case (28) are now modified such that the real wage is lower in comparison, depending on the expenditure ratio and the distributed profit ratio. This configuration effects a redistribution of the final output among households (for details see 2011a, pp. 8-12).

It is abundantly clear that the real wage is not determined by the marginal principle. The distribution of real output neither depends on a well-behaved production function nor on the marginal product of the ‘factors of production’. The real wage depends on productivity which in turn depends on the sequential production function that contains all resources. Profit is not a factor remuneration. The structural axiomatic determination of resource prices is free of unconvincing assumptions about tastes, technology and competition. All structural axiomatic variables are measurable in principle.

7 Conclusions

Behavioral assumptions, rational or otherwise, are not solid enough to be eligible as first principles of theoretical economics. Hence all endeavors to lay the formal foundation on a new site and at a deeper level actually need no further vindication. The present paper submits three non-behavioral axioms as groundwork for the theoretical reconstruction of the evolving money economy. To formally capture production the axiom set is complemented by the sequential production function.

The analytical setup is as follows. The business sector is composed of three firms. Firm *A* produces the final consumption good, firm *M* the raw material and firm *E* supplies the energy. The main results of the structural axiomatic analysis are:

- The raw material price depends on the price of the final product and on variables that refer to labor costs and the relative size of firm *A* given the productivity of firm *M*. Given the structural variables of firm *A* the raw material price moves with the square root of the price of the final product under the conditions of market clearing and equal profit ratios.
- The energy price likewise depends on selling price and the structural variables of firm *A* given the productivity of the energy producer. Relative resource prices therefore depend under the condition of market clearing and equal wage rates solely on the inverse productivity ratio, that is, on real variables.

- Profit is not a factor remuneration. For the economy as a whole there is no relation between productivity and profit.
- The price of the final product depends on the expenditure ratio, the distributed profit ratio, unit factor costs, and the relative size of the consumption good producing firm *A*. The assumption of market clearing makes it that a higher overall profit is redistributed via the changes of the resource prices between the firms.
- The real wage in the zero-profit case is directly proportional to the productivity of the consumption good producing firm *A* and its relative size. The productivity in turn depends on the organization of the resource- and labor inputs as expressed by the sequential production function. The real wage in the general case with overall positive profits is lower than in the zero profit case depending on the expenditure ratio and the distributed profit ratio.

The structural axiomatic determination of resource prices is free of unconvincing assumptions about tastes, technology and competition.

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