Essentials of Constructive Heterodoxy: Behavior

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Abstract

For a host of compelling methodological reasons, *homo oeconomicus* has to be replaced. This is consensus, the open question is how this could be accomplished. What is required first is the separation of the formal foundations into a structural and a behavioral part. This paper introduces the propensity function as general formalization of Economic Man/Woman. The propensity function is a compact formal expression of random, semi-random, and deterministic behavioral assumptions. It is shown how, in a random environment, target-oriented behavior produces stochastic stability and optimality in the product market. With *homo oeconomicus* the conception of simultaneous equilibrium, too, vanishes.

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1 Farewell to *homo oeconomicus*

> No science has been criticized by its own servants as openly and constantly as economics. The motives of dissatisfaction are many, but the most important pertains to the fiction of *homo oeconomicus.* (Georgescu-Roegen, 1971, p. 1)

It is by now well-understood that the *homo oeconomicus* approach with utility and profit maximization is not only unconvincing because of manifest unrealism, as common sense has persistently argued, but because it cannot work for deeper methodological reasons.

> The predictive weakness of theories couched in intensional vocabulary do not correlate in a manageable way with the vocabulary of other successful scientific theories; they do not divide nature at the joints; ... (Rosenberg, 1994, p. 224)

To properly divide the economy at the joints the formal foundations are in the following separated into the structural axiom set and the propensity function. The subject matter of theoretical economics is twofold, it embraces the behavior of the economic system and human behavior. The crucial methodological point is that the system has analytical precedence.

Conventional economics rests on behavioral assumptions that are formally expressed as axioms (McKenzie, 2008). Axioms are indispensable to build up a theory that epitomizes formal and material consistency. The fatal flaw of the standard approach is that – as a matter of principle – human behavior does not yield to axiomatization.

While the axiomatization of human behavior is in the last instance self-contradictory (Blaug, 1992, pp. 162-169) the axiomatization of the monetary economy's fundamental structure is feasible. Structural axioms are *free* of any explicit or implicit behavioral assumptions. This means that a general formal complement is required that captures human behavior as far as it is relevant for the functioning of the economic system.

The present paper deals with the interaction of *structural* axiomatic core and the general *behavioral* propensity function and shows how this interaction produces dynamically stable outcomes in the product market.

We proceed as follows. Section 2 provides the formal foundations with the set of four structural axioms. The objective systemic structure is then formally supplemented in Section 3 by the behavioral propensity function. This function is the general expression of the intentionality of human action. In Sections 4 and 5 the two formal building blocks of every consistent economic model are applied to the problem of product market clearing in a random environment. Section 6 concludes.

2 Axioms and assumptions

The new formal foundations of theoretical economics define the interdependencies of the real and nominal variables that constitute the consumption economy as the elementary core of the monetary economy.

The first three structural axioms relate to income, production, and expenditure in a period of arbitrary length. The period length is conveniently assumed to be the calendar year. Simplicity demands that we have for the beginning one world economy, one firm, and one product.

Total income of the household sector Y in period t 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. Nothing is implied at this stage about who owns the shares.

$$Y = WL + DN \tag{1}$$

The period counter t runs from 0, the initial period, to ∞. An anchoring in historical time is possible but not necessary at the very beginning of the analysis.

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

$$O = RL \tag{2}$$

The productivity R depends on the underlying production process. The 2nd axiom should therefore not be misinterpreted as a linear production function. Geometrically the 2nd axiom is a ray from the coordinate origin that tracks underlying discontinuous non-linearities; it does not contain any implicit assumption about increasing or decreasing returns.

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

$$C = PX \tag{3}$$

The axioms represent the pure consumption economy, that is, no investment, no foreign trade, and no government.

The period values of the axiomatic variables are formally connected by the familiar growth equation, which is added as the 4th axiom.

$$Z_t = Z_{t-1}\left(1 + \dddot{Z}_t\right)$$

or

$$Z_t = Z_0\left(1+\dddot{Z}_1\right)\left(1+\dddot{Z}_2\right)\ldots\left(1+\dddot{Z}_t\right) = Z_0\prod_{t=1}^{t}\left(1+\dddot{Z}_t\right). \tag{4}$$

with

$$Z \leftarrow W, L, D, N, R, P, X, \ldots$$

The path of the representative variable Z_t is determined by the initial value Z_0 and the rates of change $\ddot{Z}_t$ for each period. Each path has three segments: past, present, future. The past rates of change are known and can be inserted into (4). The axioms contain the minimum number of variables. Seven of the variables are elementary, three are composed. Figure 1 is the graphical representation of the first four axioms.

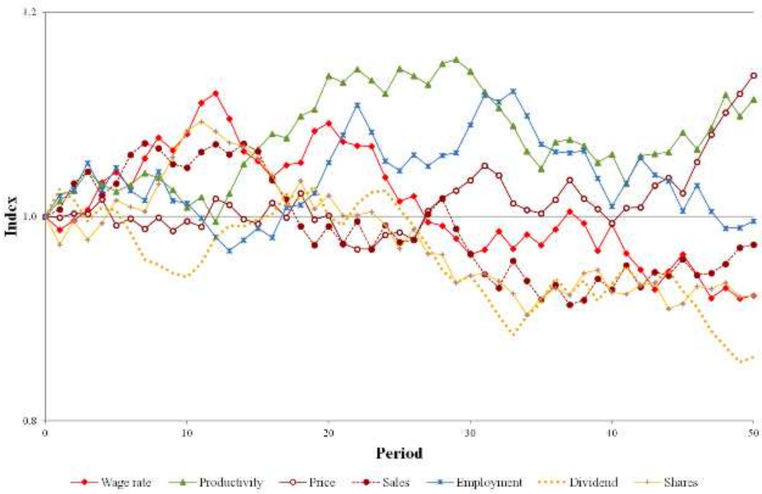

Figure 1: The pure consumption economy: paths of the seven elementary axiomatic variables W, L, D, N, R, P, X from the initial period $t = 0$ until period $t = 50$ as defined by independent symmetrical random rates of change. All paths are numerically expressed in terms of their respective initial values, therefore they start collectively at the index point 1.

Assumptions are a necessary ingredient of any theory. Their justification or, as the case may be, their futility materializes in the course of the analysis. What has to be avoided for compelling methodological reasons is assumptionism. It should be obvious that it is illegitimate to take assumptions like equilibrium, perfect competition, well-behaved production functions, optimization, etc. into the premises. Assumptionism introduces physical or psychological nonentities and thereby creates a parallel world with no connection to the economy we happen to live in. The specific difficulty with nonentities is sometimes that they cannot be readily recognized or disproved. So, most economists have not realized that equilibrium is a nonentity.

The set of objective structural axioms constitutes the *minimum* of premises. The economic content of the four axioms is perfectly transparent. The point to emphasize is that total income in (1) is the sum of wage income and *distributed profit* and not of wage income and profit.

For a start it is assumed that the elementary axiomatic variables vary at random. This produces an evolving economy. The respective probability distributions of the change rates are given in general form by:

$$\begin{array}{ll} Pr\left(l_W \leq \ddot{W} \leq u_W\right) & Pr\left(l_R \leq \ddot{R} \leq u_R\right) \\ Pr\left(l_L \leq \ddot{L} \leq u_L\right) & Pr\left(l_P \leq \ddot{P} \leq u_P\right) \\ Pr\left(l_D \leq \ddot{D} \leq u_D\right) & Pr\left(l_X \leq \ddot{X} \leq u_X\right) \\ Pr\left(l_N \leq \ddot{N} \leq u_N\right) & \end{array} \tag{5}$$

The four axioms, including (5), constitute a stochastic simulation.

It is, of course, also possible to switch to a completely deterministic rate of change for any variable and any period. The structural formalism does not require a preliminary decision between determinism and indeterminism.

Before the formalism can be applied concrete assumptions about the initial conditions and the upper (u) and lower (l) bounds of the probability distributions have to be made. This is the point where input from experience is needed. We know from observation for instance that productivity changes lie *normally* between, say, 5 percent and 0 percent per period.

We know that probability distributions may change over time and that accidents do happen. What we do not know is the exact date and extent of a possible accident in the future. For a start these features of reality are excluded from the analysis. They may be taken in as soon as the elementary relationships have been clarified.

A simulation yields a scenario and not a prediction. Each scenario is fully determined, explicit, and traceable in every detail. A simulation as defined by the four structural axioms and the probability distributions is a well-defined mathematical object just like a system of equations. While they are formally on the same footing, both mathematical objects yield different kinds of outputs: the system of equations yields a solution vector, a simulation yields a bundle of paths. This bundle has a counterpart in reality.

The upper (u) and lower (l) bounds of the respective probability distributions are, for a start, taken to be symmetrical around zero. This produces a drifting or stationary economy as a limiting case of the growing economy. There is no need at this early stage to discuss the merits and demerits of different probability distributions. Eq. (5) represents the general stochastic case which in the limit $u - l \to 0$ shades into determinism. The evolving consumption economy contains no subjective elements.

3 The propensity function

Axiomatization provides the bare *structural* bones. The first question is how the rates of change of the elementary variables are determined. The obvious next step is to invoke both, purposeful agents and pure randomness, to 'animate' (Popper, 1994, p. 164) the formalized economy. To prepare for a general answer, the rate of change of the representative variable $\ddot{Z}$ is replaced by a set of possible outcomes $\{\ddot{z}\}$. Its rationale is outlined in Figure 2.

Propensity type	Observer's state of knowledge	Set of possible outcomes $\{\ddot{Z}\}$
A: Uncertainty	a) definitive, i.e., proven by an impossibility theorem, or, b) contingent, i.e., , may be overcome with better methods or tools	$\{-100\% \leq \ddot{Z} < \infty\}$ Pr (•) not defined
B: Randomness	The set of possible outcomes is inductively inferred from more or less sophisticated observations $(x_{B1}, x_{B2}, \ldots)$ that display no dominant influence $\{\ddot{Z}\} = f_B(x_{B1}, x_{B2}, \ldots)$	e.g. $\{-3\% \leq \ddot{Z} \leq 3\%\}$ Pr (•) equally distributed
C: Directed randomness	One conjectures a direction of change $(-1, 0, 1)$ and has a hypothesis that explains it in the logical format if [antecedent] then $(-1;0;1)$; $\{\ddot{Z}\} = f_C(x_{C1}, x_{C2}, \ldots)$	e.g. $(-1;0;1)\{0\% \leq \ddot{Z} \leq 3\%\}$ Pr (•) equally distributed
D: Dependency	One has a sufficiently specified hypothesis about the influence of the independent variables $(x_{D1}, x_{D2}, \ldots)$: $\{\ddot{Z}\} = f_D(x_{D1}, x_{D2}, \ldots)$	e.g. $\{7.2\% \pm 0,3\%\}$ Pr =0.99
E. Determinism	One has a law and knows the boundary conditions: $\{\ddot{Z}\} = f_E(x_{E1}, x_{E2}, \ldots)$	e.g. $\{7.19470\%\}$ Pr =1

Figure 2: The propensity function covers five logical types that enable the derivation of the rates of change of the elementary axiomatic variables in period *t*

Figure 2 is consolidated to the propensity function (6) with $\ddot{Z}$ at first standing for the rates of change of the seven elementary variables in eq. (4).[1] The propensity function yields a definite rate of change for each period:

$$\ddot{Z} = \underbrace{(-1, 0, 1)}_{\text{Direction}} \underbrace{Pr(\{\ddot{Z}\})}_{\text{Magnitude}}. \tag{6}$$

The two components of the propensity function are direction and magnitude. In the limiting case of uncertainty, type-A, the propensity function has to be defined *ad hoc*. In the limiting case of determinism, type-E, everything is defined by the magnitude bracket, the value in the direction bracket is unity by default. At the moment no deterministic behavioral functions are known in economics. Type-A represents the *status quo*, i.e., that we have *no a priori* knowledge of the set of possible outcomes or any determinants of (6).[2] To get things going we have to take type-B as the minimalist starting point of behavioral analysis:

[1] The term propensity is here used in the sense of (Popper, 1990).

[2] Shackle regarded the explicit recognition of uncertainty as Keynes's 'big thing' (2010, p. 135). Uncertainty subsequently became the trademark of Post Keynesianism. In the present context it is kept in the background because, quite naturally, not much more can be said about it than "We simply do not know" (Keynes, 1937, p. 214).

> The simplest hypothesis is that variation is random until the contrary is shown, the onus of the proof resting on the advocate of the more complicated hypothesis ... . (Kreuzenkamp and McAleer, 1995, p. 12)

The magnitude of the rate of change is in the following left to chance. The agents are supposed to determine the direction of change.

3.1 The pure logic of behavior

The direction of change is captured in a general form by a signum function that determines the algebraic sign of the random rate of change of the axiomatic variables:

$$(-1, 0, 1)_Z = sgn\,(\text{if [A]})\,. \tag{7}$$

The direction, i.e., -1=down and +1=up, is conditional on whether one or more antecedents are satisfied or not. The antecedent [A] is a shorthand for conditions of any degree of sophistication expressed by the operators >, <, =, AND, OR etc. and variables with a time index t or prior. Type-C is the formal container for a familiar conception that has been identified as 'qualitative prediction' (Rosenberg, 1992, p. 68). The notion of directionality is by no means new in economics and can be traced back to J. S. Mill:

> Doubtless, a man often asserts of an entire class what is only true of a part of it; but his error generally consists not of making too wide an assertion, but in making the wrong *kind* of assertion: he predicated an actual result, when he should only have predicated a *tendency* to the result – a power acting with certain intensity in that direction. (Mill, 2004, p. 123), original emphasis

Type-C does exactly this: it predicates a behavioral tendency or, more specific, a conditional direction of change.

It is important to note that the axiomatic core is not affected when a specific behavioral hypothesis, which is embodied in the propensity function, is falsified. One of the outstanding characteristics of the structural axiomatic approach is the *separability* of the behavioral and non-behavioral fundamentals. This carries with it the option to employ neoclassical or Keynesian or evolutionary behavioral assumptions within one formal framework. Because it is compatible with *any* behavioral assumption the structural axiom set is intrinsically general.

The magnitude of the rate of change depends on the inductively inferred probability distribution and one has no *a priori* reason to assume either a discrete or a continuous random variable or a specific distribution. Therefore, the uniform discrete distributions in Figure 2 have to be taken as a pragmatic point of departure which in no way prevents the eventual introduction of, for example, a Gauss distribution. The propensity function (6) is a comprehensive blank form open to progressive specification. It demands no ontological commitment to either determinism or indeterminism.

Formally, for every variable of the structural axiomatic formalism there exists a reference or target variable. The realized values of the variables are superimposed by desired values.

$$\mathbb{Z} \dashrightarrow \mathbb{Z}^{\theta} \tag{8}$$

Let, for instance, $\mathbb{Z}$ stand for the actual stock of money in period t then $\mathbb{Z}^{\theta}$ stands for the desired stock. And so on for all variables that formally compose the system.

What we can say with certainty is that there are three logical configurations for the relation between the actual value of a variable and the target value:

$$\mathbb{Z} - \mathbb{Z}^{\theta} \gtreqless 0. \tag{9}$$

The most general assertion about human behavior is that it is target-oriented or intentional.

$$\mathbb{Z} - \mathbb{Z}^{\theta} \Rightarrow 0 \tag{10}$$

In formal terms this means that the difference between the actual value of a variable and the target value should eventually become zero. At the moment it is open how the agent can achieve this. Note that the target may vary in the course of time. Note also that expectations can only influence the target value, not the realized value.

In its generalized form the propensity function asserts that the directed rates of change $\ddot{Z}$, i.e., the bounded change vectors, are to different degrees dependent on the state of the world at the beginning of period t or earlier. This state is characterized in the simplest case by the difference between the actual value of another variable $\mathbb{Z}$ and an appropriate target or, more general, reference value $\mathbb{Z}^{\theta}$. The explicit function that determines the direction of change of $\ddot{Z}$ has therefore *two* parts and reads:

$$\underbrace{(-1,0,1)_Z}_{\text{Direction}} = sgn\left(sgn\left(\mathbb{Z} - \mathbb{Z}^{\theta}\right)\right). \tag{11}$$

The reference value $\mathbb{Z}^{\theta}$ may, for instance, be the profit maximum given the actual state of expectations and Z may stand for the quantity bought/sold X. The agent then changes this quantity in order to come ever closer to the profit maximum.

It is worth emphasizing that (11) is purely formal and, at this stage, does not contain more philosophy, sociology or psychology than that human behavior is directed in a random environment. We have now to determine in more detail how this works.

3.2 The information and the action function

Economic man/woman in the structural axiomatic context at first chooses an information source and this entails that there is more than one available. It is assumed here that the set of information sources is restricted to the variables of the axiom set. The information function contains two variables: the realized value $\mathbb{Z}$ of the chosen variable and the reference value $\mathbb{Z}^{\theta}$.

The reference value can be taken as the concrete result of an optimization procedure, such that the value of $\mathbb{Z}^{\theta}$ in period t is the subjectively most preferred among all other possible values given the subjective knowledge of the situation in period t and given the actual expectations (cf. Arnsperger and Varoufakis, 2006, p. 9; Georgescu-Roegen, 1966, p. 243). The reference value, however, has a wider meaning as we shall see in the following. We refrain here from speculating about what goes on in the head of an agent and treat the reference value as open interface to any promising behavioral approach that is capable of providing the value. We have at the moment no indication of how alterations of the reference value are brought about. It is assumed in the interim that it follows a type-B random path. The information function that yields one of three possible values is specified as:

$$(-1,0,1) = sgn\left(\mathbb{Z} - \mathbb{Z}^{\theta}\right). \tag{12}$$

It is certainly not the case that real world agents expect that the actual value of a variable is *exactly* equal to the corresponding reference value and that they immediately react to the smallest deviation. On the contrary, infinitesimal precision, which is an implicit property of standard equilibrium models, has to be rejected as a distorting idealization. Every action entails set-up costs and therefore inertia. To explicitly account for the inexactitude of the information function the notion of inertia is introduced with the parameter ι:

$$(-1,0,1) = sgn\left(\mathbb{Z} - \left(\mathbb{Z}^{\theta} \pm \iota\right)\right). \tag{13}$$

Since only the sign of the difference of the realized value $\mathbb{Z}$ and the reference value $\mathbb{Z}^{\theta}$ is of interest there is no urgent need for economic man/woman to measure these values with high precision. All that is needed is that economic man/woman can ascertain one of the relations: greater than, less than, or roughly equal. So measurement errors or a rule of thumb attitude does not impair the functioning of (13).

In a random environment it makes good economic sense *not* to react to small changes and deviations because it is to be expected that they, more often than not, cancel out in the following periods. The magnitude of the inertia parameter in (13) therefore determines the sensitivity of the whole system. In order to keep the following signum functions legible the inertia parameter is omitted with the understanding that it normally has a value greater than zero.

Next, economic man/woman has to choose an action or instrument variable. It is assumed that the set of action variables consists of the variables of the axiom set. The subsets, however, are different for the business and the household sector. The quantity bought X belongs to the households' subset but not the firms'.

The action variable is dependent upon the output of the information function. The direction for the random rate of change of the action variable Z is then given by:

$$\underbrace{(-1,0,1)_Z = sgn}_{\text{Action}} \underbrace{\left(sgn\left(\mathbb{Z} - \mathbb{Z}^{\theta}\right)\right)}_{\text{Information}} \quad |t. \tag{14}$$

The sign of the rate of change of the action variable depends on the sign that is provided by the information function. We thus have nine combinatorial variants of the relations between information and action as exhibited in Figure 3.

		output	information	function
		input	action	function
		-1	0	1
output	-1	$\mathbf{a_1}$	$b_\#$	$\mathbf{c_1}$
action	0	$a_\#$	$\mathbf{b_2}$	$c_\#$
function	1	$\mathbf{a_3}$	$b_\#$	$\mathbf{c_3}$

Figure 3: The explicit signum function (14) as product of the information and action function

From the nine possible combinations four are singled out as momentarily not feasible. The agent is not allowed *not* to act ($a_\#$, $c_\#$) and he is only allowed to act with a good reason, that is, he is not allowed to act spontaneously ($b_\#$). For a plus or minus input from the information function economic man/woman has to choose between two possibilities (c_1, c_3 respectively a_1, a_3). For a zero input, i.e., the realized value is equal to the reference value, no action results (b_2).

If the information function refers, for example, to the stock of final products $\bar{O}$ and if the price P has been chosen as action variable (instead of, say, employment) and the output of the information function is a plus, i.e., $\bar{O} > \bar{O}^{\theta}$, then the firm has to choose either a price increase (c_3) or a price reduction (c_1). This is an ordinal choice and it is understood that the agent believes that his action will bring him closer to the reference value, that is, from worse off to better off. Of course we do *not know* which of the alternatives the firm will choose. Because of this, the missing behavioral link is amended by the standard assumption that the firm will lower the price in order to sell off. The magnitude of the price cut is left to chance.

Even if the propensity function is – from the perspective of an outside observer – in principle correctly specified there is, because of other influences, no guarantee that the price cut will bring the stock of products closer to the reference value in period t. The propensity function is one element in a trial and error process with practically unpredictable effects on the agent's operating experience and expectations. We arrive here at an open interface to a theory of learning.

This, then, is the complete 5-type propensity function as general formal expression of behavior at a glance:

$$\dddot{Z} = sgn\left(sgn\left(\mathbb{Z} - \mathbb{Z}^{\theta}\right)\right) Pr\left(\{\dddot{Z}\}\right). \tag{15}$$

To clarify the formal relationships is one thing, to find the right behavioral link between the information and the action function is quite another. This is the next analytical step.

4 Price taking and price setting in the product market

The sales ratio is defined as:

$$\rho_X \equiv \frac{X}{O}. \tag{16}$$

A sales ratio $\rho_X = 1$ indicates that the quantity sold X and the quantity produced O are equal or, in other words, that the product market is cleared.

The expenditure ratio is defined as:

$$\rho_E \equiv \frac{C}{Y}. \tag{17}$$

An expenditure ratio $\rho_E = 1$ indicates that consumption expenditures C are equal to total income Y, in other words, that the household sector's budget is balanced.

From (3) and the other axioms and the definitions follows the price as dependent variable:

$$P = \frac{\rho_E}{\rho_X}\frac{W}{R}\left(1 + \frac{DN}{WL}\right). \tag{18}$$

This is the general structural axiomatic Law of Supply and Demand for the pure consumption economy with one firm (for the generalization see 2014). In brief, the price equation states that the price is equal to the product of the expenditure ratio ρ_E, the inverse of the sales ratio ρ_X, unit wage costs $\frac{W}{R}$, and the distributional factor $1 + \rho_D$. The structural axiomatic price formula is testable in principle and fully replaces supply-function–demand-function–equilibrium.

Conditional price flexibility is, clearly, an algebraic concept. Nothing is assumed about the behavior of the firm. Yet, what is possible, is a behavioral *interpretation*. What (18) then amounts to is price taking.

Under the condition of price setting and budget balancing one gets this switch of directionality:

$$\rho_X = \frac{1}{P}\frac{W}{R}\left(1+\frac{DN}{WL}\right) \quad \text{if} \quad \rho_E = 1. \tag{19}$$

In the simplified case of budget balancing the sales ratio depends on the price setting of the firm, on unit wage costs and the distributional factor. Changes of the wage rate, the productivity, distributed profit, and employment all act in conjunction with the product price upon the sales ratio.

5 Product market clearing by directed price setting

5.1 The stock of products

In the general case markets are not cleared. This has some obvious consequences, the first one is that the firm's stock of hitherto unsold products grows and shrinks in the course of time.

The change of the stock of – durable – products in period t is defined as the excess between output O and the quantity bought X by the households:

$$\Delta\bar{O} \equiv O - X \equiv O\left(1-\rho_X\right). \tag{20}$$

The sales ratio comes from (19).

The stock at the end of an arbitrary number of periods $\bar{t}$ is given by definition as the numerical integral of all previous stock changes plus the initial endowment:

$$\bar{O}_t \equiv \sum_{t=1}^{t} \Delta\bar{O}_t + \bar{O}_0. \tag{21}$$

The resulting interrelation between the sales ratio and the stock is given by

$$\bar{O}_t \equiv \sum_{t=1}^{t} O_t\left(1-\rho_{Xt}\right) \quad \text{if} \quad \bar{O}_0 = 0. \tag{22}$$

Seen from the firm's perspective, the stock at the end of period $\bar{t}$ is either too large, too small, or just right. This depends on the firm's target stock which is denoted by $\bar{O}^{\theta}$. The firm's objective is not to clear the market in the period under consideration, that is, to sell exactly the current output O, but to bring the actual stock as close as possible to the target stock, i.e.,

$$\bar{O}_t - \bar{O}_t^{\theta} \Rightarrow 0. \tag{23}$$

It is assumed that the firm chooses the price as instrument variable in order to adapt the actual stock to the target stock. That is, the price is no longer determined by systemic conditions but set by some agent within the firm. The firm now becomes the price setter.

5.2 Directed price setting

The price setting behavior is formalized by this propensity function:

$$\begin{aligned} (-1,0,1)_t &= sgn\left(sgn\left(\bar{O}_{t-1} - \bar{O}_{t-1}^{\theta}\right)\right) \\ \ddot{P}_t &= (-1,0,1)_t \, Pr\left(0 \leq \ddot{P}_t \leq x\right) \end{aligned} \tag{24}$$

The upper part says that the firm lowers the price if the actual stock is above the target stock and vice versa. The lower part combines the direction of change with a random rate of change. Figure 4 shows how this behavioral assumption plays out in the product market over an observation span of 50 periods.

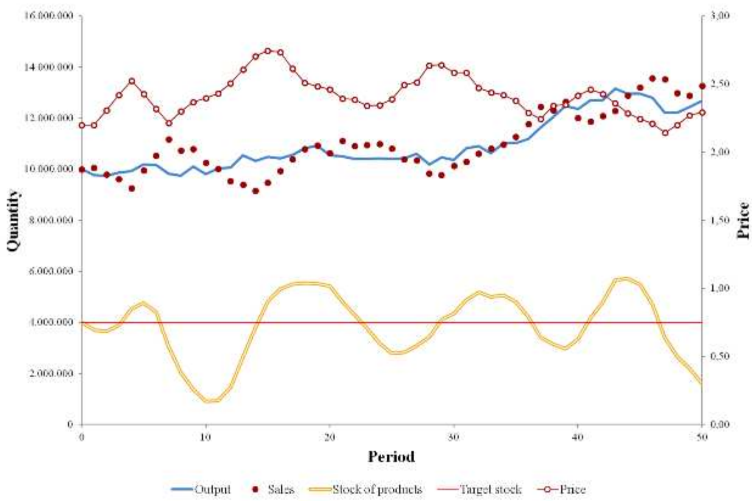

Figure 4: The three dimensional product market: directed price setting in dependence of the deviation $\gtreqless 0$ of the actual stock from the target stock

The independent variables W, R, L, D, N in (19) vary with random rates of change that are symmetrically distributed around zero and thereby produce the random environment. Note in particular that the firm's current output (2), which is different from total supply, is a composed random variable. The paths of real supply O and demand X diverge over the whole time span of observation.

The product market is cleared at the recurring intersections of the inventory curve with the target line, i.e., at $\bar{O}_t - \bar{O}_t^{\theta} = 0$. It can immediately be seen that the price falls if the actual stock is above the target stock and vice versa. Over the whole time span of observation the market is repeatedly cleared and the actual stock keeps reasonably close to the target stock. Whether the price setting functions beyond the span of observation cannot be said and is left open here. While the output path is relatively stable the sales path runs counter to the price movements. It should be obvious that recurring intersections of the inventory curve with the target line cannot be interpreted as equilibrium in the familiar sense. No such thing exists.

Finally, monetary profit is given with:

$$Q_m \equiv PX - WL \tag{25}$$

It is a necessary condition for the functioning of the product market that profit is – more often than not – positive. For the detailed treatment of profit see (2015). In the present context profit is always greater zero and equal to distributed profit.

The propensity function (24) embodies a rather simple behavioral rule. Clearly, it is possible to formulate a more sophisticated rule that reduces the swings of the inventory cycle. For the moment, the simple rule is good enough to make the decisive point, i.e., that the market representation of Figure 4 fully replaces the untenable supply-demand-equilibrium cross.

The content of Figure 4 can be summarized as follows. The price setting co-determines the sales ratio ρ_X which in turn changes the stock of products according to (20). Via the behavioral link (24) there is a feedback from the stock on the price, which quite naturally explains the inventory cycle. Because of the random changes of the independent variables this cycle cannot be completely eliminated because it is impossible for the firm to know the current market clearing price exactly. Market clearing happens, but only transitorily.

5.3 Extensions

In the structural axiomatic context the argument of the information function adopts the role of the first derivative. The formal criterion of a *behavioral optimum* is that the value of the respective information function is *zero*, i.e., economic man/woman has reached his/her target $\mathbb{Z} - \mathbb{Z}^{\theta} = 0$. In this case no further adaptive action results: $\dddot{Z} = 0$. A *general* behavioral optimum is attained if *all* information functions realize in the *same* period the configuration b_2 of Figure 3. In this case the economic system becomes stationary. Stationarity is *different* from simultaneous equilibrium. The latter is a nonentity.

Above, we have applied one propensity function for the price setting of one firm. With successive differentiation of the business sector successively more propensity functions have to be applied. Obviously, there is no hindrance to do that. Moreover, there is also no hindrance to apply propensity functions to all agents individually.

The much discussed question of microfoundations is pointless in the structural axiomatic context because the axiom set refers to one single firm, in other words, the business sector consists initially of one firm. This means that micro and macro fall into one. Starting from the compact business sector only differentiation is possible. Successive differentiation ultimately ends at the individual agent. Hence, there is no such thing as microfoundations, there is structural axiomatization, the propensity function, and successive differentiation. Taken together, this analytical procedure yields a consistent whole down to the individual level and, most important of all, testable theorems. Methodologically, the structural axiomatic approach is the only acceptable game in town.

The determination of the target value involves expectations. This means that target values can change fast and that they are generally more volatile than the actual values. Most important, target values may change simultaneously for a greater number of agents. This explains behavioral instability. For our present purposes, though, it is not necessary to occupy ourselves with the determination of targets, hence they are without further explanation taken as given.

6 Conclusion

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 four non-behavioral axioms as groundwork for the theoretical reconstruction of the evolving monetary economy. To formally capture human behavior the axiom set is complemented by the propensity function.

The propensity function is a compact formal expression of random, semi-random, and deterministic behavioral assumptions (type-A to type-E). Thus, the *structural* axiomatic core and the *behavioral* propensity function constitute the building blocks of every structural axiomatic model.

The propensity function is the general formal expression of the intentionality of human action. It does not demand any sophisticated calculations from the agent.

Economic man/woman is formally portrayed as a bundle of propensity functions. The propensity function contains the information and the action function. The information function refers to the difference between the agent's actual and desired state. The agent's course of action results from the behavioral link between the output of the information function and the output of the action function.

The information function as a constituent of the propensity function takes the role of the first derivative; a value of zero indicates in the axiomatic context a behavioral optimum. A general behavioral optimum is logically possible.

The directedness that originates from the information and action function produces stochastic stability and optimality out of randomness and keeps the economy within viable boundaries for a reasonable time span. Two type-C propensity functions – one for the business sector and one for the household sector – are sufficient to clear the product market at different points in time. This structural axiomatic account of market coordination precludes the fictitious notion of a simultaneous equilibrium.

The propensity function works with all roughly quantifiable targets in all possible economic worlds – it is truly general.

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