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Methodological Individualism and the Walrasian Tâtonnement

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Abstract. This paper proposes a tâtonnement story for Walrasian systems that explains price determination in perfectly competitive markets with respect to the behavior of individual agents whose objective is improvement in their levels of utility. Agent-level, price-adjustment rules consistent with the story lead to uniqueness and global stability of competitive equilibria under well-known, but highly restrictive, conditions. In spite of the latter restrictiveness, it is argued that this is still sufficient to establish the usefulness and explanatory viability of the Walrasian system, as well as its consistency with methodological individualism.

Key Words: Methodological individualism; Walrasian systems; the Walrasian tâtonnement.

The Walrasian model articulates a vision that underlies the way in which many of today's economists think about the economy. In one of its more common forms, the fully developed Walrasian or general-equilibrium model consists of a dynamic mathematical system whose equations characterize, at each moment, the behavior of consumers, the behavior of firms, and the operation of markets. Consumer and firm behaviors emerge from, respectively, utility maximization subject to budget constraints, and profit maximization subject to technological production possibilities. For each vector of equilibrium and nonequilibrium price values announced by an auctioneer, the unique solutions of the relevant demand-side and supply-side equations of the model at a moment on the model's time-clock (assuming such solutions exist) represent the result of the simultaneous interaction of

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the consumers, firms, and markets at that moment in light of the endowments and the history of the interactions of previous moments already determined by the model. A collection of these solutions starting with a fixed initial endowment and generated by changing prices is called a time path. A time path along which there is neither change in economic behavior by any consumer or firm, nor change in economic value in any market, is an equilibrium path. The unchanging variable values along an equilibrium path are often referred to as just an “equilibrium”. Sufficient assumptions are usually imposed in the Walrasian model to insure a unique equilibrium exists that is globally stable. An additional property of this equilibrium is that all markets clear; thus it can be said that markets operate so as, at least eventually, to equilibrate demand and supply. And the dynamic market-price-adjustment mechanism generating the model’s time paths is often taken to be a tâtonnement in that trade takes place only after market-clearing equilibrium is achieved. Of course, as parameters and other “fixed” elements modify, the equilibrium changes.

Economists have always intended that the Walrasian model, as described here, be encompassed within the tradition of methodological individualism, which generally understands individuals, with given preferences and endowments, and firms, with given technologies, to enter the market process as autonomous entities. Among other things, this tradition imposes certain restrictions on the nature of the model that affect its relation to the reality it purports to explain. But the extent to which the model actually measures up to the standards set by these restrictions, and hence, by implication, its explanatory capability, is still open to doubt. This is because, in the words of Hahn (1987:137), the typical market-price-adjustment rules attributed to the auctioneer are market-level prescriptions and generally do not constitute “…a theory of price formation based on the rational calculations of rational agents.” Moreover, general conditions on individual-agent preferences and technologies guaranteeing the uniqueness and global stability of equilibria under those rules, conditions without which, economists have thought, the model’s ability to explain real phenomenon is seriously impaired, are not known. Thus, the issue is not so much whether the Walrasian model fits a particular collection of observed real-world facts, but rather, whether it is capable of explaining any such facts at all and still remain true to methodological individualism.

In a recent paper, Kirman (1989) has concluded, at least when the model employs a tâtonnement dynamic, that it cannot. His argument, in reference to an exchange economy, is that there is little hope of obtaining conditions that ensure uniqueness and global stability of equilibria from assumptions of “reasonable generality” on individual-agent preferences.

Now part of this argument is implicit in the discussion of Sections I and II below. But the conclusion itself leaves something to be desired because it also rests, in part, on the postulation of standard price-adjustment rules at the aggregate or market level. And, as noted above, these rules are not explicitly expressed in terms of individual agent behavior. Thus the possibility remains that by postulating "individual-agent-" rather than market-price-adjustment rules, and hence returning the Walrasian model to its methodological-individualism roots, Kirman's negative conclusion might be overcome.[2] In addition, even if "reasonably general" uniqueness-and-global-stability conditions on agent preferences are unattainable, it is not clear that the viability and usefulness of the Walrasian model as an explanatory entity is actually threatened. For the well-known special instances in which uniqueness and global stability prevail may be sufficient for all practical purposes. The aim of this paper is to clarify some of these issues for the case of tâtonnement dynamics.

Briefly, the paper begins with a discussion of methodological individualism and its significance for the Walrasian system. It then describes, in the context of an exchange economy, the ways in which many versions of the Walrasian model fail to meet the standards for explanation set by the desire to adhere to methodological individualism, and the kinds of modifications that need to be made to bring those versions in line with methodological individualism. Included at this point is a discussion relating to Kirman's argument, and a presentation of a special-case-assumption on individual-agent preferences from which uniqueness and global stability are known to follow. Next, a simple example of a Walrasian tâtonnement is described in which, consistent with methodological individualism, agent-price-adjustment rules are characterized in terms of "rational calculations of rational agents," and the aforementioned, special-case conditions ensuring uniqueness and stability of global equilibria in an exchange economy continue to apply. Not only, then, does this special-case model fall within the framework of methodological individualism, but it is also viable in so far as its explanatory capability is concerned. Finally it is argued that, as a practical matter, the special-case model's speciality does

[2] One way of overcoming the conclusion for the case of nontâtonnement adjustment rules, which permit trading out of equilibrium, has been suggested by Fisher (1972). Other nontâtonnement methods that might be transferable from the single-market context in which they are developed are surveyed by Hahn (1982:788-791). Still additional approaches located somewhat beyond the confines of the standard Walrasian framework are described by Bénassy (1993).

not stand in the way of its usefulness, whatever that might be, in understanding how the microeconomy operates.

Section I

Before introducing the notion of methodological individualism, it will help to set the frame of reference by considering the metaphysical theory of mechanism that largely directed the development of the physical sciences from the seventeenth to the middle of the nineteenth century. In that theory, the universe is made up of tiny particles, whose existence is unexplained, and which behave according to simple mechanical laws. Every physical thing is understood in terms of the configuration of the particles that make it up, and all physical behavior is a consequence of the basic mechanical laws governing the behavior of the individual particles. Like all metaphysical theories, mechanism is not empirically testable. Any physical phenomenon that does not seem to fit into the mechanism mold can be attributed to an inability to come up with an appropriate mechanical model rather than to a mistaken approach to reality. But while mechanism is therefore compatible with any and all collections of observations that might come along, it is not consistent with all models of the physical world. For example, to think of light only in terms of waves is to abandon mechanism in favor of another metaphysical theory. Thus the adoption of mechanism as a world view restricts the kinds of models that are acceptable for understanding and explaining reality (e.g., Watkins 1968: 270).

Of course, social science is quite different from mechanistic physical science. It deals with thinking, feeling, reacting, and evolving human beings-not inert and changeless particles. Nevertheless, from the perspective of the social sciences, methodological individualism is a meta-theory quite analogous to mechanism. According to this meta-theory, society is made up of individual agents, whose existence is unexplained, and whose behavior conforms to laws in a manner that can be said to have been guided, approximately, by the agent's "dispositions" and their "understandings" of their own situations. Every social thing is understood in terms of the configuration of the agents that make it up, and all social behavior is a consequence of the basic behavior of its constituent agents, and the interactive effects of that behavior. Methodological individualism, too, is not empirically testable. Any social phenomenon that does not seem to fit into its mold can be attributed to an inability to come up with an appropriate model rather than to a mistaken approach to reality. And while methodological individualism is therefore compatible with any and all collections of observations that might come along, it is not consistent with all models of the social world (Watkins 1968: 270-271).

It should be emphasized that methodological individualism is made up of two components: first that macro or group objects and concepts are composed of individual (agent) objects and concepts, and second that macro behavior is derived from or determined by individual (agent) behavior. As the phrase is construed here, methodological individualism includes both, and not just one or the other, of these elements (c.f., Brodbeck 1968: 286, and Sensat 1988: 190-194).

Although the idea of methodological individualism dates at least to Epicurus (Stroizer 1985: 117-118) and, in its physical-world manifestation, was employed as the basis for mechanism by Descartes in his *Discourse* of 1637,[3] its explicit introduction into economics was probably due to Menger. In the Preface to the first edition (1871) of his *Principles (Grundsätze)*, Menger (1981:46-47) wrote, "… I have endeavored to reduce the complex phenomena of human economic activity to the simplest elements that can still be subjected to accurate observation, ... and... to investigate the manner in which the more complex economic phenomena evolve from their elements according to definite principles." Evidently, Menger felt rather strongly that this was the only method for conducting economic inquiry (c.f., Menger 1985: 93-94). Hayek (1949: 6), moreover, took virtually the same position some 75 years later: "... there is no other way toward an understanding of social phenomena but through our understanding of individual actions..." And this perspective, accepted with the same fervor of Menger and Hayek, seems to be shared by most economists today. It implies, in the final analysis, that the private economy can only be understood and explained in terms of consumers and firms; aggregate concepts, including the notion of "the economy" itself, have no independent existence or meaning apart from them.

Of course, from time to time, there appear to have been temporary "lapses" from the perspective of methodological individualism. The development of macroeconomics during the middle of the twentieth century, that is, the Keynesian Revolution through the Neoclassical Synthesis can be interpreted in this way (Blaug 1976: 161)**.** But the more recent search for micro foundations of macroeconomics reveals a yearning for methodological individualism that carries over into the macroeconomic arena. Indeed,

[3] For example, Burtt (1932: 103), and Levins and Lewontin (1985: 1-2). The notion of mechanism goes back beyond even Epicurus. See Strodack (1963: 3-4).

evidence suggests that economists never really gave up methodological individualism even throughout their mid-century focus on macroeconomic problems (Hoover 1988: 3). There always seems to have been the feeling that, in light of the possibilities of aggregation, the whole should somehow equal the sum of its parts (e.g., Samuelson 1980: 356). Moreover, with little progress made by 1967 in uncovering suitable micro foundations, Arrow referred to the persisting gap between microeconomics and macroeconomics as a "major scandal" (1967: 734). In any event, it is widely thought that the economics of the Keynesian Revolution and the Neoclassical Synthesis is in rapid decline today due, in part, to the inability to come up with appropriate micro foundations (Hoover 1988: 3,4).

Adherence to the tradition of methodological individualism has an important bearing on the nature of the Walrasian model and on its relation to the real economic world it is attempting to explain.[4] To describe that latter relation, it is first necessary to consider the idea of a "model." A model of something—call the thing T— is a construct having enough in common with the observable facets of T that insight into T can be obtained by studying the construct. Albert Einstein and Leopold Infeld (1938: 33) gave the following illustration for physical models: Imagine you are presented with a watch and asked to explain how it works, but are not allowed to remove its cover. One way to proceed is to obtain appropriate springs, gears, and what not, and build a "model" of the watch whose behavior duplicates the observed behavior of the original. You could then give an explanation of how your model behaves, and say that the original watch works analogously to, or as if it were, your model. Clearly, there are many different models, and hence explanations, that could be built. But all explanations function by identifying something in the model (in the example, the movement of the model's "hands") with what is observed (the movement of the hands on the original watch). In economics, of course, models are usually not physical things. Rather they are mental constructs based on assumptions, concepts, and relations among variables. They also abstract from a multitude of possible forces to concentrate on the minimum number necessary for explanation, and their properties are their own and not properties of that which is the object of explanation. Nevertheless, they function in much the same way as in the Einstein-Infeld example.

[4] Evidently, the perfectly competitive atomism underlying the Walrasian system is sufficient for methodological individualism, but not necessary. For models with imperfectly competitive markets and government institutions can be consistent with methodological individualism too.

The Walrasian model is properly understood in these terms. It primarily focuses on the notion of equilibrium and is built up by making assumptions about the preferences, endowments, technologies, and behaviors of individual agents, i.e., consumers and firms. Its purpose is to explain and clarify the observed, simultaneous, interacting behavior of real agents in the economy. To achieve this purpose requires, among other things, that an investigation of the questions of existence, uniqueness, and global stability of equilibria in the model be successfully undertaken. An easy way to comprehend the urgency of such an inquiry is to focus attention on a single, real-world market in isolation. Suppose one were to observe that market at a particular moment of time. In that case, one could see that so much of the market's commodity was traded at such-and-such a price or, in other words, one would observe a single point in commodity-price space. Subsequent observation at a later moment would yield a second point. In building a model to explain how these points came to be seen, the economist could, for example, assume (i) that there exist two distinct market demand curves each passing through one, but not the same, observed point, and (ii) that there exists only one market supply curve passing through them both.[5] Then, since each observed point is identified as a market equilibrium point in the model,[6] each could be explained as analogous to, or as if it were, the outcome of the interaction of supply and demand. The economist could also assert that the movement from the first point to the second occurred because of a "shift" in demand. Clearly, equilibrium must exist in the model for this explanation to work. If, moreover, the equilibrium in the model were not unique, then the explanation would be incomplete; it would allow the observed point to be identified with many equilibria, each with its own properties, and thus the reason for the movement between the two points would become clouded. Lastly, when the observed point changes from the old to the new, the equilibrium in the model would have to adjust accordingly. But if the latter equilibrium were not globally stable, then whatever dynamics there were in the model could prevent the new equilibrium from being reached and, in that circumstance, the explanation given for the observed movement from the one point to the other would

[5] These two assumptions lie in the tradition of methodological individualism because market demand and supply curves are built up from individual demand and supply curves.

[6] Note that demand curves, supply curves, and equilibrium points cannot exist in reality. They can only be present in models. Similarly, to prove that equilibrium exists and is unique and stable in a model can never imply that unique and stable equilibria exist in the real world.

break down. An alternative interpretation of reality would be to locate observed points along time-paths that converge to equilibria in the model rather that to identify them specifically as those equilibria. But in either case the questions of existence, uniqueness, and global stability have to be explored because that is the only way to be sure that the model can be linked to the real world.

A similar argument applies to the full Walrasian model with many goods, consumers, and firms. Furthermore, to be consistent with the tenets of methodological individualism, the assumptions from which the existence of unique and globally stable equilibria are to be deduced have to be imposed at the level of individual agents. The problem is that, although the existence issue has been satisfactorily resolved in this way, the dynamic adjustment rules defining the operation of markets, along with the sufficient conditions ensuring uniqueness and global stability, have tended to be expressed, as described in the next section, in terms of market excess demand functions rather than with respect to individual preferences, technologies, and behaviors. Thus the distance it is possible to go in explaining and understanding economic reality in terms of a Walrasian model that is faithful to the tradition of methodological individualism in economics has remained an open question. And this is so without even questioning the realism of assumptions and the relevance of conclusions derived from them.

Before examining these issues in greater detail, it is worth pointing out that the Walrasian system is meant to explain the determination of prices and the allocation of resources at a particular moment of time or across relatively brief time periods. Describing the evolution of the economy over long periods of time is not within its purview. It follows that those elements of the economic world that modify very slowly, and require great expanses of time to do so, may be taken as part of the fixed background within which Walrasian models are constructed. Apart from preferences and technologies, the most important of these elements for present purposes is the institution of the market. Thus the attempt to construct explanations of market behavior in terms of the behavior of individual agents, that is, the search, at the level of the individual agent, for a definition of the operation of markets and for uniqueness and global stability conditions, must necessarily take place within a given institutional, market framework. The possibility that market institutions themselves might have been built up in the past as a consequence of agent behavior is relevant for the theory of the development of markets (see, for example, Schotter 1981)-not for the characterization and analysis of Walrasian models.

Section II

Consider, first, the prospect of inferring uniqueness and global stability from the assumptions imposed in a typical Walrasian model. To simplify matters, only models of exchange economies are examined. In particular, attention is confined to a situation with I > 1 goods, i = 1,..., I, and K > 0 persons, k = 1,..., K, in which

x_{ik} -- consumption quantity of good i by person k,

x_{ik}^0 -- person k's initial endowment of good i,

$x_k = (x_{1k},..., x_{Ik})$, $\mathrm{x}_{\mathrm{k}}^0 = (x_{1k}^0,..., x_{Ik}^0)$,

$q_{ik} = x_{ik} - x_{ik}^0$ -- excess demand quantity of good i by person k,

$q_k = (q_{1k},..., q_{Ik})$,

p_i -- price of good i,

$p = (p_1,..., p_I)$,

$q_{ik} = E^{ik}(p)$ -- excess demand function for good i of person k,

$x_i = \sum_k x_{ik}$ -- market quantity of good i,

$q_i = \sum_k q_{ik}$ -- market excess demand quantity of good i,

$q_i = E^i(p) = \sum_k E^{ik}(p)$ -- market excess demand function for good i,

$q = (q_1,..., q_I)$,

$q = E(p) = (E^1(p),..., E^I(p))$,

where the E^{ik} and E^{i} are defined on $\{p : p > 0\}$. Take the E^{ik} to be derived from constrained utility maximization in the usual way, and let prices be normalized according to

(1) $$\sum_{i=1}^{I} p_i = 1.$$

It is convenient to assume $x_k^0 > 0$, for k = 1,..., K. Equilibrium in this model is known to exist as long as all utility functions are suitably continuous, increasing, and strictly quasi-concave.

Now the dynamic price-adjustment rule defining the operation of markets in a Walrasian model of this sort is often taken to be

(2) $$\frac{dp}{d\tau} = \theta\, E(p),$$

where τ represents (continuous) time, and $\theta \neq 0$ is a scalar constant. Evidently, (2) is actually a special case of the more general formulation

$$\frac{dp}{d\tau} = F(p, \tau),$$

for some function F, and is not really consistent with methodological individualism. The inconsistency arises in that (2) constitutes a specification of aggregate (market), rather than individual, behavior. Koopmans (1957: 179) put it this way: "If,... [in accordance with (2)], the net rate of increase in price is assumed to be proportional to the excess of demand over supply, whose behavior is thereby expressed? And how is that behavior motivated?" The standard interpretation of (2) is that it characterizes the activity of a market-level auctioneer. In particular, it is assumed to indicate the information that that auctioneer has, namely, the aggregate excess demand quantities in every market at each positive price vector, and how he responds to that information when making price adjustments. No justification is provided for this response in terms of the rationality of individual agents. (A more complete statement of the auctioneer's activities is provided at the start of the next section.) In spite of its non-methodological-individualism orientation, however, (2) is still employed, primarily for pedagogical reasons, as the basis for discussion in the remainder of this section. Later on, price-adjustment rules at the individual-agent level that fit into the framework of methodological individualism will be introduced. These latter rules will reflect the idea that individual agents are seeking to improve their situations or levels of utility.

Regardless, when derived, as they are, from utility maximization subject to budget constraints, in which the utility functions are appropriately continuous, increasing, and strictly quasi concave, the functions E^{ik} and E^{i} turn out to be continuous, homogeneous of degree zero, and satisfy, respectively, the budget equations

$$\sum_{i=1}^{I} p_i E^{ik}(p) = 0\,, \qquad k = 1,\dots,K\,, \tag{3}$$

and Walras' law

$$\sum_{i=1}^{I} p_i E^{i}(p) = 0\,,$$

throughout their domains. Because it is known that, as a consequence of constrained utility maximization, the E^{ik} possess still further properties (such as the analogue of Slutsky negative definiteness and symmetry of ordinary demand functions), one might ask if any of these additional properties carry over to, or impose other restrictions on, the E^{i}. That is, when the E^{i} are an outgrowth of the constrained maximization of individual utility functions, do they necessarily, by dint of those maximizations, exhibit characteristics beyond continuity, homogeneity, and Walras' law that apply generally, regardless of the particular utility functions involved? Sonnenschein (1972, 1973), Mantel (1974), and Debreu (1974) have given answers to this question. Before stating Debreu's result, which is the strongest, it is convenient to provide two definitions:

First, the function $E(p)$ is said to be *generated on D* in a model of an exchange economy with K agents, whenever there exist K initial endowment vectors x_k^0 and K corresponding continuous, increasing, and strictly quasi-concave utility functions whose constrained maximization leads, via the summing of individual agent excess demand functions, to $E(p)$, for all p in D. And second, for any real number $\varepsilon > 0$, set

$$D_\varepsilon = \left\{ p = (p_1,\dots,p_I) : p_i \geq \varepsilon \quad \text{where } i = 1,\dots I \right\}.$$

Debreu's proposition is stated without proof as follows:

Theorem 1. Let $E(p)$ be continuous, homogeneous of degree zero, and satisfy Walras' law on $\{p : p > 0\}$.Then for any $\varepsilon > 0$, $E(p)$ is generated on D_ε in a model of an exchange economy with $K = I$ agents.

The important implication of Debreu's theorem for the present argument[7] is derived from its statement that, loosely speaking, constrained utility maximization by all individuals does not, at least in the typical model of an exchange economy, generally imply anything at all about market excess demand functions beyond the already-established properties of continuity, homogeneity, and Walras' law. To obtain further restrictions on market excess demand functions would therefore require the imposition of additional postulates like, for example, the supposition that individual utility functions take on special forms. Moreover, the uniqueness and global stability of equilibria in Walrasian models of exchange economies turn on the presence of certain kinds of such further restrictions. Given the information possessed by the auctioneer, then, it follows that without the additional postulates, exchange models do not have sufficient assumption content to permit the derivation of propositions that concern uniqueness and global stability. Uniqueness and global-stability analyses, then, can only proceed by adding extra hypotheses. And to be consistent with the imperatives of methodological individualism, these extra assumptions have to be imposed at the level of the individual agent.

One well-known exemplification of such extra hypotheses in exchange models is the requirement that all agent utility functions assume a Cobb-Douglas form. Although rather restrictive, it is worth pausing for a moment to examine this case in more detail. Good i is said to be a *gross substitute* with respect to good n, $i \neq n$, provided that the partial derivative of E^i with respect to the n^{th} price, written $E^i_n(p)$, is positive, for all $p > 0$. Using normalization (1), let

$$\hat{D} = \left\{ p : p > 0 \text{ and } \sum_{i=1}^{I} p_i = 1 \right\} .$$

Assume that an equilibrium, $\overline{p} > 0$, exists in $\hat{D}$. The basic propositions relating to uniqueness and global stability on which the present illustration rests are listed below without proof:[8]

Theorem 2. If all pairs of distinct goods are gross substitutes, then

[7] The Sonnenschein and Mantel theorems alluded to, but not stated above, carry a similar implication.

[8] The proof of Theorem 3 is trivial. Although the original proof of Theorem 2 was given by Arrow and Hurwicz (1960), a more streamlined version appears in Hahn (1982: 765). A proof of Theorem 4 may be found in Katzner (1988: 287-288).

(4) $$\sum_{i=1}^{I} \overline{p}_i E^i(p) > 0$$

for all $p > 0$ such that $p \neq \zeta\ \overline{p}$ with any $\zeta > 0$.

Theorem 3. If (4) holds for all $p > 0$ such that $p \neq \zeta\ \overline{p}$ with any $\zeta > 0$, then the equilibrium price vector $\overline{p}$ is unique in $\hat{D}$.

Theorem 4. Let $\overline{p}$ be a unique equilibrium price vector in $\hat{D}$ and suppose the dynamic price-adjustment rule defining the operation of markets is given by (2). If $\theta > 0$ and (4) holds for all $p > 0$ such that $p \neq \zeta\ \overline{p}$ with any $\zeta > 0$, then $\overline{p}$ is a globally stable equilibrium in $\hat{D}$.

It remains to relate the Cobb-Douglas form for utility functions to the property of gross substitutes. Towards this end, write the utility function of agent k as

$$\mu_k = u^k(x_k),$$

where μ_k varies over the range of u^k. Denote the first-order, partial derivatives of u^k by u_i^k, for i = 1,..., I. For notational convenience, the following proposition employs the (equivalent) logarithmic version of the Cobb-Douglas configuration.

Theorem 5. Let utility functions be of the form

(5) $$\mu_k = u^k(x_k) = \sum_{i=1}^{I} \alpha_i^k \log x_{ik}\ , \qquad \text{k=1,…,K,}$$

where the α_i^k are constants such that $\sum_i \alpha_i^k = 1$, and $\alpha_i^k > 0$, for i = 1,..., I and k = 1,...,K. Assume $\mathrm{x}_\mathrm{k}^0 = (x_{1k}^0, ..., x_{Ik}^0) > 0$, for each k. Then all pairs of distinct goods are gross substitutes.[9]

Proof:

The first-order conditions for constrained maximization of the u^k are

[9] More general necessary and sufficient conditions for all pairs of distinct goods to be gross substitutes at the level of the individual agent have been given by Fisher (1972a). His results, then, could be used as the basis for slight generalizations of this theorem.

(6) $$\frac{u_i^k(x_k)}{u_n^k(x_k)} = \frac{\alpha_i^k}{\alpha_n^k}\frac{x_{nk}}{x_{ik}} = \frac{p_i}{p_n}, \qquad i, n = 1, \ldots, I, \qquad i \neq n$$

Combining these equations with the budget constraints $m_k = p.x_k$, where m_k is the "income" or the value of initial endowment of person *k* at prices *p*, and the dot $"\cdot"$ denotes inner product, gives the individual demand functions h^{ik} such that

$$x_{ik} = h^{ik}(p, m_k) = \alpha_i^k \frac{m_k}{p_i} \qquad \begin{matrix} i = 1, \ldots, I, \\ k = 1, \ldots, K. \end{matrix}$$

Since $m_k = p.x_k^0$ and $q_{ik} = x_{ik} - x_{ik}^0$ for each *i* and *k*, the excess demand functions of person *k* are

$$q_{ik} = E^{ik}(p) = \alpha_i^k \frac{p.x_k^0}{p_i} - x_{ik}^0,$$

$$= \left[\alpha_i^k - 1\right] x_{ik}^0 + \sum_{n \neq 1} \alpha_i^k \frac{p_n}{p_i} x_{nk}^0,$$

for $i = 1, \ldots, I.$ and $k = 1, \ldots, K.$ Summing over *k* yields the market excess demand functions

(7) $$q_i = E^i(p) = \sum_{k=1}^{K} \left[\alpha_i^k - 1\right] x_{ik}^0 + \frac{1}{p_i} \sum_{n \neq i} p_n \left[\sum_{k=1}^{K} \alpha_i^k x_{nk}^0\right],$$

for $i = 1, \ldots, I.$ Therefore, since $x_{ik}^0 > 0$ for all *i* and *k*, partially differentiating (7) with respect to p_n for every $n \neq i$ gives, for all $p > 0$ and all *i* and *n* such that $i \neq n$,

(8) $$E_n^i(p) = \frac{1}{p_i}\left[\sum_{k=1}^{K} \alpha_i^k x_{nk}^0\right] > 0,$$

which proves the theorem.

Q. E. D.

Note that, as one would expect, and with $x_{nk}^{0} > 0$ for all *n* and *k*, partial differentiation of (7) with respect to p_i results in

$$E_i^i(p) = -\frac{1}{(p_i)^2}\sum_{n \neq i} p_n \left[\sum_{k=1}^{K} \alpha_i^k x_{nk}^0\right] < 0, \tag{9}$$

for $i = 1,..., I$, and all $p > 0$. In any case, the combination of Theorems 2-5 clearly shows that the assumption of Cobb-Douglas utility functions, which constitute extra hypotheses on agent preferences that are consistent with the tenets of methodological individualism, are sufficient for the uniqueness and global stability of equilibrium in a world of exchange:

Theorem 6. Consider a model of an exchange economy in which initial endowment vectors are positive, utility functions are suitably continuous, increasing, and strictly quasi-concave, and, hence, in which an equilibrium price vector exists. Assume this economy has a market-level auctioneer whose information consists of the function E(p), and who adjusts market prices according to (2). If, in addition, all utility functions are of the form of (5), then equilibrium is also unique and globally stable.

Of course, Theorem 6 rules out any possibility of complementarity among goods and prohibits individual utility functions from modifying as adjustment to equilibrium takes place.

It should also be observed that the assumption of Cobb-Douglas utility functions (5) reduces the Walrasian model to a highly specialized case. And if this were the only way to obtain uniqueness and global stability, it might be argued, then the usefulness of the Walrasian model in studies that adhere to methodological individualism would be doubtful. Apart from the challenge to this argument given at the end of the next section, the question of whether there are other conditions on agent utility functions and initial endowments sufficient for uniqueness and global stability, or other conditions relating to market-level adjustment rules other than (2), is largely unresolved. Such questions, however, are not pursued further here. In addition, and as was pointed out earlier, the use of (2) itself removes the Walrasian model from lying within the boundaries dictated by the requisites of the methodological-individualism tradition. Subsequent discussion, then, considers the possibility of adjustment rules that bring the Walrasian exchange model back into the realm of methodological individualism.

Section III

The typical story that goes with dynamic adjustment rules like (2) describes the Walrasian tâtonnement in terms of the market-level auctioneer mentioned earlier. According to that story, the auctioneer announces a vector of prices, maximizing agents (who are price takers) respond with statements of their excess demand quantities which are then summed, and if market excess demand vanishes everywhere, the stated trades are then consummated. Otherwise, the auctioneer announces a new vector of prices as dictated by the adjustment rule, and the process continues. Only when zero excess demand in all markets is achieved, is trade permitted to take place. Of course, the auctioneer of this story is neither a consuming nor a producing agent in the economy. He is, rather, a fictitious being whose sole purpose is to guide the operation of the markets and, as such, is part of the given institutional structure that characterizes the markets themselves. And since the activities of the auctioneer reflect price behavior that is not explainable in terms of the actions or decisions of individual agents, like equation (2) that the story accompanies, the auctioneer is also inconsistent with methodological individualism.

Moreover, the auctioneer story and the adjustment rules that are associated with it may not describe the kind of market organization and operation that Walras actually had in mind. According to Walker (1990: 1721), Walras never mentioned an auctioneer. Rather, in full confluence with methodological individualism, he told an alternative story in which "buyers and sellers or their agents... cry out prices and change them up or down when they discover that they cannot buy or sell all they wish."[10] In any case, it is reasonable and appropriate to ask about the possibility of introducing stories and adjustment rules for a Walrasian tâtonnement that do not rely on the standard auctioneer or something similar, and are more faithful to the tradition of methodological individualism. The remainder of the present paper provides a simple illustration, in line with the above quotation, of how this might be done.

The story describing the operation of markets to be developed is based on the idea that individual agents, although retaining their price-taking characteristics, are the ones who (simultaneously) cry out prices and, as before, trade is not permitted until equilibrium is achieved. Each agent, then, announces his own vector of suggested market prices to all other market participants. The latter respond as price takers by stating their desired excess

[10] Walker (1990: 1721). This is consistent with Walras' own description (1954: 83-86). But it should be noted that, at one point in the passage cited here (p. 83), Walras does explicitly employ the term "auction," thus suggesting, if Walker's interpretation is accepted, the concept of an "auction without an auctioneer."

demand quantities, derived from appropriate maximization, at those prices. In this way, each agent answers the price announcements of all other agents. Even though it has been assumed that all agents make price announcements simultaneously, it may turn out in practice that agents make announcements sequentially. In such a case, the order in which agents take turns in making those announcements could influence individual expectations of future price-vector announcements. But although different orders might then result in different sequences of announced price vectors and different sequences of initial-endowment evaluations, and might also affect the time it takes for equilibrium to be achieved, the implicit assumption (carried over from the previous section) that utility functions remain fixed ensures, as long as a unique and globally stable equilibrium exists, that the end result will be independent of the particular order actually in play. This is because prices will end up at their equilibrium levels anyway, and trade will not take place until they do. For the same reasons, the initial price announcement of each agent does not matter either.

Continuing with the development of the story, return to the point at which each agent has responded to the simultaneous price-vector announcements of all other agents. Consider a representative agent participating in this process. Were trade actually to take place at the prices announced by that agent, the agents who responded to the price announcement would consummate their trades first, and the agent making that announcement would accept the residue of remaining demand and supply of each commodity. But if the announced prices were not equilibrium prices, then the announcing agent would find that he is unable to buy and sell what he wants at those prices. Since the announcing agent can deduce this without the occurrence of trade from the statement of excess demands by the individuals responding to his price-vector announcement, on the next round of announcements he changes his suggested price vector according to an agent-specific adjustment rule. This rule, though generally different for different agents, always reflects the following: When the agent is unable to buy as much as he would like of a particular good at the price he has announced, he raises his announced price; when he cannot sell as much as he would like, he lowers it. When the agent is able to buy more than he would like of a particular good at the price he has announced, he lowers his announced price; when he can sell more than he would like, he raises it. Proceeding in such a manner, the agent continues to modify his suggested price vector on succeeding rounds until it coincides with the market equilibrium price vector or, in other words, the price vector at which the residual the announcing agent would be required to accept is identical to that which he wants. With all agents doing the same thing, and with equilibrium unique, change would cease everywhere when all participating individuals arrive at the same equilibrium vector. At that point, since no agent would announce a new price, all agents would know that equilibrium has been reached, and trade would take place.[11] Henceforth, to distinguish it from the auctioneer story described earlier, this story will be referred to as the "agent-price-adjustment story."

It is evident that every agent in the agent-price-adjustment story is, at the same time, both a price taker and his own "auctioneer," and that price-adjustment rules accompanying the story are necessarily postulated at the individual level. Although related to maximizing behavior in a manner to be subsequently indicated, these adjustment rules as such are not objects of choice derivable from agent preferences and maximization per se. Instead they emerge independently, in the same way as agent preferences and maximization, from current dispositions and understandings developed in light of a long evolution of historical experiences, and, again like agent preferences and maximization, are taken as given at the start of the analysis. Indeed, for present purposes, such price-adjustment rules along with agent maximization are lumped together in what might be regarded as an expanded "postulate of rationality," and the behavior the adjustment rules describe is considered as part of the "rational calculations of rational agents." In any case, the hypothesizing of price-adjustment rules like these clearly falls within the framework of methodological individualism.

It is additionally evident that in the agent-price-adjustment story markets retain their perfectly-competitive character with zero transactions and information-gathering costs. But the informational requirements for price adjustment to proceed are clearly greater than those of the standard, market-level, auctioneer story in that many more messages have to be sent than when there is only a single auctioneer. This is because each auctioneer makes his own price announcements and gathers his own responses to them. If, however, only a single agent played the role of auctioneer as described in footnote 11 above, then the informational requirements would reduce to those of the market-level auctioneer case.

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[11] If there were a mechanism, such as a random draw, to determine which agent would be ***the*** price announcer, then it would not be necessary to require that all agents announce suggested prices. Price announcements by the designated price announcer would suffice. In addition, the process of convergence could be shortened by having the first agent to reach the equilibrium price vector identify it as the equilibrium price vector for everyone. Since the other agents know that this is where they will end up, they immediately move to it.

Pursuing the characteristics and implications of the agent-price-adjustment story still further, and continuing to focus attention exclusively on the world of exchange, consider, for a moment, agent k. Set

$$\tilde{q}_k = E^k(\tilde{p}^k)$$

and

$$\hat{q}_k = \sum_{\kappa \neq k} E^{\kappa}(\tilde{p}^k),$$

where $\tilde{q}_k \neq -\hat{q}_k$, $E^{\kappa}(\tilde{p}^k) = (E^{1\kappa}(\tilde{p}^k),..., E^{I\kappa}(\tilde{p}^k))$, and

$\tilde{p}^k = (\tilde{p}_{1k},..., \tilde{p}_{Ik}) > 0$ is a specific price vector announced by agent *k*. On the one hand, $\tilde{q}_k$ is the desired excess demand vector of *k* at prices $\tilde{p}^k$ and, as such, satisfies his budget constraint $\tilde{p}^k.\tilde{q}_k = 0$ where, recall, the dot denotes inner product. On the other, $\hat{q}_k$ is the vector presented to *k* by the markets at prices $\tilde{p}_k$ and, therefore, $-\hat{q}_k$ is the vector that *k* would have to accept if trade took place at $\tilde{p}_k$. Since each $E^{\kappa}(p)$ satisfies a budget constraint like (3) for all $p > 0$, it follows that

$$\tilde{p}^k.[-\tilde{q}_k] = -\sum_{\kappa \neq k} \tilde{p}^k.E^{\kappa}(\tilde{p}^k) = 0.$$

Hence, although $-\hat{q}_k$ might reach beyond the limits of agent *k*'s initial endowment (i.e., might require k to sell more than he has of particular goods), it nevertheless also satisfies his budget constraint. Were agent *k*'s utility function defined at $\hat{x}_k = -\hat{q}_k + x_k^0$, then, it would be necessary that

$$u^k(\tilde{x}_k) > u^k(\hat{x}_k),$$

where $\tilde{x}_k = \tilde{q}_k + x_k^0$. Now the agent-price-adjustment mechanism essentially requires that agent k raise his announced prices of goods for which, at $\tilde{p}^k$, market excess demand in $\tilde{q}_k + \hat{q}_k$ is positive (quantity demanded is greater than quantity supplied), and lower his announced prices for those goods such that market excess demand is negative (quantity demanded is less than quantity supplied). To the extent that these two kinds of price changes call forth, respectively, (i) increases in supply where k is a buyer and decreases in demand where k is a seller, and (ii) increases in demand where k is a seller and decreases in supply where k is a buyer, agent k, as will be illustrated momentarily, has reason to hope that the components of $\hat{q}_k$ will be altered in such a manner as to raise his utility from $u(\hat{x}_k)$. In this sense, the agent-price-adjustment rule is grounded in the individual's efforts to increase his utility, and the "theory of price determination" associated with it arises from the pursuit of self-interest in the same way as the individual's decisions concerning quantities of goods to buy and sell.

Figure 1 illustrates, in a two-good case, why agent *k* has reason to hope that the price adjustment described above might increase his utility. In that diagram it is assumed that at his initially announced price vector (reflected by the solid budget line through the initial endowment x_k^0), *k*'s constrained utility-maximizing position is at $\tilde{x}_k$ on the indifference curve labeled 1. Suppose the quantity vector he would have to accept from the markets at these prices is $\hat{x}_k'$ on indifference curve 2. Then the market excess demand for good *i*, or the difference $(\tilde{x}_{ik} - \hat{x}_{ik}')$ between the amount *k* desires and the amount market *i* wants him to take at his initially announced prices, is positive when $i = 1$ and negative when $i = 2$. Since agent *k* wishes to be a buyer of good 1 and a seller of good 2, and since, at $\hat{x}_k'$, he would neither be buying the former nor selling the latter, by raising his announced price for good 1 and lowering that of good 2 (to achieve, say, the steeper, dashed budget line through x_k^0 in Figure 1), he can hope that the markets will change what they want from him to a point such as A (which could also lie on the other side of x_k^0 in the diagram) where he would be buying (or at least selling less of) good 1, selling (or at least buying less of) good 2, and increasing his utility from $u(\hat{x}_k')$. However, even if the markets were to take him to a point like B, where he would be selling less (or possibly even more) of good 1 but buying more of good 2, his utility would still be higher than $u(\hat{x}_k')$. Of course, A or B may or may not be utility maximizing for *k* and, hence, may or may not represent the equilibrium. And whether he can actually arrive at intermediate or equilibrium points like A or B depends on how the remaining market participants react to his new price announcement. But in any case, agent *k* will always proceed with the new price announcement because, since trade takes place only after equilibrium is reached, he knows he will wind up at a point that is at least as good as x_k^0 where he started. Similarly, if agent k were required, on the basis of his initial price announcement, to accept a vector of quantities on the other side of $\tilde{x}_k$, for example $\hat{x}''_k$ in Figure 1, he would, according to the agent-price-adjustment rule, lower his announced price of good 1 and raise his announced price of good 2 (to produce the flatter, dashed budget line through x_k^0), hoping to obtain points such as C or D, which also increase his utility, this time from $u(\hat{x}''_k)$.

Actually, in the two-good case, it is not hard to show that when all utility functions are Cobb-Douglas, agent k's hopes for a market response that moves him from, say, $\hat{x}'_k$ in Figure 1 to a higher-utility point like A will k always be fulfilled unless that mark is overshot by pushing him to a point such as E having lower utility than $u(\hat{x}'_k)$. That is, points like B, where he would be buying more of the good he wants to sell, are ruled out. Let $(\hat{p}'_{1k}, \hat{p}'_{2k})$ be the initially announced price vector of agent k, and $(\hat{q}'_{1k}, \hat{q}'_{2k}) = (E^{1k}(\hat{p}'_{1k}, \hat{p}'_{2k}), E^{2k}(\hat{p}'_{1k}, \hat{p}'_{2k}))$ be agent κ's excess-demand quantities corresponding to it, for all $\kappa \neq k$. The latter excess-demand quantities would take agent k to $\hat{x}'_k$ in Figure 1 where he would sell $x_{1k}^0 - \hat{x}'_{1k}$ of good 1 and buy $\hat{x}'_{2k} - x_{2k}^0$ of good 2. Suppose k modifies his price announcement to $(\hat{p}^*_{1k}, \hat{p}^*_{2k})$, and the remaining agents, in turn, respond with

$$(\hat{q}^*_{1k}, \hat{q}^*_{2k}) = (E^{1k}(\hat{p}^*_{1k}, \hat{p}^*_{2k}), E^{2k}(\hat{p}^*_{1k}, \hat{p}^*_{2k})),$$

for $\kappa \neq k$. Write $\Delta p_{ik} = \hat{p}^*_{ik} - \hat{p}'_{ik}$ where $i = 1, 2$, and $\Delta q_{i\kappa} = \hat{q}^*_{i\kappa} - \hat{q}'_{i\kappa}$ where $i = 1, 2$, and $\kappa \neq k$. Assume that $\hat{q}'_1 = \sum_{k=1}^{K} \hat{q}'_{1k} > 0$. (An analogous result obtains if $\hat{q}'_1 < 0$). Then $\hat{q}'_2 = \sum_{k=1}^{K} \hat{q}'_{2k} < 0$ by Walras' law. Moreover, from the agent-price-adjustment rule, $\Delta p_{1k} > 0$ and $\Delta p_{2k} < 0$. It is clear, then, that, ignoring the possibility of overshooting, agent k's hopes of moving to a point like A will be fulfilled as long as $\Delta q_{1\kappa} < 0$ and $\Delta q_{2\kappa} > 0$ for all $\kappa \neq k$ because, in that case, he would be selling less of (or even buying) good 1, and buying less of (or selling) good 2.

Theorem 7. Let all agents have Cobb-Douglas utility functions as in (5). Then $\Delta p_{1k} > 0$ and $\Delta p_{2k} < 0$ together imply $\Delta q_{1\kappa} < 0$ and $\Delta q_{2\kappa} > 0$ for all $\kappa \neq k$.

Proof:

Since all utility functions are Cobb-Douglas, agent κ's excess demand functions $E^{1\kappa}$ and $E^{2\kappa}$ are continuously differentiable throughout their domains. By the mean value theorem, there exist vectors p^k such that

(10) $$\Delta q_{i\kappa} = E_1^{i\kappa}\left(\mathrm{p}^{\mathrm{k}}\right)\Delta \mathrm{p}_{1\mathrm{k}} + E_2^{i\kappa}\left(\mathrm{p}^{\mathrm{k}}\right)\Delta \mathrm{p}_{2\mathrm{k}}, \qquad i = 1,2, \ and \ \kappa \neq \mathrm{k},$$

where $p^k = \theta\left(\hat{p}_{1k}^*, \hat{p}_{2k}^*\right) + [1-\theta]\left(\hat{p}_{1k}', \hat{p}_{2k}'\right)$ for some θ in the open interval (0,1), the subscripts on the $E^{i\kappa}$, recall, represent partial derivatives, and p^k and θ are generally different for each i and κ. The conclusion of the theorem now follows by applying the inequalities (8), (9), $\Delta p_{1k} > 0$, and $\Delta p_{2k} < 0$ to (10).

Q. E. D.

Thus, in a two-good, Cobb-Douglas world, market reactions are always such that when the agent raises his announced price of a good, the residual excess demand forced upon him is reduced, and when he lowers it, the residual excess demand increases. That is, the market answer always moves him in a direction such that, if not too large, his utility rises. But that answer could still turn out to be substantial enough, even in the "right" direction, to leave him with a lower utility, such as at point E in Figure 1, than that associated with the initial market response. Therefore, although the agent-price-adjustment rule considered here cannot guarantee that the agent, through his price-announcement activity, is always able to call forth a market reaction that will increase his utility, he is still able to proceed in the hope that he can.

It should also be noted that the proof of Theorem 7 does not carry over to exchange economies with more than two goods. For in that situation (10) becomes

$$\Delta q_{ik} = \sum_{n=1}^{I} E_n^{i\kappa}\left(p^k\right)\Delta p_{nk}, \qquad i = 1,\ldots,I, \quad and \ \kappa \neq k,$$

and, for at least one i and any values of the $E_n^{i\kappa}\left(p^k\right)$ consistent with (8) and (9), at least one product in the right-hand sum is positive and at least one other product is negative. Hence two vectors $\left(\Delta p_{1k},\ldots,\Delta p_{Ik}\right)$ can be found, each consistent with the agent-price-adjustment rule, but involving different magnitudes $\left|\Delta p_{nk}\right|$, such that one vector yields $\Delta q_{i\kappa} > 0$, and the other results in $\Delta q_{i\kappa} < 0$.[12] Therefore the sign of $\Delta q_{i\kappa}$ cannot be determined, as it is in the proof of Theorem 7, from the signs of the $E_n^{i\kappa}\left(p^k\right)$ and Δp_{nk} alone. Without further assumptions, then, the agent's success at calling forth a market response that increases his utility by appropriately varying his price-vector announcements, though still possible and still reasonable to hope for, may be more difficult to achieve. An argument similar to that of Theorem 7 and the discussion surrounding it applies if the market response to k's initial price announcement lies elsewhere on the budget line connecting x_k^0 and $\tilde{x}_k$ in Figure 1.

To move to a concrete specification of agent-price adjustment rules in Walrasian models of exchange economies, let $p^k = \left(p_{1k}, ..., p_{Ik}\right) > 0$ vary over possible price announcements by agent k. The agent-price-adjustment story says that the change in announced price p^k varies directly with the difference between agent k's desired trades at p^k and those required in response to the desires of the remaining market participants at p^k. The latter difference at the price vector $\tilde{p}^k$ considered above is, as previously suggested in terms of the variable x_k,

$$\tilde{q}_k - \left[-\hat{q}_k\right] = \breve{q},$$

or

$$E^k\left(\tilde{p}^k\right) - \left[-\sum_{\kappa \neq k} E^\kappa\left(\tilde{p}^k\right)\right] = E\left(\tilde{p}^k\right),$$

where $\breve{q}$ is the market-excess-demand vector at $\tilde{p}^k$. In general, then, agent k changes p^k directly with the market-excess-demand function $E\left(p^k\right)$. Thus, letting θ_k be a known, nonzero constant for each k, one collection of price-adjustment rules that might accompany the agent-price-adjustment story is

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[12] For example, to ensure that $\Delta q_{i\kappa} > 0$, make $\left|\Delta p_{nk}\right|$ relatively large when $E_n^{i\kappa}\left(p^k\right)\Delta p_{nk} > 0$ and relatively small when $E_n^{i\kappa}\left(p^k\right)\Delta p_{nk} < 0$.

$$(11) \qquad \frac{dp^k}{d\tau} = \theta_k E(p^k), \quad \mathrm{k} = 1,...,\mathrm{K},$$

where, recall, τ denotes time. Observe that (11) is a system of equations that, for each k, is formally identical to, but has a different interpretation and significance than, (2). Observe also that, because, as suggested in previous discussion, agent k knows $E(p^k)$ from the responses of the remaining agents to his announcement of each p^{k}, he has sufficient information to change p^k in line with (11). Moreover, since it is based on market excess demand functions, the impact of Debreu's theorem impinges, with all of its force, on the analysis of the global stability of equilibria under (11).

It should be pointed out, however, that due, in part, to the formal equivalence of (11) and (2), the extra sufficient conditions ensuring uniqueness and global stability in Theorem 6, namely, that all utility functions take on the Cobb-Douglas form, apply in the present case as well. Under these conditions, then, starting at a collection of K price vectors p^k, where $\mathrm{k} = 1,...,\mathrm{K},$ each different, say, from the unique, equilibrium price vector $\overline{p}$, the individual behaviors of the K agents will eventually lead everyone to $\overline{p}$. Equilibrium in this particular Walrasian exchange model with dynamic (11) is therefore unique and globally stable. And both (i) the additional conditions that ensure uniqueness and global stability, and (ii) the price adjustment mechanism in markets, derive, unlike the Walrasian tâtonnement of the previous section, from the properties of individual agents and their behaviors. Such a Walrasian model, then, fully meets the requirements of methodological individualism.[13]

[13] This construction can be extended to include production by taking all production functions to be of the form

$$z = B[y_1]^{\beta_1} \cdots B[y_J]^{\beta_J},$$

where z denotes output, $y_1, \ldots, y_J$ represents quantities of inputs $j = 1, \ldots, J$, respectively, and B and $\beta_1, \ldots, \beta_J$ are positive constants such that $\sum_{j=1}^{J} \beta_j < 1$. Adding production in this form does not destroy the property of the Cobb-Douglas-utility-function exchange model that all pairs of distinct goods are gross substitutes. (See, for example, Katzner (1988, Exercise 5.8 on pp. 175, 481.) Hence Theorems 2-4 remain in force. Furthermore the same agent-price-adjustment

Of course, it would be better to have a story and associated price-adjustment rules for which the conditions on individual agents ensuring global stability of equilibria were expressible with greater generality than the above specification of Cobb-Douglas utility functions for every agent. More general conditions yielding uniqueness of equilibria would also be desirable. But, as has already been indicated in the context of Section II, the questions of whether there are such conditions relating to (11), and of whether there are alternative stories and adjustment rules which might further permit the manifestation of such conditions, have not yet been resolved. Regardless, it should be pointed out that, in so far as economic models, as noted in Section I, are constructed as abstractions from and explanations of empirical occurrences, the special case of Cobb-Douglas utility functions, highly restrictive though it is, is still adequate to cover all practical situations. For, as described in Section I, the purpose of the Walrasian construction is to explain observed vectors of prices and quantities that arise in the real economy. One way to do this is to interpret such prices and quantities as the unique and globally stable equilibrium prices and quantities in a suitable model. But by appropriately setting initial endowments and the parameters in agent utility functions, any such observed vectors arising in an exchange economy can appear as an equilibrium of a Walrasian exchange model with only Cobb-Douglas utility functions. This is because, given any vectors $x_k > 0$, for $\mathrm{k} = 1,\ldots,\mathrm{K}$, and $p > 0$, the parameters a_i^k can always be chosen to satisfy (6).[14] Thus, even if more general uniqueness and global stability conditions turn out to be impossible to obtain, a Walrasian model always exists that is consistent with methodological individualism, and that is capable of explaining, for exchange economies, what actually has been seen. In light of footnote 13 above, the same can be said for a world with production. Thus the question of whether more general uniqueness and global stability conditions can be found is irrelevant to the explanatory viability and usefulness of the Walrasian system.

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story and dynamic price-adjustment rules (11), where k now varies over producing as well as consuming agents, may also be employed.

[14] All that is necessary is to set

$$a_i^k = \frac{p_i x_{ik}}{p.x_k},$$

for $i = 1,\ldots,I$ and $k = 1,\ldots,K$, where p_i and x_{ik} are the respective components of the observed p and x_k .

Appendix

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