

## Some questions to Edward Fullbrook regarding his book *Market-value. Its measurement and metric*

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Measurement should be a major and important topic in any quantitative science – and it is, except in economics. The reason for this gap was pointed out by Leontief a long time ago: Prices are actually part of economic reality. Unlike other social and natural scientists, economists (in most cases) do not need to make the measurements themselves, but find the measured values already present as part of the reality to be studied (Leontief 1982, cf. Schlaudt 2021).

A few years ago, Edward Fullbrook dedicated a book to the question of economic measurement – to my knowledge, the first systematic study on this topic.. The book's cover shows the famous rabbit-duck illusion that serves to illustrate the Gestalt switch. Depending on one's predisposition, one recognises a rabbit or a duck in the picture. Once you understand this, you can consciously switch between the two interpretations. Edward Fullbrook's thesis is that neoclassical equilibrium theory is the duck whose rabbit turns out to be nothing other than measurement. Then and only then, when equilibrium has been established in the market, does price formation meet the requirements of proper measurement:

"A market which clears and is in equilibrium defines a market value equivalence relation  $=_e$  such that the market-value of the quantity of a good exchanged equals the market-value of the quantity of money exchanged for it." (p. 56)

The surprise now is that what may appear to be a minor theoretical question for specialists actually has fundamental consequences for our understanding of economics. The book mentions the following central insights:

- economic reality has an irreducible macro dimension
- market value and distribution of income and wealth are ultimately the same thing
- markets are endogeneously dynamic, and thus there cannot be a general equilibrium.

The recommendations on the spine of the book by distinguished colleagues indeed suggest that Edward Fullbrook has laid the foundation for a significant theoretical development in heterodox economics with this book – and I personally share this impression. For all my admiration, however, I have to admit that while reading the theoretically very demanding book, which draws on such fields as economics, epistemology, mathematics, measurement theory and political philosophy, it did not become completely clear to me what premises the argument is based on and how exactly its individual steps proceed. I therefore take the opportunity to address some questions to the author, the answers to which I hope may be useful to all readers.

Probably Fullbrook's most important methodological step is that, in contrast to orthodox theory, he does not simply postulate a domain of value in a deductive manner whose structure corresponds to the mathematical equations of neoclassics (the infamous "utility"), but rather tries to determine inductively which metric structure economic value has. Fullbrook calls this approach "empiricist".

I welcome this approach, but would like to point out that the word "empiricist" can be misleading. Let us note that value is not simply given in experience. As Fullbrook himself points out, value exists only in the field of forces of the market, just as weight is a meaningful physical quantity only in the earth's gravitational field:

"Just as a physical object only has weight in a gravitational field, so too a good only has market-value in the context of a system of markets, with its 'forces' of supply and demand."  
(p. 62, see also p. 114)

But the market is a historical reality. In some societies or epochs there have been no markets – and consequently no (economic) value. I find this notion very valuable, but it may lie outside the horizon of a philosophy associated with the word "empiricism".

Elsewhere, Fullbrook makes the point that in order to operationalise the concept of weight, we also need a scale (p. 50). The market, in this analogy, would be both the gravitational field *and* the scale. Here we approach a position known in epistemology as "constructivism". Constructivism is a variety of empiricism that points out that data are not simply given in bare experience, but that historically developed technology, e.g. measurement technology, also enters into their construction. This perspective makes it easier to understand the historicity of value. But the word "constructivism" may embroil one in other, irrelevant discussions, and therefore may be no more appropriate than "empiricism".

But let us return to the argument of the book. Fullbrook's first fundamental observation is that in the market, due to the law of demand, value does not have a "linear", "Euclidean" or "simple additive" structure, i.e.  $n$  pieces of a commodity do not generally have  $n$  times the value of a single traded copy of that type of commodity. The reason for this is simply the law of demand with its downward slope. Such non-additive structures are known, for example, from the theory of relativity, namely the composition law of velocities. Since the speed of light constitutes an absolute limit, composite velocities are corrected by the Lorentz factor, so that, for example,  $0.5c$  plus  $0.5c$  does not equal  $c$ , as one expects in a classical perspective, but only  $0.8c$ .

In contrast to speed, no general formula can be given for the value of commodities, since the shape of the law of addition depends on the respective law of demand, which can have a different shape in each individual case. A downward slope of the demand curve always leads to a downward correction of the total value. As Fullbrook further explains, inelastic demand even describes a situation in which the value metric becomes, in his words, "negatively non-additive", i.e. an increase in the quantity of goods reduces the total value. Fullbrook considers this relationship to be "self-evident" (p. 58). When I studied physics, it was a common joke that these words in a textbook were equivalent to two hours of extra work in reconstructing the proof, and so, unfortunately, is the case here. I will therefore try to describe the connection in other words so that it may be easier to understand. In a situation of inelastic demand, unit prices fall faster than the quantity of goods increases. So the increase in quantity is overcompensated by

the falling price, which is reflected in the fact that the aggregate or total value of the quantity of goods actually falls. In this way it becomes plausible, and on this basis the algebraic proof is also easy to carry out.

In my opinion, Fullbrook is right in his claim (even if it is not self-evident, at least for me). For a better understanding, however, I would like to ask a question. If I understand it correctly, the argumentation is based on an interpretation of the law of demand as a causal relationship with an unambiguous and one-sense direction of determination, namely the quantity of goods as the independent variable and the price as the dependent variable ("increasing the size of the market exchange set decreases its value", p. 58). Is this a legitimate reading? A quick look at the literature - from the perhaps first mention of the Law of Demand by Alfred Marshall and Mary Paley Marshall (Marshall and Marshall, 1897, p. 69) to today's standard textbooks (such as Samuelson and Nordhaus 2009, p. 26-7) shows a surprisingly nonchalant approach to this question. Sometimes quantity (demanded or offered) influences price, sometimes vice versa. Fullbrook cannot afford to be so lax. Is it legitimate, then, to commit oneself to the reading with the determination direction quantity-price, as the Gestalt-switch seems to demand? And how does one then deal with the case of completely inelastic demand, where only the reverse reading seems permissible, namely that price changes have no influence on the quantity demanded?

We can even go one step further at this point and ask in principle about the status of the Law of Demand. Can we assume that this law exists? Does it represent a truth that heterodox economists can trust – or does the Gestalt switch prove to be too conservative, burdened with too much neoclassical heritage? (This is a question I allow myself to ask as an economic layman.)

This was the simpler part of the argument in Fullbrook's book. In what follows, the argument becomes more complicated and its results more subtle. This brings me to Fullbrook's second fundamental observation, which follows immediately from the first observation that value only exists where the commodity in question can actually be exchanged in principle. From this, it can indeed immediately be deduced that one cannot measure the value of the entire quantity of all commodities, and even of any quantity of a particular commodity that accounts for more than half of the value of the total quantity of all commodities, simply because in this case by construction there can be no market exchange and thus no equilibrium situation (p. 62). A way out arises if the value of each quantity of commodities is expressed on a scale from 0 to 1 as a fraction of the value of all commodities, as is known from probabilities (I will return to the analogy later).

What seems to be a trick of only formal importance in fact entails a methodological revolution, since we are encountering a connection between the micro- and the macro-level that is not compatible with the programme of micro-foundation. Later in the book this is clearly stated:

"Mass, for example, is an additive function of micro-masses. But with market- values, as with probability, micro magnitudes depend on macro ones." (p. 119)

Fullbrook first shows this in the book with the phenomenon of inflation. From the perspective of measurement, the value of the total quantity of money is equal to that of the total quantity of goods, and the value of each unit of money is determined in a macro-micro-determination as a fraction of this total value (p. 67). Inflation presents itself as a formally simple case of non-

additivity with constant elasticity. The previous step indeed has already shown that economic value can actually only be represented as a fraction of the total value of all goods – which corresponds to an absolute scale that works without conventionally chosen units. I am not sure whether Edward Fullbrook shares this view, but I am tempted to say that the introduction of such a unit, which is formally possible and concretely implemented in money, always creates the illusion of additivity in the structure of value.

At this point I would like to make a comment and ask a question. First the comment. It is presumably this dependence of market value on macro states that leads Edward Fullbrook in chapter 2 to the conclusion that value is something inherently and irreducibly relative, just as motion has been understood in physics since Galileo. In order to establish this point, Fullbrook draws on the "little-known" economist Samuel Bailey, who in 1825 accused Ricardo of transforming value from something relative into something absolute ("entirely to lose sight of the relative nature of value, and [...] to consider it as something positive and absolute" – Bailey 1825, p. 40). I share Fullbrook's thesis of the relativity of value as it results from the previous analysis, but I am not sure whether Bailey is the right warrant for this position. Karl Marx, in his 1863 *Theories of Surplus Value*, accused Bailey in a lengthy discussion – as I understand him – of simply confusing value and price (as the numerical expression of value in money or some other commodity as a measure of value) (Marx 1989, 312). Price of course is inherently relative, but it expresses something that is not affected at least by this kind of relativity, viz. value. The interesting thing about Marx's critique is that he himself does not advocate an absolute concept of value. In particular, Marx, like Fullbrook, did not accept value without a market. So the question here is not whether value is something absolute after all, but only to understand its relativity properly, and Bailey may not have succeeded in doing this. But this is only a side note.

My question at this point concerns the exact meaning of "depend on" when it is said, "with market-values, as with probability, micro magnitudes depend on macro ones". In any mechanistic system, as we know them from physics, this is easy to understand. Mechanism means that we can derive the properties of the system from the properties and interactions of its parts, which exist independently of the system (e.g. the properties of a gas from the molecules). In the simplest case, there are no interactions and we are then dealing with mere additivity, as in the measurement of mass in classical physics (subatomic is a more complicated case). The mechanistic model has well-known limitations. In organisms, the parts do not exist independently of the system and they appear to perform a function defined with reference to the whole. Explaining such a system requires a roundabout route via evolutionary theory. In economics, if we follow Fullbrook, we seem to have a third case. Macro-dependence first slips in by a purely formal path (values, so the thesis goes, cannot be measured independently of the whole, but only as its fractions). We thus encounter a *conceptual* irreducibility of the macro level. Then, however, this purely formal relationship unfolds a *causal* meaning, translating it into an interdependence of markets, which ensures that the various markets cannot reach equilibrium at the same time (p. 84). I find these theses of the book convincing, but nevertheless there seems to be a gap that needs to be filled. What exactly is the nature of this dependence on the macro level? What causalities can be identified here? How does the conceptual irreducibility of the macro-level translate into a top down causation?

Let us go on from here. At this point in the book, a technical step follows that is the most intricate in my understanding. It is based on the two observations that, firstly, the power sets of the traded goods and the money used in the process (i.e. the sets of all subsets of these two sets) form a Boolean algebra under the three operations of union, intersection and complement, and

secondly, by exploiting the properties of the money set, an absolute value  $e'$  can thus be defined, which also forms a Boolean algebra (p. 71-2). With the Boolean structure of value, its true metric is said to be discovered. This is also how Sheila Dow summarises the main thesis on the book's spine: "Edward Fullbrook argues that understanding market value's metric as Boolean (rather than Euclidean as economics has heretofore assumed) could provide a common foundation for the heterodox approach."

Let's proceed slowly here in order to understand all the individual steps. The first thing I want to emphasise is that the Boolean structure first appears, not for value, but only for the set of commodities as the material bearers of value. Thus, at the beginning of the argument, what is at stake is not the metric of value, but the ontology of commodities. The analogy between value and probability becomes useful here, since in probability theory, this distinction is explicitly made. For instance, Roman Sikorski writes in his book *Boolean Algebras*:

"the set of all events is always supposed to form a Boolean algebra  $A_0$ . The probability is a normed measure  $\mu_0$  on  $A_0$ , i.e. a measure assuming the value 1 at the unit element of  $A_0$ ."  
(Sikorski 1969, 208)

A distinction is thus made here between the events on the one hand and the measure of their probability that is to be constructed on the other, and it is the set of the events which forms a Boolean algebra. The fact that events form a Boolean algebra however has nothing to do with the question of the measure of probability  $\mu_0$ , but is a trivial consequence of the fact that, first, sets form a Boolean algebra under the set-theoretic operations and, second, events are well-defined and identifiable elements from which sets can be formed to which these operations can be applied. – And the same is true of commodities.

This first step is therefore trivial and unproblematic. It concerns only the ontology of commodities, not the metric of their value. Next, Fullbrook argues that the money exchange space (i.e. the quantity of all money spent) is "uniform or equivaluable", since all money units have the same market value (p. 72). From the uniformity of the money exchange space, Fullbrook draws a conclusion that then becomes the basis of the metric of absolute values: If the money exchange space, which by definition has a value of 1, consists of  $n$  money units, then the market value of any subset of  $g$  money units will be  $g/n$ . On this basis, an absolute market value  $e'$  can now be introduced with the two important properties that, first, the absolute market value of the union of two disjoint sets of money or goods is equal to the arithmetic sum of their absolute market values and, second, the sums of the absolute market values of any set and its complement always add up to 1 (p. 72, Axiom D3 and D4).

Unfortunately, the book does not say this explicitly, but I assume that the absolute value  $e'$  is meant to formalise the measurement by fractions of the total value of all commodities that was suggested a few pages earlier (p. 67) (is this so?). However, I find these implications confusing, and I have a number of questions. The central insight of the first step of the book was that economic value is non-additive. Now, suddenly, an absolute value is introduced which is, after all, additive! (Note: if  $A$  and  $A'$  are two disjoint sets of commodities, but of equal value, then the value of their union is twice the value of each of them – so we are dealing with an additive structure!). Where does this property come from and how is it to be understood? I have the suspicion that the additivity in fact does not follow from the uniformity of the money exchange space. It is true that each monetary unit has the same individual value. But does this entail the linear relationship that the value of  $g$  money units is equal to  $g/n$ ? Doesn't the law of demand

apply here, which, as we saw, destroys additivity? Do we not ultimately fall victim here to the illusion of additivity that money always creates, but of whose falsity we allowed ourselves to be convinced in the first part of the book? I urgently need an explanation in order to understand the introduction of  $e'$ , and this might be useful for all readers.

Regardless of how this question is answered, a second question follows. Even if one can introduce  $e'$  as suggested, I am not sure that it is appropriate and helpful to call this metric Boolean. We have seen that trivially the set of commodities forms a Boolean algebra under the set-theoretic operations of union and intersection. Now, what about  $e'$ ? For  $e'$  only one operation appears, arithmetic addition. The interesting thing about Boolean algebra, however, is precisely the interplay between two operations (union and intersection in set theory). When applied to formal logic, this tool allows us to understand, for example, the fundamental duality of the operation of *And* or *Or*, which then structures the entire system of logic. I do not see at all how one could meaningfully speak of a Boolean algebra in the case of  $e'$  with only one operation! It is important to note that my criticism at this point does not refer to the insights of the book, but only to the question of whether the concept of Boolean algebra is a suitable expression for them, something I have doubts about.

However, if I am not wrong the only finding that seems important for the aims of the book is the fact (which is correct and not affected by the criticism) that the absolute values of any given quantity of goods and its complement add up to 1. Because this fact implies, firstly, the irreducibility of the macro level and, secondly, the interdependence of different markets that cannot reach equilibrium at the same time. The problematic additivity of  $e'$  is, if I am not mistaken, not needed anywhere in the rest of the book.

Let me sum up my questions to Edward Fullbrook:

1. Does the Gestalt switch commit us to a reading of the Law of Demand as a one-way determination of price by demand, and is this interpretation legitimate? And, more fundamentally, can the Law of Demand be accepted as an established truth in heterodox economics?
2. What is the exact meaning of "depend on" when it is said, "with market-values, as with probability, micro magnitudes depend on macro ones"? How does the conceptual irreducibility of the macro-level translate into a top down causation?
3. Does the uniformity of the money exchange space really entail the linearity or additivity of  $e'$ ? How does the additivity of  $e'$  relate to the fundamental insight of the non-additivity of value?
4. Is it appropriate to call  $e'$  a Boolean algebra, given that it contains only one operation?

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