Reply to Referee report 5

by Alia Dannenberg, Matti Estola, and Anna Dannenberg
March 21 2018

We thank the Referee for the insightful comments that help us to improve our article. Our detailed responses can be found below.

Comment 1

In the very beginning of the paper the authors claim: "the main weakness in the neoclassical theory of economics is its static nature." This claim is the core of the entire contribution, but it is critical in a twofold sense.

a) Saying "neoclassical theory of economics" is too general. This is true for microeconomic neoclassical models, but not for macroeconomic Dynamic Stochastic General Equilibrium (DSGE) models; that is, the modern macroeconomic version of the walrasian General Equilibrium framework, which are not only neoclassical stricto sensu (Real Business Cycle models), but also New-Keynesian (NK-DSGE).

Although these macroeconomic models are microfounded by means of the static framework and they are still affected by many critical issues, also "neoclassical" macro economists actually implement dynamic models.

We stress the importance that the macro theory should be derivable from the micro theory. Our theory is consistent, e.g., with national accounting principles, although there does not yet exist a (coarse-grained) macro theory that uses our micro theory (like in physics thermodynamics is derived from statistical microphysics).

b) "The main weakness is its static nature". The authors do not seem to criticize neoclassical walrasian models for their theoretical issues but only for their static modeling approach.
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Thus, I would suggest to better define the aim of the paper in this sense, that is to clarify that the main goal is not the improvement and or a critique of the neoclassical models related to their economic implications, but only to propose a dynamic refinement of the walrasian-marginalist microeconomic modeling approach.

The referee correctly points out that within the rhetoric of the neoclassical theory there are sentences like "if marginal cost is less than the price of the product, then the firm can increase its profit by increasing its production" ***(see e.g. Varian 1999 p. 387)*** *and so on. Our equations model this rhetoric, but the neoclassical modelling does not. Thus, one can correctly claim that neoclassical theoretical ideas contain the ideas behind our theory and equations. Our contribution is a bit more than modelling this neoclassical rhetoric, in our framework these ideas are axiomatised as in exact empiric natural sciences.*

Comment 2

It is not very clear what are the steps forward with respect to the other recent contributions presented by the same authors and to which they refer into this paper (that is, mainly Estola and Dannenberg, 2016 and Estola, 2017). It seems that this is a general presentation of the same

framework it has been already presented in those contributions.

There are several new aspects, most notably axiomatic formulation of the theory, and connected many-body equations of motion that enable simulations with many heterogeneous interacting agents. The simulation results have not been presented before, and these results show that the model creates business cycles and bankruptcies of firms that are common in real economies.

Comment 3

Many recent contributions try to overcome the distinction between microeconomic and macroeconomic modeling because of the so-called "aggregation problem", which is a well-known problem having a strong relevance for economists and researchers working on economic modeling. This issue can be managed, for example, within models in the Complex Adaptive Systems eld, mainly Agent-Based Models (either analytic and computational), and in general by means of modeling tools borrowed from disordered systems physics. This is due to the intrinsic nature of the economic systems, and I suspect that this newtonian dynamic refinement of the neoclassical economics could not overcome the aggregation problem (but I am aware that this is not the aim of the authors' contribution).

This is true, we have not intended to solve the aggregation problem in this paper. Here we have used similar aggregation as in statistical mechanics that yields distributions of the aggregated property. In physics it works and thus we assume that it should work in economics too. Moreover, Estola (2017) presents one solution for the aggregation problem by showing how we can calculate the average value of marginal willingness-to-pay of several heterogeneous consumers, firms, investors, etc. The aggregation problem is an interesting research topic in itself, and perhaps we should analyse it in detail in our later works to address the philosophical issues and questions raised by Referee.

This comment should be also extended to the way in which the authors represent the interactions among heterogeneous agents. These are just indirect interactions through the price system, exactly as in all neoclassical microeconomic models and neoclassical or new-keynesian DSGE macroeconomic models, and not even direct interactions among heterogeneous agents, which allow for the possibility of non-linearities and emergent properties of the economic adaptive system.

In physics, too, most interactions are indirect in fundamental nature. Direct interactions are rare, like particle collisions. A gravitational interaction between two massive bodies happens via gravitational interaction, that is, it is described by using gravitational fields of the bodies (or in quantum mechanics, via exchange of gravitons that intermediate the interaction). In common language, e.g., the interactions between planets and stars are considered to be direct gravitational interactions. Thus, interactions between firms and consumers take place via ”field”, i.e., price, and they can be considered direct interactions like gravitational interactions between massive bodies.

In physics, fundamental equations (like equations in quantum physics) are linear. From these fundamental equations it is possible to derive coarse-grained theories like hydrodynamics that contain nonlinearities. Thus, it is quite probable that if one constructs a macro theory from our micro theory, it may contain nonlinearities, of course depending on how the macro theory is constructed.

References

Estola, M. (2017). "Newtonian Microeconomics: a Dynamic Extention to Neo-classical Micro Theory". Palgrave Macmillan.

Varian, H. (1999) Intermediate Microeconomics: A Modern Approach 5th Ed. W.W. Norton & Company.