Reply to referee report 2

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1,2. We agree with the referee that the theorems are actually definitions. Our idea was that in physics, claims are proved by empirical observations. Because our simulations show that our model mimics the real world behavior, this ”kind of proves the theorems”. However, we agree to use the name “definitions” instead of “theorems”.

Actually, our definitions (the ones we have called “theorems”) describe economic laws that correspond to Newton's laws in physics. Our definitions describe objective observed regularities in an economy, like Newton's laws describe objective observed regularities within (classical) physical reality. Perhaps we should include these laws explicitly in our article. They are:

First law: In an inertial frame of reference, an economic unit either remains at rest or continues to produce / consume at a constant velocity, unless acted upon by a force. (Here we consider only production and consumption, but the frame can be used in, e.g., labour market or money market.)

Second law: In an inertial reference frame, the vector sum of the forces **F** on an economic unit is equal to the “mass” m of that unit multiplied by the acceleration **a** of the unit: **F**=m**a**. (It is assumed here that the mass m is constant, and acceleration concerns either production or consumption.)

Third law: When a body exerts a force on another body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body.

3. Stocks accumulate from flows, and thus if the produced goods are durable goods, then they accumulate to the capital stocks of firms. However, we have not separated investment and consumer goods, and thus we do not measure the stocks of produced goods. These elements can be added in the model, as well as depreciation rates for capital goods that devalue the capital stocks. These are possible future extensions of our model. The purpose of this first order approximation model is to show that our theory and model works, and future extensions that fine-tune it are considered in later publications.

4. Concerning the existing dynamic neoclassical models, MasColell et al. write at page 620: “A characteristic feature that distinguishes economics from other scientific fields is that, for us, the equations of equilibrium constitute the center of our discipline. Other sciences, such as physics or even ecology, put comparatively more emphasis on determination of dynamic laws of change. … The reason, informally speaking, is that economists are good (or so we hope) at recognizing a state of equilibrium but are poor at predicting precisely how an economy in disequilibrium will evolve. Certainly there are intuitive dynamic principles: if demand is larger than supply then price will increase, if price is larger than marginal cost then production will expand… The difficulty is in transforming these informal principles into precise dynamic laws”.

We agree with MasColell et al. in this definition of the state of the neoclassical theory. Our works are pieces of economic research where the concepts of acceleration of economic quantities are defined. We also have defined the factors that create these accelerations, and we call these reasons ”forces that create these accelerations” according to the principles of Newtonian mechanics. An economic unit that aims to improve its current welfare is moving towards a better position, similarly as in physics the forces move particles toward the positions where their potential energy is in its minimum. This is the fundamental analogy we have found between economics and physics, and we

apply this principle in our work.

All sciences apply differential or difference equations in modeling dynamic events, and Newton showed how causal relations (force creates acceleration) can be modelled by differential equations. Because economic modeling is also based on causal relations, it is natural that these relations are modelled by using similar principles as in physics. There is a limited number of mathematical techniques that can be used in describing causal relations between quantities, and therefore it is natural that similar models are used in different sciences. Nowadays biology applies similar differential equations in modelling evolution as well, and thus the same models are applicable in seemingly unrelated specific sciences.

Lastly, we stress that in DSGE model the acronym "DSGE" stands for "**dynamic** stochastic **general equilibrium**". Two observations: 1) dynamic general equilibriums in physics are such macro theories like gas in a gas chamber with constant temperature, volume and so on. The demand of general equilibrium is very restrictive if one considers dynamic phenomena because in most dynamic phenomena there exists no equilibrium. 2) DSGEs are macro models. Our model and theory behind it is at micro level. Behind DSGE models there exists nowadays no micro theory. Probably our micro theory would help in enhancing the DSGE models.

5a. In Estola & Dannenberg (2012) and Estola (2015) we compare the neoclassical and the Newtonian theory of production by using Finnish and Swedish industrial data. The Newtonian theory encompasses the neoclassical one in each tested industry, and even the first order autoregressive model (AR1) encompasses the neoclassical theory in each tested industry. The Newtonian theory encompasses the AR1 model in 10 out of 13 Finnish and 14 out of 18 Swedish industries. We use adjusted R^2 and AIC criterion in this testing.

5b. Alfred Marshall never defined economic forces that cause the acceleration of economic quantities. Actually he and other pioneers of neoclassical economics did not even define the concepts of velocity and acceleration of production, consumption, etc. Thus economic kinematics has not been defined before our work, and therefore Marshall did not define exactly the "economic forces" that cause these accelerations. This is demonstrated in Philip Mirowski's book, and can be revealed by using Google for the term "economic force" or "market force". All that you get this way is a number of economic factors like labor force, capital, etc. that according to some researchers are market forces. Thus we are the only ones who have defined the economic forces so that they actually cause the accelerations of economic quantities, and that the zero-force situation corresponds to the neoclassical optimum.

References

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