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Bayesian estimation and entropy for economic dynamic stochastic models: An exploration of overconsumption☆

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ABSTRACT

This paper examines psycho-induced overconsumption in a dynamic stochastic context. As emphasized by well-established psychological results, these psycho-distortions derive from a decision making based on simple rules-of-thumb, not on analytically sounded optimizations. To our end, we therefore compare two New Keynesian models. The first is populated by optimizing Muth-rational agents and acts as the normative benchmark. The other is a "psycho-perturbed" version of the benchmark that allows for the potential presence of overoptimism and, hence, of overconsumption. The parameters of these models are estimated through a Bayesian-type procedure, and performances are evaluated by employing an entropy measure. Such methodologies are particularly appropriate here since they take in full consideration the complexity generated by the randomness of the considered systems. In particular, they let to derive a not negligible information on the size and on the cyclical properties of the biases. In line with cognitive psychology suggestions our evidence shows that the overoptimism/overconsumption is: widespread—it is detected in nation-wide data; persistent—it emerges in full-sample estimations; it moves according to the expected cyclical behavior—larger in booms, and it disappears in crises. Moreover, by taking into account the effect of these psycho-biases, the model fits actual data better than the benchmark. All considered, then, enhancing the existing literature our findings: i) sustain the importance of inserting psychological distortions in macroeconomic models and ii) underline that system dynamics and psycho biases have statistically significant and economically important connections.

1. Introduction

Beyond its purely theoretical content, the field of dynamic stochastic models is particularly relevant for applications in several scientific contexts. In fact, such models might be efficiently used to describe the wide set of evolutive phenomena whose dynamics is random. In this respect, economics is one of the most representative subjects where this class of models plays a role of paramount importance (see e.g., Vandewalle and Ausloos [61], Ausloos and Ivanova [7], Ausloos et al. [8], Alfarano et al. [4], Li and Gao [44], Mitchell and Ackland [47] and, more recently, Dhesi and Ausloos [21], Dhesi et al. [20]).

In this paper we take advantage of the prominent example of New Keynesian theory, which is usually set up as dynamic stochastic general equilibrium (DSGE, in the usual economic jargon) models. Such dynamic models are small-scale settings aimed at formally describing an economic system. DSGE proponents assume that the system is populated by a representative so-called Muthian agent which operates subject to budget constraints and technological restrictions. Specifically, an agent is said to be Muthian if she is able to maximize her utility and to form "rational" —i.e. model-consistent—expectations. Over time, these models have become widespread and commonly used because they are a powerful tool that provide a coherent framework for policy discussion and economic analysis. In principle, they can help to identify sources of fluctuations, answer questions about structural changes, forecast the effect of policy changes, etc.

Despite its widespread use, it has long been known that the assumptions behind standard DSGE models are rather stringent. The rational expectations (RE) hypothesis is one important instance. In particular, the RE hypothesis implies that the system can be studied as if a fully-informed optimizing representative decision maker

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operates in it. The robust results achieved in cognitive psychology—not to mention the simple observation of real-life agents—clearly lowers the realism of standard DSGE models. Indeed, it is unsurprising these models still need to prove their ability to fit actual data, especially in extraordinary cyclical phases.

Our intended contribution and aim is to study the complexity of the typical DSGE model framework when a peculiar kind of perturbation is inserted. Specifically, we consider two New Keynesian models. The first, standard, is populated by fully-informed-optimizing Muth-rational agents and acts as the normative benchmark. The other allows the agents' consumption path to be different from the RE one. Throughout the paper we use the adjective "over" exactly to refer to a level of consumption larger than that featuring a Muth-rational agent. As mentioned, the motivation to do that is based on well-known results stemming from the theory of heuristics and biases (Kahneman and Tversky [37]). Indeed, cognitive psychology convincingly argues that most agents use intuitive strategies and simple heuristics such as better-than average effects, illusion of control, hindsight bias, confirmation bias and the like. These latter are reasonably effective some of the time, but they also produce biases and give rise to systematic incongruities that are at odds with statistical reasoning and, accordingly, with Muth-rationality. To our ends it is important to underline that these undisputed distortions cannot be derived from "objective" economic reasoning neither from mathematical optimization rules. Otherwise stated they can be seen as drivers of non-analytically based decisions. The rules-of-thumb we study bear other worth noticing features. They are immanent and widespread, in that affecting the representative agent supposed to operate in DSGE models. In addition, the effect of these heuristics on consumption is predictable. First, the persistent distortion is positive—intuitive reasoning generates overoptimism and, in turn, overoptimism leads to overconsumption. Second, economic booms tend to create even more overoptimism than usual. Third, bad economic times tend to make agents more Muth-rational. All that affords us to perform a well- established battery of testable hypotheses. The distortion we are interested in has another nice attribute. Ours is a form of psycho-induced overoptimism that, ipso facto, is totally disconnected from economic fundamentals. In this sense we complement the existing macroeconomic literature, which typically approaches psychological issues in a way that is crucially different from ours. In the macroeconomic literature, indeed, psychological issues enters the macroeconomic models, if any, in a very generic way—virtually all authors study "optimism" with no other qualification. By contrast, we examine peculiar psycho-biases with well-established features and we test whether these distortions vary during the cyclical phases. As mentioned, this is crucial because it affords us to impose the due discipline to our simulations.

To carry out the analysis, we use methodologies of two types: first, in line with a wide strand of literature (see among others Apte et al. [6], Canova [16], Smets and Wouters [59], Farnoosh and Ebrahimi [26], Farnoosh and Morteza [27], Hutter et al. [35]), we estimate the parameters of the models by applying an inferential Bayesian-type procedure, based on a Monte Carlo Markow Chains (MCMC) algorithm; second, we measure how the performances of the model fits the real data by applying a concept of entropy. For the use of entropy in the measurement of the performances in economic contexts, see, e.g., Perazzo et al. [51], Lorenz and Lohmann [45], Frigg [29], Januario et al. [36], Salarieh and Alasty [52], Miskiewicz and Ausloos [46], Sensoy et al. [53], Bartolacci et al. [10], and the recent and interesting survey of Tang et al. [60]. The novel approach we propose leads to the assessment of the actual size of the bias. This represents an advancement also in the economic-psychology field of research, which rarely gives indications about the size of these biases. All considered, then, the proposed standpoint could enable us to reach new and intriguing findings.

Supporting our research strategy, evidence shows that taking into account a more realistic modus operandi allows an otherwise standard DSGE model to fit better actual data both in the long-run and in an economic boom scenario. Recessions are instead characterized by more rational decision making. More importantly, all these results are in line with our a priori. One can also note that, to the extent that booms can be seen as "gains", our evidence is also somewhat in line with the prospect theory (Kahneman and Tversky [38]).

The rest of the paper is organized as follows. In the next section we deal with psycho-biases and we give support to the overconfidence/overconsumption hypothesis. Section 3 describes the theoretical benchmark model. In Section 4, we provides arguments for inserting the overconfidence hypothesis in a standard DSGE model. In Section 5, we describe the empirical data used in our study, the methodology employed to estimate the parameters and the related results. In Section 6, we analyze the model's dynamics through the impulse response functions and we compare the performance of the different model's specifications through the measures of entropy. Section 9 closes the paper.

2. Why do individuals overconsume? A brief literature review

Muth-rationality has been questioned by many authors. Just to mention, the adaptive learning literature (Evans and Honkapohja [24]) argues that individuals must relentlessly "learn" to be Muth rational. Somewhat closer to our aim, Agliari et al. [3] study a new Keynesian model with heterogeneous agents pointing out that their presence leads to several implications on the dynamic equilibrium properties. Naimzada and Pireddu [50] examine the interaction of a Keynesian good market and a stock market with biased fundamentalists. A belief bias disposes optimistic agents to overestimate and pessimistic to underestimate the reference value. Their simulations suggest that if the interaction is destabilizing, then the model may generate—and explain—boom and bust cycles. Alike Gomes [34], considering a system where individuals are endowed with distinct sentiments, finds persistent endogenous waves of optimism and pessimism. In these models, agents rationally switch between optimism and pessimism abandoning a belief if it performs poorly. As it should be clear, instead, RE models typically rely on the latent assumption that non-rational agents will not survive a (unspecified) process of evolutionary market competition. Typically, the economic literature dealing with "non-rational" agents does not deepen non-rationality. Instead, unsurprisingly, psychologists such as Kahneman and Tversky [37] and their numerous followers (Eysenck and Groome [23]) have examined in depth psychological distortions. The results of their research program on heuristics and biases have convincingly shown that most agents use intuitive strategies and simple heuristics such as better-than-average effects, illusion of control, hindsight bias, confirmation bias and the like. These latter are reasonably effective some of the time, but they also produce biases and give rise to systematic incongruities that are at odds with statistical reasoning and, accordingly, with Muth-rational expectations.

The foregoing offers the motivation to our paper. Indeed, several points need to be underlined here about these undisputed rules-of-thumb. First, these rules do not follow—hence they cannot be derived from— "objective" reasoning neither from mathematical optimization rules. Otherwise stated they can be seen as drivers of non-analytically based decisions. Second, they are immanent and widespread, in that affecting constantly the representative agent. Third, these heuristics tend to create positive biases in people's decision making. Indeed, it is well known that most individuals are overconfident about their own relative abilities, and

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