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WHY DO WE NEED TO REPLACE DSGE MODELS? A Critical View on Pre-Crisis Central Bank Models

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In this paper, we critically address pre-crisis central banking doctrine from a methodological standpoint. We argue that the underpinnings of the reigning paradigm before the crisis account for its paradigmatic failure both to predict the global crisis, and be a reliable source of inspiration for post-crisis policies. We insist on DSGE models, and emphasize the need for enhanced understanding of macro-financial interactions. In a second part, we sketch out three research directions aimed at overcoming the shortcomings of pre-crisis models. We respectively consider the merits of ensemble modeling, Homo Socialis and agent-based modeling. Finally, we conclude.

Key words: DSGE models, financial crisis, alternative methodologies

Introduction

Pre-crisis central banking doctrine has been the object of considerable criticism since the outbreak of the crisis without necessarily paving the way for viable alternative frameworks. In this paper, we argue that the underpinnings of the reigning paradigm before the crisis account for its paradigmatic failure both to predict the global crisis, and be a reliable source of inspiration for post-crisis policies. In a first part, we examine the strengths of the mainstream DSGE models, before examining how the latter came under attack

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once the issue of macroeconomic interactions and the need for preemptive moves by central banks came to the fore in central banking practices. In a second part, we sketch out three research directions aimed at overcoming the shortcomings of pre-crisis models. We respectively consider the merits of ensemble modeling (inspired by sophisticated weather forecasting techniques), the replacement of *homo oeconomicus* by the more insightful *Homo Socialis*, and finally agent-based modeling. We believe that these promising approaches lead to better foresight, and have the potential to improve central banking practices in a post-crisis scenario. Finally, we conclude.

The Reigning Paradigm Until the Global Crisis

The Strengths of Pre-Crisis DSGE Models

Central banks have adopted since the late 1990s an approach to macroeconomics known as DSGE (Dynamic Stochastic General Equilibrium) modeling, which is a branch of applied general equilibrium theory. DSGE models try to predict all macroeconomic variables, and are used to assess fiscal and monetary policies. They have benefited from the legacy of the real business cycle approach (RBC) and the seminal article by Kydland and Presscott in 1982; DSGE models are all micro-founded, and assume that agents are rational. An overview of this theoretical approach is provided by Pilkington (2011), through the careful examination of entries in dictionaries and encyclopedias. Yet, DSGE methodology departs from the RBC approach in the sense that DSGE models are populated by monopolistically competitive firms, and feature real frictions (e.g. habit formation in consumption and adjustment costs in investment). Markets no longer clear automatically in the New Keynesian DSGE models featuring nominal price and wage stickiness. DSGE models feature rational agents that are resource and budget-constrained with clearly described preferences and microeconomic objectives (Kocherlakota 2010). Agents form expectations of future macroeconomic outcomes. These forward-looking expectations are explained by the model (ibid.). The DSGE models bear a connection to empirical macroeconomic research, through the careful selection of key parameters underlying the structural apparatus of the economy, and the testing of substantive hypotheses with the help of modern statistical techniques. The micro-foundations and the use of structural policy-invariant parameters of the economy make DSGE models robust to Lucas critique (1976). The

financial accelerator mechanism is explained by Bernanke et al (1999). Christiano et al. (2001) present a model featuring frictions reflecting the persistence of sticky prices and wages in the euro area. Other influent papers in the DSGE literature have been written by Bernanke and Gertler (1999), Smets and Wouters (2003) and Iacovellio (2005). DSGE models are displayed on a research platform on the internet, the website www.dsge.net, which claims to be an "international research network for DSGE modeling, monetary and fiscal policy". The influence of DSGE models on central banking practices prior to the crisis is exemplified by the 2003 Smets-Wouters model for which the European Central Bank is full of praise. Likewise, the 2007 Smets-Woutersmodel, was enthusiastically endorsed for purposes of policy analysis.

Macro-Financial Interactions and the Need for Preemptive Moves

For Smith (2009, 2), standard New Keynesian DSGE models failed to account for the interactions between macroeconomic and financial variables before the crisis. The crisis has shown that macro-financial interactions ought to be further investigated to capture the nature of the macro-dynamics leading to the crisis. One reason for this shortcoming is that the workings of the financial sector were inadequately portrayed by DSGE models (Cagliarni et al. 2010, 26). In reality, "the financial sector's propensity to be a source of shocks is a function of, among other things, the setting of monetary policy." (ibid.). Therefore, DSGE models have begun to incorporate an active banking sector (Gerali et al. 2008; DeWalque et al. 2009; Dib 2009). Bernanke (2011) has upgraded the financial stability objective in the aftermath of the crisis. The latter must now be on par with the more solidly anchored price stability objective. Pilkington (2009) has laid bare the foundations for a renewed understanding of macroeconomic interactions and the potential build-up of financial imbalances, by relying on stock-flow consistent macroeconomic accounting structures, thereby breaking away with macroeconomic orthodoxy and its insistent focus on micro-foundations, based on the erroneous view of self-equilibrating markets at all times. Crockett (2002) had already warned, on behalf of the Bank for International Settlements, that inflation targeting policy, with its obsession for price stability, was not the most suitable approach to combat financial instability. Central banks should try to monitor credit bubbles and erratic asset prices. Pre-emptive moves under the form of monetary policy tightening could well be sound policy choices in times of euphoria and boom characterized

by apparent macroeconomic stability nonetheless containing the seeds of future instability (Minsky 1986). Although Bernanke & Gertler (1999, 74) opposed the idea in the late 1990s that central banks should respond to asset price movements unless the latter signal changes in expected inflation, the crisis has clearly demonstrated that macroeconomic stability would have be ensured by pre-emptive lowering interest rates, to offset the impact of asset movements on output and inflation volatility. Other authors have also insisted on prompt responses to asset prices misalignments in the financial markets (Cecchetti et al. 2002; Wadhani 2008, 5). Standard DSGE models circumscribe the controlling variables of monetary policy to inflation forecasts and output gaps. Yet, asset prices should be incorporated in future analyses in order to mitigate distortions in investment and consumption with the unintended risk of amplifying the business cycles and generating inflationary pressures.

DSGE Models Under Attack

Representative agent models appeared with Lucas and Rapping (1969). However, criticism abounded in the literature well before the crisis. Regarding the postulated homogeneity implied by the representative agent approach, Hartley (1997, 199) stated that "perhaps, someday, we will find a planet populated by clones where these models will be useful, but until then we cannot expect them to be of much use in studying economies about which we know." In a paper entitled "Representative agents and the micro-foundations of macroeconomics", Grabner (2002) criticizes the idea that models with representative agents (such as DSGE models) are immune to the Lucas critique. Kirman (1992) resorts to the well-known fallacy of composition and provides an example wherein the representative agent disagrees with every individual economic agent in the economy: hence, the reduction of a group of heterogeneous agents to a representative agent is "both unjustified and leads to conclusions which are usually misleading and often wrong (ibid.)." Kirman (ibid.) launches a fierce attack against the representative agent, who "deserves a decent burial, as an approach to economic analysis that is not only primitive, but fundamentally erroneous" (ibid.). Likewise, Chang, Kim, and Schorfheide (2011) have designed a DSGE model with uninsured labour income risk wherein the estimated representative-agent DSGE model gives inconsistent results with a model using the true parameters of the heterogeneous economy: "[s]ince it is not always feasible to account for heterogeneity explicitly, it is important to recognize the

possibility that the parameters of a highly-aggregated model may not be invariant with respect to policy changes." In the *Financial Times*, Willem Buiter (2009) lamented over the so-called advances in macroeconomics since the 1970s, which he considers useless. Buiter (ibid.) blames this situation on the self-referential and inward-looking nature of most macroeconomic models such as DSGE models equated to self-generated mathematical puzzles and the inner logic of intellectual games at odds with the real world, arguably prevented economists from addressing pressing concerns. Likewise, Goodhart (2007) once said of DSGE models that they excluded everything he was interested in. The US Congress hosted a series of hearings on macroeconomic modeling methods on July 20, 2010. The objective was to "question the wisdom of relying for national economic policy on a single, specific model when alternatives are available".

On this occasion, Robert Solow, Nobel Prize recipient in 1987 criticized the DSGE models that fail "to pass the smell test". For Solow, DSGE models wrongly assume a rationally designed long-term trajectory for the economy, devised by an omniscient planner. This is not what happens in the real world.

Kay (2011) authored a paper entitled "The Map Is Not the Territory: An Essay on the State of Economics" devoted the relationship between economics and the real world. Kay offered a powerful critique of mainstream economic theory and DSGE models. Kay compares the artificial worlds constructed by DSGE models to Tolkien's Middle Earth, or to the computer game Grand Theft Auto. Yet, rigour and consistency are nevertheless undeniable qualities of DSGE models. For Hennig (2010, 46), skillful mathematical modeling does not ensure scientific validity, for the interpretation of various elements of formal mathematical domain in terms of real-world social phenomena, is necessarily subject to caution.

For Chatelain (2012), the welfare cost of the crisis was underestimated by DSGE models. In the latter models, the global crisis can merely been seen as a huge exogenous shock perturbing the economy. Yet, the recovery after the crisis was much slower than what was predicted by pre-crisis models, as if the deterministic trend, around which economies are supposed to gravitate in the long-run, had become irrelevant. Furthermore, DSGE modelers have not revised the covariance between housing prices and output since the crisis. Did a structural break in the covariance occur after 2007? Unfortunately, linearized DSGE models remain silent on this matter (ibid.). Chatelain (2012) believes that deviations of the expected price of collateral from it fundamental value in DSGE models change the rules of

the game for the banking industry, and more particularly the exit options available to investment bankers: (venture capital) trade sale exit, the repurchase of the investors' shares by the company and/or its management, quotation or IPO on a stock exchange, and finally involuntary exit.

A lot has been said about the jobless recovery after the crisis with persistent unemployment exceeding the persistence of the loss of output. Jaimovich and Siu (2012) have singled out a phenomenon of job polarization on the US labor market along with sustained high unemployment levels. Pre-crisis DSGE models, with their emphasis on temporary shocks, had failed to foresee the permanent effects of these structural evolutions on the US labor market. Fiscal policy has been utterly neglected by most DSGE models. Yet, the latter gained prominence over monetary policy during the crisis (Alesina and Giavazzi 2011). For Stiglitz (2011, 597), DSGE models "treat the government as outside the system: it too is modeled as if it were exogenous. In fact, political actors are agents, who may use policies to pursue their objectives. They are engaged in a stochastic game with market participants, and this too should have been formally modeled". Katarina Juselius argues that, from an econometric standpoint, cointegrated VAR models (CVAR) are superior to DSGE models, that leave out a number of stochastic trends in the real data: "many economists were indeed blinded by the beauty of their theory models and in my view Krugman was right to point this out to the readers of *NY Times*".

All in all, the shortcomings of standard DSGE models seem to question the validity of the efficient market hypothesis in rather opaque and weakly regulated financial markets. However, proponents of DSGE models have not yet conceded defeat, as shown by a recent paper published by economists of the Federal Reserve Bank of New York (Del Negro, Giannoni & Schorfheide 2013). The build-up in financial stress in the fourth quarter of 2008 is viewed therein as an exogenous shock. The authors show that by using a standard DSGE model available to economists prior to the global crisis, it is possible to predict a sharp decline in activity with a more modest and protracted decline in inflation during the following year. What this tends to show is that controversies surrounding the relevance and the explanatory power of DSGE models are far from over.

Post-Crisis Models and the Need for a Rethink in Macroeconomics

Has there been a serious rethink within the academic community on how economics sought to be conducted in a post-crisis scenario? For James Galbraith the answer is negative as far as the mainstream is concerned: "So far as I know, no 'mainstream' department has redesigned its approach since the crisis. This is remarkable. In fact, so far as I know, no mainstream department has hired a single senior figure from any dissident tradition. You have to ask, what does this tell you?"

In a powerful critique of mainstream economics entitled Never Let a Serious Crisis Go to Waste, economic historian Mirowski (2013) argues that the reason why economists have been reluctant to change since the crisis is that significant evolutions would actually produce harmful effects on the standing of the economics profession.

The authority of economists stems from their scientific claims about policies which are supposed to make people better off. Unfortunately, these claims are derived from welfare theorems containing largely unrealistic assumptions such as substantive rationality and perfect foresight. These claims would be undermined if unrealistic assumptions of market-based perfection were replaced by more realistic ones (bounded rationality, radical uncertainty, endogenous money, financialization, emotions as drivers of human behavior and decisions etc). This would tarnish economists' scientific authority and institutional power.

Nevertheless, we believe that there exists a strong need for a rethink in post-crisis macroeconomics. In this respect, we present a few research directions with the potential to overcome some of the shortcomings of pre-crisis models; we consider respectively ensemble modeling, *Homo Socialis* and agent-based modeling.

Ensemble Modelling

By simulating phenomena studied in physics on supercomputers, weather forecasters have achieved a high degree of precision and reliability. The European Centre for Medium-Range Weather Forecasts in the UK and the National Centers for Environmental Prediction in the USA run supercomputers simulating a virtual atmosphere. The model can forecast the wind, the temperature, and the humidity at more than 20 million points from the earth's surface up to a height of 40 miles.

Could economists find some inspiration from weather forecasting techniques in the future? As odd as it may seem, the question is far from futile. Physical forces shaping hurricanes or tornadoes are not so different than the financial and economic destabilizing forces leading to credit bubbles, sovereign debt crises, hedge fund panics etc. In the light of the failure of most economists to predict the global financial crisis under the dominant paradigm of perfect self-regulating markets, could we instead acknowledge the limitations of our knowledge of the future, and seriously envision the creation of a European Center for Financial Forecasting?

More precisely, ensemble forecasting can be defined as a numerical prediction method used to generate a representative sample of the possible future states of a dynamical system. Similar to Monte Carlo analysis, ensemble forecasting relies on a large set of slightly differentiated initial conditions. The initial conditions are all seen as plausible by the modeler in the light of past and present observations, data sets and measurements. They merely define a universe of possible outcomes. As Lawson (2006; 2009) notes, unlike closed-system analysis that characterized pre-crisis models, the future is never predetermined in open systems; this is a more faithful characterization of the real world compared to closed-system mathematical models. Numerous simulations help remove the uncertainty inherent in traditional forecast models, such as the errors that stem from erroneous initial conditions and from path-dependent chaotic dynamics. Ensemble forecasting mitigates the imperfections in model formulation and algebraic techniques. The modeler thus determines an ensemble spread (whose size depends on the uncertainty level of the environment) within which the dynamical system falls. This initial choice is always made by the modeler and takes on a subjective dimension. Ensemble modeling can also be seen as doing "Macro modelling with many models".

Leutbecher and Palmer (2008, 3515) state that "numerical weather prediction models as well as the atmosphere itself can be viewed as nonlinear dynamical systems in which the evolution depends sensitively on the initial conditions." Previously discussed DSGE models are highly sensitive on initial conditions and the supposedly policy-invariant parameterizing of the economy. New forecasting techniques will allow modelers to generate a representative sample of the possible future states of a dynamical system.

Drawing on the methodology of numerical weather prediction, an approach, which is very similar to multiple Monte Carlo analysis, ensemble modeling helps collect a vast set of observations on past and current conditions, so as to retain

only the most plausible values. The importance of thorough data collection cannot be understated in this respect (hence the importance of setting up the above-mentioned Centers for Economic and Financial Forecasting). Multiple numerical predictions in ensemble modeling generally yield a range of results forming a spectrum of possible future configurations. Ensemble modeling aims at asymptotic convergence towards a pseudo-objective probability that is not postulated ex ante, as in the ergodic models vastly criticized by post-Keynesian economists, but rather empirically investigated by muddling through.

Moving Away from Homo Oeconomicus to Homo Socialis

In the aftermath of the crisis, our collective emotional and affective environment is being reshaped –sometimes violently – thereby casting a new light on the power of emotions. French philosopher Alain (1925 [1928], 26) explains that others exert power on our inner states by signaling their own emotions and passions. These inner states are spontaneously generated by others. Albeit intuitive, the emotional substrate is difficult to define, because emotions are in fact "the glue that binds society together" (Turner 2005).

A fundamental lesson is that man is intrinsically a social being who contrasts sharply with the *homo oeconomicus*, the central character in neoclassical theory. The latter theory depicts a world populated by individual agents maximizing their utility under constraint, by interacting on markets with disregard for the social dimension of these interactions.

Recent studies in behavioral economics have shown that the neoclassical, self-interested, egoist maximizer is not necessarily more successful in economic terms than the seemingly selfless, altruistic and cooperative fellow. Experimental economists have gathered overwhelming evidence in recent years that cooperative and helping behaviors are actually the norm in human interactions throughout the world. This raises the following question: If self-interest does pay, why do humans often act differently?

The legacy of Darwinism on modern economic thought, and more particularly on the *homo oeconomicus*, is obvious. Models are often based on the idea that competition rests on the centrality of rational incentive-driven *homo oeconomicus*. Contrariwise, the implications of how Darwinism accounts for alternative complex phenomena such as altruism or group dynamics are far less intuitive; In fact, explaining how altruistic behavior may arise out of natural selection, is the theoreti-

cal problem of sociobiology, and more specifically of the theory of group selection, which explains that natural selection can act on groups in spite of occasional free-rider behavior that may distort the analysis. Successful groups tend to benefit the individuals of the group, even if the latter are not related. An example is provided by Bitcoin, the new crypto-currency launched in 2009. PhD student Andrew Miller argues that the growth and sustainability of the crypto-currency is dependent, in the initial stages, on the altruistic and honest behavior of the Bitcoin miners. Although Miller's claims on Bitcoin have not yet been backed by the economics profession, the idea that altruistic or cooperative behavior (the 'Homo Socialis) might lead, under certain circumstances, to more efficient economic outcomes than purely self-interested ones, is gaining momentum within the scientific profession. For instance, in a paper titled "How Natural Selection Can Create Both Self- and Other-Regarding Preferences, and Networked Minds" (Grund et al. 2013), the authors put forward a type of "economic theory for 'networked minds' (the 'Homo Socialis') and [laid] the foundations for an evolutionarily grounded theory of other-regarding agents, explaining individually different utility functions as well as conditional cooperation". In this respect Karl Polanyi (1957, 46), had drawn the main conclusion derived from the study of early societies that he equated to the timelessness of the conception of man as a social being. For Polanyi, the economy is embedded in social structures. Market economies combine neoclassical utility-maximizing individual behavior with more natural social patterns, such as reciprocity, redistribution, shared values, traditions and various communitarian forms of organizations that determine social motivations and transcend individualities (ibid.). Therefore, humans do not systematically act as utility-maximizing rational agents driven by self-interest (the infamous "Homo oeconomicus"). Rather, the 'Homo Socialisis concerned with preserving and improving his social standing. Material goods, assets and claims on wealth are primarily social in nature. The economy is run on motives that are not linked to economic calculus or mere economic interest attached to individual ownership (ibid.). *Homo socialis* cannot be embodied in a single economic model. It is rather a perspective on social science that acknowledges the active role of other-regarding agents. It is a major improvement over pre-crisis DSGE models populated by mere individualistic utility-maximizing agents.

Agent-Based Modelling

The Economist (2010) reminds us that "Conventional economic models failed to foresee the financial crisis", and goes on to ask whether agent-based models could be more successful? Agent-based modeling (ABM) consists of computational modeling focusing on heterogeneous individuals forming a complex system. ABM, also known as agent-based computational modeling, requires both mathematical and experimental approaches for its development and application. ABM does not assume that the economic system be converging towards equilibrium. Moreover, the representative agent hypothesis is ruled out from the onset. Through the use of a bottom-up approach, ABM aim at singling out emergent macro-properties arising out of complex interactions between countless agents, who are assigned specific rules of behavior. A fine example of ABM is the Java agent-based macroeconomic simulator (JAMEL) developed by Pascal Seppecher. The software is distributed under the terms of the General Public Licence (GPL), and can be downloaded, installed and enabled on any personal computer without any technical knowledge. Seppecher has designed an innovative and powerful agent-based computational macroeconomic model. JAMEL is a free java computer program that can generate a wide range of simulations. The JAMEL-user is empowered within an operational virtual laboratory where full macroeconomic experiments are conducted without any prior technical knowledge. The user defines the initial conditions (number of agents and parameters for rules of behavior), replicates disturbances akin to exogenous shocks , monitors the real-time and system-wide effects of these shocks, and assesses their consequences on macroeconomic magnitudes (income distribution, unemployment and inflation levels, velocity, inventory levels, capacity utilization, bankruptcy rate...). Seppecher has made his simulations available online to the public, so as to replicate the stylized facts of real-world economies, such as productivity and expenditure shocks, deregulation of the labor market, introduction of a minimum wage in a deflationary context, and credit bubbles. The JAMEL software is just the first step in the process of understanding the workings of our financialized economies. An agent-based model capable of predicting a tipping point such as the Lehman Brothers (LB) bankruptcy would be a formidable project requiring "real-time simulation, fed by masses of data that would operate rather like the traffic-forecasting models now used in Dallas and in the North Rhine-Westphalia region of Germany (Economist 2010)". The resources needed for this

gigantic type of modeling enterprise is reminiscent of the enormous mass of data processed by our weather forecasting centers described in our section devoted to ensemble modeling.

Conclusion

The global crisis has called for a rethink of the models used by the economics profession. Our article has focused on central banks whose modeling practices prior to the crisis were largely inspired by the dynamic stochastic general equilibrium approach to macroeconomics. Although the latter featured undeniable analytical strengths, we have shown that the failure to predict the crisis might be explained by the inability to account for complex macro-financial interactions within the economic system. Consequently, DSGE models have come under attack since 2008. The fiercest critiques include notorious economists such as Robert Solow, Charles Goodhart and Willem Buiter. Therefore, alternative frameworks need to be put forward in order to improve central banking practices, and help avoid the past forecasting mistakes, with disastrous consequences for our economies. In this article, we have reviewed three very promising methodological directions at odds with pre-crisis models, respectively ensemble modeling, *Homo Socialis* and agent-based modeling, all requiring a paradigm shift along with the constitution of massive data sets and cutting-edge forecasting centers.

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Rezime:
Zašto treba da zamenimo DSGE modele? Kritički pogled na modele koje su koristile centralne banke u periodu pre izbijanja svetske finansijske krize

Od izbijanja svetske finansijske krize, vladajuća doktrina centralnih banaka je predmet kritika, a da pri tome nije nužno otvoren put za održivu alternativu. U ovom radu tvrdimo da se u temeljima vladajuće paradigme nalazi objašnjenje za njen paradigmatični neuspeh, kako u predviđanju globalne krize

tako i na polju postkrizne monetarne politike. U prvom delu rada se proučavaju dobre strane vladajućih DSGE modela. Nakon toga proučavamo kako su vladajući DSGE modeli postali predmet kritika onda kada je pitanje makroeknomskih interakcija i potrebe za preventivno delovanje centralnih banaka došlo u prvi plan. U drugom delu skiciramo tri istraživačka pravca koja imaju za cilj prevazilaženje nedostataka modela koje su koristile centralne banke u periodu pre izbijanja svetske finansijske krize. Posebno se razmatraju dobre strane ansambl modeliranja (inspirisano sofisticiranim tehnikama vremenske prognoze), zamena *homo oeconomicus-a* pronicljivim *homo socialis-om*, i na kraju modeliranje zasnovano na ponašanju agenata u sistemu. Mišljenja smo da ovi obećavajući pristupi vode ka boljim predviđanjima, a imaju i potencijal da poboljšaju prakse centralnih banaka u postkriznom periodu. Na kraju rada, izvodimo zaključak.

Ključne reči: DSGE modeli, finansijska kriza, alternativne metodologije

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