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THE FINANCIAL CRISIS AND DSGE MODELS. A CRITICAL EVALUATION

Summary: The global financial crisis has spurred a critical debate about the state of macroeconomics as a discipline and prompted new research questions. The one of the strongest line of critique is directed toward the Dynamic Stochastic General Equilibrium (DSGE) models. In such a context, the aim of this article is twofold. First, to point out in a non-technical manner the main deficiencies of the DSGE modelling approach; particularly, with respect to the inadequate treatment of financial markets. Second, to provide the overview of some recent developments in this area. The conclusion of this paper is that despite the substantial advances in the DSGE methodology, many important challenges remain unaddressed.

Keywords: DSGE models, macroeconomics, financial crisis.

1. Introduction

The worldwide financial crisis that erupted in 2007 has revealed the fragility of major financial institutions and triggered the sharpest global recession since the 1930s. According to the estimates of International Labour Organization [see *World of Work*… 2010], 29.4 million jobs were lost globally by the end of 2010. The International Monetary Fund is forecasting that banks' and other financial institutions' crisis-related cumulative losses will total 2.2 trillion USD [see *Global Financial*… 2010, p. 13]. The US Federal Reserve and the European Central Bank purchased approximately 2.5 trillion USD of government debt and troubled private assets from banks, which is considered to be the largest monetary policy action in the world history. In many advanced economies, public debt is still rising, fiscal risks remain high, and significant structural weaknesses persist in sovereign balance sheets, which could have adverse consequences for growth over the medium term. All these events require rethinking the role of global finance for real activity and will represent a challenge for economic research for years to come.

The mass media, some policymakers, and many prominent economists interpreted the recent financial crisis as a crisis of economics and, in particular, of macroeconomics. The critical debate about the state of macroeconomics as a discipline appeared in many places like the respected newspapers, academic journals, internet blogs, scientific conferences, and workshops. This reflects the widespread concern

about the causes and consequences of the financial turmoil. The majority of the criticisms relates to the assumptions of modern macroeconomics, the inadequacies of these theories for dealing with the financial crisis, and the consequent spillover effects for the whole economy. For example, the Nobel Prize winner Paul Krugman writing in the New York Times [Krugman 2009] claims that the macroeconomics of the last 30 years is spectacularly useless at best and positively harmful at worst. He believes that "the economics profession has gone astray because economists, as a group, mistook beauty clad in impressive-looking mathematics, for truth" [Krugman 2009, p. 36]. De Grauwe [2009, p. 9] states that macroeconomics is in deep trouble and "the field must be revamped fundamentally". He blames the underlying paradigm of macroeconomic models, namely rational expectations assumption. Skidelski [2009, p. 11] said that there is "a persistent bias in economics towards an idealised account of human behaviour; what Joseph Schumpeter called the Ricardian Vice of excessive abstraction". Former UK central banker and LSE professor Willem Buiter wrote: "most mainstream macroeconomic theoretical innovations since the 1970s (…) have turned out to be self-referential, inward-looking distractions at best. Research tended to be motivated by the internal logic, intellectual sunk capital and esthetic puzzles of established research programmes rather than by a powerful desire to understand how the economy works" [Buiter 2009]. Colander *et al.* [2009] argue that the failure of economists to anticipate and model the financial crisis has deep methodological roots. That failure is due to the inability of current models to describe the reality. A similar criticism can be found in Arestis [2009], Colander [2008], Kirman [2010], Solow [2008].

The one of the strongest lines of critique is directed toward the main workhorse of modern macroeconomics – Dynamic Stochastic General Equilibrium (DSGE) models. A common feature of DSGE models is that the decision rules of economic agents are derived from the assumptions about preferences and technologies by solving intertemporal optimization problems. These models, which emphasize the dependence of current choices on expected future outcomes, have moved from academic circles to the policymaking community. Today many central banks in Central and Eastern European countries have developed their own DSGE models and, currently, many others are beginning or are planning to do so[1].

DSGE models were developed to explain and support policy in "normal" times and they were relatively successful in this. Before the global crisis, they largely abstracted from financial intermediaries. However, the recent events revealed the stark limitations of those models. In such a context, the aim of this article is twofold. First, to point out in a non-technical manner the main deficiencies of the DSGE modelling approach, particularly with respect to the inadequate treatment of financial markets behaviour. Second, to provide the selective overview of some recent developments in this area, which are intended to bring these models closer to the reality.

[1] Some CEE central banks that have developed DSGE models are: Czech National Bank, Central Bank of Hungary, Bank of Estonia, Bank of Latvia, National Bank of Poland, National Bank of Slovakia, Croatian National Bank.

The remainder of the paper proceeds as follows. The next section briefly describes the history, assumptions, structure, and critique of the baseline DSGE model. The main drawbacks regarding the financial markets and the overview of latest extensions are presented in the third section. The final section concludes with a summary and directions for future research.

2. Overview of DSGE methodology and its critique

Before detailing the model, it is useful to sketch the historical process that has led to its development and influences its current uses. The origins of the DSGE methodology lie in the Real Business Cycle literature [see Wickens 2008, p. 4]. This approach developed following the seminal work of Kydland and Prescott [1982], and Long and Plosser [1983], and provided an explicit intertemporal general equilibrium model of the economy with flexible prices based on optimizing decisions made by households and firms. Originally, the emphasis of these models was on real factors and the role of stochastic technology shocks in generating the business cycle. However, later research in DSGE models included Keynesian short-run macroeconomic features, such as Calvo [1983] type staggered pricing behaviour. Hence, this new DSGE modelling framework was labelled as "new neoclassical synthesis" or "new Keynesian" modelling paradigm[2].

The DSGE approach combines micro-foundations of both households and firms optimization problems with a large collection of rigidities [see Christiano *et al.* 2005; Smets *et al.* 2003]. The name of this class of models points to some of its outstanding characteristics. The term "dynamic" refers to the forward-looking behaviour of households and firms. "Stochastic" corresponds to the inclusion of shocks that allow for unexpected events. "General" indicates that the model includes all markets in the economy. "Equilibrium" points to the assumptions that supply and demand balance out instantaneously and it also refers to the inclusion of explicit constraints and objectives for the households and firms. The key advantage of modern DSGE models over traditional macroeconometric models is that the interpretation of their parameters allows for overcoming the famous "Lucas critique". This is done by means of so-called "deep" parameters, which describe the structural features of the economy, like the preferences of agents, and more importantly do not vary with policy regime changes.

Following Tovar [2008], the main building blocks of the baseline DSGE model[3] can be shortly summarized as follows. The DSGE model is an (open or closed economy) fully micro-founded model with real and nominal rigidities. In this model,

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[2] In macroeconomic literature, the terms "new-Keynesian" or "new neoclassical synthesis" are used synonymously; see for example Clarida *et al.* [1999], Goodfriend and King [1997], Mankiw [2006].

[3] There are a lot of different extensions and modifications of DSGE models. Hence, we refer to a standard version of these models inspired by Smets and Wouters [2003] as the baseline or benchmark DSGE model.

households consume, decide how much to invest, and are monopolistic suppliers of differentiated types of labour, which allows them to set wages. In turn, firms hire labour, rent capital, and are monopolistic suppliers of differentiated goods, which allows them to set prices. Both households and firms face a large number of nominal frictions (eg. sticky wages and prices or partial indexation of wages and prices) limiting, in each respective case, their ability to reset prices or wages. On the real side, capital is accumulated in the endogenous manner and there are real rigidities arising from adjustment costs to investment, variable capital utilisation, or fixed costs. Households preferences display habit persistence in consumption, which means that the utility flow from consumption depends on current as well as past consumption. The utility function is separable in terms of consumption, leisure, and real money balances. Fiscal policy is usually restricted to Ricardian setting, while monetary policy is conducted through an Taylor-type interest rate feedback rule, in which the interest rate is set in response to deviations from an inflation target and some measure of economic activity (most often – output gap). Furthermore, some degree of interest rate smoothing is often assumed. This basic model is enriched with a stochastic structure associated with different types of shocks such as supply side shocks (productivity and labour supply), demand side shocks (preference, investment specific, government spending), cost-push or mark-up shocks (price mark-up, wage mark-up, risk premium), and monetary shocks (interest rate or other target variables). These shocks are often assumed to follow a first-order autoregressive process. In general, such framework is designed to capture plausible business cycle dynamics of an economy. On the monetary side, it attempts to capture some of the most important elements of the transmission mechanism.

Two main methods for evaluating DSGE models have been proposed in the literature: calibration and econometric estimation. Calibration methods were very popular a few years ago, but their popularity has declined [Tovar 2008]. This partly reflects improvements in computational power and the development of new econometric methods, which have made econometric estimation more accessible and appealing. In the empirical literature, there are different econometric techniques available for estimating DSGE models [DeJong 2007]. The examples of these include: generalized method of moments (GMM), minimum distance estimation based on the discrepancy between VAR and DSGE impulse response functions, full-information maximum likelihood, and Bayesian methods. Each method has certain advantages and drawbacks, but the Bayesian approach seems to be most often used at present. This technique obtains parameter estimates by combining the authors' prior knowledge on the parameters, which comes from microeconomic estimates or previous time series data, with the information content of the data.

Despite impressive advances made in DSGE modelling, the benchmark model faces some important challenges. We start from the three most fundamental and interrelated issues: aggregation problem, representative agent, and rational expecta-

tions (RE) assumptions. The DSGE approach embodies the methodological norm, according to which, a macro theory not only should be built from preference-based micro theory, but also should flow directly from the aggregation of the individual acts of choice. In this context, taking into consideration the Sonnenschein-Mantel-Debreu theorem, the aggregation problem means that the aggregation of individual behaviours does not generally inherit the nice properties of the agent behaviours. In other words, individuals operating with even very simple rules generate together rather sophisticated behaviour at the aggregate level. In order to avoid the aggregation problem, DSGE methodology makes the representative agent assumption, which implies "that the whole economy acts like a single optimizer" [Solow 2008, p. 244]. This leads to the omission of agent co-ordination problems, the distribution problems, asymmetric information, and any other complex aggregate behaviour that emerges form the interaction among agents.

An assumption that has come in for the strongest criticism is that of RE. It implies that economic agents' forecasts are always unbiased and have only unsystematic errors. However, it is argued that RE seemed to be at odds with other social-science findings about actual economic behaviour of human beings [Spahn 2009]. Also, empirical evidence contradicts these strong requirements. Recently there has been a growing literature whose aim is to refine our knowledge on expectations formations and get rid of the most extreme characteristics of the RE hypothesis. The new literature of learning assumes that agents' forecasting models have limited abilities and the exact values of the parameters are discovered only gradually, so agents continuously learn about the behaviour of the economy (as economists do when facing serious recessions such as the recent one).

Abandoning the classic assumption of fully flexible prices allowed DSGE models to better explain observed characteristics of the business cycle. These results, however, are based on a potentially restrictive assumption for the price setting behaviour of individual firms: they are allowed to reset their prices only at randomly arriving times, which is sometimes called the "time-dependent" Calvo pricing rule. In estimated DSGE models this rule gives relatively infrequent price changes – in every nine months on average. Hence, an important question is whether this assumption is realistic enough?

The next major area of critique is the treatment of the labour market. As a consequence of the stylised conditions, there is no involuntary unemployment in the baseline DSGE model and the labour is a homogenous good that can be deployed readily and universally. The employees and jobs are all identical and labour markets are not characterised by a large number of institutional regulations. This abstracts from many key aspects of the real labour market.

The DSGE model consists of a system of non-linear stochastic difference equations. Finding closed-form solutions for these is impossible so there is a need for some approximation techniques. The most widely used technique relies on taking a first-order Taylor approximation to the equilibrium conditions around the

non-stochastic steady-state and studying the behaviour of endogenous variables in response to small stochastic perturbations to the exogenous process. Essentially, this means that an analysis is restricted by only considering linear models with additive random shocks. This maybe a valid approximations for small shocks, but not for infrequent but possibly large shocks. Generally, the practice of removing all non-linearities and most of the interesting parts of uncertainty from the DSGE models should be perceived as a singificant drawback.

Finally, taking the DSGE models to the data may be quite challenging because, from the empirical point of view, none of these models actually represents the data generating process for the observed time-series and, in general, they are not specifically designed for such a purpose. The DSGE models were designed to gain insights about specific economic relationships rather than describe the actual economy. In the DSGE literature, the theoretical concepts have been captured not against specific data figures, but against filtered data. That is why certain constraining preconditions and data transformations may be necessary, for instance: detrending, the elimination of outliers, the selection of appropriately stable periods, or the elimination of structural breaks. Furthermore, estimates may be biased by model misspecification and parameter identification may not always be easy to achieve. Such difficulties may cast doubts about the practical use of available DSGE models, which may also be more significant in CEE countries given the frequent underlying problems related to data, rapid structural change, and frequent policy shifts.

Although we do not pretend to make an exhaustive list of criticism, it is also possible to mention that more work is required in modelling inflation dynamics, incorporating more explicitly the role of fiscal policies, improving the interaction between trade and financial openness, and especially modelling financial markets. The latter is discussed in the next section.

3. Modelling the financial sector

Possibly, the main weaknesses in current DSGEs is the absence of the appropriate way of modelling financial markets. The relevance of the financial structure of the economy is well-known as reflected by the repetitive waves of financial crises across the world. Therefore, by excluding a formal modelling of financial markets or financial frictions, the current benchmark DSGE model fails to explain the important regularities of the business cycle. It also excludes any possible analysis of other key policy issues, such as financial vulnerabilities, illiquidity, or the financial systems' procyclicality. The weak modelling of financial markets in these models also limits their use for stress testing in financial stability exercises.

In the baseline DSGE model investment is financed directly by households' savings without the involvement of financial intermediaries. The intertemporal utility optimization is based on the assumption that all debts are ultimately paid in full, thereby removing all credit risk and default. This follows from the assumption of

what is known technically as the transversality condition, which means, in effect, that all economic agents with their rational expectations are perfectly credit worthy. All fixed-interest financial assets are identical so that there is a single rate of interest in any period, i.e. no risk premia. Over time the single rate of interest may change as borrowing and savings propensities change. Under such circumstance no individual economic agent or firm is liquidity constrained, which implies the absence of credit rationing. Thus, there is no need for commercial banks or even money [see Arestis 2009]. The DSGE model relies on a frictionless world, where lenders and borrowers have the same information about risks and returns, costlessly monitor the use and repayment of borrowed funds, and are not faced with search and transaction costs.

The critique so far may appear as unfair as it neglects the various refinements that were proposed in order to develop and improve the basic model set-up. The most common approach is based on "financial accelerator" mechanism [Bernanke *et al.* 1999]: a negative shock leads to lower investment, which causes losses for firms and reduces their net worth. This increases their borrowing costs (due to higher interest rate premium) that make them to invest even less. This credit channel amplifies the effect of the original shock and means that financial frictions affect the economy via prices of loans. Such a framework was used by Goodfriend and McCallum [2007], who provided an endogenous explanation for steady state differentials between lending and money market rates. Canzoneri *et al.* [2008] let households finance a long-term consumption good by means of periodical loans from banks and attach liquidity premium to bank deposits. Cúrdia and Woodford [2009] derived optimal monetary policy in the presence of time-varying interest rate spreads in a model with heterogeneous agents.

The second stream of research introduces financial frictions via collateral constraints. Agents are heterogeneous in terms of their rate of time preference, which divides them into lenders and borrowers. The financial sector intermediates between these groups and introduces frictions by requiring that borrowers provide collateral for their loans. Hence, this approach introduces frictions that affect directly the quantity of loans. The applications relying on this framework include Calza *et al.* [2009], who analyse the impact of mortgage market characteristics on monetary transmission. Brzoza-Brzezina *et al.* [2010] use models with collateral constraints and monopolistic competition in the banking sector to examine the impact of financial frictions on monetary transmission and a credit crunch scenario. Iacoviello and Neri [2010] estimate a model with collateral constraints on US data in order to study the role of housing market shocks on the economy.

The other works which offer a promising avenue to improve the manner in which financial and credit frictions are incorporated into the DSGE models are Dib [2010], Gerali *et al.* [2010], Gilchrist *et al.* [2009], Pierrard *et al.* [2010].

Summarizing the recent developments in the area of modelling the financial sector, two important issues should be clearly stated. First, there are still a number of increasingly relevant problems that has not yet been successfully incorporated into

mainstream DSGE models. For instance: asset bubbles, currency risk premia, term structure of interest rates, portfolio choice and composition, home equity bias or modelling the gross asset and liability positions. Second, the introduction of the additional financial ingredients in a benchmark model already loaded with other questionable assumptions (see previous section) is not convincing. The fact that an additional assumption helps fit the aggregate dynamics in a model which is misspecified elsewhere cannot provide any profound and meaningful insights about the behaviour of the economy.

4. Conclusions

The financial meltdown and the substantial policy responses stirred a heated debate within and outside the economics profession about the applicability and usefulness of the current generation of DSGE models. While these models are a very promising approach to analysing macroeconomic relationships, there are still many questions which cannot be answered or which can be answered only tentatively using such models. The crisis has shown that one particularly important ingredient is missing: standard DSGE models have left out financial markets from their structure. It is clear that the economy cannot be understood without financial markets – either as the source or as the propagator of shocks – and proper model-based policy advice could not be made without a model that incorporates financial markets. For this reason, intensive work should be undertaken on how the significance of credit developments and of the monetary aggregates can be better integrated into DSGE models. Increasing attention must be paid to the fact that households and enterprises can be very different as well as to the need to focus more on this heterogeneity and its possible implications for the economy as a whole. Finally, greater consideration should be given to the fact that uncertainty still prevails about the precise structure of the economy and that expectations are not formed entirely rationally.

To conclude, the DSGE models need to be developed further to be able to analyse and quantify factors that the recent crisis showed essential. The number of new papers that deal with financial markets prove that macroeconomists are taking this challenge serious.

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KRYZYS FINANSOWY A MODELE DSGE. KRYTYCZNA OCENA

Streszczenie: Globalny kryzys finansowy wywołał krytyczną debatę nad obecnym stanem makroekonomii jako dyscypliny naukowej oraz skłonił do stawiania nowych pytań badawczych. Jeden z najsilniejszych nurtów tej krytyki dotyczy klasy dynamicznych, stochastycznych modeli równowagi ogólnej (skrótowo: DSGE). W kontekście opisywanej debaty, rozważania w niniejszym artykule mają dwa cele. Pierwszy dotyczy opisowego wskazania głównych wad metodologii DSGE, ze szczególnym uwzględnieniem nieadekwatnego ujęcia procesów zachodzących na rynkach finansowych. Drugim celem artykułu jest natomiast selektywny przegląd ostatnich osiągnięć w omawianym obszarze. W podsumowaniu stwierdzono, iż pomimo znacznego postępu w rozwoju metodologii DSGE, wiele ważnych problemów w dalszym ciągu pozostaje bez rozwiązania.