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Toward a New Microfounded Macroeconomics in the Wake of the Crisis

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Abstract

The Great Recession that followed the financial crisis of 2007 is not only the largest *economic crisis* after the Great Depression of the 1930s, it also signals a *crisis of economics* as a discipline. This is not only the consequence of the inadequacy of *mainstream* macroeconomics, and specifically the DSGE workhorse model, to forecast such a huge event, or at least to detect the worrying tendencies towards it. Even more relevant is the choice to explicitly avoid the modelling of large crises (that for someone is a motivation for not attacking pre-crisis DSGE models focused on the analysis of small deviations from the *steady-state*), so denying the intrinsic nature of capitalism, a system that necessarily proceeds through cycles and (extended) crises. The replies of the DSGE approach to critics have led to extensions regarding for instance the role of financial frictions, heterogeneous agents, and bounded rationality (though typically in the form of quasi-rational expectations). The alternative paradigm of Agent-Based Macroeconomics can take into account all these elements at once within an evolutionary modelling framework based on heterogeneity *and* interaction, so capable to endogenously reproduce *complex* dynamics, from small fluctuations to large crises, due to innovation and industrial dynamics, rising inequality and financial instability, and so on. The integration between Agent-Based Macroeconomics and the (post-Keynesian) Stock-Flow Consistent approach represents a promising way for the future development of this research field.

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1 Introduction

A decade has passed since the beginning of the crisis which, starting from the sub-prime mortgage sector of the United States, battered the US financial system and then triggered a world-scale economic crisis, the Great Recession. As is well known, the crisis arrived undetected from the vast majority of economists.¹ This has shed some discredit on the economic profession, and prompted a wave of critiques on mainstream theoretical framework and on the dominating approach in macroeconomic modelling: the Dynamic Stochastic General Equilibrium (DSGE now on). This class of models, among Central Banks' toolkits, came under fire for two main reasons: first, their failure to foresee the disruptive event; second, for their inability to provide any help in explaining and finding a way out of the crisis. A statement from former president of the ECB, Jean-Claud Trichet, is emblematic in this sense: 'Macro models failed to predict the crisis and seemed incapable of explaining what was happening to the economy in a convincing manner. As a policy-maker during the crisis, I found the available models of limited help. In fact, I would go further: in the face of the crisis, we felt abandoned by conventional tools' (Trichet, 2010, p.5). The identification of the reasons for this spectacular failure has been at the centre of a large debate on the adequacy of DSGE models. After ten years the debate is still on and DSGE models are still the dominating approach in macroeconomic modelling. Simplifying a bit, we can identify two main positions in the debate. On the one hand, those who dismiss DSGE models, contending that the drawbacks causing their poor performances in face of the crisis lay at the very core of this approach, which is therefore unavoidably fallacious and thus should be abandoned (e.g. Buiter, 2009; Solow, 2010; Stiglitz, 2011). On the other hand, those who defend the approach and suggest development and improvements. In this second group the stance has been undoubtedly more apologetic, at least about the methodology and its theoretical roots (e.g. Ascari, 2011; Reis, 2017); drawbacks are considered escapable and only seldom the importance of pluralism in modelling approach is acknowledged (Blanchard, 2017). However, the presence of deficiencies and omissions in DSGE literature is not denied.

In September 2017 the Università Politecnica delle Marche hosted a conference entitled *Economics, Economic Policies and Sustainable Growth in the Wake of the Crisis*. The goal was to have academics confronting in a pluralistic environment about the lessons learned from the crisis and the subsequent long-lasting recession. More than seventy papers were presented, fourteen were AB models. We selected five of them to be published in a special section of *Industrial and Corporate Change*² on advancement in the Agent-Based (AB from now on) modelling approach. We believe that these works are of great interest not

¹See Bezemer (2009) for a partial list of economists who did foresee the crisis.

²Volume 27, Issue 6.

only because they present developments to their belonging literature. Their contribution is probably even more significant if looked from a broader perspective, taking into account the aforementioned debate on the fitness of macro models. In fact, each of the papers brings an advancement in one (or more) of the areas in which DSGE literature showed inadequate. This is even more significant taking into account that the AB approach *per se* circumvents some of the weaknesses of mainstream models, as we will try to show in Section 4.

The remaining of this paper is organised as follows. In Section 2 we overview some of the main critiques raised towards DSGE models and, in Section 3, we briefly discuss how this literature reacted trying to overcome some of the most glaring criticisms. Then, in Section 4 we move on to analyze where AB models stand with respect to those DSGE drawbacks, stressing that AB modelling is a sound tool for analyzing the economy as an *evolving complex system*, in which macro dynamics emerge from the (direct/endogenous) interaction of many heterogeneous micro entities. In this section we provide with a concise review of the main approaches within the AB macro field, and discuss the main characteristics of the emerging AB-SFC (where SFC stays for Stock Flow Consistent) macro modelling trend in the literature, well represented in the present special section. Overall, the papers included in the special section present innovative contents along the way ‘toward a new microfounded macroeconomics in the wake of the crisis’. Finally, we propose some conclusive remarks.

2 The debate

The debate ignited by the crisis took place on academic journals, newspapers, and (largely) on the blogosphere and it is therefore vast and fragmented. Nonetheless, albeit the disomogeneity, it is possible to identify some recurrent topics. In this section we will offer a brief overview listing some of the main critiques raised against mainstream macroeconomics and DSGE models, with no ambition to provide with an exhaustive review of the literature.

The most comprehensive and trenchant critiques are those directed to the whole *mainstream* macroeconomic framework and particularly to the DSGE workhorse model. Two elements are recurrently considered as the root of the limitations of this approach: the alleged perfect rationality of economic agents and an overconfidence in the self-regulation ability of the markets. Both these elements have a long record of critiques and according to several authors (e.g. Buiter, 2009; Skidelsky, 2009) they are not only at odds with reality, but combined delineate a theoretical frame in which major crises cannot find place and which should therefore be abandoned. A similar opinion but from a different perspective is proposed by Krugman (2009) referring to the dichotomy between what can be considered

as two strands of the mainstream approach,³ namely the Neo-Classical (NC) or freshwater economists and the New-Keynesian (NK) or saltwater economists, though in our view both can be labelled as *neoclassical*.⁴ Therefore in our view, it does not surprise that, according to Krugman, while being considered more pragmatic, NK was not able to distinguish itself from NC in offering sounder policy advices. According to Krugman, NK uniformed to NC in two key aspects. First, the fascination for the above-mentioned ‘recurrent elements’: perfect markets and rational individuals. Second, the neglect of a role for fiscal policy in fighting recessions.⁵ Krugman’s perspective includes both the stances we identified in the debate: on the one hand, the harsher critics focusing on the theoretical weaknesses and suggesting a revolution in the approach, and on the other hand the more apologetic signalling the holes in the literature and calling at most for an evolution within the same theoretical framework. Kirman (2010) denounces the inappropriateness of this latter stance when he states ‘We persist in clinging to the basic models and making them more mathematically sophisticated whilst overlooking their fundamental flaws.’ (*ibidem* p.512).

We hereafter try to provide with a short list of main criticism, starting from ‘fundamental flaws’. The following list should by no means be considered as a comprehensive critique to the mainstream framework, as this would be beyond the scope of this paper (for a thorough review of the critiques to the mainstream approach, see for example Delli Gatti et al., 2011).

- *Confidence in the Market.* The first component of our list coincides with the first of the two above-mentioned recurrent elements. The mathematical failure of the General Equilibrium (GE) in representing either a stable or unique equilibrium has been exposed since the 70s (Ackerman, 2002). Even when the theoretical soundness of the GE approach is not queried, the excessive confidence in market forces at the very core of the Efficient Market Hypothesis (EMH) and of the whole GE framework has been harshly criticised. This element is identified by several authors as the reason for the inability of DSGE models to cope with out-of-equilibrium and non-linear dynamics, as those characterizing financial crises (Krugman, 2009; Kirman, 2010; Haldane, 2016). In fact, as openly recognised by Robert Lucas, these models could not foresee the crisis because they can only produce ‘a forecast of what could be expected conditional on a crisis not occurring’ (Lucas, 2009).⁶ Other authors (e.g. Skidelsky, 2009), specifically

³New Consensus Macroeconomics (Meyer, 2001) or the New Neoclassical Synthesis (Goodfriend, 2007).

⁴Skidelsky (2018) notices that unlike other strands of Keynesian economics, New Keynesians - or saltwater economists - do not account for fundamental uncertainty and this is in his view the reason why they are bound to collapse into neo-classical economics.

⁵After eight years, Olivier Blanchard, as we will see a very active voice in the debate on the state of macro, expressed his surprise in the lack of more research on fiscal policies after the crisis (Blanchard, 2016) somehow signalling how this gap has not been filled.

⁶It is curious to notice how strongly this recalls a famous (very often miss-quoted) quote by Keynes: ‘The

referring to the financial side of the economy, suggest that the loose financial regulation, which made the sub-prime crisis possible, finds its theoretical motivation in the EMH.

- *Rationality.* Agents' subjective expectations correspond to the mathematical conditional expectations implied by the model, therefore forecasts include only random errors. Agents are assumed both to know how '*the model*' of the economy works and to have access to all relevant informations. That is equivalent to say that there is a universal model of the world and that events unfold according to a well known probability distribution. This is in extreme synthesis the Rational Expectations Hypothesis (REH). A concept which is one of the tenets of DSGE models and was developed in contrast to '*fundamental uncertainty*' (Keynes, 1921; Knight, 1921). This *model consistent* form of rationality has attracted numerous critiques ranging from its implausibility as an assumption on human behaviour (Simon, 2000; Frydman and Phelps, 2013), to its uselessness in the face of extreme events (Hendry and Mizon, 2010; Hendry and Meullbauer, 2018) or novelties (Stiglitz, 2018), and the unreasonable existence of *the model* of the economy (Kay, 2012). On a more practical stance, the idea that agents are aware of the data-generating process representing the economy makes the REH unfit to cope with financial crises (White, 2009; Syll, 2012).
- *Representative Agent.* The coincidence of complex macroeconomic sectors with single representative agents is both considered as theoretically unsound (e.g. Kirman, 2010; Stiglitz, 2018; Hendry and Meullbauer, 2018) and as a too unrealistic assumption (e.g. De Grauwe, 2009; Solow, 2010). In a nutshell, in the passage from the individual to the aggregate level several characteristics of individual functions are lost; numerous highly restrictive assumptions are therefore required in order to obtain the desired (Kirman, 1992) behaviour of a representative agent. The main harmful consequence of this peculiar form of microfoundation is that it cancels out crucial economic aspects as heterogeneity, interactions, conflicts of interests, meaningful information asymmetries, and institutions as underlined by several authors (e.g. Brock and Durlauf, 2006; Solow, 2010; McCombie and Negru, 2014; Stiglitz, 2018). All matters which play a crucial role in leading the economy toward unsustainable paths.⁷

- *Unrealistic assumptions.* Lavoie (2014) lists instrumentalism - next to model-consistent long run is a misleading guide to current affairs. In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us that when the storm is past the ocean is flat again' (Keynes, 1923, p.80).

⁷Moreover, as recognised by Galí (2017), the standard assumption of infinitely lived representative agent can hardly coexist with the presence of bubbles, as this would violate transversality conditions.

rationality, optimizing agent, atomism, scarcity, and unfettered markets - as one of the presupposition of mainstream economics. May it be due to the specific assumptions underlying a theory (Pasinetti, 2012) or to the whole methodology, based on mathematical deductivist modelling (Lawson, 2009), the lack of realism is a further element often identified as a theoretical root of the crisis (e.g. Skidelsky, 2009; Kay, 2012), even with respect to New-Keynesian approach which, adding some friction, departs only slightly from Neo-Classical models. Of particular interest to our contribution is Caballero (2010), according to whom ‘we need to spend much more effort in understanding the topology of interactions in real economies.’ (*ibidem*, p. 100). In his view economists should embrace *complexity* rather than shy away from it, choosing instead to pursue ‘quantitative mathematical formalizations of a precise but largely irrelevant world’ (*ibidem*, p. 100).

- *Lack of financial ‘details’*. This last element is strictly linked to the former. Nonetheless, due to its centrality in the events which inspire this work and to its highly recurring appearance in the debate, we decided to single it out. Before the crisis, mainstream macro modelling was highly deficient in its approach to the financial side of the economy (De Grauwe, 2009) and this might have hampered the capacity of economists to foresee the crisis and to even observing the unfolding of the events which caused it. Stiglitz (2011, p.598) blames the aforementioned representative agent: ‘no financial markets (who is lending to whom?); no scope accordingly for excess indebtedness (who owes money to whom?) or for deleveraging (who is reducing their indebtedness to whom?); no problem of debt restructuring; no meaningful capital structures (since the single individual is bearing all the risk, it is obvious that nothing can depend on whether finance is provided in the form of debt or equity); no role for bankruptcy’. While Hendry and Meullbauer (2018,p.323), referring to the DSGE models identify critical omissions regarding shifts in credit availability, *households balance sheets* (more on this below), and an explicit representation of different assets (rather than their aggregation into the net worth). It is important to underline how the trivial (or even absent) representation the financial sector can be seen as ‘a failure of observation rather than a fundamental failure of concept.’ (Krugman, 2018, p.160). The neglecting of monetary aspects is deeply rooted in a monetary theory that does not take into account technical and historical aspects on the functioning of monetary systems (Goodhart, 2009) and in which money is neutral.

A recurrent similitude in this debate compares economic with weather forecasting. What we believe is essential to stress is that there is a key difference. The approach used in

developing weather forecasting has no implications whatsoever on the probability of a storm to occur. Economic and financial crisis are not natural phenomena though. Economic theories, inspire or at least legitimate, the economic policies which make crisis more or less likely to occur.

3 DSGE's answers to critiques

How did the mainstream economists reacted to these numerous critiques. As mentioned above, two main reactions emerged. On the one hand, those dismissing critiques and counterattacking, often misrepresenting critiques and possible alternative frameworks. On the other hand, those admitting some of the limitations of DSGE models, and asking for a development of the literature. Vines and Wills (2018), in their meritorious work on how the benchmark New Keynesian model should be rebuilt after the crisis, identify four main required changes: '(i) incorporating financial frictions rather than assuming that financial intermediation is costless; (ii) relaxing the requirement of rational expectations; (iii) introducing heterogeneous agents; (iv) underpinning the model - and each of these three new additions - with more appropriate microfoundations.' (Vines and Wills, 2018, p.4). Some efforts have already being made in this direction.⁸

The recent crisis has led to a renewal of the interest in financial factors within a macro setting. Before the crisis, a standard DSGE model with New Keynesian features (NK-DSGE) has been developed, though it failed to predict the crisis due to the lack of mechanisms able to reproduce a large financial and then economic crisis. However, the literature on financial factors was not empty already before the crisis, as the *financial accelerator* mechanism proposed by Bernanke et al. (1999) testimonies. For sure, mainstream macroeconomics has not given the due importance to financial factors, differently for instance from the post-Keynesian approach and particularly the research streamline following Minsky's *financial instability hypothesis*. Such an underestimation of financial issues has also led the mainstream to avoid an appropriate analysis of large crisis events as an intrinsic feature of capitalist development. After the crisis, the financial accelerator mechanism has been rediscovered and included in otherwise standard DSGE models, representing one of the two main mainstream approaches in modelling *financial frictions*. The other main approach has been based on *borrowing constraints* as in Kiyotaki and Moore (1997). Therefore, recent advancements deal with various financial issues and take care of the effects of financial frictions on the real economy.

⁸We want to stress how criticising DSGE models without taking into account recent efforts to overcome aforementioned limitations would not only be unfair but also counterproductive as the accusation of misrepresenting the literature would weaken the critics.

By now, there is an ample literature that we have not the space to review. Let's just stress that fundamental differences with the ABM approach remain: for instance, while DSGE-like models provide mechanisms like optimal defaults (namely, an ex-ante optimization of the fraction on debt on which a default is considered), ABMs suggest to explicitly model the direct interaction among heterogeneous agents, thus explaining financial contagion and bankruptcy chains, as well as their effects on macroeconomic dynamics.

The *representative agent* hypothesis has been at the core of DSGE modelling and still is largely adopted within this field. Unfortunately, this could be a reasonable assumption only in the case in which any aggregation bias resulting from the reduction of a complex system, like the whole economy or a sector, to the behavior of a single agent is negligible. This is hardly the case when we consider the huge heterogeneity in preferences and degrees of rationality among individuals, as well as observing the non-normal distributions that characterize many dimensions, from income and wealth distribution, to firm size, productivity levels, spatial agglomeration, and so on. While AB models include both heterogeneity and interaction – in a sense, a strong form of heterogeneity –, DSGE models have faced this issue basically according to two approaches:

1. by considering two classes of agents; or
2. including the whole agents' distribution, typically focusing on income and wealth.

As for the first approach, a typical implementation features two classes of households – patient and impatient. In particular, a model with two income classes can be considered in which the *rich* save more than the *poor* and then provide the latter with loans, for instance to maintain a high standard of consumption. A very good example of such kind of an approach is Kumhof et al. (2015).⁹ In other cases, the two groups of agents are distinguished by their degree of rationality – rational agents vs. bounded rational ones.

Another advancement within mainstream macroeconomics, which is strictly related to what we are discussing, has regarded agents' rationality. Not only DSGE models with a fraction of *non-Ricardian* agents have been implemented, but various (more refined and mathematically elegant) approaches have been proposed in the literature, from statistical learning, to restricted perceptions and rational inattention (Woodford, 2013). Just to make an example, Gabaix (2014) proposed a *sparse max* operator, which is a less than fully attentive and rational version of the traditional max operator. In this setting, the bounded rational agent maximizes its utility function both with respect to consumption and (in)attention. In other words, the bounded rational agent optimally chooses how to be inattentive. Some

⁹Though in this paper a fundamental assumption is that the *rich* have also a *love for money* in their utility function, while one may wonder why this is not the case for other people, at least in principle.

doubts may arise regarding the truly boundedly rational nature of an agent that seems to be rather characterized by a sort of meta-rationality according to which the optimal degree of inattention (namely, bounded rationality) is determined. Overall, it seems that the various proposals for dealing with the actual limitations of individual's cognitive and informational limitations are leading to some sort of quasi-Rational Expectations (RE) equilibrium models, which only partly deviate from the fully rational benchmark, perhaps underestimating the macroeconomic effects of an agents' behavior more in line with the Herbert Simon's original interpretation of bounded rationality (Simon, 1959).

As for the second approach to dealing with heterogeneity, in past decades a minority of mainstream macroeconomists have developed models with a continuum of heterogeneous households in a setting with incomplete markets (and no aggregate uncertainty), as for instance in Aiyagari (1994) and Krusell et al. (1998).¹⁰ A very good recent example is the HANK model proposed by Kaplan et al. (2018). The model yields empirically realistic distributions of wealth and marginal propensities to consume based on uninsurable income shocks and multiple assets with different degrees of liquidity and different returns. A major result is that the indirect effects of an unexpected decrease in interest rates – operating through a general equilibrium increase in labor demand – far outweigh direct effects such as intertemporal substitution, which is the one found in Representative Agent New Keynesian (RANK) economies. In this setting, though agents are fully rational, the Ricardian equivalence does not hold, and as a consequence the fiscal reaction to the monetary expansion is a key determinant of the macroeconomic response.

These attempts in overcoming some of the shortage of DSGE models are in our view praiseworthy, at least because they recognize the weaknesses of the literature. However, we believe that the suggested improvements are and cannot but be unsatisfactory. They are unsatisfactory because for instance financial frictions do not give justice to the complex interaction between agents within the real and the financial sector. The inclusion of heterogeneity leaves aside the interactions among agents. The limitation of rationality are very partial. They cannot but be unsatisfactory because they at best tackle one criticism, leaving the rest of the framework with related drawbacks untouched. 'Various knobs and whistles have been added to this workhorse framework, often involving market frictions in price-setting, competition and credit provision. These add colour to the model's dynamics but, by and large, leave intact its properties - stable, stationary, oscillatory' (Haldane, 2016, p.5). Therefore, the introduction of new elements (for instance, some additional 'frictions') coming from the *periphery* of mainstream macroeconomics (where a lot of work on micro-data has been done which is relevant for macro issues) into *core* DSGE models, according

¹⁰See Guvenen (2011) for a review article.

to the classification proposed by Caballero (2010), is an incremental strategy that could not work: ‘We are digging ourselves, one step at a time, deeper and deeper into a Fantasyland, with economic agents who can solve richer and richer stochastic general equilibrium problems containing all sorts of frictions’ (Caballero, 2010, p.90). In a sense, this is as adding new ‘epicycles’ to a Ptolemaic system.¹¹

4 Agent-based models and the debate

The economy is an *evolving complex system* (Anderson et al., 1988) composed of heterogeneous (bounded rational) agents which (locally) interact and aim at adapting to a continuously changing environment characterized by non-linearities and out-of-equilibrium dynamics.¹² Such a complex system and its intricated dynamical properties could lead researchers to completely abandon the idea of analytically study it, like *institutionalism* suggests. By contrast, the way followed by mainstream economics has been to (strongly) *reduce* the complexity of the economic system, even proposing to describe collective dynamics by means of a ‘representative agent’,¹³ in order to study it with a closed-form mathematical model. According to Caballero (2010), while narrative was the chosen tool by *institutionalism*, because no mathematical models can describe the richness of the world this approach would like to explain, “modern core of macroeconomics swung the pendulum to the other extreme, and has specialized in quantitative mathematical formalizations of a precise but largely irrelevant world” (Caballero, 2010, p.100). The challenge is to find another way between these two polar opposites, that in our view cannot be based on a series of extensions to fix a wrong model (still centered on a Real Business Cycle core) but rather on a *complexity* view of the economy (Kirman, 2011).

Agent based modelling is a research methodology based on computational methods which is largely employed in the study of complex systems, in which heterogeneous micro-entities interact according to different network topologies giving rise to emergent macro-properties. AB models have been introduced in economics to study how complex aggregate phenomena may emerge from the bottom up, based on the direct interaction among heterogeneous agents (Tsfatsion and Judd, 2006).¹⁴ Two major characteristics are at the basis of an

¹¹See Fagiolo and Roventini (2017) for a critical discussion of the theoretical, empirical and political-economy pitfalls of the DSGE-based approach to policy analysis.

¹²See Dosi and Virgillito (2017) for a discussion on how *coordination* and *change*, which typically are treated as separated issues in mainstream economics, should be analyzed together, as two interrelated aspects which explain the evolution of complex economic systems. In particular, they propose a ‘bicycle conjecture’ according to which *in order to stand up you must keep cycling*.

¹³See Kirman (1992) for a well-known critic of the representative agent hypothesis.

¹⁴However, one of the first attempts to model an economy starting from its individual components dates

interpretation of the economy as a complex system:

- *heterogeneity*. Agents may differ along many dimensions such as information, income, wealth, financial fragility, spatial location, and so on. In a model with heterogeneous agents, aggregate regularities are not approximated by the behavior of a *representative agent* (Kirman, 1992), which may lead to some inconsistencies as data are often characterized by *power law* distributions, rather than being Gaussian distributed. As a consequence, it is hardly possible to reduce the complexity of an economic system to the behavior of a single (representative) agent, given that the average does not represent the behavior of the system, and representative agent models may suffer from a fallacy of composition. However, also mainstream models have introduced some degree of heterogeneity. For instance, the recent debate in the DSGE (Dynamic Stochastic General Equilibrium) models community is focused on the introduction of financial frictions and agents' heterogeneity regarding income and wealth distributions (as said before);
- *interaction*. What is still missing in mainstream macroeconomics is *direct interaction* among heterogeneous agents. Mainstream DSGE-like models implicitly assume a complete network among agents (i.e. each agent is connected to every other agent), even when agents are heterogeneous. By contrast, AB models present different topologies of interaction, thus heterogeneity plays an even more relevant role being interrelated with network dynamics. A relevant example of the central role played by networks of heterogeneous agents is *financial contagion*: the default of a financially fragile agent may lead to another failure, and so on, giving rise to a *bankruptcy cascade*, thus amplifying the effects of financial factors, and possibly leading to large crises (see, for instance, the so-called network-based financial accelerator in Delli Gatti et al., 2010).

Therefore, AB models are featured by both heterogeneity *and* interaction, so that we can refer to them also as models with Heterogeneous Interacting Agents (HIA).

In recent decades there has been a blossoming of AB macroeconomic models.¹⁵ In some cases the AB methodology has been applied to partial disequilibrium contexts with macroeconomic relevance, as in Delli Gatti et al. (2010) in which heterogeneous firms, belonging to two sectors (upstream and downstream firms), interact with financially fragile heterogeneous banks in order to finance their production, giving rise to a *network-based financial accelerator*.¹⁶ In what follows, we focus on contributions aimed at integrating the analysis back to Orcutt (1957) and the *microsimulation* approach.

¹⁵See Delli Gatti and Dawid (2018) for a comprehensive review.

¹⁶An earlier contribution in which financially fragile firms are considered is Delli Gatti et al. (2005) in which the authors focus on firms' (power law) distribution and Minskian instability, though only based on

of financial factors and the working of the real economy, by including financial contagion and bankruptcy chains in a fully-fledged macroeconomic model.¹⁷

A paper in which all markets are described by a truly *decentralized matching mechanism* with heterogeneous interacting agents is the one proposed by Riccetti et al. (2015),¹⁸ in which the interplay between finance and the real economy is at the core of endogenous business cycles and extended crises. Further extensions of this AB macro model have been proposed for investigating various macroeconomic topics as the financialization of non-financial firms (Riccetti et al., 2016), inequality and consumer credit (Russo et al., 2016), and financial regulation (Riccetti et al., 2018). Overall, in this modelling framework the consistency of economic and financial flows is checked, so that there are no black holes in the macroeconomic accounting. For instance, let's think about the firms' entry-exit process: when a firm goes bankrupt, some other agents (connected to the defaulted one) suffer a loss; moreover, the resources needed for financing the new entrant(s) are not exogenous (as in previous models of the same research streamline and in others in the literature) but they are subtracted from dividends before their distribution to households. This is not only a matter of macro accounting, but also a way to appropriately taking into account the effects of economic and financial flows, on micro, meso and macro variables. Given the example we made, firm (and bank) defaults may have a negative impact on consumption, and then on macro dynamics, because bankruptcies subtract resources to households which are instead used to finance new entrants. Accordingly, financial factors may (strongly) affect the real economy.

Dosi et al. (2010) proposed a macroeconomic model in which a Schumpeterian innovation process is combined with Keynesian demand management (K+S). In this case, while the interaction between capital producers and final goods producers is explicitly modelled through AB techniques, other markets are kept as simple as possible. The core of the model is the innovation process introduced according to an evolutionary perspectives (Nelson and Winter, 1982; Dosi, 1988). The authors have then disaggregated other markets, giving more space to financial factors. In other words, it is possible to note a tendency to enlarge the modelling framework to proceed towards the construction of a fully-fledged macro model. The model generates endogenous growth and fluctuations punctuated by major crises and can reproduce a long list of stylized facts. The K+S model has been employed to perform *indirect* interaction between heterogeneous firms and an aggregated banking sector.

¹⁷Without any pretense of generality, we propose a discussion centered around three main directions of research in the macro ABM field, while a comprehensive review can be found in Delli Gatti and Dawid (2018).

¹⁸This line of research comes from previous attempts to building an AB macro model with decentralized mechanisms to describe the working of markets with heterogeneous interacting agents, as for instance in Russo et al. (2007).

policy analyses concerning innovation, fiscal, monetary, and industrial policies, stressing that is the strong complementarity between Schumpeterian (technological) and Keynesian (demand-related) policies ensures that the economy follows a path of sustained stable growth (Dosi et al., 2013, 2015). Recent advances have regarded the labor market and the potential damages of flexibility (Dosi et al., 2017b), environmental issues (Lamperti et al., 2018), and the open-economy (Dosi et al., 2017c). Moreover, this framework has been employed to experiment various form of expectations showing that simple schemes may perform better than more complicated ones in an evolving complex system, so that we can speak of ‘rational heuristics’ (Dosi et al., 2017a).¹⁹

While the K+S model started from an initial core centered around innovation dynamics in an evolutionary setting then proceeding by including more financial factors towards a macro framework, a reversed process has characterized the evolution of the research streamline centered around Delli Gatti et al. (2010) – and then the analysis of business cycles in an evolving credit-network economy, in a partial disequilibrium context – and Riccetti et al. (2015) – based on a fully decentralized matching for analyzing market interactions among heterogeneous agents in a macro setting. In this case, the starting point was *financial fragility* and the fundamental role of agent’s heterogeneity along financial dimensions and credit-network interactions in shaping macro dynamics. Successively, the framework has been amended to implement a fully-fledged AB-SFC macroeconomic model with heterogeneous interacting agents, including capital goods and innovations, again along evolutionary lines (Caiani et al., 2016). Building on the latter contribution, the interplay between innovation and inequality has been investigated, highlighting that increasing inequality may damage innovative activities thus hampering long-run economic growth (Caiani et al., 2018a,b). Another line of development has regarded topics related to open-economy macroeconomics (see the contribution by Caiani, Catullo and Gallegati in this issue).

The EURACE large-scale modelling framework of the European economy (see, for instance, Dawid et al. (2018a) for a comprehensive presentation of the model) has considered the consistency between flows and stocks as a relevant aspect to be included in the model since the first versions.²⁰ Also in this class of models, the interaction between the financial and the real spheres of the economy is key in generating endogenous business cycles. It is worth to note that the various authors involved in the development of such a framework have stressed the importance of agents’ behavioral rules and provided some references coming from behavioral and experimental economics, as well as from management studies.

¹⁹See also Sinitskaya and Tesfatsion (2015); Colasante et al. (2017) on this point.

²⁰Another model, not related to the EURACE project, which takes care of SFC in a macro ABM setting is Seppelcher (2012); see also the contribution of Seppelcher, Salle and Lavoie in this issue.

Different topics have been investigated in this framework, for instance: financial and macro-prudential regulation (Cincotti et al., 2010; Dawid et al., 2018b), regional dynamics and innovation policies (Dawid et al., 2014), fiscal policies (Dawid et al., 2018b; Teglio et al., 2018).

Before moving to the analysis of the advancement of AB literature, we want to make a consideration inspired by the content of this special section. It seems that a new standard is emerging in AB macro modelling. Even the papers included in this special section present models in which the AB modelling combines the Stock-Flow Consistent (SFC) approach (Godley and Lavoie, 2007; Caverzasi and Godin, 2014). Few words on the SFC are required to fully appreciate the implication of this *marriage*. This is a macro-modelling approach made of two components: a rigorous accounting framework and a set of behavioural equations determining all variables' values not directly implied by the accounting. The rigorous accounting ensures consistency under three perspectives. '*Flow consistency*: Every monetary flow comes from somewhere and goes somewhere. [...]; (ii) *Stock consistency*: The financial liabilities of an agent or sector are the financial assets of some other agent or sector. [...] *Stock-flow consistency*: Every flow implies the change in one or more stocks.' (Nikiforos and Zezza, 2017, p. 1207). Despite the centrality of the accounting rules and albeit the denomination 'SFC' might cause some controversy, this approach should not be considered simply as a generalised respect of budget constraints. Key characterising features are the followings. The financial side of the economy and the monetary system are explicitly modelled. The economy is represented as a network of interrelated (sectoral) balance sheets, therefore, financial and real dynamics develop conjunctly and shape one another through continuous feedbacks. Moreover, these models are based on a historical notion of time, in which the long period is just a chain of short periods,²¹ hysteresis (more on this below) and path dependency can be therefore fruitfully studied in their unfolding.²² Final (and crucial point), imbalances in the balance sheets and reactions to those imbalances are among the main drivers of the economic system.

All this implies that in practice, a model in which for instance the source of a stock of money is not made explicit, or in which flows do not accumulate in (multiperiodal) stocks, or even in which the financial sector is not modelled, should not be considered SFC, no matter the respect of budget constraints or accounting.

²¹This notion of time, typical of the post Keynesian approach, derives from the work of Robinson and Kalecki.

²²It is important to notice that the SFC approach has been developing since the 80s, starting from the work of Wynne Godley (e.g. Godley and Cripps, 1983) within the post-Keynesian (PK) school of thought, whose influence can be found, beyond the theories underlying the behavioural equations. The whole framework has neat (Dos Santos, 2006) PK roots.

One of the major limitations of SFC models is arguably the lack of heterogeneity, as sectors in these models are traditionally aggregated. The *marriage* between AB and SFC is therefore one of mutual interest. On the one hand, the complex emerging dynamics of the AB model are nested in a coherent macroeconomic framework; on the other hand, SFC models are not blind to what happens within a sector. Most importantly, what originates from this union is a highly informative framework in which the economy is represented as an evolving and dynamic multi-layered network of financial relationships (Caiani et al., 2016). The macro accounting identities and constraints typical of the SFC accounting emerge from the interactions of single agents' balance sheets, so do the properties of the system at meso level. The three levels of analysis micro, meso, and macro are therefore explicitly represented and this allows to obtain a highly informative multidimensional investigation of the economic system.

We totally agree with Godley and Cripps (and with Dos Santos and Zezza, 2008, from whom we took this quote) when they state that the SFC 'logic can help to organize information in a way that enables us to learn as much from it as possible. That is what we mean by macroeconomic theory (...)' (Godley and Cripps, 1983, p. 44). The relevance of this approach to macroeconomics was made evident by the eruption of the financial crisis, which came as a surprise for the overwhelming majority of economists. We believe some passage of Besley and Hennessy (2009) is emblematic in this regard. The letter addressed to the Queen of England resumes the results of the forum held by the British Academy to answer to the famous question raised by the Queen herself 'Why didn't anybody notice?'

Everyone seemed to be doing their own job properly on its own merit. [...] The failure was to see how collectively this added up to a series of interconnected imbalances [...]. Individual risks may rightly have been viewed as small, but the risk to the system as a whole was vast. So in summary [...] the failure to foresee the timing, extent and severity of the crisis [...] was principally a failure of the collective imagination of many bright people, [...] to understand the risks to the system as a whole (Besley and Hennessy, 2009, p.3).

Organizing informations at macro level, as suggested by Godley, might have helped to '*stimulate the imagination*' over the possible impacts of observed phenomena on the economic system as a whole.

Our opinion is that it is impossible to cope with the complexity of the economic system relying on a unique point of view, as *bright* one can be, and as *lively* his imagination. What we are advocating here is the necessity to rely on multiple perspectives to understand at best a multidimensional subject as economics.

This is meant to be both a call for pluralism and also a vindication of the major strength of the AB-SFC approach, where the microfoundation, and the coherent and comprehensive accounting framework at micro and macro levels combine ensuring that no financial flows or balance sheet disequilibrium is overlooked in its existence and consequences.

5 The papers of the special section

Three main characteristics make this special session of great interest. First, the five papers included well testify the versatility of the AB macro modelling approach, as the five subjects tackled differ substantially one another: hysteresis, mark up and price setting, fiscal policy, securitization, and fiscal consolidation in a Monetary Union. Second, the findings and their policy implications are most of the time not simply informed but also made possible by the specific microfoundation based on heterogenous interacting agents. Different approaches - *i.e.* with a representative agent or a with aggregate sectors - would not be able to reach the same conclusions. Third, all the works offer contributions in areas in which the mainstream macro modelling literature appeared to be deficient in light of recent economic events. The former governor of the Federal Reserve, in a speech entitled ‘Macroeconomic Research After the Crisis’ (Yellen, 2016), listed five macroeconomic questions made urgent by the crisis. The first question refers to the long term effects of falls in aggregate demand on aggregate supply (*i.e. hysteresis*). The second refers to the impacts of heterogeneity on the economy. The third inquiries which are the interactions between the real and the financial sector. The fourth is about the determinant of inflation. The final question concerns international spillover. Albeit, this was not planned when the conference or the special section were organised, it is curious to note how this special issue provides answers to each of these questions.

Dosi et al. (2018) provide a contribution to the debate on hysteresis, whose originality goes well-beyond the approach utilised. The authors building on Dosi et al. (2016) and Dosi et al. (2017b) present two regimes of labour market conditions and study both inter-regime and intra-regime hysteresis, that is to say switching or not to the other regime within the simulation. In the *Fordist regime*, wages are anchored to productivity and firing occurs when profits fall negative; in the *Competitive regime* the labour market is decentralised and wages change responding to unemployment. In both regimes higher workers’ skill increase the chance to be hired and unemployment spells decrease skills. The model presents several channels which determine negative long lasting effects of a fall in aggregate demand. Hysteresis emerges indeed as the combined results of a fall in labor’s skills, lower firms’ innovation and investment, and increased volatility in firms entry. The main finding of the paper is the negative effect of increased labor market flexibility on hysteresis. This puts the

work in sharp contrast with traditional mainstream contributions on the causes of hysteresis, as Blanchard and Summers (1986) where hysteresis is imputed to wage rigidity caused by labour union. Brancaccio and Saraceno (2017) note how the neat separation between cycles (or short run), where demand effects can exert impacts on economic outcome, and long run equilibrium where output levels depend exclusively on supply side elements, is a typical tenet of Walrasian economics and DSGE models. Contributions, like Blanchard and Summers (1986), to a certain extent overcome the dichotomy between short and long run, reverting to market rigidities, which prevent market forces (*i.e.* deflation) to restore the long run equilibrium. The contribution of Dosi et al. (2018) and the potential of the AB-SFC approach are here self evident. The model provides a far broader explanation for hysteresis, which has several causes. This can inform policy makers and help to develop a wider range of policies against the prolonged effects of a fall in aggregate demand, well beyond *structural reforms* to make the market less rigid. Moreover, the historical time approach allows to study the unfolding of events with no tension toward a predetermined centre of gravity. Hysteresis, in AB macro model and in particular in Dosi et al. (2018) therefore is not seen as an exception in the path toward general equilibrium, but it can be studied, more fruitfully, as the outcome of the normal succession of events.

Sepecher et al. (2018) tackle an often overlooked subject: they put forward a very interesting study of the mark-up and of its determinants, trying to understand the possible differences among sectors. In particular, their AB-SFC model emphasises two core elements in single firms' price setting process: on the one hand, the trade off between profit margins and market shares and on the other hand, the interdependence among firms in competition. This complex coordination problem, which involves a multitude of heterogenous individuals, is explicitly reproduced through an AB-SFC model and it is not buried underneath simplifying assumptions, such as the Walrasian auctioneer or through what the authors define as a 'fixed point reasoning' (Sepecher et al., 2018, p.4), coming from the solution of an optimization as in the Neoclassical macroeconomics. To describe the potential of AB modelling in tackling this approach we cannot do best than relying on the words' of the authors. '*Disaggregation and heterogeneity* are required to study coordination issues. *Micro interactions* are necessary to model market mechanisms and the endogenous emergence of aggregate patterns' (Sepecher et al., 2018, p.163, italic in the original text). A rather stable structure of mark-ups emerges by this process and the result is interpreted in light of PK and Evolutionary literatures as representing social norms shaped by market conditions. Relative prices ultimately depend on the quantity of labor embedded in the different goods. This '*rediscover*' of a classical price determinant represents an interesting alternative to standard price theories. The importance of a study on this subject is well expressed by (Krugman,

2018, p. 163), when describing the conventional approach to macroeconomics says: ‘We start with rational behaviour and market equilibrium as a baseline, and try to get economic dysfunction by tweaking that baseline at the edges; this approach has generated big insights in many areas, but wages and prices isn’t one of them.’

As mentioned in Section 2, the lack of research on fiscal issues was acknowledged by leading mainstream scholars such as Blanchard and Krugman. The third paper of this special session provides a contribution to filling this gap. Assenza et al. (2018) enter the debate on the effectiveness of fiscal policy. In presenting their work, the authors notice how the different stands in the original debate between Blinder and Solow (BS) on one side and Barro on the other side were associated with different macroeconomic approaches. Blinder and Solow (1973), relying on an aggregative IS-LM framework, suggested that government debt might exert a positive effect on economic activity due to the wealth effect attached with the accumulation of public bonds by households. On the contrary, the strand initiated by Barro (1974) - and then developed relying on ultra-rational Ricardian households - maintains that consumption would not be increased by expansionary policies, as households in their choices would discount the future increase in public expenditure required to cover current deficit. Assenza et al. (2018) differ substantially and, relying on a macro AB models based on Assenza et al. (2015), test for three different fiscal regimes. The results of the simulation are very intriguing. The authors show that the model tends to reach an unemployment rate consistent with a balanced budget. They label this property of their model as *Balanced Budget Emerging Property (BBEP)*. This is due to *crowding-in* effects. That is to say, when unemployment is high, transfers and public expenditure financed in part with deficit, stimulate consumption and then investment. This does not happen when unemployment is low.

Mazzocchetti et al. (2018) represent a distinct example of the strength of the AB-SFC approach in reproducing the interrelations between the financial and the real sector. The model further develops the large AB-SFC macro model Eurace (Cincotti et al., 2012) to include the market for securities (adding two new financial sectors, namely financial vehicle corporations and a mutual fund) next to the markets already present in the previous versions of the model, that is to say the markets for consumption and capital goods, housing, labor, stocks and public bonds. The paper shows the effects of securitization on business cycles. A parameter sets the securitization propensity of banks. The more they securitize, moving assets from their balance sheet to that of financial vehicles, the more they can increase their lending activity while respecting the boundaries imposed by monetary authorities, say Basel-type regulations. As a result, in the short run securitization exerts a positive impact on the economy, boosting output in a debt-led growth. This however comes at the expenses of

increased financial fragility and in the long run, higher level of securitization are associated with more severe financial crisis. We believe that this model represents a very interesting contribution to this special issue both for its innovative character and for it clearly shows the benefits of the approach. In fact, this work represents the first macro model based on AB methodology to reproduce the securitizing system. Unlike other works on the matter (e.g. Botta et al., 2018; Nikolaidi, 2015), the model includes heterogeneous agents in each sector. And this allows for the incorporation of dynamics of bankruptcies cascade. The ability to detect contagion dynamics in financial networks (Delli Gatti et al., 2010) is one of the major successes of agent-based macro models. Moreover, linking the business cycle with (rather innovative) financial dynamics, the model is manifestly able to capture the feedbacks among the real and the financial sector at micro and macro level and this, as mentioned above, is one of the main strengths of the AB-SFC approach.

The last paper of the special issue tackles the last question listed by Yellen, concerning international spill-overs. Caiani et al. (2018) put forward an AB-SFC model of a Monetary Union characterised by strong trade links and study the impact of fiscal consolidation. As such it contributes to the debate on the effects of austerity in the Euro Area, from the specific perspective of AB-SFC models. It is, indeed, one of the very few (together with Dosi et al., 2017c; Petrovic et al., 2017) multi-country model within this approach. The model encompasses international flows of both real and financial assets and analyses the outcome of different fiscal regimes represented as different limits imposed to the ratio between debt and GDP. The supposed benefits of fiscal consolidations appear to be questionable. Expansionary fiscal policies generally do result in higher public debt and inflation, but increase real GDP, labour productivity, and employment. Whereas restrictive fiscal policies, due to their recessionary effects, may not lead in the long run to lower debt to GDP levels. The most interesting and original finding of the paper is probably the asymmetric impact that such policies may exert on the countries forming the Monetary Union. Austerity indeed exacerbates the difference between more and less productive countries. The latter see their economies and financial positions deteriorate further, as a consequence of fiscal consolidation. An important role in this matter is played by two insightful features of this model strictly linked to the approach utilised: the entry-exit process of firms and banks, and the innovation dynamics. The entry-exit process depends on households' portfolio choice. Higher rates of return and lower perceived riskiness lead to higher equity participation. Defaults of firms harm on the one hand the balance sheet of banks - due to non-performing loans - leading to lower credit issuance, and on the other hand the level of employment, while banks' defaults worsen the condition of public finance. As in the previous contribution, the feedbacks between the real and financial sector, and between the micro and the macro level

of analysis are therefore explicitly represented by the model. As regards innovation, we wish to underline an often overlooked strength of the AB literature. It is undeniable that the literature as a whole is much less developed, at least in terms of number of contributions, than DSGE modelling. Nonetheless as with bankruptcy cascades in Mazzocchetti et al. (2018), the model by Caiani et al. (2018) takes insights from (and contribute to) a well established strand of AB literature: the evolutionary and neo-Schumpeterian AB macro models with R&D process and innovation (e.g. Dosi et al., 2010).

6 Conclusions

Blanchard (2018) suggests that there should be five types of macro models: (i) *foundational models*, aiming at providing theoretical insights, without the ambition of representing specific economies; (ii) *DSGE models* (or *core models*, Vines and Wills, 2018), which should represent a broadly accepted theoretical framework to study the macroeconomic implications of distortions; (iii) *policy models*, which should be able to inform on the consequence of shocks or on the outcome of specific policies; (iv) *toy models*, which should provide with broad economic intuitions and be used for pedagogical purposes; (v) *forecasting models*, whose goal does need to be explained. This taxonomy is clearly debatable, furthermore was conceived for general equilibrium models. Nonetheless it can be used to make some final considerations on the content of this special section.

We believe that in the wake of the crisis, taking into account, on the one hand, the poor performances and the flaws (see Section 2) of DSGE models, and, on the other hand, the strengths of the AB (and AB-SFC) approach, it should not be a matter of controversy that important insights for each of above typology can be drawn from this approach. Most likely, given the complexity of the economic phenomena there should be more than one approach for each of the typologies above. According to Howitt (2012), the AB methodology is in some sense the polar opposite to that of DSGE. By now, variegated versions of DSGE models have been proposed and a renewed version of the DSGE model could continue to be used by central banks and policy makers. Nonetheless, ABMs can be used by the policy makers alongside with DSGE models, allowing them to evaluate the policy implications from a different perspective based on an alternative methodology. In our view, this is not only referred to the central role of heterogeneity *and* interaction, but also the the rich and alternative microfoundations proposed within the AB field. Just to make an example, typically AB macro models feature a reversed causation with respect to the Neoclassical saving-investment sequence: there are loans that creates saving (and not the vice versa); this also means that banks are credit creators and not financial intermediaries. Though it seems that this well-

known fact in the Keynesian tradition has been recently rediscovered by central banks and some papers (see for instance Zoltan and Kumhof, 2015), this makes a great difference for the interpretation of the crisis and of its monetary and financial dimensions. Furthermore, the alternative view proposed by the AB approach, by rooting its analysis in the Evolutionary and (post-)Keynesian traditions, provides a macroeconomic framework in which even large crises may emerge from the bottom-up, as an inherent feature of capitalism. For this reason, AB(-SFC) macro models could be very useful because of their ability in detecting evolutionary tendencies like unbalanced financial patterns leading to large crises. While quantitative forecasting is still a difficult task for AB models,²³ a qualitative assessment of worrying economic and financial trends, possibly leading to extended crises, should be considered as a useful tools for macroeconomists. Nonetheless, if one agrees that heterogeneity, interactions, real-financial feedbacks at micro and macro level play an important role in economic systems, it would be plainly foolish not to take more into consideration the contribution of AB (and AB-SFC) macro-literature, which are testified by the content of this special session. ‘The global financial crisis is an opportunity to rebalance those scales, to take uncertainty and disequilibrium seriously, to make the heterodox orthodox’ (Haldane, 2016, p.36).

References

- Ackerman, F., 2002. Still dead after all these years: interpreting the failure of general equilibrium theory. *Journal of Economic Methodology* 9 (2), 119–139.
- Aiyagari, S. R., 1994. Uninsured idiosyncratic risk and aggregate saving. *The Quarterly Journal of Economics* 109 (3), 659–684.
- Anderson, P. W., Arrow, K., Pines, D., 1988. *The Economy as a Complex Adaptive System*, 1st Edition. Santa Fe Institute Series. Addison-Wesley.
- Ascari, G., 2011. Macroeconomic models: Better horses for tougher courses. *Manchester School, University of Manchester* 79 (s2), 17–20.
- Assenza, T., Colzani, P., Delli Gatti, D., Grazzini, J., 2018. Does fiscal policy matter? Tax, transfer and spend in a macro ABM with capital and credit. *Industrial and Corporate Change* 27 (6).

²³Although something is happening regarding that, as well as in general referring to calibration and estimation, we have no space here to further discuss these topics

- Assenza, T., Delli Gatti, D., Grazzini, J., 2015. Emergent dynamics of a macroeconomic agent based model with capital and credit. *Journal of Economic Dynamics and Control* 50 (1), 5–28.
- Barro, R. J., 1974. Are government bonds net wealth? *Journal of Political Economy* 82 (6), 1095–1117.
- Bernanke, B. S., Gertler, M., Gilchrist, S., 1999. The financial accelerator in a quantitative business cycle framework. In: Taylor, J. B., Woodford, M. (Eds.), *Handbook of Macroeconomics*. Vol. 1 of *Handbook of Macroeconomics*. Elsevier, Ch. 21, pp. 1341–1393.
- Besley, T., Hennessy, P., 2009. The Global Financial Crisis – Why Didn’t Anybody Notice? *British Academy Review* 14, 8–10.
- Bezemer, D. J., 2009. No one saw this coming. Understanding financial crisis through accounting models. SOM Research Reports. University of Groningen, SOM research school, Groningen 09002.
- Blanchard, O., 2016. A conversation on risks of recession in the near future with Olivier Blanchard and Ryan Avent.
URL <https://equitablegrowth.org/event/next-recession-conference/>
- Blanchard, O., 2017. The need for different classes of macroeconomic models. Policy briefs, Peterson Institute for International Economics.
URL <https://piie.com/blogs/realtime-economic-issues-watch/need-different-classes-macroeconomic-models>
- Blanchard, O., 2018. On the future of macroeconomic models. *Oxford Review of Economic Policy* 34 (1-2), 43–54.
- Blanchard, O., Summers, L. H., 1986. Hysteresis and the european unemployment problem. In: *NBER Macroeconomics Annual 1986, Volume 1*. National Bureau of Economic Research, Inc, pp. 15–90.
- Blinder, A. S., Solow, R. M., 1973. Does fiscal policy matter? *Journal of Public Economics* 2 (4), 319–337.
- Botta, A., Caverzasi, E., Tori, D., 2018. The macroeconomics of shadow banking. *Macroeconomic Dynamics* *forthcoming*.
URL <https://www.cambridge.org/core/journals/macroeconomic-dynamics/article/macroeconomics-of-shadow-banking/735CD6DAF61977634677B41830A3D70E>

- Brancaccio, E., Saraceno, F., 2017. Evolutions and contradictions in mainstream macroeconomics: The case of Olivier Blanchard. *Review of Political Economy* 29 (3), 345–359.
- Brock, W. A., Durlauf, S. N., 2006. Social interactions and macroeconomics. In: Colander, D. (Ed.), *Post Walrasian Macroeconomics*. Cambridge University Press, Cambridge, New York, Ch. 5, pp. 97–115.
- Buiter, W. H., 2009. The unfortunate uselessness of most 'state of the art' academic monetary economics. MPRA Paper, University Library of Munich, Germany.
URL <https://EconPapers.repec.org/RePEc:pra:mprapa:58407>
- Caballero, R. J., 2010. Macroeconomics after the crisis: Time to deal with the pretense-of-knowledge syndrome. *Journal of Economic Perspectives* 24 (4), 85–102.
- Caiani, A., Catullo, E., Gallegati, M., 2018. The effects of fiscal targets in a monetary union: a multi-country agent based-stock flow consistent model. *Industrial and Corporate Change* 27 (6).
- Caiani, A., Godin, A., Caverzasi, E., Gallegati, M., Kinsella, S., Stiglitz, J. E., 2016. Agent based-stock flow consistent macroeconomics: Towards a benchmark model. *Journal of Economic Dynamics and Control* (69), 375–408.
- Caiani, A., Russo, A., Gallegati, M., 2018a. Does inequality hamper innovation and growth? An AB-SFC analysis. *Journal of Evolutionary Economics*.
URL <https://doi.org/10.1007/s00191-018-0554-8>
- Caiani, A., Russo, A., Gallegati, M., 2018b. Are higher wages good for business? An assessment under alternative innovation and investment scenarios. *Macroeconomic Dynamics* forthcoming.
URL <https://doi.org/10.1017/S1365100518000299>
- Caverzasi, E., Godin, A., 2014. Post-Keynesian stock-flow-consistent modelling: A survey. *Cambridge Journal of Economics* 39 (1), 157–187.
- Cincotti, S., Raberto, M., Teglio, A., 2010. Credit money and macroeconomic instability in the agent-based model and simulator Eurace. *Economics - The Open-Access, Open-Assessment E-Journal* 4, 1–32.
- Cincotti, S., Raberto, M., Teglio, A., 2012. The Eurace macroeconomic model and simulator. In: *Agent-based Dynamics, Norms, and Corporate Governance. The Proceedings of the 16-th World Congress of the International Economic Association. Vol. II*. Palgrave.

- Colasante, A., Palestrini, A., Russo, A., Gallegati, M., 2017. Adaptive expectations versus rational expectations: Evidence from the lab. *International Journal of Forecasting* 33 (4), 988–1006.
- Dawid, H., Harting, P., Neugart, M., 2014. Economic convergence: Policy implications from a heterogeneous agent model. *Journal of Economic Dynamics and Control* 44 (C), 54–80.
- Dawid, H., Harting, P., Neugart, M., 2018b. Bubbles, crashes and the financial cycle: Insights from a stock-flow consistent agent-based macroeconomic model. *Review of International Economics* forthcoming.
- Dawid, H., Harting, P., van der Hoog, S., Neugart, M., 2018a. A heterogeneous agent macroeconomic model for policy evaluation: Improving transparency and reproducibility. *Journal of Evolutionary Economics* forthcoming.
- De Grauwe, P., 2009. Warring economists are carried along by the crowd. *Financial Times*. URL <http://www.ft.com/cms/s/0/93c8744c-7655-11de-9e59-00144feabdc0.html>
- Delli Gatti, D., Dawid, H., 2018. Agent-based macroeconomics. In: Hommes, C., LeBaron, B. (Eds.), *Handbook of Computational Economics: Volume 4 Heterogeneous Agents Modeling*. Elsevier, pp. 63–156.
- Delli Gatti, D., Desiderio, S., Gaffeo, E., Cirillo, P., Gallegati, M., 2011. *Macroeconomics from the Bottom-up*. Springer.
- Delli Gatti, D., Di Guilmi, C., Gaffeo, E., Giulioni, G., Gallegati, M., Palestrini, A., 2005. A new approach to business fluctuations: heterogeneous interacting agents, scaling laws and financial fragility. *Journal of Economic Behavior and Organization* 56 (4), 489–512.
- Delli Gatti, D., Gallegati, M., Greenwald, B., Russo, A., Stiglitz, J. E., 2010. The financial accelerator in an evolving credit network. *Journal of Economic Dynamics and Control* 34 (9), 1627–1650.
- Delli Gatti, D., Gallegati, M., Greenwald, B. C., Russo, A., Stiglitz, J. E., 2010. The financial accelerator in an evolving credit network. *Journal of Economic Dynamics and Control* 34, 1627–1650.
- Dos Santos, C. H., 2006. Keynesian theorizing during hard times: Stock-flow consistent models as an unexplored frontier of keynesian macroeconomics. *Cambridge Journal of Economics* 30 (4), 541–65.
- Dos Santos, C. H., Zezza, G., 2008. A simplified, benchmark, stock-flow consistent post-keynesian growth model. *Metroeconomica* 59 (3), 441–78.

- Dosi, G., 1988. Sources, procedures and microeconomic effects of innovation. *Journal of Economic Literature* 26, 126–171.
- Dosi, G., Fagiolo, G., Napoletano, M., Roventini, A., 2013. Income distribution, credit and fiscal policies in an agent-based Keynesian model. *Journal of Economic Dynamics and Control* 37 (8), 1598–1625.
- Dosi, G., Fagiolo, G., Napoletano, M., Roventini, A., Treibich, T., 2015. Fiscal and monetary policies in complex evolving economies. *Journal of Economic Dynamics and Control* 52 (C), 166–189.
- Dosi, G., Fagiolo, G., Roventini, A., 2010. Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and business cycles. *Journal of Economic Dynamics and Control* 34 (9), 1748–1767.
- Dosi, G., Napoletano, M., Roventini, A., Stiglitz, J. E., Treibich, T., 2017a. Rational heuristics? Expectations and behaviors in evolving economies with heterogeneous interacting agents. LEM Papers Series 2017/31, Laboratory of Economics and Management (LEM), Sant’Anna School of Advanced Studies, Pisa, Italy.
URL <http://www.lem.sssup.it/WPLem/files/2017-31.pdf>
- Dosi, G., Pereira, M., Roventini, A., Virgillito, M., 2017b. When more flexibility yields more fragility: The microfoundations of Keynesian aggregate unemployment. *Journal of Economic Dynamics and Control* 81 (C), 162–186.
- Dosi, G., Pereira, M. C., Roventini, A., Virgillito, M. E., 2016. The effects of labour market reforms upon unemployment and income inequalities: an agent based model. LEM Papers Series 2016/27, Laboratory of Economics and Management (LEM), Sant’Anna School of Advanced Studies, Pisa, Italy.
URL <http://www.lem.sssup.it/WPLem/files/2016-27.pdf>
- Dosi, G., Pereira, M. C., Roventini, A., Virgillito, M. E., 2018. Causes and consequences of hysteresis: Aggregate demand, productivity and employment. *Industrial and Corporate Change* 27:6.
- Dosi, G., Roventini, A., Russo, E., 2017c. Endogenous growth and global divergence in a multi-country agent-based model. LEM Papers Series 2017/32, Laboratory of Economics and Management (LEM), Sant’Anna School of Advanced Studies, Pisa, Italy.
URL <https://ideas.repec.org/p/ssa/lemwps/2017-32.html>
- Dosi, G., Virgillito, M. E., 2017. In order to stand up you must keep cycling: Change and coordination in complex evolving economies. *Structural Change and Economic Dynamics*.

URL <https://www.iris.sssup.it/retrieve/handle/11382/521758/37003/dx.doi.org/10.1016/j.strueco.2017.06.003>

- Fagiolo, G., Roventini, A., 2017. Macroeconomic policy in dsge and agent-based models redux: New developments and challenges ahead. *Journal of Artificial Societies and Social Simulation* 20 (1).
- Frydman, R., Phelps, E. S., 2013. Which Way Forward for Macroeconomics and Policy Analysis? In: Frydman, R., Phelps, E. S. (Eds.), *Rethinking Expectations: The Way Forward for Macroeconomics*. Princeton University Press, pp. 1–46.
- Gabaix, X., 2014. A sparsity-based model of bounded rationality. *The Quarterly Journal of Economics* 129 (4), 1661–1710.
- Galí, J., 2017. Some scattered thoughts on DSGE models. In: Gürkaynak, R. S., Tille, C. (Eds.), *DSGE Models in the Conduct of Policy: Use as intended*. CEPR Press, pp. 86–92.
- Godley, W., Cripps, F., 1983. *Macroeconomics*. Oxford University Press.
- Godley, W., Lavoie, M., 2007. *Monetary Economics An Integrated Approach to Credit, Money, Income, Production and Wealth*. Palgrave MacMillan, New York.
- Goodfriend, M., 2007. How the world achieved consensus on monetary policy. *Journal of Economic Perspectives* 21 (4), 47–68.
- Goodhart, C. A. E., 2009. The continuing muddles of monetary theory: A steadfast refusal to face facts. *Economica* (76), 821–830.
- Guvenen, F., 2011. Macroeconomics with heterogeneity: a practical guide. *Economic Quarterly* (3q), 255–326.
- Haldane, A. G., 2016. The dappled world. GLS Shackle Biennial Memorial Lecture, Bank of England.
- Hendry, D., Mizon, G. E., 2010. On the mathematical basis of inter-temporal optimization. *Economics Series Working Papers 497*, University of Oxford, Department of Economics.
- Hendry, D. F., Meullbauer, J. N. J., 2018. The future of macroeconomics: Macro theory and models at the Bank of England. *Oxford Review of Economic Policy* 34 (1-2), 287–328.
- Howitt, P., 2012. What have central bankers learned from modern macroeconomic theory? *Journal of Macroeconomics* 34 (1), 11–22.

- Kaplan, G., Moll, B., Violante, G. L., 2018. Monetary policy according to hank. *American Economic Review* 108 (3), 697–743.
- Kay, J., 2012. The map is not the territory: Models, scientists, and the state of modern macroeconomics. *Critical Review* 24 (1), 87–89.
- Keynes, J. M., 1921. *Treatise on Probability*. Macmillan and Co: London.
- Keynes, J. M., 1923. *A Tract on Monetary Reform*. Macmillan and Co., Limited, 1923: London.
- Kirman, A. P., 1992. Whom or what does the representative individual represent? *Journal of Economic Perspectives* 6 (2), 117–136.
- Kirman, A. P., 2010. The economic crisis is a crisis for economic theory. *CESifo Economic Studies* 56 (4), 498–535.
- Kirman, A. P., 2011. *Complex Economics: Individual and Collective Rationality*. Routledge.
- Kiyotaki, N., Moore, J., 1997. Credit cycles. *Journal of Political Economy* 105 (2), 211–248.
- Knight, F., 1921. *Risk, Uncertainty and Profit*. Houghton Mifflin: Boston.
- Krugman, P., 2009. How did economists get it so wrong? *The New York Times Magazine*. URL <https://www.nytimes.com/2009/09/06/magazine/06Economic-t.html>
- Krugman, P., 2018. Good enough for government work? *Macroeconomics since the crisis*. *Oxford Review of Economic Policy* 34 (1-2), 156–168.
- Krusell, P., Smith, A. A., Jr., 1998. Income and wealth heterogeneity in the macroeconomy. *Journal of Political Economy* 106 (5), 867–896.
- Kumhof, M., Rancière, R., Winant, P., 2015. Inequality, leverage, and crises. *American Economic Review* 105 (3), 1217–1245.
- Lamperti, F., Dosi, G., Napoletano, M., Roventini, A., Sapio, A., 2018. Faraway, so close: Coupled climate and economic dynamics in an agent-based integrated assessment model. *Ecological Economics* 150, 315–339.
- Lavoie, M., 2014. *Post-Keynesian Economics: New Foundations*. Cheltenham:Edward Elgar.
- Lawson, T., 2009. The current economic crisis: its nature and the course of academic economics. *Cambridge Journal of Economics* 22, 759–777.

- Lucas, R., 2009. In defence of the dismal science. *The Economist*.
 URL <https://www.economist.com/finance-and-economics/2009/08/06/in-defence-of-the-dismal-science>
- Mazzocchetti, A., Raberto, M., Teglio, A., Cincotti, S., 2018. Securitisation and business cycle: An agent-based perspective. *Industrial and Corporate Change* 27 (6).
- McCombie, J. S., Negru, I., 2014. On economic paradigms, rhetoric and the micro-foundations of macroeconomics. *European Journal of Economics and Economic Policies: Intervention* 11 (1), 53–66.
- Meyer, L. H., 2001. Does money matter? *Review* (May), 1–16.
- Nelson, R. R., Winter, S. G., 1982. *An Evolutionary Theory of Economic Change*. The Belknap Press of Harvard University Press, Cambridge.
- Nikiforos, M., Zezza, G., 2017. Stock-flow consistent macroeconomic models: A survey. *Journal of Economic Surveys* 31 (5), 1204–1239.
- Nikolaïdi, M., 2015. Securitization, wage stagnation and financial fragility: A stock-flow consistent perspective. *Greenwich Papers in Political Economy* (27).
- Orcutt, G. H., 1957. A new type of socio-economic system. *Review of Economics and Statistics* 39(2), 116–123.
- Pasinetti, L. L., 2012. A few counter-factual hypotheses on the current economic crisis. *Cambridge Journal of Economics* (36), 1433–1453.
- Petrovic, M., Ozel, B., Teglio, A., Raberto, M., Cincotti, S., 2017. Eurace Open: An agent-based multi-country model. Working Papers 2017/09, Economics Department, Universitat Jaume I, Castellón (Spain).
- Reis, R., 2017. Is something really wrong with macroeconomics? *Oxford Review of Economic Policy* 34 (1-2), 132–155.
- Riccetti, L., Russo, A., Gallegati, M., 2015. An agent based decentralized matching macroeconomic model. *Journal of Economic Interaction and Coordination* 10 (2), 305–322.
- Riccetti, L., Russo, A., Gallegati, M., 2016. Financialisation and crisis in an agent based macroeconomic model. *Economic Modelling* 52 (PA), 162–172.
- Riccetti, L., Russo, A., Gallegati, M., 2018. Financial regulation and endogenous macroeconomic crises. *Macroeconomic Dynamics* 22 (04), 896–930.

- Russo, A., Catalano, M., Gaffeo, E., Gallegati, M., Napoletano, M., 2007. Industrial dynamics, fiscal policy and R&D: Evidence from a computational experiment. *Journal of Economic Behavior and Organization* 64 (3-4), 426–447.
- Russo, A., Riccetti, L., Gallegati, M., 2016. Increasing inequality, consumer credit and financial fragility in an agent based macroeconomic model. *Journal of Evolutionary Economics* 26 (1), 25–47.
- Seppelcher, P., 2012. Flexibility of wages and macroeconomic instability in an agent-based computational model with endogenous money. *Macroeconomic Dynamics* 16 (S2), 284–297.
- Seppelcher, P., Salle, I. L., Lavoie, M., 2018. What drives markups? evolutionary pricing in an agent-based stock-flow consistent macroeconomic model. *Industrial and Corporate Change* 27 (6).
- Simon, H., 1959. Theories of decision-making in economics and behavioral science. *American Economic Review* 49, 253–283.
- Simon, H. A., 2000. Bounded rationality in social science: Today and tomorrow. *Mind and Society* 1 (1), 25–39.
- Sinitskaya, E., Tesfatsion, L., 2015. Macroeconomies as constructively rational games. *Journal of Economic Dynamics and Control* 61 (C), 152–182.
- Skidelsky, R., 2009. Economic theory: How to rebuild a newly shamed subject. *Financial Times*.
URL <https://www.ft.com/content/098e5930-e843-11de-8a02-00144feab49a>
- Skidelsky, R., 2018. How economics survived the economic crisis. Project Syndicate.
URL <http://prosyn.org/EN9CLNg>
- Solow, R., July 2010. Prepared statement, house committee on science and technology,. Tech. rep., Subcommittee on Investigations and Oversight.
- Stiglitz, J. E., 2011. Rethinking macroeconomics: What failed, and how to repair it. *Journal of the European Economic Association* 9 (4), 591–645.
- Stiglitz, J. E., 2018. Where modern macroeconomics went wrong. *Oxford Review of Economic Policy* 34 (1-2), 70–126.
- Syll, L. P., 2012. Rational expectations – a fallacious foundation for macroeconomics in a non-ergodic world. *Real-world economics review* (62).

- Teglio, A., Mazzocchetti, A., Ponta, L., Raberto, M., Cincotti, S., 2018. Budgetary rigour with stimulus in lean times: Policy advices from an agent-based model. *Journal of Economic Behavior and Organization* forthcoming.
- Tesfatsion, L., Judd, K. L. (Eds.), 2006. *Handbook of Computational Economics*. Vol. 2 of *Handbook of Computational Economics*. Elsevier.
- Trichet, J. C., 2010. Reflections on the nature of monetary policy non-standard measures and finance theory. Frankfurt, Opening address at the ECB Central Banking Conference <http://www.ecb.europa.eu/press/key/date/2010/html/sp101118.en.html> (18 November).
- Vines, D., Wills, S., 2018. The rebuilding macroeconomic theory project: an analytical assessment. *Oxford Review of Economic Policy*, pp. 1–42.
- White, W., 2009. Modern macroeconomics is on the wrong track. *Finance and Development* 46 (4).
- Woodford, M., 2013. Macroeconomic analysis without the rational expectations hypothesis. *Annual Review of Economics* 5 (1), 303–346.
- Yellen, J. L., 2016. Macroeconomic Research After the Crisis: a speech at “The Elusive ‘Great’ Recovery: Causes and Implications for Future Business Cycle Dynamics” 60th annual economic conference sponsored by the Federal Reserve Bank of Boston, Boston, Massachusetts, October 14, 2016. Speech, Board of Governors of the Federal Reserve System (U.S.).
URL <https://EconPapers.repec.org/RePEc:fip:fedgsq:915>
- Zoltan, J., Kumhof, M., 2015. Banks are not intermediaries of loanable funds - and why this matters. Bank of England working papers 529, Bank of England.