
UNIVERSITÉ CÔTE D'AZUR

# IS THERE CROSS-FERTILIZATION IN MACROECONOMICS? A QUANTITATIVE EXPLORATION OF THE INTERACTIONS BETWEEN DSGE AND MACRO AGENT-BASED MODELS

***Documents de travail GREDEG***
***GREDEG Working Papers Series***

Muriel Dal Pont Legrand
Martina Cioni
Eugenio Petrovich
Alberto Baccini

**GREDEG WP No. 2022-25**
**https://ideas.repec.org/s/gre/wpaper.html**

# Is there cross-fertilization in macroeconomics?

**A quantitative exploration of the interactions between DSGE and macro agent-based models**[1]

**Version 2**

**July 2022**

**Muriel Dal Pont Legrand♦, Martina Cioni* Eugenio Petrovich*, Alberto Baccini***

*GREDEG Working Paper No. 2022-25*

**Abstract**. This paper compares Dynamic Stochastic General Equilibrium (DSGE) and Macro Agent-Based Models (MABMs) by adopting mainly a distant reading perspective. A set of 2,299 papers is retrieved from Scopus by using keywords related to MABM and DSGE domains. The interactions between the two streams of DSGE and MABM literature are explored by considering a social axis (co-authorship network), and an intellectual axis (cited references and bibliographic coupling). The analysis gave results that are neither consistent with a unitary structure of macroeconomics, nor with a simple dichotomic structure of alternative paradigms and separated academics communities. Indeed, the co-authorship network shows that DSGE and MABM form fragmented communities still belonging to two different larger MABM and DSGE communities rather neatly separated. Collaboration insists mainly inside the smaller groups and inside each of the two larger DSGE and MABM communities. Moreover, the co-authorship network analysis does not show evidence of systematic collaboration between MABM and DSGE authors. From an intellectual point of view, data show that DSGE and MABM articles refer to two different sets of bibliographic references. When a measure of paper-similarity is adopted, it appears that DSGE literature is fragmented in 4 groups while the MABM articles are clustered together in a unique group. Hence, DSGE approach is less monolithic than at the time of the New Synthesis: indeed, a large and a growing literature has developed at the margins of the core DSGE approach which includes elements of heterogeneous agent modelling, social interactions, experiments, expectations formation, learning etc. The analysis gave no evidence of cross-fertilization between DSGE and MABM literature whilst it rather suggests a totally dissymmetric influence of DSGE over MABM literature, i.e., only MABM modelers look at DSGE but not vice-versa. The paper questions the capacity of the current dominant approach to benefit from cross-fertilization.

**Keywords:** Macroeconomics, DSGE, macro agent-based models, heterogeneity, New Synthesis, cross-fertilization, hybrid models, co-authorship network, co-citation analysis, bibliographic coupling, paper similarity.

**PRELIMINARY VERSION.**

---

[1] A first version of this paper was presented at the STOREP annual conference, Siena, 2019, in a HES session at the Annual ASSA Meeting held in 2021, and at the Seminario del Gide, FCEA, Universidad de la Republica, Uruguay in March 2021. We are grateful to all participants for their valuable comments and especially to John Davis, Domenico Delli Gatti, and Romain Plassard who commented on several versions of the paper. As usually, the authors are responsible for all remaining errors.

♦ Université Cote d'Azur, CNRS, GREDEG, France. Contact: muriel.dal-pont-legrand@univ-cotedazur.fr.

* Università degli Studi di Siena.

## 1. Introduction

The history of macroeconomics is punctuated by episodes of heated controversy alternating with periods of relative calm. It has been observed that the natural tendency of macroeconomists is to interpret those episodes as expressions of an academic consensus. Thus, when these scholars attempt to apply an *ex post* historical perspective on the development of their field, this generally results in a retrospective history of their own field in which the recent course of macroeconomics tends to be presented as the outcome of a linear progression based on the continuous integration of elements borrowed from competing approaches as soon as those elements are shown to significatively improve the empirical validity of these models[2].

This vision of economics as resulting from linear and continuous technical progress has supported the myth in modern macroeconomics which always considers the most recent model to be more accurate, sophisticated, and "truer". For those interested in the recent history of macroeconomics, this "idealized narrative" not only has no foundations it also masks several major developments in the discipline. Such narratives usually begin with Lucas's (1972, 1975, 1977) seminal contributions, and offers a story which explains how continuous and cumulative progress led economists to the current Dynamic Stochastic General Equilibrium (DSGE) models. It starts by outlining how following Lucas's monetary (equilibrium) business cycles, several critiques led to Kydland and Prescott's (1982) development of a Real (equilibrium) Business Cycles model in which agents react to shocks in an environment of perfect information. Some interpretations of this first phase have been too hasty and focused on the story of the "winners" which hides the importance of contributions such as those of Lucas (1987) but they do not pose a real problem. However, if the (hi)story goes on to describe a second phase characterized by the gradual introduction of new (Keynesian) ingredients, a correct interpretation requires more accurate investigation. These gradual additions have been considered successive "refinements" of the sub-discipline in a process of gradual convergence which finally led to the emergence of a consensus in the early 2000s. This consensus has been enshrined in the term "New Synthesis" which culminated in Woodford's (2003) new synthesis and is described in Blanchard (2008: 5-6) as "improvements both in the formalization of these markets and in neoclassical synthesis numerical techniques are, however, allowing for steadily richer and larger models." It should be noted that this view is presented as being strongly supported by empirical evidence. It is true that, in this period, economists observed a significant decrease in macroeconomic volatility, an element which was interpreted straightforwardly as resulting from successful economic policies:

> "*My thesis in this lecture is that macroeconomics in this original sense has succeeded: Its central problem of depression prevention has been solved, for all practical purposes, and has in fact been solved for many decades*" (Lucas 2003:1).

For the great majority of macroeconomists, this maturity was clearly the logical outcome of a long process characterized by both technical improvements and gradual integration of Keynesian

[2] Here, we should mention the debates among New Keynesians which oppose those who favor external validity (empirical validation based on the capacity of the simulated model to produce data with the same stochastic properties as those observed empirically) to those who support internal validity (*i.e.* empirical validation of the hypothesis) (see Dal Pont (1999) and for a detailed presentation of recent debates Sergi (2017, ch. 5). This debate is important in our context because it influenced the evolution of the DSGE models: in general, elements which increase external validity are integrated (according to the New Classical School methodology), with internal validity being more important for those Keynesians (which include Joseph Stiglitz and others) who consider empirical validation of the hypothesis as crucial.

ingredients, while for others, there was no consensus at all, but only the absorption / transformation of few key Keynesian features in New Classical (acceptable) terms. Blanchard (2016: 1) expresses this perfectly: "(S)ome see them (DSGE models) as the sign that macroeconomics has become a mature science, organized around a microfounded common core. Others see them as a dangerous dead end[3]."

The DSGE model vision of presenting macroeconomics as a consensual outcome based on a (quantitative) theory[4] and allowing joint understanding of the essence of fluctuations and control of macroeconomic volatility, was widespread among scholars until the aftermath of the 2008 crisis. At this point, while the debate assumed a different basis which highlighted and made more audible some of longstanding criticisms of these models, their long awaited (by some economists) exposure did not happen.

In that context, the development of Macro Agent-Based Models[5] (MABMs) and the new audience they attracted, led to diverging interpretations of the crisis and about the key-features of macroeconomic models. For some economists, this episode is interpreted as a major opportunity to reverse the trend of macroeconomic research. MABMs not only seem to have gained in influence[6] but some economists see (or hope) their deeper influence in the recent inclination in the DSGE models' research agenda for new macroeconomic issues such as expectations or heterogeneity. For other economists, this episode is purely temporary and based on a momentary loss of domination by DSGEs but will have no durable impact -if it even only has an impact – on the development of macroeconomics. A third interpretation could be the one developed by Davis (2019):

> *"By nature, it (specialization) involves departures from existing research, and can accordingly be characterized as a centrifugal type of force that tends to produce a more diverse research frontier. Operating against this, scholarly research also exhibits centripetal forces in the form of research that tends to link up disparate research initiatives and produce shared research programs. (…) Shared research programs produced by centripetal forces broaden understanding but also run the risk of ignoring questions and issues that depart from main lines of research. Diversity in a research frontier produced by centrifugal forces increases innovation in ideas but runs the risk of less disciplinary coherence." (ibid: 271-272)*

One could then consider that there is an alternation of periods of bursting then of refocusing of economic knowledge[7]. Davis' position is very interesting since, it offers a plausible explanation to what has been also observed by other economists[8], i.e. the fragmentation of economics. Following the same line, some economists consider that now economics, under the influence of a specialization trend,

[3] Refer e.g. to Solow (2010) and the various papers from the 2018a Symposium.

[4] The term "quantitative theory" refers to the fact that these models (i.e. DSGEs) are both a theory and an economic policy instrument.

[5] Agent-based models (ABMs) is the term used by several different disciplines. Agent-based computational economics (ACE) models are a specific application of an ABM. ACEs include a variety of models, essentially FABM (financial agent-based models) and MABM (macro agent-based models). All of them stem from the complex economics contribution(s) initiated for the most part by the Santa Fe Institute (cf. Fontana 2010). In this paper, we focus on MABM.

[6] This influence can be measured by the number of published papers and the number of specialist journal (Dal Pont Legrand and Truc, 2021) in this area, and their potential influence in some institutions responsible for economic policy design (cf. Plassard 2019).

[7] Davis (2019) goes further discussing after the transitional *versus* permanent state of fragmentation. This point is of course related to our purpose nevertheless not directly at this stage. We refer again to this point in the conclusion.

[8] Rodrik (2015).

became a science of multiple models (Rosenberg, 2021). Nevertheless, this diagnosis has to be nuanced. Indeed, in macroeconomics, one cannot observe such a proliferation of models: macroeconomics seems to have completely escaped this trend. Indeed, macroeconomics is dominated by the DSGE approach, and this even after the admission of their empirical difficulties by their adherents (Blanchard 2018, or Haldane and Terrell 2018).

So if one cannot deny the recent proliferation of new macroeconomic models which constitute a competitive fringe, it is nevertheless more difficult to identify the influence this fringe can have on the core. Our purpose is precisely to determine if there is an effective dialogue between those competing approaches, and to what extent a cross-fertilization process can be visualized. In our view, these questions are important for two reasons. First, they may lead to a different interpretation of the recent history of macroeconomics and the nature of the so-called consensus episode. Second, they could lead to a new discussion of the general evolution of the sub-discipline, on its capacity to maintain a dialogue with alternative approaches, and finally on the (theoretical) conditions which would allow (or not) such a cross-fertilization.

Using both history of economic analysis and bibliometric tools, this paper examines (i) if DSGE and MABM research programs may reveal a process of internal fragmentation, and (ii) if there is cross-fertilization between competing research programs. Both problems are explored by two complementary scientometric techniques. The first one consists in exploring collaboration among scholars working on DSGE and MABM, by observing their co-authorship network. The second one consists in the exploration of contents of DSGE and MABM articles, by observing their bibliographing coupling network. The bibliographic coupling network is built by observing the bibliographic references contained in articles, and the similarity between pairs of articles id proportional to the number of their common references.

The paper is organized as follows: section 2 provides some context to the emergence of the MABM literature which emphasizes both its roots and the autonomy of its research agenda, and its potential connections with the DSGE approach. Section 3 defines the research questions. Section 4 describes how the data set was built and what we try to measure. Section 5 analyzes the structure of the network of collaboration inside and between MABM and DSGE authors. Section 6 analyzes the intellectual landscape of MABM and DSGE through bibliographic coupling technique. In Section 7 the notion of paper similarity is introduced and articles are classified in clusters by using a community detection technique. In Section 8 results are discussed and Section 9 concludes.

## 2. The DSGE and MABM: research agendas, roots, objectives and method.

The 2008 financial crisis has greatly increased criticism of the capacity of modern macroeconomic models to deal with large-scale crises and financial instability. Economists who todays adhere to the DSGE models adopted a methodology which consider that there are no macroeconomic phenomena which cannot be modeled (and then explained) by microeconomics. Consequently, they propose to model aggregate macroeconomic variables dynamics identically to the single "standard"[9] microeconomic agent. More than that, they are convinced that this model can explain all sort of situations. Indeed,

[9] "By 'standard' microeconomics, we mean microeconomics founded on rational individuals *i.e.* based on a selfish *Homo Oeconomicus* who makes axiomatic-defined rational calculations aimed at maximizing a context-independent utility function" (Delli Gatti *et al.* 2011: 2).

> « *DSGE models in macro do share common features. All of them make sure that they are consistent with the National Income and Product Accounts. (…) All of them lay out clearly how people make decisions. All of them are explicit about the constraints imposed by nature, the structure of markets and available information on choices to households, firms and the government. (…) A useful aphorism in macroeconomics is: "If you have an interesting and coherent story to tell, you can tell it in a DSGE model. If you cannot, your story is incoherent".*[10]

Dynamic stochastic general equilibrium (DSGE) models are criticized for their core assumptions which assume all coordination issues as resolved and enable an exclusive focus on the behavior of optimal dynamics[11] but hinder our understanding of how relatively small shocks can generate a large-scale crisis.

In the years following the 2008 crisis, macroeconomic agent-based models (MABMs) came to be seen by many as directly challenging DSGE models in relation to this issue.[12] This notwithstanding, it would be misleading to consider that MABM only emerged as a reaction to DSGE models and to the criticism they faced after the 2008 Crisis.[13][14] Indeed, agent-based models are quite old. Despite few earlier attempts, those models really emerged at the Santa Fé Institute[15] and were initially mainly developed for microeconomic issue. It is only in the early 2000s that one can really identify the development of the macroeconomics of heterogenous interacting agents. This approach is now well structured in the academic landscape, having their own scientific societies, key journals[16] and, ultimately, doctoral training programs[17]. Thanks to the crisis, several voices were raised to favor the gradual development of this approach in the policy makers circles[18] and the first experiences already started (Plassard 2019).

MABM modelers consider that the DSGE conception of macroeconomic microfoundations overlooks the various ways in which the micro and macroeconomic levels intertwined. MABMs' modeling strategy is based on the introduction of heterogeneity and social interaction(s): as soon as individuals are no more modeled in isolation, i.e. if social interactions matter, *emergence* happens[19], and logically the "standard" aggregation method (on which DSGE models are based) becomes inappropriate. Secondly, the way those models are built and then calibrated/simulated, allows them to developed

[10] Chari develops these arguments in front of a sub-commission of the *Committee on Science, Space and Technology*.
[11] Cf. Colander *et al.* (2008).
[12] This challenge takes both direct and indirect forms, and the arguments culminated in 2018 with the publication of two Special Issues in the *Oxford Review of Economic Policy* and the *Journal of Economic Perspectives,* respectively noted Symposia (2018a) and (2018b).
[13] Cf. Dilaver *et al.* (2018) for a first reflection on the hybrid models produced by the confrontation of DSGE and macro agents-based models, Dal Pont Legrand (2021) for a presentation of the genealogy and objectives of the various MABMs, Plassard (2019) for the analysis of the penetration process of MABMs at the Bank of England.
[14] This section is deeply inspired by elements which are developed in detail in Dal Pont Legrand (2021).
[15] Cf. Fontana (2010).
[16] Cf. Dal Pont Legrand and Truc (2021).
[17] The Santa Anna School of Economics shares with few international partners a PhD program focused on Agent-based method and quantitative analysis.
[18] Cf. for instance speech delivered by Jean-Claude Trichet to the European Central Bank Conference (Frankfurt, November 18, 2010). It represents a (famous and unexpected) example of the sudden interest of policy makers in MABMs: "The atomistic, optimizing agents underlying existing models do not capture behaviour during a crisis period. We need to deal better with heterogeneity across agents and the interaction among those heterogeneous agents. (…) Agent-based modelling dispenses with the optimization assumption and allows for more complex interactions between agents. Such approaches are worthy of our attention".
[19] Emergence occurs when an entity is observed to have properties which its individual parts on their own do not have. Also, these properties emerge only through the interactions among these parts. For a more detailed discussion, see the introduction in Delli Gatti *et al.* (2008a).

specific economic policy models, adapted to specific situations. [20] These elements naturally predisposed the MABM literature to focus on (financial) instability issue(s) to try to *explain*[21] (and not just to *mimic*) large scale crises *i.e.* the essence being to understand how relatively small shocks are at the origin of deep downturns in order to understand in turn the salient disproportion between cause(s) and effect(s), between shocks and propagation[22]

The methodological openness of MABM allows them to be mobilized by different theories, from post-Keynesians to evolutionists, and therefore tends to "bring together" a certain number of works critical of the dominant theory. Indeed, MABMs have come to represent an opportunity for heterodox theories to benefit from explicit microeconomic foundations[23].

The MABM modeling strategy remains constrained by the need then to calibrate and measure the fluctuations, allows them to produce results which are ultimately comparable to those obtained by the DSGE models, an element which places them as a natural opponent to DSGE approach. Despite this, it would be misleading to consider that the evolution of the DSGE research agenda was dictated by the criticisms addressed by MABMs.

DSGE models expanded the scope of their research agenda long before the crisis. Mainly they developed their modeling strategy in three frontiers, integrating more heterogeneity in the microeconomic foundations, allowing a new role for expectations and finally, integrating better the functioning of the financial sphere as well as the understanding of its impact on fluctuations. Without denying that the Great Recession prompted DSGE modelers to explore these new topics in greater depth, one cannot strictly associate their interest for these topics to the necessity to better understand the crisis, their program was initiated before[24].

**3. Research questions.**

The intellectual journey about DSGE and MABM summarily described in the preceding section poses some questions about the current state of the two approaches to macroeconomics and their interactions. A first question regards the degree of unity or fragmentation of the DSGE and MABM literatures. The second one is about interactions or cross-fertilization among MABM and DSGE.

Both questions were addressed by scholars by adopting a qualitative or close-reading perspective and separately for DSGE and MABM. As for DSGE models, for instance, Christiano et. al (2018) implicitly classified waves of DSGE models by analyzing their assumptions and methodologies.

As for MABM, Dawid and Delli Gatti (2018), for instance, claimed that MABM is not a monolithic stream of literature. They identified eight groups of scholars gathered around institutions or ideas: (i) CATs based at the University Catholic of Milano, (ii) K&S based as Santa Anna School of Economics in Pisa; (iii) AGH (Ashraf, Gershman and Howitt), (iv) EUbi (Bielefeld university) and (v) Euge (University of Genoa) both considered as extension of EURACE (European program which involved 7 universities in

[20] This sub-section is directly taken from Dal Pont Legrand (2021: 6-7).
[21] Cf. Dal Pont Legrand and Hagemann (2019).
[22] Cf. Stiglitz (2015) for a detailed discussion.
[23] For instance, see Heise (2017) for a characterization of mainstream complexity economics.
[24] One can notice here the evolution of the issues addressed by the DSGE models. As emphasized by Christiano (2018): "At a deeper level, micro data influences, in a critical but slow-moving manner, the class of models with which we work. Our discussion of the demise of the pure real business cycle model is one illustration of this process. The models of financial frictions and heterogeneous agents discussed below are an additional illustration of how DSGE models evolve over time in response to micro data." (*ibid*: 124).

France, Germany, Italy, Turkey, UK) coordinated by Cincotti (Genoa University), (v) JAMEL (Java agent based macroeconomic laboratory) developed in Paris 13 by Seppecher, (vii) LAGOM (not an acronym but a Swedish word (equilibrium and harmony) and (viii) LEN model developed by Lengnick. In reference to cross-fertilization no specific work about MABM is available, but Di Guilmi (2017) analyzed in a close reading perspective the cross fertilization between agent-based models and heterodox approaches, while Brancaccio et al. (2021) studied neoclassical influences in agent-based literature.

In the scientometrics perspective here adopted, the two questions about fragmentation and cross-fertilization can be operationalized by observing (i) the network of scholars authoring either DSGE or MABM articles and their links of collaboration, and (ii) the network formed by the stream of published articles in these two areas. To this end, two corpora of literature are retrieved from Scopus by using DSGE-related and MABM-related keywords. By exploring the network of authors of the articles of the two corpora, it is possible to verify the existence and the extent of formal collaborations, in the form of co-authorship, among DSGE and MABM scholars. By considering the bibliographing coupling network of articles, it is possible to explore the extent of intellectual interaction or cross-fertilization between DSGE and MABM literatures.

Analytically, we can distinguish two axes of interactions between the fields: a social axis, which is operationally investigated with the co-authorship network, and an intellectual axis, which is operationally investigated with the bibliographic coupling network. Both networks can show three main types of community structure: a *unitary* structure, in which the network is characterized by only one big community, a *divided* structure, in which the network is split into two communities (in principle, one corresponding to DSGE and the other to MABM), and a *fragmented* structure, in which the network is parceled out into more than two communities. By cross-tabulating the two axes over the three types of community structure, a matrix of nine possible scenarios is obtained, as in Table 0. Some of them are compatible with cross-fertilization between fields, whereas others are not.

In particular, if the bibliographic coupling network is characterized by only one, big community (first row in Table 0), we can assume that knowledge circulates freely, without a stark division between the MABM and DSGE approaches. If the co-authorship network too is unitary (facet A of Figure 0), we have complete integration, both social and intellectual, of the field of macroeconomics. By contrast, if the co-authorship network results to be divided or fragmented, we have either a scenario of “gang warfare”, if we have only the MABM and DSGE camps (B), or a cohabitation of specialized communities, if we have several communities each living in its own social niche (C).

If the bibliographic coupling network is divided into two communities, on the other hand, we have two paradigms or research programs in competition with a low rate of mutual communication (second row in Table 0). The co-authorship network can be again unitary, divided or fragmented: in the first case (D), cross-fertilization is possible because the difference in intellectual approach does not cause a scission in the collaboration structure; in the second case, the division into paradigm is reflected into the division between academic communities. In this situation, cross-fertilization is hindered both by intellectual and social barriers, and, hence, is not to be expected (E). In the third case, the fragmentation on the social layer, which is not starkly divided among opposing “schools”, may allow for knowledge flows between the approaches, at least within some of the social groups (F).

| | *Number of detected communities in the co-authorship network* | | |
|---|---|---|---|
| *Number of detected communities in the bibliographic coupling network* | 1: Unity of academic community | 2: Alternative academic communities | More than 2: Plurality of academic communities |
| 1: Unity of science | A. Macroeconomics is a unitary research field / Complete cross-fertilization | B. Gang warfare in a unitary research field /Complete cross-fertilization | C. Normal science with (specialized) local academic communities/ Complete cross-fertilization |
| 2 : Alternative approaches | D. Coexistence of alternative approaches to macroeconomics/ Cross fertilization possible | E. Rival paradigms/ No cross-fertilization | F. Differentiated alternative paradigms/ Cross fertilization possible |
| More than 2: pluralism | G. Fragmented pluralism /Cross fertilization possible | H. Fragmentation (specialization) in rival communities / Cross fertilization possible | I. Fragmentation of macroeconomics / Cross fertilization possible |

**Table 0. Nine possible scenarios for intellectual and social interactions between DSGE and MABM.**

Lastly, the complete fragmentation of the bibliographic coupling network into multiple communities corresponds to a scenario of intellectual pluralism, in which MABM and DSGE are generic label not able to fully capture the variety of research programmes to macroeconomics (third row in Table 0). The fragmentation on the intellectual layer may be then associated with a unitary collaboration network (G): in this case, knowledge may circulate thanks to social links between actors. Or, it can be associated with a divided academic community made of two rival schools (H), or with a pluralist academic community (I).

To sum up, the cross-interaction between the structures of the intellectual and of the social networks conditions the rate of cross-fertilization between MABM and DSGE: some configurations allows for a complete flow and exchange of economic knowledge (A, B, C), one constitutes an obstacle for the interaction (E), and others are compatible with both (D, F, G, H, I).

From this analytic framework, we can derive the following research questions:

(i) are the authors of DSGE and MABM articles part of a unique community of scholars linked by frequent co-authorship relations? If this is the result of the analysis, it could correspond to a scenario of unity of macroeconomics communities and possibly to a generalized cross-fertilizations among different approaches;

(ii) alternatively, do DSGE and MABM authors belong to two different monolithic communities of scholars, where co-authorship relations exist only among the members of each community? If this is the case, it could be interpreted as a scenario of two alternative approaches with no cross-fertilization;

(iii) or, instead, do DSGE and MABM authors form fragmented communities with relatively strong collaboration links inside each community and weakier collaborations among the members of different communities?

(iv) are the articles of DSGE and MABM literatures part of a unique corpus of documents that have common references? If this is the result, it could correspond to the ideal case of unity of science: contemporary macroeconomics has commons problems and results reached by using common instruments. Hence the cross-fertilization between the two streams of literatures could be considered as complete;

(v) alternatively, do the DSGE and MABM articles belong to two different monolithic intellectual clusters, with two different sets of bibliographic references? This could be the case of two alternative approaches to macroeconomics facing each other with very limited or no cross-fertilization at all;

(vi) or, instead, are DSGE and MABM articles fragmented in many clusters each one characterized by a specific set of bibliographic references? This scenario could correspond to the idea of fragmentation of macroeconomics, and the extent of cross fertilization may be more or less pronounced.

As anticipated, Table 0 contains a proposal of labels for characterizing the nine possible scenarios. It should be noted that a careful qualitative analysis of the detected communities is necessary for giving a correct interpretation of these labels, especially in the cases of "pluralism".

**4. Data building and descriptive statistics**

The corpus of articles for the bibliometric analysis was collected using a *keywords-based* search strategy (Zitt *et al.* 2019). Specifically, two arrays of terms associated with DSGE and MABM research programs were individuated based on the authors' expert knowledge and used to query the multidisciplinary database Scopus via its web interface.[25] For DSGE, the following search string was used:

```
TITLE-ABS-KEY ( dsge  AND model* )
```

For MABM, a longer search string was used to capture all the topics related with MABM:

```
( ( TITLE-ABS-KEY ( macroeconomic  AND  agents-based  AND  models ) ) )  OR
( TITLE-ABS-KEY ( agent-based  AND  9eynesian  AND  models )  OR  TITLE-ABS-
KEY ( "Agent-based Keynesian models" )  OR  TITLE-ABS-KEY ( agent-based  AND
macroeconomics )  OR  TITLE-ABS-KEY ( "Agent-based macroeconomics" )  OR
TITLE-ABS-KEY ( agent  AND  complex  AND  macroeconomic  AND  dynamics )  OR
TITLE-ABS-KEY ( agent  "Complex macroeconomic dynamics" ) )  OR  TITLE-ABS-
KEY ( "agent based"  fluctuations  AND  macroeconomics )  OR  TITLE-ABS-KEY (
"agent based"  "business cycle" )  OR  TITLE-ABS-KEY ( "agent based"  "business
fluctuations" )  OR  TITLE-ABS-KEY ( "agent based"  "endogenous growth" )  OR
TITLE-ABS-KEY ( "agent based"  AND  "systemic risk"  AND  financial )
```

Terms were searched in the titles, abstracts, and keywords of publications. Note that queries were not restricted to economic research areas in order to retrieve also those publications that are not published in journals classified by Scopus in economics. This was especially important for MABM articles, which are published also in journals outside the field.

The DSGE query resulted in 1909 records, the MABM query in 418 records. 28 records appeared in both queries, so that the overall corpus amounted to 2,299 unique records. Of these, we retained only the records suitable for citation analysis, i.e., those with cited references. They amounted to 1889 and

[25] Search date: February 11, 2021. Scopus was accessed via University of Siena's subscription. Raw data are available at XXXX.

392 for DSGE and MABM datasets, respectively. Of these, 90.1% for DSGE and 73.7% for MABM are classified as "research articles" by Scopus. The final corpus, hence, included 2,253 distinct records, with 28 overlapping articles appearing in both datasets. Dataset characteristics are summarized in Table 1 below.

| | **DSGE dataset** | **MABM dataset** |
|---|---|---|
| Records | 1909 | 418 |
| Records without CRs (%) | 20 (1%) | 26 (6.2%) |
| Records with CRs (%) | 1889 (99%) | 392 (93.8%) |
| Research articles (% on records with CR) | 1716 (90.1%) | 289 (73.7%) |
| Min Pub Year | 2000 | 1989 |
| Max Pub Year | 2021 | 2021 |
| Distinct cited references | 33,768 | 13,146 |

**Table 1. Descriptive statistics of DSGE and MABM datasets.**

Figure 1 shows the temporal distribution of the records, which are mainly concentrated in the period after 2005. The complete bibliographic records, including full metadata and cited references, were downloaded from Scopus. To improve the reliability of citation analysis, cited references were cleaned using the CRExplorer software (Thor et al. 2016). CRExplorer allows to individuate and merge variants of the same reference by an algorithm based on string similarity. The process was humanly supervised to avoid wrong merging and individuate further variants to unify. After this consolidation process, the DSGE and MABM datasets included, respectively, 33,768 and 13,146 distinct cited references, with 1,461 shared references between the two sets.

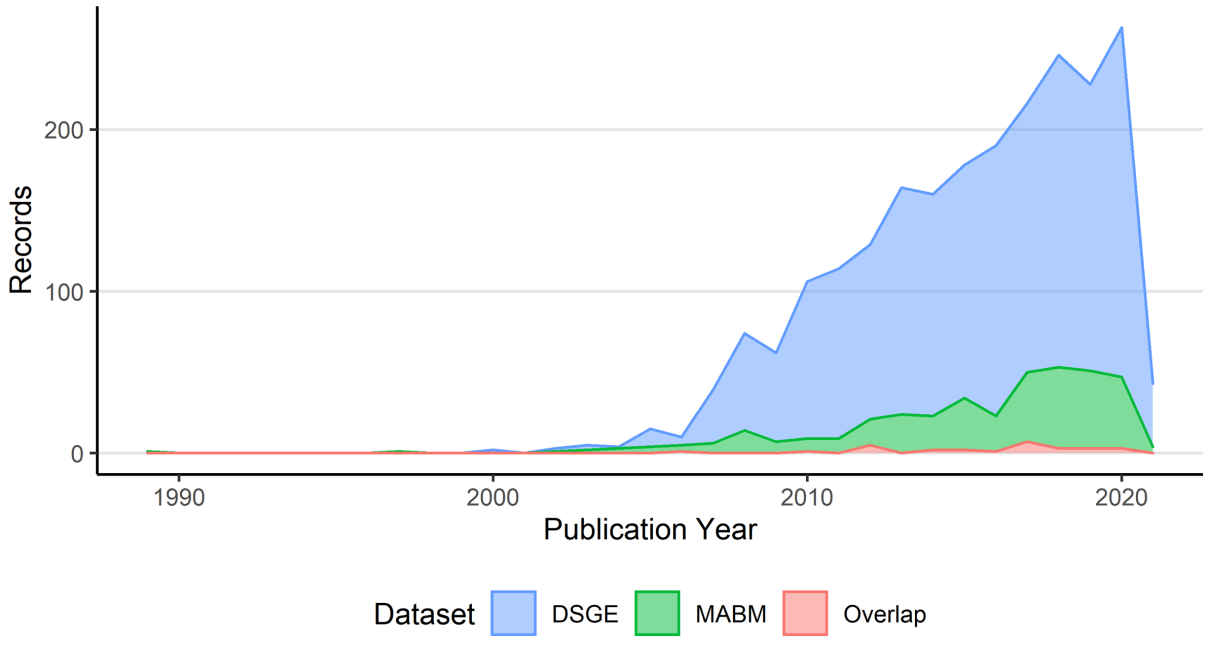


**Figure 1. Temporal distribution of DSGE and MABM datasets.**

Table 2 summarizes the productivity and concentration statistics of the two datasets. The DSGE dataset includes 421 journals, the MABM dataset 180 journals. The average number of papers per journals is double for the DSGE than for the MABM (4.5 vs 2.2). The concentration of papers is calculated as the share of papers published by the TOP5 (TOP10) journals, *i.e.* the five (ten) journals that host the largest numbers of articles. These concentrations are similar in the two datasets.

| | **DSGE dataset** | **MABM dataset** |
|---|---|---|
| **Journals** | 421 | 180 |
| Paper/Journals | 4.5 | 2.2 |
| Concentration of papers in TOP5 journals (C5_J) | 24.2 | 25.3 |
| Concentration of papers in TOP10 journals (C10_J) | 35.7 | 36.5 |
| **Authors** | 2,298 | 582 |
| Avg. productivity | 0.8 | 0.7 |
| Concentration of production of TOP5 authors (C5_A)° | 5.2 | 29.1 |
| Concentration of production of TOP10 authors (C10_A)° | 7.9 | 44.6 |
| Concentration of production of TOP5 authors (C5_A)§ | 2.3 | 8.4 |
| Concentration of production of TOP10 authors (C10_A) § | 4.4 | 13.5 |

° Without double counting of papers co-authored by two or more top5/top10 author; § Fractional counting of contributions.

**Table 2. Productivity and concentration statistics of DSGE and MABM datasets.**

The number of authors of the papers reflects the different number of records in the two datasets (Table 1), the DSGE dataset includes 2.298 authors, the MABM includes 582 authors with a similar author average productivity (0.8 vs 0.7). The concentration of production of top five and top ten authors is proxied by using two different indicators. The first one is calculated as the share of top five (top ten) authors' papers on total papers, by eliminating the double counting of papers co-authored by two or more TOP5 (TOP10) authors. The second indicator is based on a fractional counting of papers, and it is computed by to each author a share of the paper equal to the inverse of the number of authors (for example, if a paper is co-authored by 2 researchers, each of them has a share equal to 0.5). This indicator is calculated as the sum of TOP5 (TOP10) authors' fractioned papers on total papers (cf. Table 3). The MABM is much more concentrated than DSGE dataset according to both indicators. Table 3 highlights the top 10 most prolific authors in the two datasets.

In sum, DSGE and MABM literatures are different in size, publishing outlets and concentration in terms of authors.

| **DSGE dataset** | | **MABM dataset** | |
|---|---|---|---|
| Authors | No. Articles | Authors | No. Articles |
| Schorfheide F. | 25 | Gallegati M. | 40 |
| Minford P. | 22 | Roventini A. | 25 |
| Gupta R. | 18 | Russo A. | 18 |
| Rubio M. | 17 | Delli Gatti D. | 17 |
| Kolasa M. | 17 | Dosi G. | 14 |
| Caraiani P. | 17 | Cincotti S. | 13 |
| Meenagh D. | 16 | Napoletano M. | 13 |
| Smets F. | 15 | Giulioni G. | 12 |
| Wouters R. | 14 | Raberto M. | 12 |
| Stähler N. | 14 | Dawid H. | 11 |

**Table 3. TOP10 most productive authors in DSGE and MABM datasets.**

### 5. The co-authorship networks.

As anticipated, the metadata about authors of articles of MABM and DSGE papers are used for building a co-authorship network where nodes are authors and the weighted edges linking pairs of nodes indicate the number of their co-authored papers. By adopting suitable exploratory techniques, it is possible to detect communities of authors inside the network.

**Figure 2** draws the co-authorship network among all the authors of the corpus. The figure clearly shows that there are some relatively big groups of authors working together, but it shows also that the big part of authors prevalently works in small, separated groups. Among the possible pairs of authors, less than 9% are reachable. The average distance among reachable pair of nodes is 9.26, and the distance between the most distant vertices (Peng T. and Yi G.) is 23. This is a first indication of the existence of a plurality of academic communities and at a first sight it appears that no clearcut demarcation exists between two monolithic alternative DSGE and MABM academic communities.

For investigating the nature of the groups of authors and of collaborations it is useful to consider a simple classification of the authors (2,788) according to the papers they wrote. To the first group belong 2,201 DSGE authors (blue nodes of Figure 2), i.e. authors writing only papers retrieved by using DSGE keywords. The second group (green nodes) consists of 493 MABM authors writing only papers retrieved by using MABM keywords. The third group (red nodes) consists of 56 authors writing the small groups of papers retrieved by using both DSGE and MABM keywords; the fourth group (pink nodes) consists of 38 authors writing some papers retrieved by using DSGE keyword and others retrieved by using MABM keywords.

The introduction of this information in Figure 2 permits to note that the biggest group of authors in the network is composed exclusively by DSGE-authors. This notwithstanding, DSGE authors prevalently work in small, separated groups. MABM authors compose many small groups, some of them very well connected. Moreover, MABM authors forms a relatively big group on the right of the figure to which

also red authors belong, i.e. authors of the papers retrieved by using MABM and DSGE keywords. It is also evident that DSGE authors are not connected to these red authors. At the opposite, the authors contributing to both DSGE and MABM literature (pink nodes) are linked to small, isolated groups of DSGE authors, and not to the core of DSGE authors.

Another way for exploring the structure of collaboration network consists in searching for weak-components, i.e. connected subgraphs in the network. In this case, a component of the graph is a subgraph where each node is reachable by every other node through a sequence of distinct edges and nodes. The left panel of the **Figure 3** confirms that the co-authorship network is fragmented in many small components, but it shows also that there is one big component, colored in purple. The two main groups of DSGE authors and MABM authors seen in Figure 2 belong to this big component. It should be noted that starting from a MABM author on the right, a DSGE author on the left is reachable only after a long pattern passing through many peripheral DSGE authors.

More consistently, it is also possible to explore the structure of collaboration network by algorithms based on modularity (Blondel et al. 2008). The application of the Louvain algorithm individuates 835 communities with a modularity: 0.956, indicating that near all collaborations among authors take place within the detected communities and not between authors belonging to different communities. The big part of these communities (92%) is composed by groups of up to five coauthors. Only 19 communities are composed by 20 or more co-authors. The right panel of the Figure 3 shows the communities detected in the network: the authors classified according to keywords as DSGE are grouped in many different communities of coauthors. Analogously, the MABM authors are grouped in different communities of coauthors.

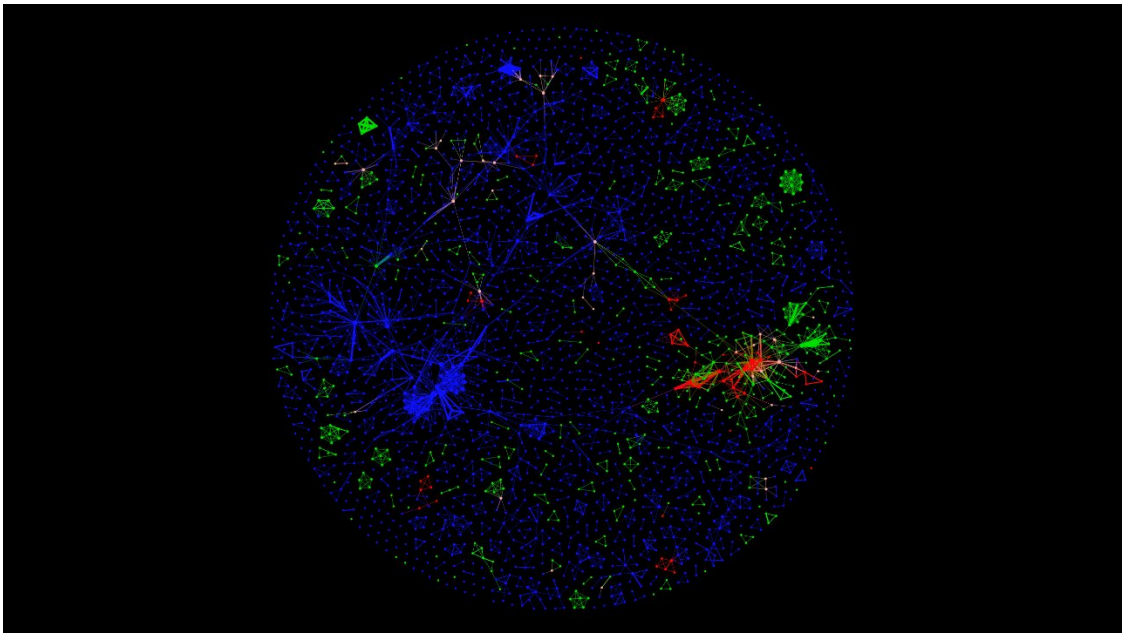

*Figure 2. The co-authorship network. Each node represents an author. Blue nodes indicate DSGE authors writing only DSGE papers; green nodes are MABM authors; red nodes are authors writing papers retrieved by using both DSGE and MABM keywords; pink node are authors writing some papers classified as DSGE and others classified as MABM. The dimension of a node is proportional to its degree, i.e. the number of co-authors. The link between a pair of nodes indicates a co-authorship relation. The thickness of links is proportional to the number of papers co-authored by the pair of authors. Graph energized in Gephi by Fruchterman-Reingold algorithm.*

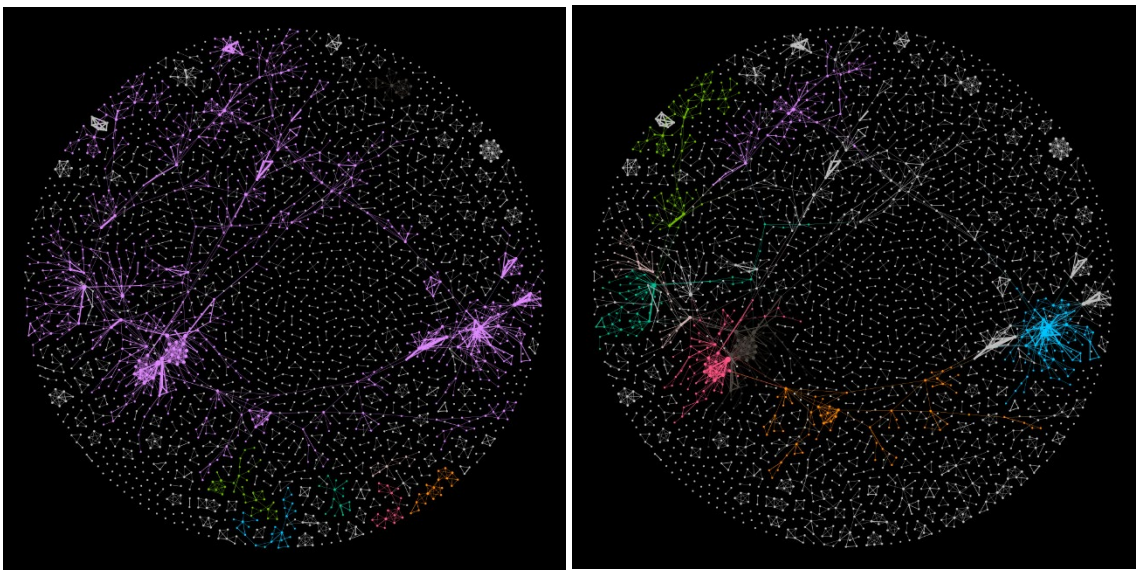

*Figure 3. Left panel: Weak-components in the co-authorship network. Each node represents an author. Different colours indicate different weak components of the network. The biggest weak components coloured in purple indicates that authors in the main group of MABM and authors in the main group of MABM are reachable from each other through very long patterns. Right panel: communities in the coauthorship network. Different colours indicate different communities according to Louvain algorithm. DSGE and MABM authors appears to be fragmented in different communities. Graphs energized in Gephi by Fruchterman-Reingold algorithm.*

Finally, **Figure 4** draws the biggest weak component of the co-authorship network, by individuating with different colours the communities detected in it by the Louvain algorithm. Each node is labelled according to the author it represents, and the dimension of the label is proportional to the betweenness centrality of each author. Betweenness centrality of an author is the proportion of all shortest path between pairs of other vertices that include the considered author. It indicates the amount of influence of an author in the flow of information in the co-authorship network.

The exploratory analysis of co-authorship shows that the network generated by DSGE and MABM authors is fragmented in many different academic communities. It also indicates no evidence of systematic collaboration between MABM and DSGE authors. Some MABM scholars wrote a few papers that can be retrieved by searching for DSGE. DSGE scholars do not author MABM papers or papers that can be retrieved by using MABM keywords. Hence, different communities of co-authors appear to belong to two different larger communities rather neatly separated, gathering respectively MABM and DSGE authors. In particular, the analysis here developed appears coherent with the expert classification of MABM communities proposed by Dawid and Delli Gatti (2018): indeed, Figure 4 shows that Cincotti, Dawid, the Sant'Anna group represent separated communities around the central one to which belong Galligati and Delli Gatti.

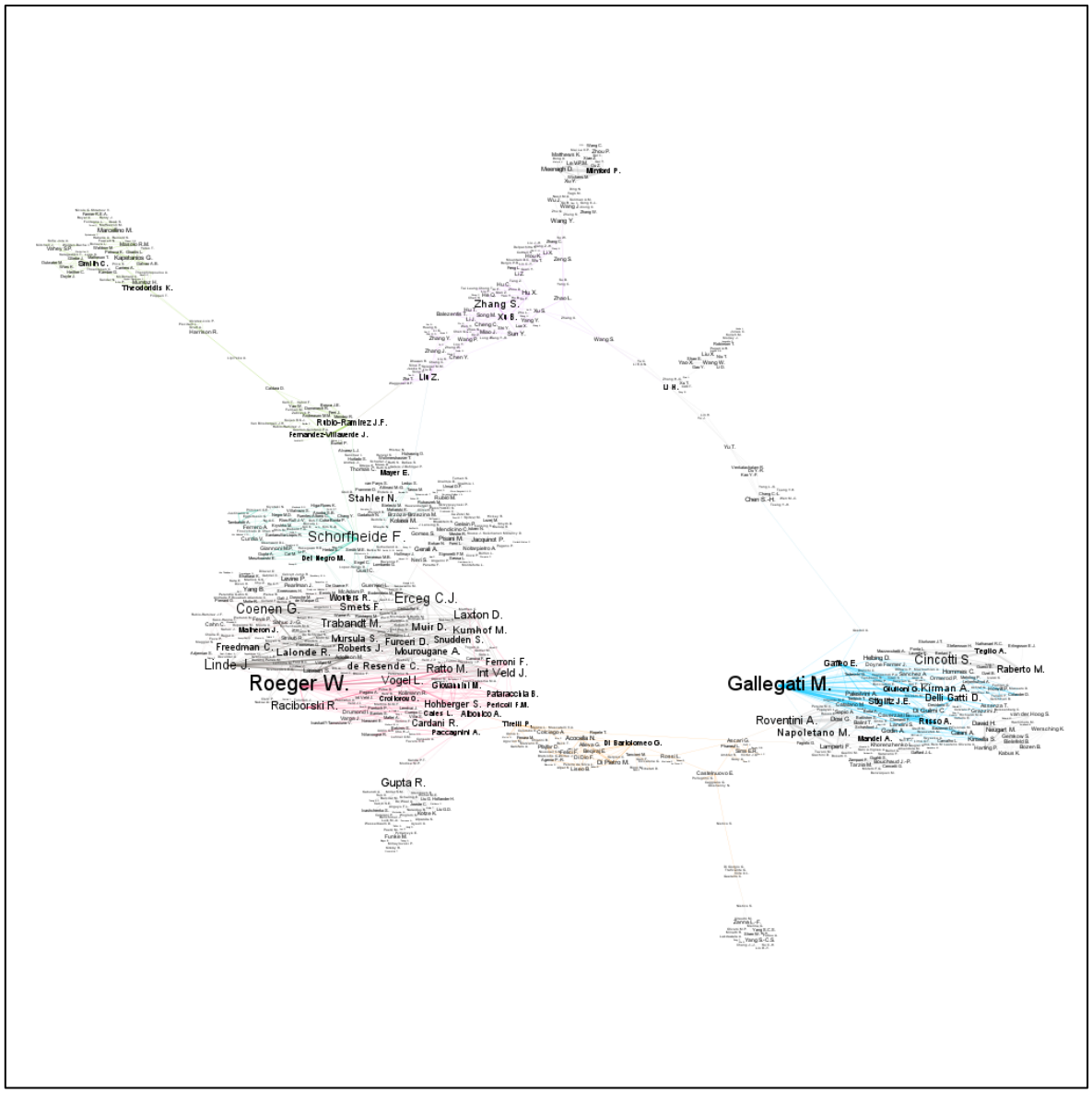


*Figure 4. Communities of co-authors in the biggest weak component of the co-authorship network. Only nodes of the biggest weakly connected (purple nodes in Figure 3, left panel) component are reported. Nodes and edges are coloured according to the communities to which they belong (as in Figure 3, right panel). The proportion of the labels is proportional to betweenness centrality of each author. Graph energized in Gephi by Fruchterman-Reingold algorithm.*

### 6. DSGE and MABM: have they common references?

From the summary statistics presented in section III, it is apparent that DSGE and MABM are two communities characterized by different publication habits. In section IV it is argued that they are fragmented in different social communities of authors. The question is whether the distance in terms of habits of publication and of academic communities, is also a distance from an intellectual point of view. This question is not approached by considering the methodological and theoretical differences between DSGE and MABM, as done for example by Colander et al. (2008), Delli Gatti *et al.* 2011, Dal Pont Legrand (2021) or Kirman (2021), but by adopting a bibliometric approach.

The simplest way for analysing the intellectual structure of a research field is to consider its cited references, by finding the "bulk" or the cited references of a field, *i.e*. the most referenced papers

appearing in the bibliography of the considered literature. This simple approach is problematic in the current setting, since the two sets of DSGE and MABM citing articles are very different in size (see Table 1). Hence, by adopting a simple ranking of references based no rough count would make disappear the MABM references . Moreover, if MABM and DSGE datasets are analysed separately, by ranking the most cited references of the two groups of papers, there is a high probability that cross cited papers, if any, do not appear in the lists.

For overcoming this problem, an alternative strategy is adopted by analysing the referenced papers by through the notion of co-citation: two referenced papers (RP) are co-cited when at least two citing papers cite both. The co-citation network of the cited references was built by considering the whole set of DSGE and MABM papers. In this network a node represents a cited or referenced paper, and the weighted link between a pair of nodes indicates the number of papers that cited both the cited papers. For example, if two RPs are linked by an edge with a weight of 3, it indicates that the two RPs are cited together by 3 citing papers. A graph-cut technique based on the weights of the edges was then applied for finding components, called "islands", inside the network. An island is defined as the maximal subnetwork of RPs where two connected RPs are linked by a number of co-citations greater than the number of co-citations linking any RPs in the island to any RPs out of the island. Note that islands can be identified in correspondence of different number of co-citations, and this permits to avoid the problem size reported above.

By applying this technique, the co-citation network can be partitioned in two islands: the citing papers of the whole database used two different non-overlapping bulks of literature. The two islands turn out to be clearly interpretable as the DSGE island and MABM island, by indicating that the intellectual milieu of the two approaches is different and non-overlapping. The two islands contain each the most relevant papers, i.e. the most co-cited papers, for DSGE and MABM.

The blue island reported in Figure 5 is the DSGE island. It contains 194 references papers linked by 855 edges. The minimum height of the island is 19, in particular there are 80 pairs of papers co-cited 19 times, *i.e.* each pair is co-cited by 19 citing papers. The maximum height of the island is 360, in particular, there is one pair of references co-cited by 360 citing papers. The two papers are: "2007_Smets, F._Shocks and frictions in us business cycles: a Bayesian DSGE approach" and "2005_Christiano, L.J._Nominal rigidities and the dynamic effects of a shock to monetary policy". With no doubt those two papers are of fundamental importance. They represent key-moments in the development of DSGE models: Christiano's paper became of central importance for the understanding of monetary policy transmission and Smet's paper a key-reference for estimation technics.[26]

[26] One can mention that Smet's contribution to macroeconomics, and to DSGE modeling, is still very central. He (with co-authors) produced in 2016 one of the rare models (Booms and Banking Crises) which after the crisis took seriously the issue of propagation.

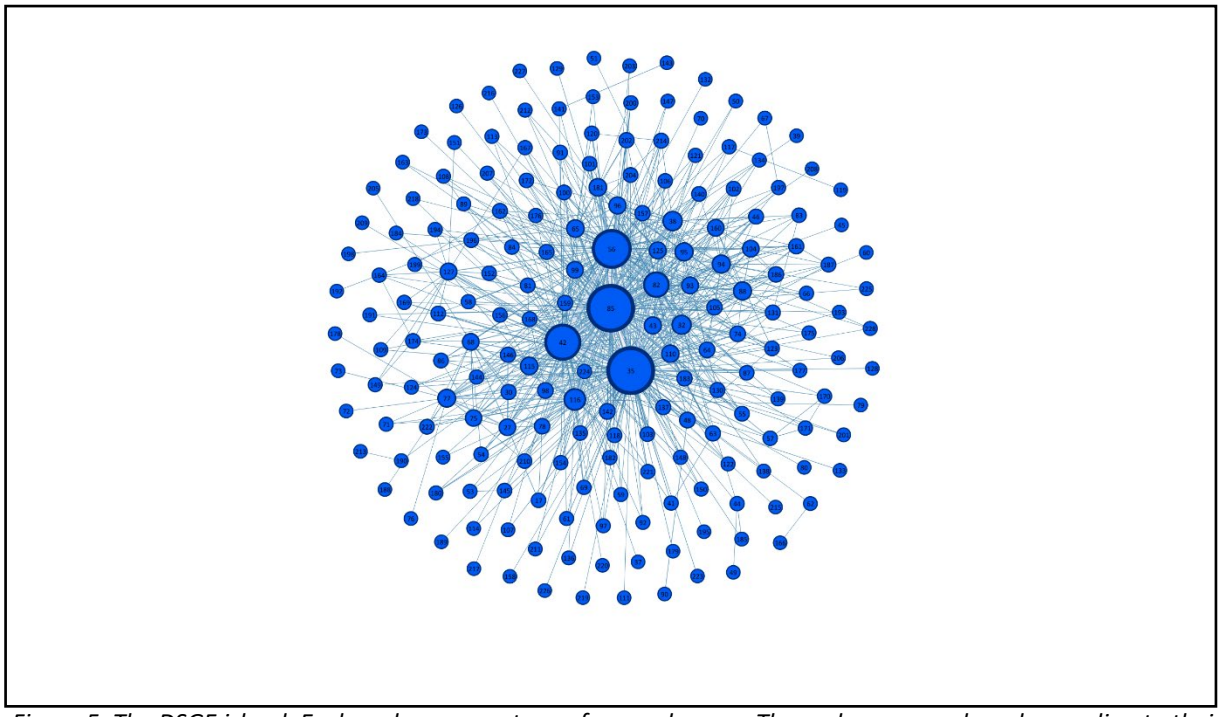

*Figure 5. The DSGE island. Each node represents a referenced paper. The nodes are numbered according to their identification code listed in the Appendix 1. The dimension of a node is proportional to its degree in the island, i.e. the number of referenced papers in the island linked to it. The thickness of the link between a pair of nodes is proportional to the number of co-citations they received in the general network, i.e. to the number of citing papers in the general network co-citing both the papers of the pair.*

The green island reported in Figure 6 is the MABM island. It contains 34 referenced papers linked by 93 edges. The minimum height of the island is 16, in particular there are 19 pairs of papers co-cited 16 times, i.e. each pair is co-cited by 16 citing papers. The maximum height of the island is 55, in particular there is one pair co-cited by 55 citing papers. The two papers are: "2013_Dosi, G._Income distribution, credit and fiscal policies in an agent-based Keynesian model" and "2010_Dosi, G._Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and business cycles"."

One could wonder why only Dosi's contribution is so prominent. With no doubt the paper published in 2010 which proposes to better analyse the interaction between short-run influence of effective demand (Keynes, K) and long run forces of innovation (Schumpeter, S) is of high interest but there are many other ABM models which analyse the role of credit and fiscal policies. It maybe that this group of researchers identified under the acronym of K-S group, develop estimation tools which allow direct comparison (at the global level) of models (stochastic) behaviours. If our interpretation is right, this means that apart from his pure theoretical content, DSGE models have imprinted the field of their methodology, of the relationship they impose between theory and facts. This also means that, if the convergence of empirical validation methods is achieved, there is perhaps the possibility of seeing ultimately, in the absence of a direct theoretical confrontation, an empirical confrontation of macroeconomic models.

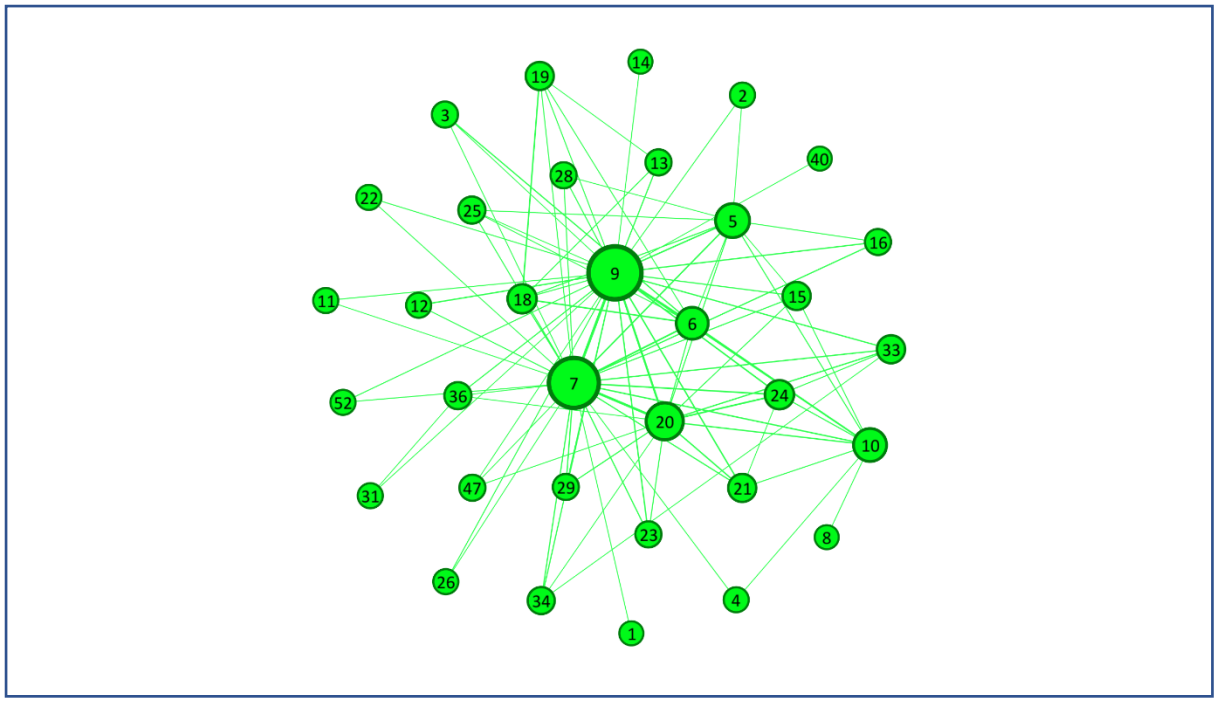


*Figure 6. The MABM island. Each node represents a referenced paper. The nodes are numbered according to their identification code listed in the Appendix 2. The dimension of a node is proportional to its degree in the island, i.e. the number of referenced papers in the island linked to it. The thickness of the link between a pair of nodes is proportional to the number of co-citations they received in the general network, i.e. to the number of citing papers in the general network co-citing both the papers of the pair.*

### 7. How similar are DSGE and MABM articles?

The analysis of CRs has permitted to individuate two sets of the most cited references, by starting from the whole database and without adopting a previous classification of the citing papers. At this stage it appears that DSGE and MABM appear as two different and monolithic approaches to macroeconomics, originating from two different intellectual approaches and without evident overlaps and internal fragmentations. For investigating the robustness of this representation, in particular for exploring the existence of overlaps and internal fragmentations, we have explored the data by using the notion of paper similarity.

The basic idea is to measure similarity between a pair of papers by considering their bibliographic references (for a recent overview, see Todeschini and Baccini, 2016, and Petrovich 2020). The technique is known as bibliographic coupling. The similarity was implemented on the basis of the classical Jaccard similarity coefficient between sets (Jaccard 1912). If A and B represent two sets, the Jaccard coefficient is defined as

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|}$$

where $|\cdot|$ denotes the cardinality of a set. It holds $0 \leq J(A,B) \leq 1$. In the present case, the similarity between two articles is proportional to the number of common bibliographic references appearing in both the articles. Hence, if two articles have exactly the same set of references, *i.e.* when $A = B$, the maximum similarity $J(A,B) = 1$ is achieved. In contrast, the minimum similarity $J(A,B) = 0$ occurs when two articles have no bibliographic references in common, *i.e.* when $A \cap B = \emptyset$.

The corpus of 2,253 articles contains 43,288 bibliographic references. Similarities are calculated for each pair of papers and visualized as a network in Figure 7. Similarity network data are energized by using the ForceAtlas2 algorithm (Jacomy *et al.* 2014) of the software Gephi (Bastian et al 2009). The algorithm turns structural proximities into visual proximities and similar papers appear as near nodes. Each node is colored according to the partition to which it belongs. The three partitions considered in Figure 7 are "keyword based", i.e. they are based on the keywords used for searching in the Scopus database. The partition of blue nodes correspond to DSGE articles (1861); the green nodes are MABM articles (364) and the red nodes are the articles (28) articles retrieved by using both DSGE and MABM keywords. 44

Figure 7 shows that the considered articles tend to form two different groups of papers corresponding to DSGE and MABM. The contact area between the two groups is occupied by the red articles and by come blue and green articles. At a first sight, the papers in this area maybe considered as the ones interested by cross-fertilization.

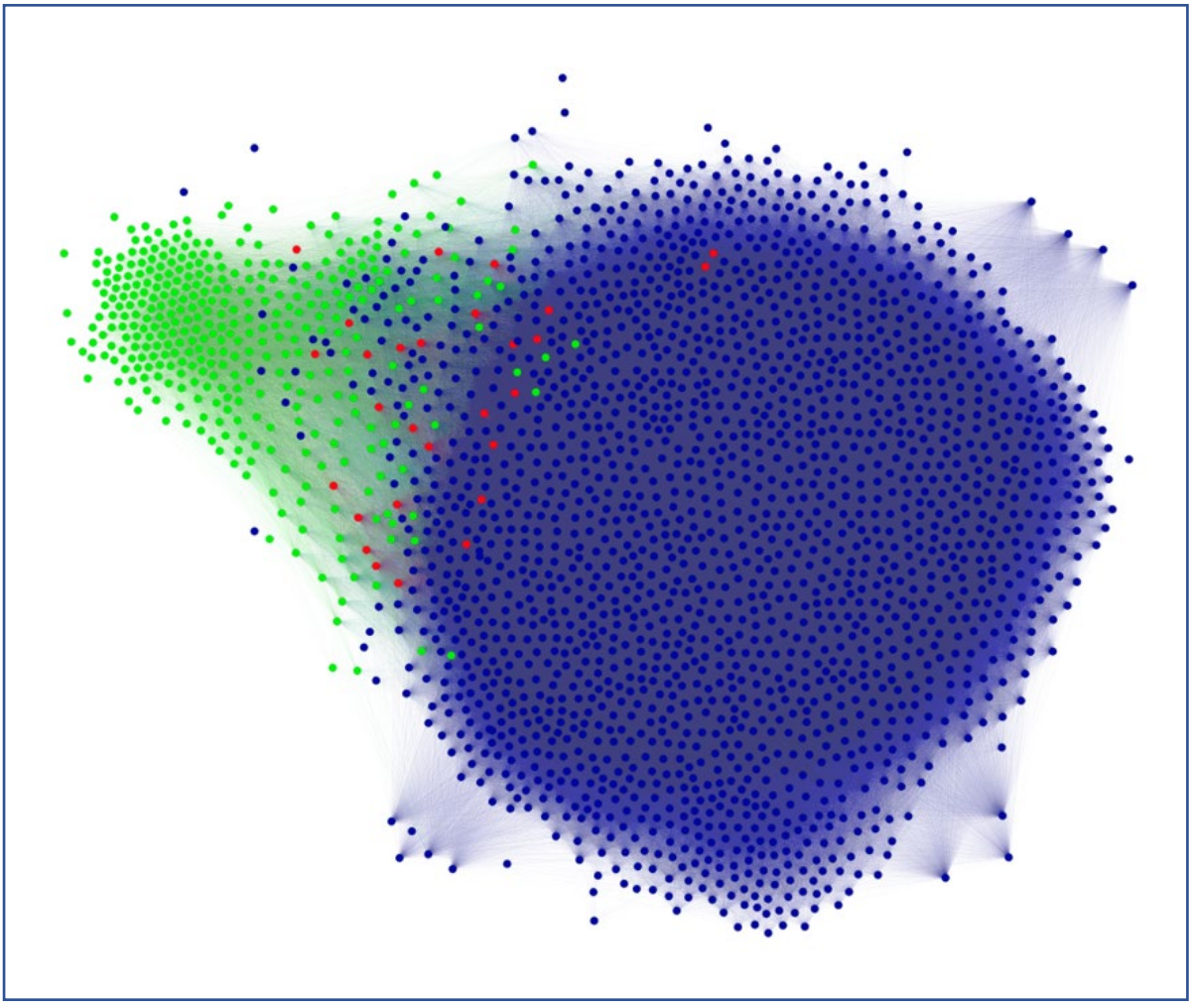

*Figure 7. Similarity network among articles. Each point of the figure is an article. Different colours indicate different groups of articles according to the keywords used for retrieving them: blue indicates articles retrieved by using DSGE keywords; green indicates MABM articles and red indicates overlapped articles, i.e. articles retrieved by using both DSGE and MABM keywords. Thickness of an edges is proportional to the similarity score between its endpoint articles. Jaccard similarity between each pair*

*of articles is computed by considering their bibliographic references. The ForceAtlas2 algorithm turns similarities into visual proximity, hence similar papers appear as near nodes.*

In Figure 8 the similarity network is partitioned by using the Louvain algorithm (Blondel et al. 2008) as implemented in the software Gephi. The Louvain algorithm consists in the optimization of the modularity of the network (Newman 2004; Newman and Girvan 2004) (Resolution: 1; Modularity 0.14; Communities: 21 of which 16 are composed by only one isolated article). In Figure 8 different node colours indicate different clusters of articles. Thickness of an edge is proportional to the similarity score between its endpoints. Network data are energized by using the ForceAtlas2 algorithm of the software Gephi. Also in Figure 8 communities appear as groups of near nodes.

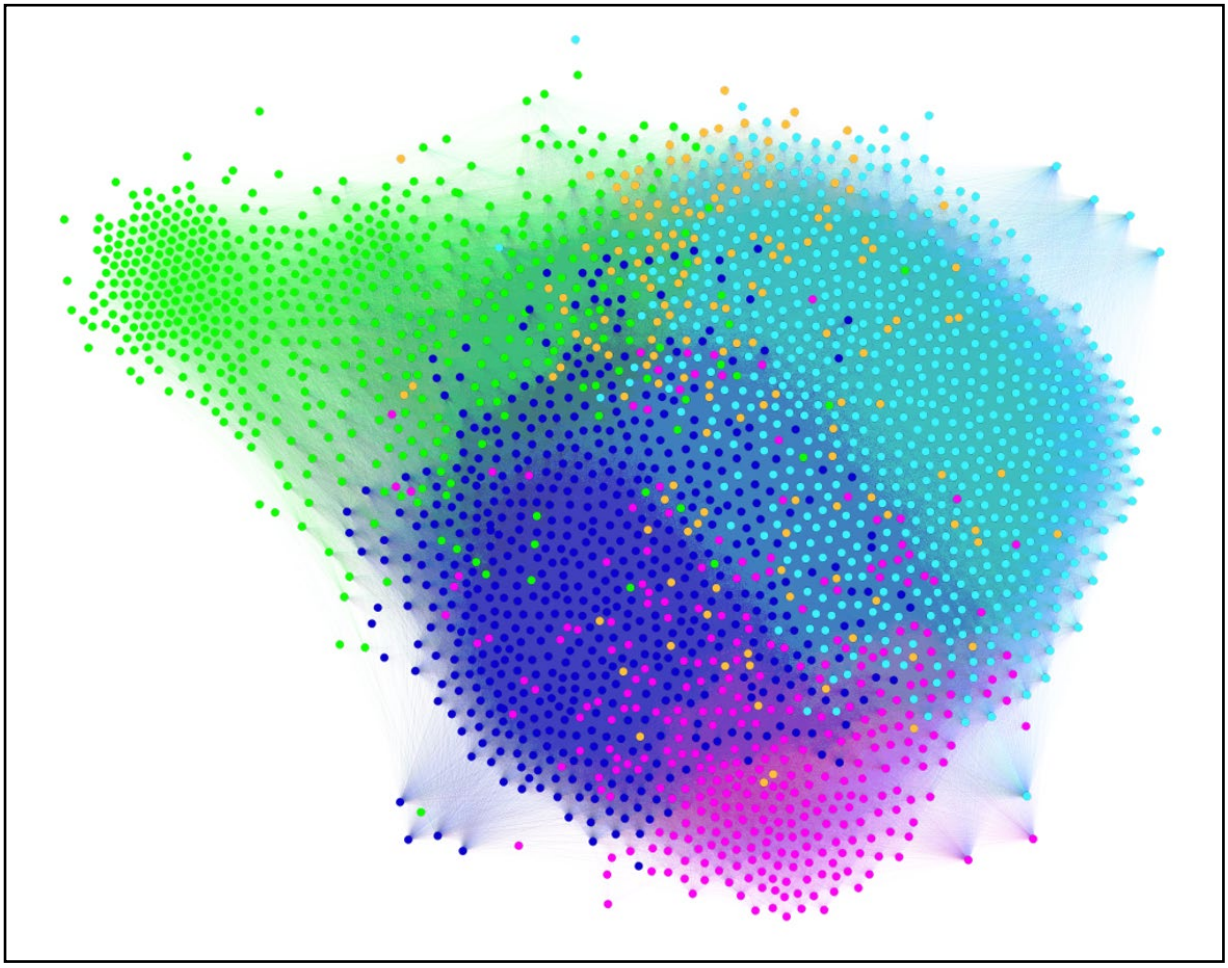

*Figure 8. Communities of articles based on similarities of cited references. Each point of the figure is an article. Different colours indicate different communities of articles detected by using the Louvain algorithm applied to similarity network. Thickness of an edges is proportional to the similarity score between its endpoint articles. Jaccard similarity between each pair of articles is computed by considering their bibliographic references. ForceAtlas2 algorithm energizes by turning similarities into visual proximity so that similar papers appear as near nodes, and communities appear as groups of near nodes.*

From a visual comparison of Figure 7 and Figure 8, it appears that the Louvain algorithm confirms that the articles retrieved by using MABM keywords form the green cluster. It shows also that the green cluster attracted within itself all the articles positioned in the area of contact between DSGE and MABM clusters in Figure 7. In particular, near all the articles retrieved by DSGE and MABM keyword

are now clustered in the MABM cluster. Moreover, Louvain algorithm splits the articles retrieved by using DSGE keywords into 4 different clusters. Of these four clusters the blue one is the nearest to the groups of green articles. The light blue articles and the purple ones are distant from the green set. Scattered in the graph there is also a relatively small set of pink papers. More analytically, Table 4 compares the keywords-based classification (column) and the Louvain algorithm classification (rows).

While the analysis of references returned a neat bipartition between DSGE and MABM, the community detection algorithm applied to the paper similarity network supports a more nuanced representation of the macroeconomic fields. DSGE approach appears fragmented in a few different interacting clusters of articles. MABM approach confirms to be unitary, but it tends to attract articles at the boundary between the two alternative approaches. Hence, from an intellectual point of view we are in a pluralism scenario, according to Table 0, but with the important qualification that the fragmentation happens inside each of, and not between to, the two sets of articles retrieved by using MABM and DSGE keywords.

**8. Discussion**

The interactions between the two streams of DSGE and MABM literature are explored by considering the social axis represented by co-authorship network, and the intellectual axis as proxied by cited references and bibliographic coupling. The exploratory analysis gave results that are neither consistent with a unitary structure of macroeconomics, nor with a simple dichotomic structure of alternative paradigms and separated academics communities.

Indeed, in reference to the social axis, and to research questions (i)-(iii), the co-authorship network shows that DSGE and MABM authors are neither part of a unique community of scholars linked by frequent co-authorship relations, nor of two different monolithic communities, where co-authorship relations exist only among the members of each community. DSGE and MABM form fragmented communities of co-authors that appears to belong to two different larger communities rather neatly separated, gathering respectively MABM and DSGE authors. Collaboration insists mainly inside the smaller groups and inside each of the two larger DSGE and MABM communities. The co-authorship network analysis does not show evidence of systematic collaboration between MABM and DSGE authors. The social groups found for MABM authors appears coherent with the clusters proposed in a closed-reading perspective by Dawid and Delli Gatti (2018).

In reference to the intellectual axis, and to research questions (iv)-(vi) when the cited references are analysed, it emerges that DSGE and MABM articles are not part of a unique corpus of documents that have common references. They refer instead to two different sets of bibliographic references. When a more refined measure of paper-similarity is adopted, an apparently more pluralistic scenario emerges composed by five groups of relatively similar articles. A closer look to these groups indicates that DSGE literature is fragmented in 4 groups while the MABM articles are clustered together in a unique group. By combining these information, it can be suggested that the apparent pluralistic scenario actually indicates the existence of two alternative paradigms (DSGE and MABM), one of which (DSGE) is fragmented in groups of articles referring to a common bulk of literature.

It is possible to better qualify the DSGE groups of Table 4, in reference to the classification proposed by Christiano et al. (2018). The blue articles are devoted to “standard DSGE” with particular attention to nominal rigidities (Calvo). One can suspect here that issues rlated to nominal rigidities - because of their capacity to propagate (and potentially, to amplify) fluctuations – are natural candidates for

potential cross-fertilization. The light blue articles can be labelled as "Bayesian DSGE". The most cited papers of this community are Smets (2007) and Christiano (2005). The purple articles are DSGE articles incorporating financial frictions and housing markets. Pink articles are probably DSGE articles emphasizing methodological aspects, problems of estimation and the use of DSGE for teaching purposes. Hence, the detected groups of DSGE articles appear as the result of a fragmentation by specialization of a stream of literature adopting a unitary approach to macroeconomics.

Figure 9 compares the trend of the clusters individuated by the Louvain algorithm. Until the mid-2000s there are very few articles, all belonging to the light blue and pink clusters, as highlighted also by Figure 1. In the following years, the number of articles grows for all clusters, with an acceleration after the crisis, but the pink one, that remains stable along the period. This is coherent with a growing specialization of DSGE literature after 2008, with a constant limited interest in methodological questions (pink groups).

| **Louvain algorithm** | **MABM (Green)** | **DSGE (Blue)** | **Overlap (Red)** | **Total** |
|---|---|---|---|---|
| 0 - Light Blue: Bayesian DSGE | 1 | 660 | 2 | 663 |
| 1 – Blue: DSGE/Nominal rigidities | 10 | 547 | 5 | 562 |
| 2 – Green: MABM and cross-fertilized(?) | 343 | 170 | 20 | 533 |
| 3 – Purple: DSGE/Financial friction/housing markets | 2 | 323 | 1 | 326 |
| 4 – Pink: DSGE/methodology and education | 2 | 151 | 0 | 153 |
| Isolated articles | 6 | 10 | 0 | 16 |
| Total | 364 | 1,861 | 28 | 2,253 |

**Table 4. Distribution of articles according to different classifications.** *Columns refer to the classification obtained by Scopus keyword search. Colors reported in the columns refers to Figure 7. Rows refer to the classification obtained by applying Louvain algorithm and colors refer to Figure 8.*

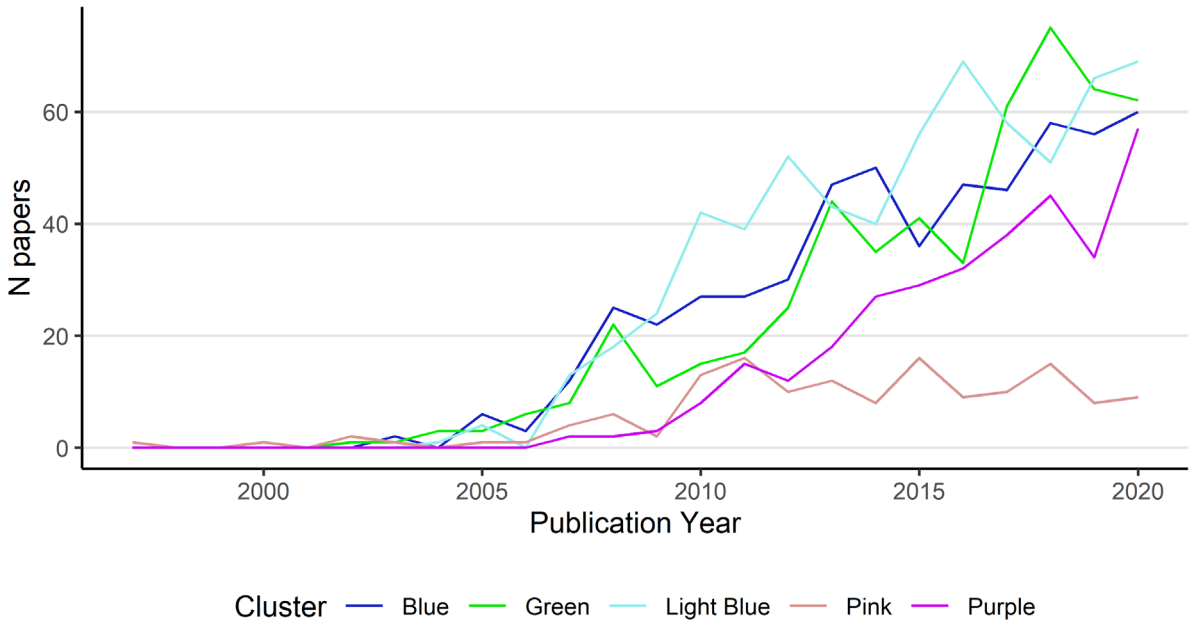


**Figure 9. Distribution of articles according to Louvain algorithm classification.** *Colors of the curves refer to Figure 8 and to rows of Table 4.*

As for green MABM group, it contains almost all the articles retrieved by MABM keywords that represent a unique core of literature with a bulk of common references. It also contains a set of 170 articles retrieved by DSGE keywords, and 20 out of 28 red articles retrieved by both sets of keywords. This seems to suggest that if there is cross-fertilization between DSGE and MABM, this cross-fertilization is largely asymmetric, taking the form of a dissymmetric influence of DSGE models on MABM literature.

Though, a closer look to these 170 articles indicates that they are mainly devoted to the critical recognition of DSGE models from a methodological point of view or in a history of economic thought perspective. They were near all published in the years after 2008; their cited references are fragmented, with a prevalence of classics of macroeconomics and of papers that consider macroeconomics in a critical or in a history of economic thought perspective. So, what appears as a piece of DSGE literature (blue color in Figure 7) is in fact a group of papers which do not really belong to the seraglio of DSGE models but mainly refer to DSGE models in a critical or historical perspective.

**9. Conclusive remarks**

The quantitative analysis of DSGE and MABM literature returns a scenario of two alternatives approaches fragmented each within itself, with no evidence of cross-fertilization. The only clues of cross-fertilization suggest rather a totally dissymmetric influence of DSGE over MABM literature, i.e. only MABM modelers look at DSGE but not vice-versa. This results corroborates the close-reading analysis of Brancaccio et al. (2021) of the influence of neoclassical paradigm on agent based models.

Our investigation reveals that the DSGE approach is less monolithic than at the time of the New Synthesis: indeed, a large and a growing literature has developed at the margins of the core DSGE approach which includes elements of heterogeneous agent modelling and social interactions, bounded rationality, macroeconomics experiments, expectations formation, learning *etc*. It is an open question

if the distinct DSGE groups documented in this work are also recognized as communities by DSGE modelers.

We acknowledge the variety of possible degrees of "absorption" and consider the specific case of "Hybrid" Models. Next step will be to distinguishes between the specific goals associated to the different modeling strategies proposed by hybrid models and to examine to what extent those different models take part of a cross-fertilization process. We still have to provide a more accurate analysis of the set of papers (the 170) which seem to be the closest to MABM's community and of the 28 overlapped papers. While for the moment the cross-fertilization process is quite dissymmetric, this does not mean that in fine there will not be a hybrid sort of models which could emerge and finally could be recognized by the two competing approaches. Nevertheless, as we can already guess, this opportunity is not easily accessible, and it would be interesting to identify which sort of model (i.e. based on which methodology, characterized by what core hypothesis) could be a potential candidate for such a (uncertain) fate. Reflecting on those issues, the paper aims to better identify the nature of that process and *in fine*, questions the capacity of the current dominant approach to (still) benefit from cross-fertilization.

Appendix 1. DSGE: the most cited references. Legenda of Figure 5.

| Id | Label | Degree |
|---|---|---|
| 17 | 1989_Bernanke, B._Agency costs, net worth, and business fluctuations | 5 |
| 27 | 1997_Kiyotaki, N._Credit cycles | 14 |
| 30 | 2010_Gertler, M._Financial intermediation and credit policy in business cycle analysis | 8 |
| 32 | 2003_Woodford, M._ Interest and Prices: Foundations of a Theory of Monetary Policy | 24 |
| 35 | 2007_Smets, F._Shocks and frictions in us business cycles: a bayesian DSGE approach | 138 |
| 37 | 1980_Taylor, J.B._Aggregate dynamics and staggered contracts | 1 |
| 38 | 1982_Kydland, F.E._Time to build and aggregate fluctuations | 25 |
| 39 | 1983_Long, J.B._Real business cycles | 1 |
| 41 | 2008_Nakamura, E._Five facts about prices: a reevaluation of menu cost models | 4 |
| 42 | 1983_Calvo, G.A._Staggered prices in a utility-maximizing framework | 91 |
| 43 | 1993_Taylor, J.B._Discretion versus policy rules in practice | 16 |
| 44 | 2001_Evans, G.W._ Learning and Expectations in Macroeconomics | 4 |
| 45 | 1989_Blanchard, O.J._The dynamic effects of aggregate demand and supply disturbances | 1 |
| 46 | 1994_Hamilton, J.D._ Time Series Analysis | 7 |
| 48 | 2004_Schmitt-Grohé, S._Solving dynamic general equilibrium models using a second-order approxim | 10 |
| 49 | 1997_Brock, W.A._A rational route to randomness | 1 |
| 50 | 1995_Cogley, T._Output Dynamics in Real-Business-Cycle Models | 2 |
| 51 | 1972_Lucas, R.E._Expectations and the neutrality of money | 1 |
| 53 | 1997_Greenwood, J._Long-run implications of investment-specific technological change | 3 |
| 54 | 2014_Christiano, L.J._Risk shocks | 5 |
| 55 | 2008_Galì, J._ Monetary policy, inflation, and the business cycle: An introduction to the new Keynesi | 6 |
| 56 | 2003_Smets, F._An estimated dynamic stochastic general equilibrium model of the euro area | 102 |
| 57 | 2009_Jaimovich, N._Can news about the future drive the business cycle? | 5 |
| 58 | 2000_Fuhrer, J.C._Habit formation in consumption and its implications for monetary-policy models | 4 |
| 59 | 2002_Mankiw, N.G._Sticky information versus sticky prices: a proposal to replace the new Keynesian | 3 |
| 60 | 1997_Goodfriend, M._The new neoclassical synthesis and the role of monetary policy | 1 |
| 61 | 2003_Eggertsson, G.B._The zero bound on interest rates and optimal monetary policy | 3 |
| 62 | 2005_Shimer, R._The cyclical behavior of equilibrium unemployment and vacancies | 2 |
| 63 | 2004_Bils, M._Some evidence on the importance of sticky prices | 8 |
| 64 | 2009_Canova, F._Back to square one: Identification issues in DSGE models | 10 |
| 65 | 2004_Del Negro, M._Priors from general equilibrium models for VARS | 18 |
| 66 | 2008_Del Negro, M._Forming priors for DSGE models (and how it affects the assessment of nominal | 4 |
| 67 | 1993_Gourieroux, C._Indirect inference | 2 |
| 68 | 2011_Gertler, M._A model of unconventional monetary policy | 14 |
| 69 | 2008_Christensen, I._The financial accelerator in an estimated New Keynesian model | 4 |
| 70 | 2007_Gertler, M._External constraints on monetary policy and the financial accelerator | 1 |
| 71 | 2013_Angeloni, I._Capital regulation and monetary policy with fragile banks | 3 |
| 72 | 2012_Kannan, P._Monetary and macroprudential policy rules in a model with house price booms | 1 |
| 73 | 2013_Lambertini, L._Leaning against boomÃ¢â‚¬â€&#3 | 1 |
| 74 | 1997_Rotemberg, J.J._An Optimization-Based Econometric Framework for the Evaluation of Moneta | 10 |
| 75 | 2010_Gerali, A._Credit and banking in a DSGE Model of the Euro Area | 13 |
| 76 | 2014_Rubio, M._Macroprudential and monetary policies: Implications for financial stability and welf | 1 |
| 77 | 2005_Iacoviello, M._House prices, borrowing constraints, and monetary policy in the business cycle | 19 |
| 78 | 1997_Carlstrom, C.T._Agency costs, net worth, and business fluctuations: a computable general equ | 9 |
| 79 | 2007_Goodfriend, M._Banking and interest rates in monetary policy analysis: a quantitative explorat | 1 |
| 80 | 2016_Wu, J.C._Measuring the macroeconomic impact of monetary policy at the zero lower bound | 1 |
| 81 | 2007_Schmitt-Grohé, S._Optimal Simple and Implementable Monetary and Fiscal Rules | 6 |
| 82 | 2007_An, S._Bayesian analysis of DSGE models | 49 |
| 83 | 1985_Hansen, G.D._Indivisible labor and the business cycle | 5 |
| 84 | 1995_Kass, R.E._Bayes factors | 5 |
| 85 | 2005_Christiano, L.J._Nominal rigidities and the dynamic effects of a shock to monetary policy | 137 |
| 86 | 2010_Curdia, V._Credit Spreads and Monetary Policy | 6 |
| 87 | 2008_Christoffel, K._ The New Area-Wide Model of the Euro Area: A Micro-Founded Open-Economy | 5 |
| 88 | 2000_Clarida, R._Monetary policy rules and macroeconomic stability: Evidence and some theory | 20 |

| | | |
|---|---|---|
| 89 | 2006_Erceg, C.J._SIGMA: A new open economy model for policy analysis | 3 |
| 90 | 2008_Kim, J._Calculating and using second-order accurate solutions of discrete time dynamic equilib | 1 |
| 91 | 2005_Lubik, T._A Bayesian look at new open economy macroeconomics | 5 |
| 92 | 2007_Ireland, P.N._Changes in the federal reserve's inflation target: Causes and consequences | 3 |
| 93 | 1980_Blanchard, O.J._The solution of linear difference models under rational expectations | 15 |
| 94 | 2004_Lubik, T.A._Testing for Indeterminacy: An Application to U.S. Monetary Policy | 20 |
| 95 | 2002_Sims, C.A._Solving linear rational expectations models | 20 |
| 96 | 2007_Del Negro, M._On the fit of New Keynesian models | 16 |
| 97 | 2008_Cogley, T._Trend Inflation, Indexation, and Inflation Persistence in the New Keynesian Phillips | 3 |
| 98 | 2007_Adolfson, M._Bayesian estimation of an open economy DSGE model with incomplete pass-thr | 10 |
| 99 | 2005_Gali, J._Monetary policy and exchange rate volatility in a small open economy | 14 |
| 100 | 2007_Lubik, T.A._Do central banks respond to exchange rate movements? A structural investigation | 6 |
| 101 | 2010_Fernandez-Villaverde, J._The econometrics of DSGE models | 5 |
| 102 | 1999_Uhlig, H._A toolkit for analysing nonlinear dynamic stochastic models easily | 6 |
| 103 | 2005_Rabanal, P._Comparing new Keynesian models of the business cycle: a Bayesian approach | 5 |
| 104 | 2006_Sims, C.A._Were there regime switches in U.S. monetary policy? | 14 |
| 105 | 2000_Klein, P._Using the generalized Schur form to solve a multivariate linear rational expectations | 9 |
| 106 | 1977_Dixit, A.K._Monopolistic competition and optimum product diversity | 5 |
| 107 | 1982_Rotemberg, J.J._Monopolistic price adjustment and aggregate output | 2 |
| 108 | 2005_Monacelli, T._Monetary policy in a low pass-through environment | 3 |
| 109 | 2010_Leeper, E.M._Dynamics of fiscal financing in the United States | 3 |
| 110 | 2000_Erceg, C.J._Optimal monetary policy with staggered wage and price contracts | 17 |
| 111 | 2015_Guerrieri, L._OccBin: a toolkit for solving dynamic models with occasionally binding constraint | 1 |
| 112 | 2011_Christiano, L._When is the government spending multiplier large? | 6 |
| 113 | 2008_Coenen, G._Tax reform and labour-market performance in the euro area: A simulation-based | 3 |
| 114 | 2010_Justiniano, A._Can structural small open-economy models account for the influence of foreign | 2 |
| 115 | 2003_Schmitt-Grohé, S._Closing small open economy models | 18 |
| 116 | 1999_Bernanke, B.S._The financial accelerator in a quantitative business cycle framework | 34 |
| 117 | 2005_Uhlig, H._What are the effects of monetary policy on output? Results from an agnostic identifi | 4 |
| 118 | 1998_Brooks, S.P._General methods for monitoring convergence of iterative simulations | 6 |
| 119 | 2002_Canova, F._Monetary Disturbances Matter for Business Fluctuations in the G-7 | 1 |
| 120 | 1984_Doan, T._Forecasting and conditional projections using realistic prior distributions | 5 |
| 121 | 1992_Christiano, L.J._Current real-business-cycle theories and aggregate labor-market fluctuations | 4 |
| 122 | 1999_King, R.G._Resuscitating real business cycles | 3 |
| 123 | 2007_Fernandez-Villaverde, J._Estimating macroeconomic models: a likelihood approach | 6 |
| 124 | 2008_Gertler, M._An estimated monetary DSGE model with unemployment and staggered nominal | 3 |
| 125 | 1999_Geweke, J._Using simulation methods for Bayesian econometric models: Inference, developm | 15 |
| 126 | 1982_Rotemberg, J.J._Sticky prices in the United States | 1 |
| 127 | 2007_Galì, J._Understanding the effects of government spending on consumption | 15 |
| 128 | 2010_Edge, R.M._How useful are estimated DSGE model forecasts for central bankers? | 1 |
| 129 | 2005_Fagan, G._An area-wide model (AWM) for the euro area | 1 |
| 130 | 2010_Iskrev, N._Local identification in DSGE models | 7 |
| 131 | 1988_King, R.G._Production, growth and business cycles: I. The basic neoclassical model | 7 |
| 132 | 1997_Hodrick, R.J._Postwar U.S. business cycles: an empirical investigation | 1 |
| 133 | 1998_Judd, K._ Numerical Methods in Economics | 1 |
| 134 | 2004_Ireland, P._Technology Shocks in the New Keynesian Model | 3 |
| 135 | 2011_Justiniano, A._Investment shocks and the relative price of investment | 5 |
| 136 | 2011_Christiano, L.J._Introducing financial frictions and unemployment into a small open economy | 2 |
| 137 | 1988_Greenwood, J._Investment, capacity utilization, and the real business cycle | 7 |
| 138 | 2009_Ratto, M._QUEST III: An Estimated Open-Economy DSGE Model of the Euro Area with Fiscal an | 2 |
| 139 | 2007_Adolfson, M._Forecasting performance of an open economy DSGE model | 3 |
| 140 | 2003_Woodford, M._ Interest and Prices | 6 |
| 141 | 1995_Merz, M._Search in the labor market and the real business cycle | 3 |
| 142 | 1999_Clarida, R._The Science of Monetary Policy: A New Keynesian Perspective | 10 |
| 143 | 1996_Andolfatto, D._Business cycles and labor-market search | 1 |
| 144 | 2011_Altig, D._Firm-specific capital, nominal rigidities and the business cycle | 4 |
| 145 | 2006_Fisher, J._The dynamic effects of neutral and investment-specific technology shocks | 5 |

| | | |
|---|---|---|
| 146 | 2010_Iacoviello, M._Housing Market Spillovers: Evidence from an Estimated DSGE Model | 8 |
| 147 | 2004_Smets, F._Forecasting with a Bayesian DSGE model: an application to the Euro area | 2 |
| 148 | 1996_Yun, T._Nominal price rigidity, money supply endogeneity, and business cycles | 4 |
| 149 | 2009_Mountford, A._What are the effects of fiscal policy shocks? | 3 |
| 150 | 1991_Leeper, E.M._Equilibria under 'active' and 'passive' monetary and fiscal | 3 |
| 151 | 2010_Leeper, E.M._Government Investment and Fiscal Stimulus | 2 |
| 152 | 2009_Forni, L._The General Equilibrium Effects of Fiscal Policy: Estimates for the Euro Area | 5 |
| 153 | 2002_Chari, V.V._Can sticky price models generate volatile and persistent real exchange rates? | 2 |
| 154 | 1995_Kimball, M.S._The quantitative analytics of the basic neomonetarist model | 4 |
| 155 | 1998_Sims, C.A._Bayesian methods for dynamic multivariate models | 2 |
| 156 | 2011_Adjemian, S._Dynare: Reference Manual Version 4 | 5 |
| 157 | 1976_Lucas, R.E._Econometric policy evaluation: a critique | 8 |
| 158 | 2011_Liu, Z._Sources of macroeconomic fluctuations: A regime-switching DSGE approach | 1 |
| 159 | 2010_Justiniano, A._Investment shocks and business cycles | 8 |
| 160 | 2008_Justiniano, A._The time-varying volatility of macroeconomic fluctuations | 14 |
| 161 | 2005_Primiceri, G.E._Time varying structural vector autoregressions and monetary policy | 8 |
| 162 | 1999_Gali, J._Technology, employment, and the business cycle: Do technology shocks explain aggre | 7 |
| 163 | 2005_Francis, N._Is the technology-driven real business cycle hypothesis dead? Shocks and aggregat | 2 |
| 164 | 1993_Baxter, M._Fiscal policy in general equilibrium | 4 |
| 165 | 2010_Justiniano, A._Monetary policy and uncertainty in an empirical small open-economy model | 7 |
| 166 | 2005_Hall, R.E._Employment fluctuations with equilibrium wage stickiness | 1 |
| 167 | 2012_Coenen, G._Effects of fiscal stimulus in structural models | 4 |
| 168 | 2008_Adolfson, M._Evaluating an estimated new Keynesian small open economy model | 6 |
| 169 | 2010_Cogan, J.F._New Keynesian versus old Keynesian government spending multipliers | 4 |
| 170 | 2012_Schmitt-Grohé, S._What's news in business cycles | 4 |
| 171 | 2006_Beaudry, P._Stock prices, news, and economic fluctuations | 4 |
| 172 | 2006_Boivin, J._ DSGE models in a data-rich environment | 5 |
| 173 | 1994_McGrattan, E.R._The macroeconomic effects of distortionary taxation | 1 |
| 174 | 2002_Blanchard, O._An empirical characterization of the dynamic effects of changes in government | 6 |
| 175 | 2007_Canova, F._ Methods for Applied Macroeconomic Research | 3 |
| 176 | 2001_Boldrin, M._Habit persistence, asset returns, and the business cycle | 4 |
| 177 | 2009_Chari, V.V._New Keynesian models. not yet useful for policy analysis | 3 |
| 178 | 2015_Iacoviello, M._Financial business cycles | 1 |
| 179 | 2007_Chari, V.V._Business cycle accounting | 1 |
| 180 | 2012_Jermann, U._Macroeconomic effects of financial shocks | 3 |
| 181 | 2000_Schorfheide, F._Loss function-based evaluation of DSGE models | 18 |
| 182 | 2005_Smets, F._Comparing Shocks and Frictions in US and Euro Area Business Cycles: A Bayesian DS | 4 |
| 183 | 1999_Gali, J._Inflation dynamics: a structural econometric analysis | 8 |
| 184 | 2001_Gali;, J._European inflation dynamics | 2 |
| 185 | 2007_Milani, F._Expectations, learning and macroeconomic persistence | 2 |
| 186 | 2006_Boivin, J._Has monetary policy become more effective? | 9 |
| 187 | 2005_Cogley, T._Drifts and volatilities: Monetary policies and outcomes in the post WWII U.S | 6 |
| 188 | 2009_Monacelli, T._New Keynesian models, durable goods, and collateral constraints | 1 |
| 189 | 1979_Townsend, R.M._Optimal contracts and competitive markets with costly state verification | 1 |
| 190 | 2007_Aguiar, M._Emerging market business cycles: the cycle is the trend | 2 |
| 191 | 2000_Chari, V.V._Sticky price models of the business cycle: can the contract multiplier solve the pers | 2 |
| 192 | 2007_Ravenna, F._Vector autoregressions and reduced form representations of DSGE models | 1 |
| 193 | 2010_Christiano, L.J._DSGE models for monetary policy analysis | 2 |
| 194 | 2005_Coenen, G._Does government spending crowd in private consumption? Theory and empirical | 4 |
| 195 | 1985_Anderson, G._A linear algebraic procedure for solving linear perfect foresight models | 1 |
| 196 | 2007_Fernandez-Villaverde, J._ABCs (and Ds) of understanding VARs | 6 |
| 197 | 1993_Smith, A._Estimating nonlinear time-series models using simulated vector autoregressions | 4 |
| 198 | 1994_Ingram, B.F._Supplanting the | 1 |
| 199 | 2006_Basu, S._Are technology improvements contractionary? | 3 |
| 200 | 1989_Sargent, T.J._Two models of measurements and the investment accelerator | 4 |
| 201 | 2011_Komunjer, I._Dynamic identification of dynamic stochastic general equilibrium models | 2 |
| 202 | 2004_Ireland, P._A method for taking models to the data | 8 |

| | | |
|---|---|---|
| 203 | 1989_Altug, S._Time-to-Build and Aggregate Fluctuations: Some New Evidence | 2 |
| 204 | 2004_Fernandez-Villaverde, J._Comparing Dynamic Equilibrium Models to Data: A Bayesian Approac | 6 |
| 205 | 2012_Gertler, M._Financial crises, bank risk exposure and government financial policy | 1 |
| 206 | 2012_Gilchrist, S._Credit spreads and business cycle fluctuations | 2 |
| 207 | 1999_Christiano, L.J._Monetary policy shocks: What have we learned? | 3 |
| 208 | 2005_Bernanke, B.S._Measuring the effects of monetary policy: A factor-augmented vector autoreg | 1 |
| 209 | 2007_Blanchard, O._Real Wage Rigidities and the New Keynesian Model | 1 |
| 210 | 2010_Christiano, L._ Financial Factors in Economic Fluctuations | 5 |
| 211 | 2008_De Graeve, F._The external finance premium and the macroeconomy: US post-WWII evidence | 2 |
| 212 | 2000_DeJong, D.N._A Bayesian approach to dynamic macroeconomics | 3 |
| 213 | 2005_Neumeyer, P.A._Business cycles in emerging economies: The role of interest rates | 1 |
| 214 | 1980_Sims, C.A._Macroeconomics and reality | 7 |
| 215 | 2013_Bianchi, F._Regime switches, agentsÃ¢â‚¬â„&#1 | 1 |
| 216 | 1995_Cooley, T.F._Economic growth and business cycles | 1 |
| 217 | 2000_Greenwood, J._The role of investment-specific technological change in the business cycle | 1 |
| 218 | 2001_Fagan, G._ An Area-Wide Model (AWM) for the Euro Area | 2 |
| 219 | 2009_Del Negro, M._Monetary policy analysis with potentially misspecified models | 1 |
| 220 | 2002_Smets, F._Openness, imperfect exchange rate pass-through and monetary policy | 1 |
| 221 | 2003_Christiano, L.J._The great depression and the Friedman-Schwartz hypothesis | 4 |
| 222 | 2010_Meh, C.A._The role of bank capital in the propagation of shocks | 6 |
| 223 | 2013_Del Negro, M._DSGE model-based forecasting | 1 |
| 224 | 1995_Diebold, F.X._Comparing predictive accuracy | 4 |
| 225 | 2005_Schorfheide, F._Learning and monetary policy shifts | 2 |
| 226 | 2010_Edge, R.M._A comparison of forecast performance between Federal Reserve staff forecasts, si | 1 |
| 227 | 2001_Otrok, C._On measuring the welfare cost of business cycles | 1 |
| 228 | 2009_Benati, L._VAR Analysis and the Great Moderation | 3 |

Appendix 2. MABM: the most cited references. Legenda of Figure 6.

| Id | Label | Degree |
|---|---|---|
| 1 | 2008_Deissenberg, C._Eurace: a massively parallel agent-based model of the European economy | 1 |
| 2 | 2012_Seppecher, P._Flexibility of wages and macroeconomic instability in an agent-based computat | 2 |
| 3 | 2013_Riccetti, L._Leveraged network-based financial accelerator | 3 |
| 4 | 2015_Riccetti, L._An agent based decentralized matching macroeconomic model | 2 |
| 5 | 2010_Cincotti, S._Credit money and macroeconomic instability in the agent-based model and simula | 11 |
| 6 | 2010_Delli Gatti, D._The financial accelerator in an evolving credit network | 9 |
| 7 | 2013_Dosi, G._Income distribution, credit and fiscal policies in an agent-based Keynesian model | 27 |
| 8 | 2016_Russo, A._Increasing inequality, consumer credit and financial fragility in an agent based macr | 1 |
| 9 | 2010_Dosi, G._Schumpeter meeting Keynes: A policy-friendly model of endogenous growth and busi | 30 |
| 10 | 2016_Caiani, A._Agent based-stock flow consistent macroeconomics: Towards a benchmark model | 10 |
| 11 | 2006_Dosi, G._An evolutionary model of endogenous business cycles | 2 |
| 12 | 1982_Nelson, R.R._ An evolutionary theory of economic change | 2 |
| 13 | 1992_Kirman, A._Whom or what does the representative individual represent? | 3 |
| 14 | 2012_Napoletano, M._Wage formation, investment behavior and growth regimes: an agent-based a | 1 |
| 15 | 2015_Assenza, T._Emergent dynamics of a macroeconomic agent based model with capital and cred | 5 |
| 16 | 2011_Delli Gatti, D._ Macroeconomics from the bottom-up | 3 |
| 18 | 2005_Delli Gatti, D._A new approach to business fluctuations: heterogeneous interacting agents, sca | 6 |
| 19 | 1993_Greenwald, B.C._Financial market imperfections and business cycles | 5 |
| 20 | 2015_Dosi, G._Fiscal and monetary policies in complex evolving economies | 14 |
| 21 | 2014_Dawid, H._Economic convergence: policy implications from a heterogeneous agent model | 5 |
| 22 | 2013_Lengnick, M._Agent-based macroeconomics: A baseline model | 2 |
| 23 | 2017_Ashraf, Q._Banks, market organization, and macroeconomic performance: An agent-based co | 3 |
| 24 | 2017_Fagiolo, G._Macroeconomic policy in DSGE and agent-based models redux: new development | 6 |
| 25 | 2007_Russo, A._Industrial dynamics, fiscal policy and R&D: Evidence from a computational expe | 4 |
| 26 | 2006_Tesfatsion, L._Handbook of Computational Economics: Agent-based Computational Economics | 2 |
| 28 | 2012_Raberto, M._Debt, deleveraging and business cycles: An agent-based perspective | 3 |
| 29 | 2017_Dosi, G._When more flexibility yields more fragility: the microfoundations of Keynesian aggreg | 3 |
| 31 | 2006_Napoletano, M._Are business cycles all alike? A bandpass filter analysis of the Italian and US cy | 2 |
| 33 | 2012_Fagiolo, G._Macroeconomic policy in DSGE and agent-based models | 5 |
| 34 | 2008_LeBaron, B._Modeling macroeconomies as open-ended dynamic systems of interacting agents | 4 |
| 36 | 1999_Stock, J.H._Business Cycle Fluctuations in US Macroeconomic Time Series | 4 |
| 40 | 2012_Dawid, H._ The Eurace@ Unibi Model: An Agent-Based Macroeconomic Model for Economic P | 1 |
| 47 | 2008_Fagiolo, G._Are output growth-rate distributions fat-tailed? Some evidence from OECD countr | 3 |
| 52 | 2009_Farmer, J.D._The economy needs agent-based modelling | 2 |

**References**


Bastian, M., Heymann, S. and Jacomy, M. (2009). *Gephi: An Open Source Software for Exploring and Manipulating Networks*.

Blanchard O. (2008). Neoclassical Synthesis. In: Durlauf S.N., Blume L.E. (eds) *The New Palgrave Dictionary of Economics*. Palgrave Macmillan, London.

Blanchard O. (2016). Do DSGE Models Have a Future? Policy Brief. *Peterson Institute for International Economics*, PB, 16-11.

Blanchard O. 2018. On the future of macroeconomic models. *Oxford Review of Economic Policy*, Oxford University Press, vol. 34(1-2), 43-54.

Blondel, V.D. et al. (2008). Fast unfolding of communities in large networks, *Journal of Statistical Mechanics: Theory and Experiment* 2008.10, P10008.

Boissay F., F. Collard, F. Smets, 2016. Booms and Banking Crises. *Journal of Political Economy*, University of Chicago Press, 24(2), 489-538.

Brancaccio, Emiliano, Mauro Gallegati, and Raffaele Giammetti, 2021. Neoclassical influences in agent-based literature: A systematic review, Journal of Economic Surveys, n/a.

Caballero R.J. (2010). Macroeconomics after the Crisis: Time to Deal with the Pretense-of-Knowledge Syndrome. *Journal of economics perspectives*, 24 (4), 85-102.

Christiano, L.J., Eichenbaum, M.S., and Trabandt, M. (2018). On DSGE Models. *Journal of Economic Perspectives,* 32(3), 113–40.

Cogley, T. and Nason, J. M. (1995). Output Dynamics in Real-Business-Cycle Models. *American Economic Review*, 85(3): 492-511.

Colander D., P. Howitt, A. Kirman, A. Leijonhufvud, and P. Mehrling (2008). "Complexity and Dynamics in Macroeconomics: Alternatives to the DS GE Models", *American Economic Review: Papers & Proceedings*, 98:2, 236–240.

Dal Pont M. (1999). *Croissance cyclique, monnaie et finance : un essai de mise en relation théorique,* thèse pour le doctorat de sciences économiques, Université Nice-Sophia Antipolis, GREDEG CNRS.

Dal Pont Legrand M. (2021). Some Reflections on Financial Instability in Macro Agents-Based Models. Genealogy and objectives, in *Financial Instability, Market Disruptions and Macroeconomics. Lessons from Economic History and the History of Economic Thought*, Ed. By A. Arnon, C. Marcuzzo and A. Rosselli, Springer Verlag.

Dal Pont Legrand M. and A. Truc (2021). Agent-based approach and Economics: quantifying disciplinary interactions. Working Paper, To be presented at the Annual ASSA Meeting 7-9 January 2022, HES Session.

Davis J. (2019). Specialization, fragmentation, and pluralism in economics. *The European Journal of the History of Economic Thought*, 26(2), 271-293.

Delli Gatti D., S. Desiderio, E. Gaffeo, P. Cirillo and M. Gallegati (2011). *Macroeconomics from the Bottom-up*, New Economic Windows, Springer Verlag, Italia, Milano.

Di Guilmi, C. (2017). The agent-based approach to post Keynesian macro-modeling. Journal ofEconomic Surveys, 31(5), 1183–1203. https://doi.org/10.1111/joes.12244

Fontana M. (2010) "The Santa Fe Perspective on Economics: Emerging Patterns in the Science of Complexity", History of Economic Ideas, XVII, 167-196.

Haldane AG, Turrell AE (2018). An interdisciplinary model for macroeconomics. *Oxford Review of Economic Policy*, 34(1–2):219–251.

Jaccard, P. (1912). "The distribution of the flora in the alpine zone". In: *New Phytologist* 11 (1912), 37–50.

Jacomy, M. et al. (2014). "ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software", *PLOS ONE* 9.6, pp. 1–12. doi: 10.1371/journal.pone.0098679.

Kirman A. (2021). Rational expectations in a changing world. Revue d'*Economie Politique*, 3, 485-509.

Lucas R. 1972. Expectations and the neutrality of money. *Journal of Economic Theory*, Elsevier, vol. 4(2), pages 103-124, April.

Lucas R. 1975. An Equilibrium Model of the Business Cycle. *Journal of Political Economy*, University of Chicago Press, vol. 83(6), pages 1113-1144, December.

Lucas R. 1977. Understanding business cycles. *Carnegie-Rochester Conference Series on Public Policy,* Elsevier, vol. 5(1), pages 7-29, January.

Lucas R. 1987. *Models of business cycles*. Oxford: Basil Blackwell, 1987. pp. 120.

Lucas R. 2003. Macroeconomic Priorities. *American Economic Review*, 93(1), 1-14.

Newman, M.E.J. (2004). Fast algorithm for detecting community structure in networks, *Physical Review E*, 69, p. 066133. doi: 10.1103/PhysRevE.69.066133.

Newman, M.E.J. and Girvan, M. (2004). Finding and evaluating community structure in networks, *Physical Review E*, 69 026113. doi: 10.1103/PhysRevE.69.026113.

Petrovich, E. (2020). Science Mapping, *ISKO Encyclopedia of Knowledge Organization*, https://www.isko.org/cyclo/science_mapping.

Plassard R. 2019. The incorporation of agent-based models into the Bank of England's tool kit. Working paper, presented at the Annual ASSA Meeting, HES session, 3-5 January, Chicago.

Rodrik D. (2015). *Economics Rules*. Oxford University Press, Oxford, United Kingdom.

Rosenberg A. (2021). The nature of DSGE macroeconomics, in *A modern Guide to Philosophy of Economics,* Edited by H. Kincaid and D. Ross, Elgar Modern Guides.

Sergi F. (2017). *De la révolution Lucasienne aux modèles DSGE*, Thèse pour le doctorat de sciences économiques, Université Paris 1 Panthéon Sorbonne.

Solow R., (2010). Building a science of economics for the real world. House Committee on Science and Technology, Subcommittee on Investigations and Oversight. July 2010.

Symposium (2018a). Rebuilding macroeconomic theory, *Oxford Review of Economic Policy*, 34(1-2).

Symposium (2018b). Macroeconomics a Decade after the great Recession, *Journal of Economic Perspectives*, 32(3), summer 2018.

Thor, A., Marx, W., Leydesdorff, L., & Bornmann, L. (2016). Introducing CitedReferencesExplorer (CREXplorer): A program for reference publication year spectroscopy with cited references standardization. *Journal of Informetrics*, 10(2), 503–515.

Todeschini, R. and Baccini, A. (2016). Handbook of Bibliometric Indicators. Quantitative Tools for Studying and Evaluating Research. Weinheim (Germany): Wiley-VCH, 2016. isbn: 978-3-527-33704-0.

Woodford, M. (2003). *Interest and Prices*. References. Princeton University Press, Princeton and Oxford.

Zitt, M., Lelu, A., Cadot, M., & Cabanac, G. (2019). Bibliometric Delineation of Scientific Fields. In W. Glänzel, H. F. Moed, U. Schmoch, & M. Thelwall (Eds.), Springer Handbook of Science and Technology Indicators (pp. 25–68). Springer International Publishing.

# DOCUMENTS DE TRAVAIL GREDEG PARUS EN 2022
## *GREDEG Working Papers Released in 2022*

**2022-01** Patrice Bougette, Oliver Budzinski & Frédéric Marty
*Self-Preferencing and Competitive Damages: A Focus on Exploitative Abuses*

**2022-02** Benjamin Montmartin & Marcos Herrera-Gomez
*Imitative Pricing: The Importance of Neighborhood Effects in Physicians' Consultation Prices*

**2022-03** Benjamin Montmartin
*Geography, Growth and Inequalities: Market Failures and Public Policy Implications*

**2022-04** Basheer Kalash
*Agglomeration and Technological Specialization*

**2022-05** Abir Khribich, Rami H. Kacem & Damien Bazin
*The Impact of Social Development on Renewable Energy Consumption in Tunisia: A Need for Sustainability and Equity of Capabilities*

**2022-06** Jeremy Srouji
*Reframing The US Dollar Debate: What Outlook for the US Dollar as World Money?*

**2022-07** Jean-Luc Gaffard
*Norme, fait, fluctuation*

**2022-08** Jean-Luc Gaffard
*L'inflation : phénomène durable ou transitoire ? Un aperçu historique pour comprendre le temps présent*

**2022-09** Augendra Bhukuth, Damien Bazin & Abir Khribich
*Socioemotional Wealth and Product Differentiation in the Informal Economy: A Simple Theroetical Model*

**2022-10** Damien Bazin & Thierry Pouch
*Du corporatisme au communisme : les sentiers sinueux du professeur Henri Denis. Retour sur un épisode académique français*

**2022-11** Augendra Bhukuth, Damien Bazin, Ani Wulandri & Valentina Teslenko
*Social Capital in Micro-family Enterprises: A Case Study in East Java, Indonesia*

**2022-12** Gérard Mondello
*Differentiated Beliefs in Accident Models under Risky Environment*

**2022-13** Jeremy Srouji & Dominique Torre
*The Global Pandemic, Laboratory of the Cashless Economy?*

**2022-14** Basheer Kalash, Sarah Guillou, Lionel Nesta & Michele Pezzoni
*Does Lab Funding Matter for the Technological Application of Scientific Research? An Empirical Analysis of French Labs*

**2022-15** Barbara Buljat
*Immersive Technologies Affecting Psychological Factors that Lead to Voluntary Pro-Environmental Behavior: A Transdisciplinary Survey*

**2022-16** Frédéric Marty
*Quelle articulation entre la législation européenne sur les marchés numériques (Digital Markets Act) et le droit de la concurrence ? Réflexions à partir de l'histoire des Sherman Act et FTC Act*

**2022-17** Andrea Guido, Alejandro Martinez-Marquina & Ryan Rholes
*Reference Dependence and the Role of Information Friction*

**2022-18** Giuseppe Attanasi, Michela Chessa, Sara Gil Gallen & Elena Manzoni
*Bargaining with Confirmed Proposals: An Experimental Analysis of Tacit Collusion in Cournot and Bertrand Duopolies*

**2022-19** Cyrielle Gaglio, Erika Kraemer-Mbula & Edward Lorenz
*Digitalization, Innovation and Productivity in South African Micro and Small Enterprises*

**2022-20** Jean-Luc Gaffard
*Repenser l'économie du travail*

**2022-21** Gérard Mondello
*Information Source's Reliability*

**2022-22** Jean-Sylvestre Bergé
*Towards a New "Antecedent Legal Method"*

**2022-23** Frédéric Marty
*Artificial Intelligence: Opportunities and Managerial Challenges*

**2022-24** Mattia Guerini, Lionel Nesta, Xavier Ragot & Stefano Schiavo
*The Zombification of the Economy? Assessing the Effectiveness of French Government Support during COVID-19 Lockdown*

**2022-25** Muriel Dal Pont Legrand, Martina Cioni, Eugenio Petrovich & Alberto Baccini
*Is There Cross-fertilization in Macroeconomics? A Quantitative Exploration of the Interactions between DSGE and Macro Agent-Based Models*