The Standard Narrative on History of Macroeconomics: Central Banks and DSGE Models

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Abstract

How do macroeconomists write the history of their own discipline? This article provides a careful reconstruction of the history of macroeconomics told by the practitioners working today in the dynamic stochastic general equilibrium (DSGE) approach.

Such a tale is a "standard narrative": a widespread and "standardizing" view of macroeconomics as a field evolving toward "scientific progress". The standard narrative explains scientific progress as resulting from two factors: "consensus" about theory and "technical change" in econometric tools and computational power. This interpretation is a distinctive feature of central banks' technical reports about their DSGE models.

Furthermore, such a view on "consensus" and "technical change" is a significantly different view with respect to similar tales told by macroeconomists in the past—which rather emphasized the role of "scientific revolutions" and struggles among competing "schools of thought". Thus, this difference raises some new questions for historians of macroeconomics.

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Introduction

How do macroeconomists providing expertise in policy-making write the history of their own modelling practices? This article answers the question by focusing on technical reports about dynamic stochastic general equilibrium (DSGE) models in use at central banks and other policy-making institutions.

My analysis results in a reconstruction of the history of macroeconometric modelling told by the practitioners working today in the field. First, I illustrate that such a tale is a *standard narrative*. The word "standard" has a threefold meaning: (1) a widespread narrative, peculiar to the DSGE community of modellers and encompassing different sorts of contributions (articles, textbooks, technical reports); (2) an interpretation of the history of macroeconomics relying on a traditional view of the history of science about "scientific progress"; (3) a tool for the standardization of the field, legitimizing the current DSGE models. Section 1 of this article analyzes this threefold character of the standard narrative.

The standard narrative claims that the evolution of macroeconometric modelling has to be understood as "scientific progress" (a "steady accumulation of knowledge"; Blanchard, 2000, 1375). Therefore, DSGE models are the most recent step of a 60-years evolution: as such, they embody a "greater amount of knowledge" than past models. My second purpose is to illustrate that the standard narrative explains scientific progress in a specific and distinctive way, referring to two driving forces. On the one hand, the "consensus" among macroeconomists (a common ground of questions and methods) brought "theoretical progress" (an improvement of the conceptual toolbox or "theory" for macroeconomic modelling). On the other hand, scientific progress has been driven by improvements in "technologies", i.e. new mathematics, statistics, econometrics and computers. This "technical change" enhanced the consistency between models and "facts"—"better techniques" improved the ability of models to replicate and to forecast aggregate data. Technical change is depicted as exogenous to macroeconomics: macroeconomists simply "import" in their models new techniques which were previously elaborated elsewhere (by mathematicians, statisticians, econometricians, computer scientists). Sections 2 and 3 describe this twofold character of scientific progress in the standard narrative.

Historians of macroeconomics are use to mention (and criticize) the history told by macroeconomists, also referring to it as a "standard narrative" (see for instance Duarte, 2012 or Hartley, 2014). However, most of these mentions and critiques target a very different story about "scientific progress": a story which narrates the fierce *struggle* among "schools of thought" and the advent of "*scientific revolutions*" (and "counter-revolutions"). This story, that one could label "the revolution view", is told by an older generation of macroeconomists. Since Lawrence Klein (1947)'s idea of *The Keynesian Revolution*, macroeconomists liked indeed to refer to "revo-

lutions": think, as few examples, to the "monetarist counter-revolution" (Johnson, 1971), to the "rational expectations revolution" (Begg, 1982; Miller, 1994) also labeled the "new classical (counter-)revolution" (Blinder, 1986). The revolution view is today widespread in macroeconomics textbooks (see for instance Dornbusch et al., 2007, 574). Similarly, the story about "competing schools" fighting each other has also been widely popularized by macroeconomists. One of the most famous and substantial development of this idea is Edmund Phelps (1990)'s *Seven Schools of Macroeconomic Thought*.[1] Since the publishing of *An Introduction to Competing Schools of Thought* (Snowdon et al., 994f), Brian Snowdon and Howard Vane also follow the revolution view (Snowdon and Vane, 2005; Snowdon, 2007). As for revolutions, many textbooks refer to competing schools of thought—see for instance Heijdra and van der Ploeg (2002, Introduction) and Chugh (2015, Chapter II). My contribution, relying on the contemporary DSGE literature and especially on less conventional materials (technical reports from central banks), draws attention to the fact that the revolution view seems to be challenged by another, more recent view based on the idea of consensus and technical change. Besides, this new view grant a substantial role to "techniques"—while the revolution view focuses mostly on the history of "ideas", i.e. the history of theories.

In a nutshell, this article provides a new and more systematic account of the way macroeconomists working today in the field see the history of their own practices. The final purpose of my analysis of this standard narrative is to bring to the fore some questions for further historical research. Indeed, there are several shortcomings in the standard narrative—namely inaccurate, incoherent or unconvincing accounts of events and ideas. Though a comprehensive criticism of all of them is far beyond the scope of this contribution, I discuss in the concluding remarks how the analysis of the standard narrative would contribute to further research in the history of macroeconomics.

[1] Though not using the terminology of "schools", another similar argument has been made by Robert Hall (1976), with the distinction between "salt-water" and "fresh-water" (or "clear-water") macroeconomics. This is another *topos* in textbooks (see for instance Burda and Wyplosz, 2013, 16).

1 The threefold character of the standard narrative

1.1 The standard narrative as a widespread narrative

DSGE models are today a compelling framework for macroeconomic research addressing business cycles and monetary policy.[2] Few years after the publishing of the seminal contributions by Smets and Wouters (2003), Woodford (2003) and Christiano et al. (2005), DSGE models have become hegemonic in the field.[3] As argued for instance by Varadarajan Chari (from the Minneapolis Fed and the University of Minnesota), there is now "no other game in town":

> [...] any interesting model must be a dynamic stochastic general equilibrium model. From this perspective, there is no other game in town. [...] A useful aphorism in macroeconomics is: "If you have an interesting and coherent story to tell, you can tell it in a DSGE model".[4]
>
> Chari (2010, 2)

DSGE models spread out across academia—research in universities and other institutions, teaching, publishing of articles and books. Moreover, they proliferate in "policy-making institutions"—namely, national and international organizations engaged in providing expertise and advice on economic policies. In the last decade, the outgrowth of DSGE modelling was particularly impressive within central banks and international institutions such as the International Monetary Fund (IMF). As emphasized by Olivier Blanchard (the former IMF chief economist), DSGE models have become "ubiquitous" for conducting policy analysis:

[2] This is not the case in other sub-fields that address different aggregate phenomena (such as growth, development or financial markets). See for instance, for macroeconomics of growth, Aghion and Howitt (2009).

[3] Early developments of DSGE models include Cooley (1995); Henin (1995); Goodfriend and King (1997). The label "DSGE" has been introduced by Rankin (1998).

[4] Even if "there is no other game in town" is a strong claim, there is indeed a gigantic amount of research on DSGE models. Let consider, for instance, the number of working papers about DSGE models inventoried by the RePEC New Economics Papers (NEP) database (`https://ideas.repec.org/n/`). There are 13136 entries (from 22/06/1998 until 01/08/2017) for the class "D[S]GE"—which represents in average a dozen of working papers per week during ten years, involving about 6000 authors. Let compare this figure with those concerning "Macroeconomics" as a whole (including all approaches and sub-fields) and to other classes of recently expanding fields: "Macroeconomics" includes 40036 entries, "Experimental economics" 10028 entries and "Cognitive and behavioural economics" 7105 entries. Note that these illustrative figures are not a substitute to further bibliometric analysis.

> DSGE models have become ubiquitous. Dozens of teams of researchers are involved in their construction. Nearly every central bank has one, or wants to have one. They are used to evaluate policy rules, to do conditional forecasting, or even sometimes to do actual forecasting.[5]
>
> (Blanchard, 2008, 24)

Table 1 (see Appendix) provides a first overview (non exhaustive) of the spread of DSGE models in policy-making institutions during the early 2000s. The European Central Bank (ECB) and the IMF played a pioneering role in developing DSGE models for expertise. Rapidly, the Federal Reserve Board and other Western central banks adopted them; then, DSGE models also take roots in central banks in Latin America (e.g. Chile) and Asia (e.g. Thailand). Moreover, policy-making institutions other than central banks adopted DSGE models (e.g. the European Commission, the French Ministry for the economy and finance). Though it is beyond the scope of this paper to discuss this matter, it seems interesting to note that the outgrowth of DSGE models in policy-making institutions closely followed the changes in monetary policies during the "Great Moderation" period. Central banks listed below share indeed all the same monetary policy objective, namely price stability. Most of them switched to inflation targeting between the end of the 1990s and the beginning of the 2000s (New Zealand being the first to adopt inflation targeting in 1990; see Hammond, 2015 and Jahan, 2012).

Furthermore, the spread of DSGE models was not significantly interrupted by the 2008 crisis, as shown by Table 2 (see Appendix). New policy-making institutions adopted DSGE models, both in developed countries (Luxembourg, Portugal, Iceland, Japan, Australia, ...) and in developing countries (especially in Latin America and Asia). Moreover, policy-making institutions that were already using DSGE models developed new versions of them: a "second generation" of DSGE models arise in policy-making institutions such as ECB, Reserve Bank of New Zealand, Banco de Espãna, ... These recent DSGE models were developed in the wake of 2008 financial crisis and they consequently integrated a more careful description of financial sector and banking mechanisms.

In the meanwhile of this impressively rapid expansion of the DSGE approach, DSGE modellers had formulated their own narrative about the rise of their own modelling practices. My first claim is that this narrative is a "standard" one—a norm, a benchmark, a *topos* of the DSGE literature. This widespread tale encompasses different sorts of contributions: articles in peer-review journals, books, working papers, technical reports, textbooks. The standard narrative is also a common ground for authors holding different positions in the field: officers in

[5] For a more comprehensive overview of the different uses of DSGE models in central banks, see for instance Hammond (2015).

policy-making institutions, young as well as seniors academics, Bank of Sweden Prize laureates, ...[6] Besides, the standard narrative is a worldwide argument, encompassing different national contexts. Thus, the standard narrative cannot be precisely related to one leading figure, or to one leading contribution—there are here no "great authors" and no "masterpieces" to look at: it is the result of a *collective* story-telling.[7] History seems to be a concern and an argument developed by the DSGE modellers community as a whole.

Table 3 (see Appendix) illustrates my point. This table summarizes the role of historical considerations in different sorts of recent contributions to macroeconomics. Note that only a small group of articles in peer-review journals addresses history as their main topic. Conversely, textbooks grant to history a substantial place (chapter, section). Moreover, and this is the most surprising finding, technical reports from policy-making institutions devote as well a place to historical considerations. Despite being conceived as technical pieces—they are just supposed to present equations and estimation methods for a given DSGE model—these contributions address historical aspects (though to different extents).

Moreover, I would say that such a substantial concern about history is a specific characteristic of macroeconomics, and that it has an unusual magnitude with respect to other sub-fields of economics. This is much evident if we compare, for instance, macroeconomics and microeconomics most common textbooks: to my best knowledge, there are no microeconomics textbooks addressing the history of microeconomics (neither of general equilibrium, of game theory, nor of industrial organization); conversely, as shown in Table 3, all most common macroeconomics textbooks address the history of macroeconomics. Hence, I would say that the standard narrative plays, in macroeconomics and especially within the DSGE approach, a distinctive role in building a scientific community (as suggested, within a different context, by Beller, 2001).

1.2 The standard narrative as a tale of scientific progress

The standard narrative characterizes the current state of knowledge in macroeconomics as "better" or "greater" than the past state of knowledge: this is the basic definition of "scientific progress". It could be found for instance in Blanchard's article "What Do We Know that about Macroeconomics that Fisher and Wicksell

[6] Note that the boundaries between academia and policy-making institutions moved significantly during the last decade. Central banks became a workhouse for academic research, by increasing publications in academic journals and by a closer connection with universities (PhD funding and supervision, invited scholars, ...).

[7] Conversely, in the revolution view of the history of macroeconomics, we can easily identify some seminal contributions, made by preeminent figures in the field, such as Klein, Phelps or Hall (*cf.* Introduction).

Did Not?":

> the answer [to the question in the title] is very clear: we have learned a lot. Indeed, progress in macroeconomics may well be the success story of twentieth century economics: [...] a surprisingly steady accumulation of knowledge.
>
> (Blanchard, 2000, 1375)[8]

This accumulation is not only "steady", but also astonishingly rapid, as emphasized for instance by Jesús Fernández-Villaverde (University of Pennsylvania):

> In the comparatively brief space of 30 years, macroeconomists went from writing prototype models of rational expectations (think of Lucas, 1972 to handling complex constructions like the economy in Christiano et al., 2005). It was similar to jumping from the Wright brothers to an Airbus 380 in one generation.
>
> (Fernández-Villaverde, 2010, 63)

Thanks to scientific progress, macroeconomics has evolved from an early stage of knowledge ("prototypes") to an advanced stage ("complex constructions")—or, if compared to progress in aeronautical engineering, "from the Wright brothers plane to an Airbus 380". This remark shows a positivist enthusiasm about the improvements brought by scientific progress. As such, the standard narrative belong to a long-standing tradition in the history of natural sciences and in the history of economics. More specifically, the standard narrative seems an illustration of the "whig history" advocated by Paul Samuelson (1987).[9]

Moreover, the standard narrative is about looking at the past with a *retrospective* and a *teleological* standpoint. On the one hand, past macroeconomic models are presented and assessed using the standards of current DSGE models—hence, past models are described as "primitive" with respect to "modern" models. This is for instance the role granted to history by Charles Jones (Stanford University) in his textbook:

> We'll begin by tracing the historical development of [DSGE] models. It's a great way to understand some of the limitations of the early models and how they have evolved—and continue to evolve—to overcome these limitations.

[8] Also note the overabundant use by Blanchard of the word "progress" in his two (co-written) textbooks (Blanchard et al., 2013; Blanchard and Johnson, 2013, resp. chapter 24 and chapter 25). The idea of "progress" is mentioned and discussed eight times in four pages—including an emphatic paragraph headline "Progress in all fronts".

[9] Thus the standard narrative should be seen rather as a firmly motivated standpoint than as a "naïve" view (made-up unmindfully by amateurish historians).

(Jones, 2014, 407)

On the other hand, the standard narrative aims at rationalizing the origins of the DSGE models (providing a "rational reconstruction")—hence, DSGE models should be seen as the "natural" or "logical" outcome of the evolution of macroeconomic modelling.

Though the standard narrative describes scientific progress as a "steady accumulation of knowledge", it does not dismiss entirely the revolution view. Conversely, debates and controversies among schools of thought are seen as a factor for scientific progress. However, the standard narrative rejects the idea of scientific revolutions. Progress is "steady", which means linear and continuous. According to Blanchard, revolutions and schools of thought are indeed only a superficial appearance of history: "On the surface, the history of macroeconomics in the twentieth century appears as a series of battles, revolutions, and counterrevolutions" (Blanchard, 2000, 1375). Hence, if "battles" do eventually occur, they should be interpreted as the "constructive" steps for "improving" the state of knowledge, as emphasized for instance by Giorgio Rodano (Università La Sapienza) in a book chapter devoted to "Contemporary Controversies in Macroeconomics":

> the disputes, debates, skirmishes and head-on battles between scholars played *a constructive role in the progress of the discipline*. [...] discussion in macroeconomics, far from being sterile, has actually favoured a *real improvement of the discipline*
>
> (Rodano, 2002, 307, my emphases)

In "The Current State of Macro", Blanchard explains *how* controversies among rival approaches had contributed to scientific progress. In short, disagreements are efficiently settled by confronting knowledge with "facts":

> Researchers split in different directions [...] engaging in bitter fights and controversies. Over time however, *largely because facts have a way of not going away*, a largely shared vision both of fluctuations and of methodology has emerged.
>
> (Blanchard, 2008, 2, my emphasis)

Blanchard's account of how controversies among schools are settled by "facts" can be seen as broadly inspired by Karl Popper (1934, 1963)'s account of scientific progress: accumulation of knowledge is possible thanks to falsifiability, and systematic confrontation of knowledge with "facts". Note that neither Blanchard nor any other author in the standard narrative discusses the evolution of macroeconomics in Popperian terms; however, I think that this is the implicit view underlying the standard narrative.

Another illustration of the standard narrative view on scientific progress can be found in Costas Azariadis (Washington University in St. Louis) and Leo Kaas (University of Konstanz)'s article "Is dynamic general equilibrium a theory of everything?" (Azariadis and Kaas, 2007). The article is built on the analogy between physics (the "theory of everything", an hypothetical theoretical framework encompassing different theories in physics) and the evolution of macroeconomics. Similarly to the string theory in physics, the DSGE approach could be seen as such an unifying framework for macroeconomics:

> As a matter of scientific principle, a "correctly" specified DGE [dynamic general equilibrium] model amounts to a theory of everything that seeks to achieve for modern macroeconomics goals similar to those string theory has set for modern physics. Pushing the analogy with string theory a bit further, one may interpret DGE as an attempt to devise a unified theoretical platform meant to explain a list of key empirical regularities or "big facts" in economic growth, asset returns, and business cycles.
>
> (Azariadis and Kaas, 2007, 14)

Azariadis and Kaas's quote above is a condensed illustration of the arguments already found in Blanchard. First, the authors adopted a teleological perspective ("DSGE models seek to achieve goals"); second, they depicted DSGE approach as an achievement of a cumulative process, integrating theoretical insights that shared a methodological common ground ("a unified theoretical platform") and a common set of objects ("meant to explain big facts"). A similar argument about the DSGE models as a "theory of everything" could be found in the macroeconomics textbook by Michael Wickens (University of York):

> The virtue of DSGE macroeconomics is brought out by the following encounter with a frustrated student. He protested that he knew there were many theories of macroeconomics, so why was I teaching him only one? My reply was that this was because only one theory was required to analyse the economy, and it seemed easier to remember one all-embracing theory than a large number of different theories.
>
> (Wickens, 2012, xv)[10]

Narayana Kocherlakota (former President of the Federal Reserve Bank of Minneapolis) takes a further step in putting aside controversies and revolutions from the history of macroeconomics. In his 2009 "Annual report essay" as President of the Fed of Minneapolis, he claims:

[10] Indeed, Wickens's textbook is one of the few macroeconomics textbooks exclusively centered around DSGE models.

> According to the media, the defining struggle of macroeconomics is between people: those who like government and those who don't. In my essay, the defining struggle in macroeconomics is between people and technology. [...] At any given point in time, there are significant conceptual and computational limitations that restrict what macroeconomists can do. The evolution of the field is about the eroding of these barriers.
>
> (Kocherlakota, 2009, 6)

This quote introduces what I think is the most distinctive characteristic of the view of progress in the standard narrative: the role of "technical change". According to Kocherlakota, the "evolution of the field" is indeed driven not by "struggles" among schools of thought[11], but by innovations that overcome the "conceptual and computational limitations". Note that, in this "struggle against technology", macroeconomists ("people") are all on the same side.

1.3 The standard narrative as a tool for standardization

What is the purpose, the function of this narrative? Why do macroeconomists bother with history? Because the standard narrative legitimizes DSGE models as the standard or "mainstream" approach for macroeconomic analysis, as well in academia as in policy-making institutions. The standard narrative provides a rational argument for excluding competing practices: it is a tool for the standardization of the field. To say it otherwise, the standard narrative plays a crucial role in the "rhetoric" of macroeconomics: it is a tool for persuasion, hence widely used in the "scientific conversation" among macroeconomists (McCloskey, 1985).

The *Bulletin de la Banque de France* provides a telling illustration of this role of the standard narrative:

> DSGE models of the last generation, which integrated the most recent theoretical and econometric developments, are today *most advanced tools for macroeconomic analysis.*
>
> (Avouyi-Dovi et al., 2007, 50, my emphasis, my translation)

Like Avouyi-Dovi et al. (2007), many other DSGE modellers working in policy-making institutions follow the same line of argument in their technical reports. They claim indeed that their DSGE models are a natural choice for policy analysis *because* they incorporate theoretical and technical changes of the last decades. Douglas Laxton (IMF) claims for instance that

[11] In the quote, controversies among political agendas: but, in the revolution view, political disagreements among schools of thought are frequently assimilated with their theoretical and methodological disagreements—as it is for instance explicit in Hall (1976)'s distinction between salt and fresh water macroeconomics.

> Much of the success of GEM [Global Economy Model, Bayoumi (2004)] and the other DSGE models has been a result of their strong links to the academic literature.
>
> (Laxton, 2008, 214)

Kirdan Lees (Reserve Bank of New Zealand, RBNZ) follows Laxton's claim in his presentation of the RBNZ DSGE model (Kiwi Inflation-Target Technology, KITT):

> KITT, the new [RBNZ] model, *advances our modelling towards the frontier in terms of both theory and empirics*. KITT reconfirms the Reserve Bank's commitment to having *a theoretically well-founded model* at the heart of the monetary policy process.
>
> (Lees, 2009, 5, my emphases)

As DSGE models are the achievement of the scientific progress ("most recent theoretical and econometric developments"), hence they should be considered as the best, most valuable approach to macroeconomics and to policy-making. Adopting DSGE models is about "being modern", as suggested by the macroeconomists from the Indian National Council of Applied Economic Research (NCAER):

> India has set out to modernise its macroeconomic policy apparatus, particularly in the area of monetary policy [...]. Recognising the growing need for modern policy analysis tools, National Council of Applied Economic Research (NCAER) undertakes a research initiative to develop a DSGE model for India on an accelerated basis.
>
> (Banerjee et al., 2015, 2)

Faith in scientific progress, as formulated for instance by Fernandez-Villaverde (*cf. supra*) is essential to this idea that DSGE models are the *most* pertinent instrument for providing expertise. Therefore, putting into question the role of DSGE models sounds as non-sense: Would you imagine, today, someone who is likely to prefer flying with the Wright brothers plane rather than with an Airbus 380?

A similar rhetorical question is raised by Chari during his testimony before the U.S. Senate (Committee on Science and Technology). U.S. representatives organized this hearing to investigate "the appropriate roles and limitations of models such as DSGE models" (Broun, 2010, 1).[12] While taking into consideration the criticisms raised by the recent financial and economic crisis, Chari argues that putting into question DSGE models results in a foolish rejection of scientific progress:

[12] Besides Chari, also Robert Solow, David Colander, Roger Farmer, Scott Page and Sidney Winter testified before the Committee. For a comprehensive comment on these hearings see for instance De Vroey (2015, chap. 20).

> The recent crisis has raised, correctly, the question of how best to improve modern macroeconomic theory. I have argued we need more of it. After all, when the AIDS crisis hit, we did not turn over medical research to acupuncturists. In the wake of the oil spill in the Gulf of Mexico, should we stop using mathematical models of oil pressure?
>
> (Chari, 2010, 9-10)

Chari's metaphors refer to the positivist rhetoric in engineering and medicine. The current state of knowledge (medical research, modern engineering, DSGE models) is seen as evidently "greater" and obviously "better" than the past state of knowledge. Hence, there is no reason for looking back at obsolete and disqualified notions—which, in addition, are considered as pre-scientific or unscientific approaches (acupuncturists or oil-drilling without engineering support). These metaphors provide a strong rationale in favor of the use of DSGE models, as well as an argument against the criticisms addressed to DSGE models after the 2008 crisis.

Moreover, the standard narrative plays also an important role in justifying the future developments of the field. According to linear character of the scientific progress, macroeconomics will keep evolving by perpetuating its current modelling practices:

> Rather than pursuing elusive chimera dreamt up in remote corners of the profession, the best way of using the power in the modelling style of modern macroeconomics is to devote more resources to it.
>
> (*ibid.*)

According to Chari, to pursue scientific progress implies to maintain DSGE models as the mainstream, standard approach for macroeconomics (in the quote above, "modern macroeconomics" stands actually for "DSGE models").[13] Hence, we need to "devote more resources to it", instead of "dreaming up" about fallacious alternatives ("acupuncturists", in the previous metaphor). This conclusion would not be motivated by Chari's personal interest (his participation to the DSGE approach) but by his concern in the future of science and society ("to prevent the new big crisis"):

> Even if it does seem like special interest pleading, I would argue that if we want to prevent the next big crisis, the only way to do so is to devote substantially more resources to modern macroeconomics so that we can attract the best minds across the world to the study and development of mainstream macroeconomics.

[13] A similar use of the adjective "modern" (as opposed to "traditional") could also be found in central bank reports (*cf. supra*) or in textbooks (Chugh, 2015, 170).

(*ibid.*)[14]

Furthermore, the financial and economic crisis in 2008 had strengthened this function of the standard narrative. To illustrate this point, my article relies mostly on materials published after or during the crisis (though they do not directly refers to it, as Chari did in his testimony).[15]

And yet, is the standard narrative an *effective* argument? Does the DSGE approach really succeeded in marginalizing and excluding the competing practices? The spread of DSGE over academia and policy-making institutions, as reported in Table 1 and 2, is indeed an impressive phenomenon. However, this does not always imply that DSGE models became "the only game in town". Actually, many policy-making institutions, while introducing DSGE models, still kept using also other models, pertaining to other approaches—like old-fashion models *à la* Klein and Goldberger (1955) and statistical-oriented models inspired from Sims (1980).[16] This "pluralism" in modelling practices within policy-making institutions could be explained by different factors, depending on the various contexts specific to a given institution (the pre-existing modelling traditions, the relation with other institutions within the country and abroad, the education of modellers, generational issues, ...). Of course, explaining this pluralism is far beyond the scope of this article.

2 Consensus, theoretical progress and microfoundations

The previous sections illustrated how macroeconomists working today in the field hold a common narrative about the history of macroeconomics, how it is used in their rhetoric, and how this narrative is built on the idea of a scientific progress driven by "consensus" and technology. This section address the idea of consensus.

[14] Similar conclusive remarks can be found at the end of historical chapters in two textbooks, Blanchard and Johnson (2013, 570) and Jones (2014, 429).

[15] Of course, the crisis had an ambivalent effect. On the one hand, it did not interrupt the diffusion of DSGE models (see Table 2) and the standard narrative persisted and even became more virulent and explicit (as illustrated by Chari's statement). On the other hand, the crisis encouraged a shift in the position of some contributors to the standard narrative—in addition, of course, to the criticisms coming from outside the DSGE approach. A typical illustration of the change within the DSGE approach is Blanchard (2016). For a complete comment on the evolution of Blanchard's thought, see Brancaccio and Saraceno (2017). In spite of this ambivalence, I think that the first effect (the persistence of the standard narrative) has been (for now) more important than the other (the abandon of the standard narrative).

[16] For a more comprehensive use of the different models in use in central banks, see for instance Hammond (2015).

First, it must be noted that the word "consensus" has a specific scope in the standard narrative, namely consensus *about theory*. I suggest to understand the word "theory" as the relevant *toolbox* for building different models. Hence, a model is a close mathematical system, characterized by some precise formalisms and concepts, while a theory encompasses different models. For instance, the real business cycle (RBC) theory encompasses Kydland and Prescott (1982)'s model, Long and Plosser (1983)'s model, Hansen (1985)'s model, etc. In short, a theory provides a wide set of concepts and formalisms, as well as a general methodology for combining them and building a syntax and a semantic for *a class of models*.[17] In a nutshell, the point of the standard narrative is the following: consensus is an agreement among macroeconomists about the relevant toolbox for model building. Moreover, consensus is also *dynamic*: it is an agreement about *which new features should be added* to the toolbox. Adding new features (new concepts, new formalisms) results in a "theoretical progress"—an improvement of the toolbox at modellers' disposal.

Today's DSGE models are the achievement of the dynamic driven by consensus, as claimed for instance by the modellers of ToTEM (Terms Of Trade Economic Model, the DSGE model of the Bank of Canada):

> [Our] staff relies most heavily on one main model for constructing macroeconomic projections and conducting policy analysis for Canada. *This work-horse model reflects the consensus view* of the key macroeconomic linkages in the economy.
>
> (Murchison and Rennison, 2006, 3, my emphasis)

Furthermore, consensus means that the toolbox for building a DSGE models has came to include concepts and formalisms issued from different theoretical insights—different toolboxes, used in different, past models. DSGE models are indeed frequently presented as a "synthesis" of previous models—the "new neoclassical synthesis", an expression introduced by Goodfriend and King (1997).

An underlying condition for a consensus to exist, is that different theoretical insights are compatible (commensurable) in terms of object, conceptual framework and methodology: hence, they can be combined ("synthesized") in one single toolbox for building one single class of models. This vision is, again, deeply rooted in a positivist vision of the history of sciences; moreover, it should be seen as an(other) implicit rejection of Thomas Kuhn (1962)'s vision of scientific revolutions—where accumulation is not possible but within a same paradigm.Moreover, the consensus arise from a "constructive" perspective—everyone works toward a common purpose, within a common ground of objects, concepts and methods.

[17] This definition has neither the ambition to be universal, nor the pretension to be an original contribution to the philosophy of models. It is a simple definition which is congruent with the distinction between "model" and "theory" that seems current in the DSGE literature.

2.1 DSGE models as a synthesis

A DSGE model can be easily described as a combination of different theoretical insights. In a non-technical way, one could resume a DSGE model to a list of five "ingredients" (following Boumans, 1999's metaphor):[18]

1. The purpose of the model is to analyze macroeconomics fluctuations ("the business cycle"), i.e. co-movements in aggregate time series around a stochastic trend (Lucas, 1977; Nelson and Plosser, 1982). The pertinent theoretical toolbox is neo-Walrasian general equilibrium and, more specifically, optimal growth models (Kydland and Prescott, 1982).

2. The model economy is populated by representative (or homogeneous) agents (households, firms). Individuals behave "rationally", which means that: (i) each agent solves an optimization problem under constraint (utility/profit maximization, cost minimization), for an infinite number of periods; (ii) each agent forms rational expectations on the future state of his environment (Muth, 1961); (iii) individual optimal plans are mutually interdependent and compatible. Consequently, all markets clear (simultaneously and interdependently); equilibrium is unique, stable and intertemporal. Finally, the aggregate characteristics of the economy results from the sum of individual behaviors of agents, consistently with the idea of "microfoundation" of macroeconomics, as it was formulated by Lucas.[19]

3. Model's dynamic results from stochastic disturbances (shocks). Disturbances are "impulse" to the fluctuations, while shifts in optimal behavior of individual agents are "responses" or "propagation mechanisms" of the fluctuation (following the "rocking chair" model inspired by Frisch, 1933). Shocks can be real (affecting technologies, preferences, mark-ups) or nominal (interest rates, prices).

[18] Note that DSGE models are a moving target. The ingredients presented here refer to the benchmark version of the model, such as presented by Smets and Wouters (2003); Woodford (2003); Christiano et al. (2005). Recent developments include additional features such as heterogeneous agents, banking sector and financial markets, non-rational expectations. See for instance Branch and McGough (2009); Castelnuovo and Nistico (2010); De Graeve et al. (2010); Boissay et al. (2013).

[19] There are actually many microfoundational programs in macroeconomics which investigated the relationship between individual behavior and aggregate phenomena (Hoover, 2012). Lucas's program is one particular example, characterized by the representative agent hypothesis. As this program had became hegemonic and as I will not address here alternative programs, I will simply use the word "microfoundations" instead of "lucasian microfoundations" or "representative agent microfoundations".

4. At the individual level, price and wage changes are not immediate, which implies a price/wage rigidity (or "stickiness") on the aggregate level. The nominal rigidity at the microeconomic level relies on an imperfect competition framework (monopolistic competition *à la* Dixit and Stiglitz, 1977); price/wage adjustments follow Calvo, 1983).

5. Monetary policy plays an active role in determining the aggregate equilibrium, through the nominal interest rate (Woodford, 2003). Central bank's behaviour follows a monetary rule (inspired by Taylor, 1993).

Formally, a DSGE model consists in a three-equation system:[20]

$$x_t = \mathbb{E}_t(x_{t+1}) - \frac{1}{\sigma^c}\left[R_t - \mathbb{E}_t(\pi_{t+1})\right] + \epsilon_t^c \quad (1)$$

$$\pi_t = \rho^{\pi}\mathbb{E}_t(\pi_{t+1}) + \psi x_t) + \epsilon_t^a \quad (2)$$

$$R_t = \rho_1^R R_{t-1} + \rho_2^R \pi_t + \rho_3^R x_t + \epsilon_t^R \quad (3)$$

Equation (1) describes the goods market equilibrium, as a function of the expected output gap x_t, the elasticity of consumption σ^c and the expected real interest rate. Equation (2) sets the evolution of aggregate prices, as a function of expected inflation $\mathbb{E}_t(\pi_{t+1})$ and the degree of price rigidity ψ. Equation (3) accounts for central bank's behaviour in setting nominal interest rate R_t ($\rho_{1,2,3}^R$ being sensitivity parameters). The dynamic of the model economy around its steady state results from stochastic i.i.d disturbances on preferences, technologies and monetary policy (ϵ_{c_t,a_t,R_t}) .

Relying on this presentation, we can better understand Goodfriend and King (1997)'s claim that DSGE models are a "new neoclassical synthesis":

> Methodologically, the new synthesis involves the systematic application of intertemporal optimization and rational expectations as stressed by Robert Lucas. In the synthesis, these ideas are applied to the pricing and output decisions at the heart of Keynesian models, new and old, as well as to the consumption, investment, and factor supply decisions that are at the heart of classical and RBC models.
>
> (Goodfriend and King, 1997, 232).

[20] As traditionally suggested by Clarida et al. (1999); for a formal derivation of these equations from the individual maximization problems, see Woodford (1998) or, for a simplified version, Walsh (2003, chap. 5).

A DSGE models looks indeed like an "old" Keynesian model:[21] a system of three equations, including a demand equation, a supply equation and a policy rule. Among the five ingredients, ingredients 1-3 are an inheritance of new classical and RBC theoretical framework; ingredients 4-5 have been developed by the new Keynesian approach in the 1980s (Mankiw and Romer, 1991).[22] Hence, a DSGE model could be understood as the structured combination of these different theoretical insights.

According to the standard narrative, such a synthesis historically results from a linear sequence of models (an accumulation of knowledge). Macroeconometricians of the Bank of England, in their introduction to the technical report about the Bank of England Quarterly Model (BEQM), emphasize this idea of a "suite of models":

> The [BEQM] is *a valuable addition to the Bank's "suite of models". It does not represent a significant shift* in the Committee's view [...] its value lies in the fact that its more consistent and clearly articulated economic structure better captures the MPC's [Monetary Policy Committee] vision of how the economy functions and so provides the Committee with a more useful and flexible tool to aid its deliberations.
>
> (Harrison et al., 2005, 1, my emphasis)

Consequently, DSGE models such as BEQM should be seen as the final outcome of this progressive evolution.

2.2 The five steps of theoretical progress

The standard narrative provides a detailed account of the progressive evolution toward the synthesis. Following a teleological perspective, each step of this evolution is an incremental, linear improvement of the theoretical toolbox for model building. The standard narrative identifies five steps (Epaulard et al., 2008). Each step corresponds to the emergence of a "school of thought". Therefore, in the standard narrative, there are not such things as competing schools of thought and "revolutions". Firstly, because schools of thought are represented as a sequence; one school (one step) is always leading to another school (the following step), hence different schools are not coexisting for a long period of time. Secondly, there are no revolutions because, while emerging, new schools of thought does not overthrow

[21] I will use the term "Keynesian" referring to models *à la* Klein and Goldberger, 1955, despite the fact that this definition is arguable (for an early criticism, see for instance Leijonhufvud, 1972). Indeed, this distinction it is not pertinent here.

[22] The delimitation and characterization of the new Keynesian economics is a controversial topic in itself (see for instance Sergi, 2016). Again, this is beyond the scope of this article.

the previous ones; instead, they suggest improvements and amendments, that are accepted as an improvement by pre-existing schools—therefore, "accumulation of knowledge" takes place thanks to consensus.

According to the standard narrative, the first step corresponds to the rise of Keynesian macroeconometric models. For Michael Woodford (a key figure of the new neoclassical synthesis), these Keynesian models are the direct ancestor of DSGE models.[23]

> In important respects, [DSGE models] remain direct descendants of the Keynesian macroeconometric models of the early postwar period
>
> (Woodford, 2009, 269).

Like Woodford, macroeconomists in central banks present their DSGE models as the direct descendants of the Keynesian macroeconometric, that where dominant in policy-making institutions since the 1950s. For Lees (RBNZ), the DSGE model KITT is the subsequent development of a "modeling tradition" going back to this period:

> Central banks around the world are both customers and developers of medium to large scale macroeconomic models and have been for some time. In the RBNZ's case we have been building and using these models since 1971 [...] The development of the KITT model carries on this modeling tradition.
>
> (Lees, 2009, 5)[24]

The emergence of new classical macroeconomics in the 1970s (Lucas, 1972, 1976, 1975; Sargent, 1976; Lucas and Prescott, 1971) is the second step of theoretical progress. Despite this approach brought radical different insights with respect to the Keynesian approach (such as rational expectations, dynamic equilibrium, representative agents, ...), the standard narrative does not consider it as a breakthrough. Indeed, new classical models are regarded as constructive criticisms toward Keynesian models; furthermore, the former developed theoretical propositions to improve the latter, which were "theoretically inadequate" or "primitive". Technical report about RAMSES (the DSGE model of the Riksbank Aggregate Macromodel for Studies of the Economy of Sweden) illustrates this view:

[23] Taking into account the role of nominal interest rate in its own works and in the DSGE approach, Woodford also refers to the "Stockholm school", in particular to Knut Wicksell. For a discussion on this claim, see Boianovsky and Trautwein (2006).

[24] See also Wickens (2012, xiii), who goes even back to Keynes: "DSGE macroeconomics has emerged in recent years as the latest step in the development of macroeconomics from its origins in the work of Keynes in the 1930s."

> [Keynesian models] assume that players in the economy are governed by various rules of thumb. [...] One reason for choosing this way of describing the economy was *the lack of technical tools (theories and computers)*
>
> (Adolfson et al., 2007, 7, my emphasis).

Riksbank's modellers implicitly refers to the absence, in Keynesian models, of a theoretical description of the behavior of individuals in line with the general equilibrium framework—namely, the absence of individual optimizing behavior. As this shortcoming results from a "lack of technical tools", new classical models represent a theoretical progress (to the extent they developed such needed tools). The way of modelling expectations is more precise illustration of this argument. Rational expectations are a simple "upgrade" of the "primitive" way to model expectations in Keynesian models. According for instance to the Bank of Canada modellers: "Another important shortcoming of 1970s and 1980s macro models was the primitive way in which they accounted for agents' expectations." (Murchison and Rennison, 2006, 4) An even more explicit account of the constructive transition between Keynesian and new Classical models is given by Blanchard and David Johnson in their textbook:

> The intellectual atmosphere in macroeconomics was tense in the early 1970s. But within a few years, a process of integration (of ideas, not people, because tempers remained high) had begun, it was to dominate the 1970s and the 1980s. Fairly quickly, the idea that rational expectations was the right working assumption gained wide acceptance.
>
> (Blanchard and Johnson, 2013, 565)

The conceptual refinement of macroeconomic models has been extended by the RBC approach during the 1980s—the third step in the standard narrative chronological account of the theoretical progress. RBC models should hence be seen as the logical suite of Lucas (1972, 1976) work. Following for instance Avouyi-Dovi et al. (2007, 44), from Banque de France, "RBC models are the best illustration of [Lucas's] methodological recommendations". However, RBC models are also considered, in the standard narrative, as having many defaults, namely to ignore monetary phenomena and not tackling policy evaluation ("the pioneers of this new approach thrown the baby out with the bathwater"; Epaulard et al., 2008, 2).

A further step was needed: new Keynesian models in the 1980s and the early 1990s elaborated the needed microfoundational apparatus for addressing monetary phenomena. According to the standard history, new Keynesian models have been a constructive amendment for adding new dimensions to RBC models. They provided a constructive addition to the conceptual improvement of the field, and they worked in the same methodological and theoretical line as the RBC models and

the new classical economics. The continuity between RBC and new Keynesian models is emphasized, for instance, in this discussion of a DSGE model for the Indian economy:

> The use of DSGE models to analyze business cycles was championed by Kydland and Prescott (1982), who found that a real business cycle (RBC) model with exogenous technology shocks helps explaining a significant portion of the fluctuations in the US economy. Much of the research in this area has, since then, attempted to uncover and understand other potential sources of business cycle fluctuations.
>
> (Gabriel et al., 2010, 1)[25]

Finally, starting from the mid-1990s, this constructive cooperation between the two approaches has been achieved by the rise of DSGE models (Cooley, 1995; Henin, 1995; Goodfriend and King, 1997). Charles Plosser—president of the Fed of Philadelphia (2006-2015) and one of the pioneers of the RBC approach (Long and Plosser, 1983)—considers that DSGE models should be seen as the "latest update" of RBC models, with the useful addition of Keynesian features (Plosser, 2012, 2). A similar assessment could be found in Blanchard (2008) and, as emphasized above, in many other presentation of DSGE models as a synthesis.

2.3 Microfoundations as theoretical progress

The crucial improvement emphasized by the standard narrative is the extension of the toolbox of macroeconomic modelling to new concepts and formalisms allowing *microfoundation* of models. Abiding the Lucasian microfoundational program is put forward by DSGE modellers as the very fundamental essence of theoretical progress allowed by consensus. As Sanajay K. Chugh (University of Pennsylvania) explains in the historical chapter of his textbook, microfoundations is all what "modern macroeconomics" is about:

> Modern macroeconomics begin by explicitly studying the microeconomic principles of utility maximization, profit maximmization and market clearing. [...] This modern macroeconomics quickly captured the attention of the profession through the 1980s [because] it actually begin with microeconomic principles, which was a rather attractive idea. Rather than building a framework of economy-wide events from the top down [...] one could build this framework using microeconomic discipline from the bottom up.

[25] See also Jones (2014, 409): "[RBC theory] led to an explosion of additional research as economists sought to enrich the models to include other shocks and explain other economic variables."

(Chugh, 2015, 170)

Modellers in policy-making institutions are more explicit than Chugh in explaining why microfoundations are so appealing. Namely, microfoundations ensure the logical "consistence" and the intellectual rigor of macroeconomic analysis, as argued here, for instance, by modellers from the Swiss National Bank:

> The key property of DSGE models is that they rely on explicit microfoundations and a rational treatment of expectations in a general equilibrium context. They thus provide a coherent and compelling theoretical framework for macroeconomic analysis.
>
> (Cuche-Curti et al., 2009, 6)

ECB's modellers give a similar assessment of their DSGE model EAGLE (Euro Area and GLobal Economy):

> The microfoundations of the model together with its rich structure allow to conduct a quantitative analysis in a theoretically coherent and fully consistent model setup, clearly spelling out all the policy implications.
>
> (Gomes et al., 2010, 5)

Modellers of the Central Bank of Norway suggest a more detailed account of what should be intended by "coherent". In their presentation of NEMO (Norwegian Economy MOdel), they explain how microfounded models provide easier *understanding* of economic mechanisms:

> Various agents' behaviour is modelled explicitly in NEMO, based on microeconomic theory. A consistent theoretical framework makes it easier to interpret relationships and mechanisms in the model in the light of economic theory. One advantage is that we can analyse the economic effects of changes of a more structural nature [...] [making] possible to provide a consistent and detailed economic rationale for Norges Bank's projections for the Norwegian economy. This distinguishes NEMO from purely statistical models, which to a limited extent provide scope for economic interpretations.
>
> (Brubakk and Sveen, 2009, 39)

In all the above quotes, there are actually two underlying arguments supporting the use of microfoundations. The first is about models as "laboratories" for economic policy. The second is about "structural parameters".

The argument of models as "laboratories" for policy analysis is a distinctive insight of Lucas's methodology, however this conception is ambivalent in Lucas's

own writings (Sergi, 2017b). The baseline idea is that macroeconomic models could be used instead of natural or laboratory experiments for assessing the effects of alternative policies. The basic idea is that, as natural or laboratory experiments, models rely on isolation and control of causal mechanisms at work in the real world (as emphasized by Mäki, 2005). Assumptions characterizing microfounded DSGE models as supposed to play such an isolation and control role. This is for instance what is argued by Kocherlakota:

> macroeconomists must conduct their experiments inside economic models that are highly stylized and simplified versions of reality.
>
> (Kocherlakota, 2009, 1-2)

Another among the technical reports quoted above explicitly refers to DSGE as "laboratories", and to the idea that improvements in theory (microfoundations) allowed them to play such a role for policy analysis:

> As a result of recent advances in macroeconomic theory and computational techniques, it has become feasible to construct richly structured dynamic stochastic general equilibrium models and use them as laboratories for the study of business cycles and for the formulation and analysis of monetary policy.
>
> (Cuche-Curti et al., 2009, 39)

The second argument in favor of microfoundations is that they rely on "structural" or "deep" parameters. In the DSGE approach, this is closely related to the first idea, as argued by Surach Tanboon (Bank of Thailand):

> If we do want to predict the effect of a policy experiment, we must model deep parameters that govern individual behavior.
>
> (Tanboon, 2008, 4)

The need for deep parameters in policy evaluation is another inheritance of Lucas's work, namely is celebrated critique (Lucas, 1976). Following a particular (and arguable) interpretation of this critique (Sergi, 2017c), most DSGE modellers considers that their models are not vulnerable to the Lucas Critique *because* they are microfounded:

> Being micro-founded, the model enables the central bank to assess the effect of its alternative policy choices on the future paths of the economy's endogenous variables, in a way that is immune to the Lucas (1976) critique.

(Argov et al., 2012, 5)

> [The DSGE] approach has three distinct advantages in comparison to other modelling strategies. First and foremost, its microfoundations should allow it to escape the Lucas (1976) critique.

(Cuche-Curti et al., 2009, 6)

> The main advantage of this type of models, over more traditional reduce-form macro models, is that the structural interpretation of their parameters allows to overcome the Lucas (1976). This is clearly an advantage for policy analysis.

(Medina and Soto, 2006a, 2)

3 The exogenous technical change: computers and Bayesian econometrics

This section addresses the second driving factor of scientific progress is "technology". Yet, as illustrated by Kocherlakota (2009, 6)'s claim, progress in macroeconomics is rather "a struggle between people and technology" rather than a struggle between ideas. The Bank of Canada modellers also present their DSGE model ToTEM (Terms-of-Trade Economic Model) by referring to the same argument:

> In essence, ToTEM takes advantage of the technological progress in economic modeling and computing power that has occurred over the past decade to enhance the fundamental strengths of QPM.[26] The new model has a stronger theoretical foundation, is easier to work with, and better explains the dynamics of the Canadian economy.

(Murchison and Rennison, 2006, vii)

technical change is another form of accumulation of knowledge: in this case, technical knowledge, in terms of mathematical, statistical and econometrics methods *and* technical knowledge in terms of *tools* to apply these methods—namely, computers. technical change results in an improvement of the model "data-fit", i.e. ability of models in consistently reproducing and/or predicting data. Jordi Galì and Mark Gertler, for instance, emphasizes how the ability of models in "capturing data" has "remarkably" improved over the last years:

[26] "Quarterly Projection Model", the model for forecasting previously in use at the Bank of Canada.

> Overall, the progress has been remarkable. A decade ago it would have been unimaginable that a tightly structured macroeconometric model would have much hope of capturing real world data, let alone of being of any use in the monetary policy process.
>
> (Galí and Gertler, 2007, 2)

Galì and Gertler refer to technical change for "highly structured models". This precision illustrates the narrow interpretation made by the standard narrative of the *scope* of technical change: an improvement of the data-fit for *theoretical models*.

Let consider another example. DSGE modellers from the Swiss National Bank, in their presentation of their model (named DSGE-CH), argue that, in the past decades, macroeconomics faced a dilemma (a "trade-off"): either a model abides theoretical standards, or it performs satisfactorily in terms of data-fit. Thanks to technical change, such dilemma is no more pertinent for today's DSGE:

> The conventional wisdom [...] is that there is a trade-off between theoretical and empirical coherence [...]. Recent work seems to contradict this view. Not only have the new-generation models proved quite successful in fitting the data (Christiano et al., 2005), but some evidence exists that DSGE models may outperform less theoretically oriented forecasting models
>
> (Cuche-Curti et al., 2009, 7).[27]

technical change is seen as a relative phenomenon, resulting in an "out-performing" of theoretical models *with respect to* "less theoretical" models. Cuche-Curti and co-authors are indirectly targeting the vector-autoregressive (VAR) approach (Sims, 1980). The competition between DSGE and VAR is explicit, as for instance in ECB technical report about the NAWM model (Christoffel et al., 2008, 7).[28]

This "relative" technical change also involves five steps (see again Epaulard et al., 2008), mirroring the five steps of theoretical progress. All begin with Keynesian macroeconometric models *à la* Klein and Goldberger (1955) and their structural econometric methods. This was a "tremendous progress" (Blanchard and Johnson, 2013, 562) in terms of data fit and prediction. New classical macroeconomics—in particular with Lucas (1976) and the subsequent line of work by Sargent (1976); Hansen and Sargent (1980)—introduced another significant improvement. They putted into question the structural character of parameters in

[27] Erceg et al. (2005, 1) and Bayoumi (2004, 2) suggest that, during the 1990s, this dilemma originated a divide between academic modelling (oriented by theoretical concerns) and modelling in policy-making institutions (oriented by empirical concerns).

[28] VAR modellers hold a similar perspective: according to them, the evolution of macroeconomics results from a tension between "theory-driven" and "data-driven" models (Spanos, 2009; Juselius, 2010).

Keynesian models, opening the way for models with "true" or "deep" structural parameters derived from microfoundations (*cf. supra*). However, this came to the expense of data fit. The third step of technical change is the introduction of calibration by Kydland and Prescott (1982). Conversely to new classical macroeconometric models such as Hansen and Sargent (1980), the calibrated RBC models did not involve heavy computational and econometric efforts. In addition, their ability in mimicking aggregate data was considered has much more satisfying. However, calibrated RBC models also encountered serious criticisms: some variables in the model were not behaving like in the data (pro-cyclical wages); some values chosen for calibrating the model were unlikely (wage-elasticity of worked hours); many important macroeconomic series were abstracted from the model (nominal prices, monetary variables).

According to the standard narrative, these shortcomings of calibration have been solved, first, in a theoretical way: RBC models incorporating new Keynesian features (nominal and real rigidities on wages and prices) fitted the data much better than the basic RBC models. Hence, the first versions of "calibrated DSGE models" embody the technical change allowed by calibration while improving of his consistency with data thanks to additional theoretical developments. Modellers of SIGMA (the first DSGE in use at the Fed Board) illustrate this point:

> The focus of the [RBC literature] on coherent theoretical underpinnings came at the expense of empirical realism. In recent years, there has been a surge of interest in developing optimization-based models that are more suited to fitting the data. Consistent with this more empirical orientation, "state-of-the-art" stochastic dynamic general equilibrium (SDGE) models have evolved to include a large array of nominal and real rigidities.
>
> Erceg et al. (2005, 1)

However, calibration still represented, for many macroeconomists, an unsatisfactory empirical method if compared to traditional econometric estimation techniques (see for instance Hansen and Heckman, 1996; Sims, 1996; Hartley et al., 1997. On the one hand, the choice of the values for calibrated parameters was considered as allowing too much freedom to the modeller. On the other hand, the absence of any precise measure of the goodness of fit implied a controversial assessment of the consistency between data and models' simulations. In other words, calibration is considered by many macroeconomists as a loosely defined methodology. This is for instance Lees's (RBNZ) retrospective opinion:

> One of the key motivating factors behind replacing the existing forecasting model was to utilize the macroeconomic data more formally to estimate

> or inform the model parameters within KITT. In contrast, FPS[29] is a calibrated macroeconomic model, where the values for the parameters in the model are simply chosen to produce a model that fits the data "well", in the judgement of the modeler, where "well" is defined loosely if at all.
>
> (Lees, 2009, 13)

I think that this standard narrative on technical change can be summarized by Figure 1 (see Appendix). According to the standard narrative, DSGE models represent a technical change in combining three different characteristics: the theoretical consistency of the model (microfoundations), the econometric estimation of parameters and the fit between the model and the data. Among these three requirements, previous macroeconomic models only fulfilled two: Keynesian models (step one of technical change) were estimated econometrically and they fitted the data, but they were not theoretically consistent; new Classical models (step two) were estimated and theoretically consistent, but they performed poorly in terms of data fit; benchmark RBC models and RBC models with additional new Keynesian features (steps three and four) fitted the data and were theoretically consistent, but they did not abide econometric estimation. Finally, DSGE models are the perfect compromise to this (im)possible trinity, thanks to two factors: Bayesian estimation and increase in computational power.

The five and last step of technical change corresponds hence to the resolution of the trilemma, thanks to Bayesian econometrics and new computational power. Technical report about the MOdel for the ISraeli Economy (MOISE) describes the success of DSGE models as resulting from to these two technical innovations:

> The widespread adoption of [DSGE models] was the result not only of progress in economic theory, but also advances in econometric practice. Specifically, the reintroduction of Bayesian methods into macroeconomics, made possible by increased computer power, enabled the estimation of models that previously could only be calibrated.
>
> (Argov et al., 2012, 1-2)

On the one hand, Bayesian econometrics has reintroduced indeed a statistical test of parameters, as well as a measure of the consistency between model's simulated series and observed aggregate data. In addition, for complex models, Bayesian estimation is supposed to be more easily tractable than the frequentist econometric methods such as the maximum-likelihood (Fernández-Villaverde, 2010, 6-7).[30]

[29] Forecasting and Policy System, the model previously in use at RBNZ.

[30] Fernandez-Villaverde's point is that Bayesian econometrics relies on integrating a maximum-likelihood function (instead of maximizing it) and that integration can be easier computed by a software (than maximization).

On the other hand, the development of computer power has been important to manage more and more complex models and data-sets. A direct consequence of the diffusion of new computers is also the emergence of software dedicated to solving and estimating DSGE models.[31] The widespread use of such software made possible an easier and efficient design and estimation of DSGE models, across a wider and wider audience. technical change in computer sciences has hence been crucial in the development of DSGE models:

> No matter how sound were the DSGE models presented by the literature or how compelling the arguments for Bayesian inference, the whole research program would not have taken off without the appearance of the right set of tools that made the practical implementation of the estimation of DSGE models feasible in a standard desktop computer.
>
> (Fernández-Villaverde, 2010, 13)

The same claim can be found in IMF technical report on the GEM model:

> By supporting the development of tools like the DYNARE project, the IMF and a few other policy-making institutions have made a very useful investment that may make it possible in a matter of years to gradually retire an older generation of models that have been either calibrated or estimated with very unreliable estimation procedures.
>
> (Laxton, 2008, 215)

Both quotes above illustrate how technical change is explained by the standard narrative. Bayesian econometrics as well as computational power are "technical tools", arising endogenously in the first place. Indeed, macroeconomics simply "reintroduced" these technical tools that "appeared" elsewhere. By chance, these methods constitutes are "the right set of tools", and "more reliable" than past estimation techniques (or "more effective" than older computers).

As emphasized by Fabrice Collard (University of Bern):

[31] The field of economics (in general) has been impacted by the rise of software helping in managing mathematical and statistical computation (such as MATLAB or SAS). Moreover, macroeconomists developed specific programs for solving and estimating DSGE models. DYNARE (Juillard, 1996) has been the pioneer of those programs, and it represents, still today, a widespread tool in DSGE community. Policy-making institutions also developed their own DSGE-software: YADA (ECB; `http://www.texlips.net/yada/`), TROLL (IMF; `http://www.intex.com/troll/`), IRIS (a cooperation among IMF, Czech Republic central bank and RBNZ; `http://iristoolbox.codeplex.com/`).

> technological progress is given a key role in the long maturing process that led to current macroeconomics. [...] the evolution of ideas in the field was [...] the outcome of constant progress in neighboring sciences. For instance, the development of optimal control, dynamic programming, Kalman filtering, econometrics among others permitted/facilitated the emergence of dynamic models and rational expectations. They also drastically changed the way we evaluate our models and enhanced their falsifiability. The development of computers permitted the development of simulation/estimation techniques and promoted the development of new algorithms to solve heterogeneous agent models or models featuring strong non-linearities.
>
> Collard (2016, 139)

Technological progress is indeed a progress of "neighboring sciences", such as optimal control and computers.

It is interesting that Robert Lucas endorses the standard narrative account for technical change in his recent address to the History of Economics Society:

> And then I see the progressive [...] element in economics as entirely technical: better mathematics, better mathematical formulation, better data, better data-processing methods, better statistical methods, better computational methods. I think of all progress in economic thinking, in the kind of basic core of economic theory, as developing entirely as learning how to do what Hume and Smith and Ricardo wanted to do, only better.
>
> (Lucas, 2004, 22)[32]

4 Concluding remarks: the shortcomings of the standard narrative (and what to do about it)

The standard narrative is not *per se* a bad or wrong historiographical perspective on the recent developments in macroeconomics. It is indeed a very proficient attempt to rationalize and to legitimate the current state of the discipline (*cf.* 1.3). It also a common ground among DSGE modellers defining the boundaries of this scientific community (*cf.* 1.1).

However, from a perspective of a historian of macroeconomics, the standard narrative is not a satisfying interpretation. It lacks of a basic requirement for historiographical research, namely to introduce a distance between the object and

[32] Actually, similar arguments can be found earlier in Lucas's writing (see Sergi, 2017b); his view of history might have been rather a source of inspiration for the standard narrative than a late rejoinder. However, the views of the older generation is an issue beyond the scope of the paper.

the historian—a reserve, a rational criticism. To the extent it serves a standardization function in the field, the standard narrative has no critical perspective to offer. Therefore, I think that historians of macroeconomics, though they might not start by rejecting *ex ante* the whole tale made by the standard narrative, have nevertheless the obligation of putting it into question. Primarily, this implies, to question the two driving factors of the scientific progress in the standard narrative.[33] This involves addressing two questions: (1) Do the five steps of theoretical progress actually correspond to a continuum of methods and concepts, evolving linearly thanks to consensus? (2) Do quantitative methods actually correspond to "neutral" tools, entirely at macroeconomists' disposal and ready to be appropriated for their purposes?

The first matter pertains to the history of macroeconomic theories. A significant amount of contributions has already analyzed the transformation of macroeconomics in the 1970s (see in particular Hoover, 1988; Vercelli, 1991; De Vroey, 2009, 2015). These works contradict the standard narrative and are more in line with the revolution view: new Classical macroeconomics should be considered as a Kuhnian revolution (an incommensurable shift in the object, method and conclusion of macroeconomics), rather than a "constructive debate" among macroeconomists working within the same theoretical perspective. Conversely, the subsequent steps of macroeconomic history (RBC and new Keynesian approach in the 1980s) share indeed a common ground (the microfoundational program set in motion by Lucas); however, it seems also arguable that they were cooperating constructively (see for instance Sergi, 2017a, chap. 3-5), even if this question has not been addressed yet by history of macroeconomic theories. Hence, I think that the first task for providing a serious assessment on the pertinence of the standard narrative is to investigate the tensions within the new scientific paradigm pioneered by Lucas. As a second task, I think we shall point out the lack of factual accuracy in the standard history: its "five step" results in a sketchy description of the many rival approaches to macroeconomics during the 1970s, 1980s and 1990s: disequilibrium theory, monetarisms, sunspots and many other theoretical contributions are not even mentioned in the standard narrative. Uncovering these approaches is, first of all, a matter of factual precision; moreover, and most importantly, it is crucial to understand the way those approaches influenced the current state of macroeconomics (either by opposition or by cooperation). Research toward this direction has already started with an investigation on alternative microfoundational programs (Duarte and Lima, 2012), on disequilibrium theory (Backhouse

[33] These do not include its underlying general view on scientific progress: I am not aiming at discussing the pertinence of the idea of progress on science or in economics (on this question, see for instance Lawson, 1987; Backhouse, 1997 or Bridel, 2005). More modestly, my questions simply refer to progress in the recent history of macroeconomics, as it is described by the standard narrative.

and Boianovski, 2013; Renault, 2016); further developments addresses for instance sunspots models Cherrier and Saïdi (2015); Assous and Duarte (2017) and alternative programs for formulating expectations (Dechaux, 2017).

The second question (are quantitative methods "neutral" tools?) pertains to "histories of econometrics" (Boumans and Dupont-Kieffer, 2011) and, broadly, the history of quantitative methods. These contributions already emphasized that quantitative methods are strictly interdependent with theoretical and methodological questions (see in particular Morgan, 1990; Boumans, 2004; Desrosières, 2008; Armatte, 2009; Qin, 2013)—or, in short, that econometrics is a "creative synthesis between theory and evidence" (Morgan, 1990, 1). Following this conclusions, it seems arguable to consider that macroeconomic modelling evolved following an exogenous technical change, as claimed by the standard narrative. Indeed, the choice of a particular quantitative method brings substantial change in a modelling approach—changes that cannot be simply considered as the "choice of the best technique" at modellers' disposal.

Subsequently, the final question that should be addressed by the historian is the following: if theoretical and technical change cannot explain the rise of DSGE models in macroeconomics (both in academia and in policy-making institutions), what is then the actual reason? Indeed, if DSGE models do not embody the "accumulation of knowledge" (because such an accumulation simply do not exist), hence their hegemonic role in the field is no more a natural or logical achievement of a linear process. Providing an alternative explanation implies to develop the "external" history of macroeconomics, taking into account the historical context. An important factor to be considered is the evolution of the role of policy-making institutions (field of expertise, demands) and their relationship with policy-makers and political context. This kind of analysis has already been developed for the rise of Keynesian models during the 1940-1970 (see for instance Armatte and Dahan-Dalmenico, 2004; Maes et al., 2011; Desrosières, 2008; Armatte, 2009; Renault, 2016), but it still remains an unexplored field for the most recent developments in macroeconomics, including the rise of DSGE models.

Finally, as these three types of questions are closely related, it seems that history of macroeconomics cannot address them separately: a substantial questioning of the standard narrative should hence proceed from a simultaneous investigation of the evolution of theories, quantitative methods and expertise.

Appendix

Table 1: DSGE models in policy-making institutions, by year /1 Before 2008

Institution	**Model name**	**Year**	**References**
European Central Bank	NAWM	2003	Smets and Wouters (2003); Christoffel et al. (2008)
International Monetary Fund	GEM	2003	Bayoumi (2004)
Federal Reserve Board	SIGMA	2005	Erceg et al. (2005)
Bank of England	BEQM	2005	Harrison et al. (2005); Harrison and Oomen (2010)
Czech National Bank	New Model or G3	2005	Beneš et al. (2005)
European Commission	QUEST	2005	Ratto and Röger (2005); Ratto et al. (2009)
International Monetary Fund	GFM	2006	Botman et al. (2006)
Bank of Canada	ToTEM	2006	Murchison and Rennison (2006)
Norges Bank	NEMO	2006	Brubakk and Sveen (2009)
Bank of Finland	AINO	2006	Kilponen and Ripatti (2006)
Banco de España	BEMOD	2006	Andrés et al. (2006)
Banco central de Chile	MAS	2006	Medina and Soto (2006a)
International Monetary Fund	GIFM	2007	Kumhof et al. (2010)
Sveriges Riksbank (Sweden)	RAMSES	2007	Adolfson et al. (2007)
Bank of Thailand		2007	Tanboon (2008)
Swiss National Bank	DSGE-CH	2007	Cuche-Curti et al. (2009)
French Ministry for the Economy and Finance	Omega3	2007	Carton and Guyon (2007)

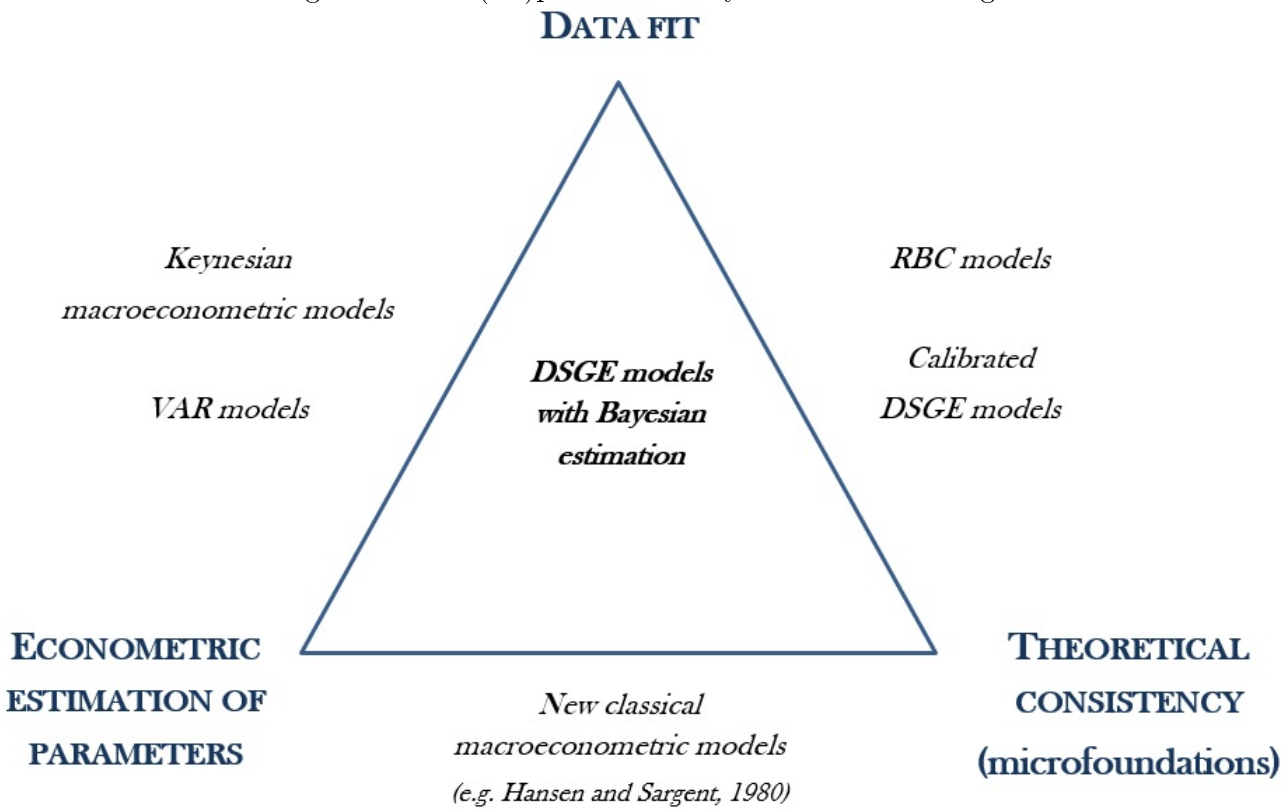
Table 2: DSGE models in policy-making institutions, by year /2 After 2008

Institution	**Model name**	**Year**	**References**
Banco Central de Reserva del Perú	MEGA-D	2008	Castillo et al. (2009)
Banco Central do Brasil	SAMBA	2008	Gouvea et al. (2008); De Castro et al. (2011)
Banco de la Republica (Colombia)	PATACON	2008	González et al. (2011)
Reserve Bank of Australia		2008	Jääskelä and Nimark (2008)
Ministère de l'économie du Luxembourg	LSM	2008	Deak et al. (2011)
Banco de Portugal	PESSOA	2008	Almeida et al. (2008, 2013)
South Africa Reserve Bank		2008	Steinbach et al. (2009); Du Plessis et al. (2014)
Reserve Bank of New Zeland	KITT	2009	Lees (2009)
Banco de España	MEDEA	2009	Burriel et al. (2010)
Czech Ministry of Finance	HUBERT	2009	Štork et al. (2009); Alitev et al. (2014)
Banque centrale du Luxembourg	LOLA	2009	Pierrard and Sneessens (2009); Marchiori and Pierrard (2012)
Bangko Sentral ng Pilipinas		2009	McNelis and Glindro (2009)
Federal Reserve Board	EDO	2010	Chung et al. (2010)
Bank of Japan	M-JEM	2010	Fueki et al. (2010)
Sedlabanki Islands		2010	Seneca (2010)
European Central Bank	EAGLE	2010	Gomes et al. (2010)
Federal Reserve Bank of Chicago		2012	Brave et al. (2012)
Bank of Israel	MOISE	2012	Argov et al. (2012)
Banco de España and Deutsche Bundesbank	FiMOD	2012	Stähler and Thomas (2012)
Federal Reserve Bank of New York		2013	Del Negro et al. (2013)
NCAER (India)		2015	Banerjee et al. (2015)
Reserve Bank of New Zealand	NZSIM	2015	Kamber et al. (2015)

Table 3: The place of history of macroeconomics in recent literature

Place of historical considerations	**Type of contribution**	**References**
Full article	Article in peer review journal	Ayouz (2008); Azariadis and Kaas (2007); Blanchard (2000); Collard (2016); Woodford (2009)
	Chapter in a collective book	Rodano (2002)
	Central bank report	Avouyi-Dovi et al. (2007); Epaulard et al. (2008)
Chapter or section (for articles)	Central bank report	Argov et al. (2012); Bayoumi (2004); Harrison et al. (2005)
	Textbook	Blanchard and Johnson (2013); Blanchard et al. (2013); Dornbusch et al. (2007); Chugh (2015); Jones (2014)
Introductory remarks	Book	Woodford (2003)
	Central bank report	Adolfson et al. (2007); Brubakk et al. (2006); Castillo et al. (2009); Christoffel et al. (2008); Cuche-Curti et al. (2009); De Castro et al. (2011); Erceg et al. (2005); Galí and Gertler (2007); Harrison and Oomen (2010); Jääskelä and Nimark (2008); Lees (2009); Laxton (2008); Medina and Soto (2006b); Murchison and Rennison (2006); Tanboon (2008)
	Textbook	Heijdra and van der Ploeg (2002); Walsh (2003); Wickens (2012)
Incidental remarks	Article in peer review journal	Blanchard (2008, 2016); Blanchard et al. (2010); Fernández-Villaverde (2010)
	Central bank report	Andrés et al. (2006); Beneš et al. (2005); Fueki et al. (2010); Seneca (2010)
	Textbook	Burda and Wyplosz (2013); Mankiw (2016)

Figure 1: The (im)possible trinity of technical change



References

Adolfson, M., Laséen, S., Lindé, J., and Villani, M. (2007). RAMSES: A New General Equilibrium Model for Monetary Policy Analysis. *Sveriges Riksbank Economic Review*, 2:5–39.

Aghion, P. and Howitt, P. (2009). *The Economics of Growth*. MIT Press, Cambridge (MA).

Alitev, I., Stork, Z., and Bobkova, B. (2014). Extended DSGE model of the Czech economy. Technical Report 1/2014, Ministry of Finance of the Czech Republic.

Almeida, V., de Castro, G. L., and Félix, R. M. (2008). Improving Competition in the Non-Tradable Goods and Labour Markets: The Portuguese Case. Technical Report 16/2008, Banco de Portugal.

Almeida, V., de Castro, G. L., Félix, R. M., Júlio, P., and Maria, J. R. (2013). Inside PESSOA. A detailed description of the model. Technical Report 16/2013, Banco de Portugal.

Andrés, J., Burriel, P., and Estrada, Á. (2006). BEMOD: A DSGE Model for the Spanish Economy and the Rest of the Euro Area. Technical Report 0631, Banco de España.

Andrés, J., Burriel, P., and Estrada, A. (2006). BEMOD: A DSGE Model for the Spanish Economy and the Rest of the Euro Area. Technical Report WP-0631, Banco de Espana Research Paper.

Argov, E., Barnea, E., Binyamini, A., Borenstein, E., Elkayam, D., and Rozenshtrom, I. (2012). MOISE: A DSGE Model for the Israeli Economy. Technical Report 2012.06, Bank of Israel.

Armatte, M. (2009). Crise financière: modèles du risque et risque de modèle. *Mouvements*, 2009(2):160–176.

Armatte, M. and Dahan-Dalmenico, A. (2004). Modèles et modélisations, 1950-2000. nouvelles pratiques, nouveaux enjeux. *Revue d'histoire des sciences*, 57(2):243–303.

Assous, M. and Duarte, P. G. (2017). Challenging Lucas: From Overlapping Generations to Infinite-lived Agent Models. Available at SSRN 2910531.

Avouyi-Dovi, S., Matheron, J., and Fève, P. (2007). Les modèles DSGE. Leur intérêt pour les banques centrales. *Bulletin de la Banque de France*, 161:41–54.

Ayouz, M. (2008). Les modèles DSGE. *Diagnostic(s)*, 2(6):25–40.

Azariadis, C. and Kaas, L. (2007). Is Dynamic General Equilibrium a Theory of Everything? *Economic Theory*, 32(1):13–41.

Backhouse, R. (1997). *Truth and Progress in Economic Knowledge*. Edward Elgar, Cheltenham.

Backhouse, R. and Boianovski, M. (2013). *Tranforming Modern Macroeconomics. Exploring Disequilibrium Microfoundations (1956-2003)*. Cambridge University Press, Cambdrige (UK).

Banerjee, S., Basu, P., et al. (2015). A Dynamic Stochastic General Equilibrium Model for India. Technical Report 109, National Council of Applied Economic Research.

Bayoumi, T. (2004). GEM: A New International Macroeconomic Model. Technical Report 239, International Monetary Found.

Begg, D. (1982). The Rational Expectations Revolution. *Economic Outlook*, 6(9):23–30.

Beller, M. (2001). *Quantum Dialogue. The Making of a Revolution*. University of Chicago Press, Chicago (IL).

Beneš, J., Hlédik, T., Kumhof, M., Vávra, D., and Banka, C. N. (2005). An Economy in Transition and DSGE. What the Czech National Bank's New Projection Model Needs. Technical Report 12/2005, Czech National Bank.

Beneš, J., Hledik, T., Kumhof, M., and Vavra, D. (2005). An Economy in Transition and DSGE: What the Czech National Bank's New Projection Model Needs. Technical report, Czech National Bank, Research Department.

Blanchard, O., Giavazzi, F., and Amighini, A. (2013). *Macroeconomics: A European Perspective*. Pearson, Cambridge.

Blanchard, O. J. (2000). What Do We Know about Macroeconomics That Fisher and Wicksell Did Not? *De Economist*, 148(5):571–601.

Blanchard, O. J. (2008). The State of Macro. Technical Report 14259, National Bureau of Economic Research.

Blanchard, O. J. (2016). Do DSGE Models Have a Future? *Peterson Institute for International Economics Policy Briefs*, 16(11):1–4.

Blanchard, O. J., Dell'Ariccia, G., and Mauro, P. (2010). Rethinking Macroeconomic Policy. *Journal of Money, Credit and Banking*, 42(1):199–215.

Blanchard, O. J. and Johnson, D. W., editors (2013). *Macroeconomics. 6th Edition.* Pearson, Cambridge.

Blinder, A. S. (1986). Keynes after Lucas. *Eastern Economic Journal*, 12(3):209–216.

Boianovsky, M. and Trautwein, H.-M. (2006). Wicksell after Woodford. *Journal of the History of Economic Thought*, 28(2):171–185.

Boissay, F., Collard, F., and Smets, F. (2013). Booms and Systemic Banking Crises. Technical Report 1514, European Central Bank.

Botman, D. P., Laxton, D., Muir, D., and Romanov, A. (2006). A New-Open-Economy-Macro Model for Fiscal Policy Evaluation. Technical Report 06/45, International Monetary Found.

Boumans, M. (1999). Build-in justification. In Morgan, M. S. and Morrison, M., editors, *Models as Mediators. Perspectives on Natural and Social Science*, pages 66–96. Cambridge University Press, Cambridge.

Boumans, M. (2004). *How Economists Model the World into Numbers.* Routledge, Londres.

Boumans, M. and Dupont-Kieffer, A. (2011). A History of the Histories of Econometrics. *History of Political Economy*, 43(Suppl 1):5–31.

Brancaccio, E. and Saraceno, F. (2017). Evolutions and Contradictions in Mainstream Macroeconomics: The Case of Olivier Blanchard. *Review of Political Economy.*

Branch, W. A. and McGough, B. (2009). A New Keynesian Model With Heterogeneous Expectations. *Journal of Economic Dynamics and Control*, 33(5):1036–1051.

Brave, S. A., Campbell, J. R., Fisher, J. D., and Justiniano, A. (2012). The Chicago Fed DSGE Model. Technical Report 2012-2, Federal Reserve Bank of Chicago.

Bridel, P. (2005). Cumulativité des connaissances et science économique. Que cherche-t-on exactement à cumuler? *Revue européenne des sciences sociales. European Journal of Social Sciences*, XLIII(131):63–79.

Broun, P. (2010). Building a Science of Economics for the Real World. Opening Statement.

Brubakk, L., Husebø, T. A., Maih, J., Olsen, K., and Østnor, M. (2006). Finding NEMO: Documentation of the Norwegian economy model. Technical Report 2006/6, Norges Bank, Staff Memo.

Brubakk, L. and Sveen, T. (2009). NEMO. A New Macro Model for Forecasting and Monetary Policy Analysis. *Economic Bulletin*, 80(1):39–47.

Burda, M. and Wyplosz, C. (2013). *Macroeconomics: A European text*. Oxford University Press, Oxford.

Burriel, P., Fernández-Villaverde, J., and Rubio-Ramírez, J. F. (2010). MEDEA: A DSGE Model for the Spanish Economy. *SERIEs*, 1(1-2):175–243.

Calvo, G. (1983). Staggered Prices in a Utility-maximizing Framework. *Journal of Monetary Economics*, 12(3):383–398.

Carton, B. and Guyon, T. (2007). Divergences de productivité en union monétaire. Présentation du modèle Oméga3. Technical Report 2007/08, Direction Générale du Trésor et de la Politique Economique.

Castelnuovo, E. and Nistico, S. (2010). Stock Market Conditions and Monetary Policy in a DSGE Model for the US. *Journal of Economic Dynamics and Control*, 34(9):1700–1731.

Castillo, P., Montoro, C., and Tuesta, V. (2009). Un modelo de equilibrio general con dolarización para la economía peruana. Technical Report 2009-006, Banco Central del Chile, Documento de Trabajo.

Chari, V. V. (2010). Testimony before the committee on Science and Technology, Subcommittee on Investigations and Oversight, US House of Representatives. In *Building a Science of Economics for the Real World*.

Cherrier, B. and Saïdi, A. (2015). The Indeterminate Fate of Sunspots in Economics. Available at SSRN 2684756.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, 113(1):1–45.

Christoffel, K., Coenen, G., and Warne, A. (2008). The New Area-Wide Model of the Euro area. Technical Report 944, European Central Bank.

Chugh, S. K. (2015). *Modern Macroeconomics*. MIT Press, Cambridge (MA).

Chung, H. T., Kiley, M. T., and Laforte, J.-P. (2010). Documentation of the Estimated, Dynamic, Optimization-based (EDO) Model of the US Economy. Technical Report 2010-29, Federal Reserve Board, Division of Research & Statistics and Monetary Affairs.

Clarida, R., Gali, J., and Gertler, M. (1999). The Science of Monetary Policy: A New Keynesian Perspective. Technical Report 7147, National Bureau of Economic Research.

Collard, F. (2016). A History of Macroeconomics: A Macroeconomic Viewpoint. *Œconomia. History, Methodology, Philosophy*, 6(1):139–147.

Cooley, T. F., editor (1995). *Frontiers of Business Cycle Research*. Princeton University Press, Princeton (NJ).

Cuche-Curti, N. A., Dellas, H., and Natal, J.-M. (2009). DSGE-CH. A Dynamic Stochastic General Equilibrium Model for Switzerland. Technical Report 5, Swiss National Bank.

De Castro, M. R., Gouvea, S. N., Minella, A., dos Santos, R. C., and Souza-Sobrinho, N. F. (2011). Samba: Stochastic Analytical Model with a Bayesian Approach. Technical Report 239, Central Bank of Brazil.

De Graeve, F., Dossche, M., Emiris, M., Sneessens, H., and Wouters, R. (2010). Risk Premiums and Macroeconomic Dynamics in a Heterogeneous Agent Model. *Journal of Economic Dynamics and Control*, 34(9):1680–1699.

De Vroey, M. (2009). *Keynes, Lucas: d'une macroéconomie à l'autre*. Dalloz, Paris.

De Vroey, M. (2015). *A History of Modern Macroeconomics from Keynes to Lucas and Beyond*. Cambridge University Press, Cambridge.

Deak, S., Fontagné, L., Maffezzoli, M., and Marcellino, M. (2011). LSM: A DSGE model for Luxembourg. *Economic Modelling*, 28(6):2862–2872.

Dechaux, P. (2017). *Les indicateurs de confiance des consommateurs : théorie, histoire et méthodologie*. PhD thesis, Université Paris 1 Panthéon Sorbonne, Paris.

Del Negro, M., Eusepi, S., Giannoni, M., Sbordone, A., Tambalotti, A., Cocci, M., Hasegawa, R., and Linder, M. H. (2013). The FRBNY DSGE Model. Technical Report 647, Federal Reserve Bank of New York.

Desrosières, A. (2008). *L'Argument statistique. Pour une sociologie historique de la quantification*. Presses des Mines, Paris.

Dixit, A. K. and Stiglitz, J. E. (1977). Monopolistic Competition and Optimum Product Diversity. *American Economic Review*, 67(3):297–308.

Dornbusch, R., Fischer, S., and Startz, R. (2007). Macroeconomics. 10th edition.

Du Plessis, S., Smit, B., and Steinbach, S. (2014). A medium-sized open economy DSGE model of South Africa. Technical Report 14/04, South African Reserve Bank.

Duarte, P. G. (2012). Not Going Away? Microfoundations in the Making of a New Consensus in Macroeconomics. In Duarte, P. G. and Lima, G. T., editors, *Microfoundations Reconsidered. The Relationship of Micro and Macroeconomics in Historical Perspective*, pages 190–237. Edward Elgar, Cheltenham.

Duarte, P. G. and Lima, G. T., editors (2012). *Microfoundations Reconsidered. The Relationship of Micro and Macroeconomics in Historical Perspective*. Edward Elgar, Cheltenham.

Epaulard, A., Laffargue, J.-P., and Malgrange, P. (2008). La nouvelle modélisation macroéconomique appliquée à l'analyse de la conjoncture et à l'évaluation des politiques publiques. Présentation Générale. *Economie & prévision*, 2(183-184):1–13.

Erceg, C. J., Guerrieri, L., and Gust, C. (2005). SIGMA: A New Open Economy Model for Policy Analysis. Technical Report 835, Board of Governors of the Federal Reserve System. International Finance Discussion Papers.

Fernández-Villaverde, J. (2010). The Econometrics of DSGE Models. *SERIEs*, 1(1-2):3–49.

Frisch, R. (1933). Propagation Problems and Impulse Problems in Dynamic Economics. In Frisch, R. and Koch, K., editors, *Essays in Honour of Gustav Cassel*, pages 171–147. George Allen and Unwin Ltd., Londres.

Fueki, T., Fukunaga, I., Ichiue, H., and Shirota, T. (2010). Measuring Potential Growth with an Estimated DSGE Model of Japan's Economy. Technical Report 10-E-13, Bank of Japan.

Gabriel, V., Levine, P., Pearlman, J., and Yang, B. (2010). An Estimated DSGE Model of the Indian Economy. Technical Report 29, University of Surrey.

Galí, J. and Gertler, M. (2007). Macroeconomic Modeling for Monetary Policy Evaluation. Technical Report 13542, National Bureau of Economic Research.

Gomes, S., Jacquinot, P., and Pisani, M. (2010). The EAGLE. A Model for Policy Analysis of Macroeconomic Interdependence in the Euro Area. Technical Report 1195, European Central Bank.

González, A., Mahadeva, L., Prada, J. D., and Rodríguez, D. (2011). Policy Analysis Tool Applied to Colombian Needs. PATACON Model Description. *Ensayos sobre política econÓmica*, 29(66):222–245.

Goodfriend, M. and King, R. (1997). The New Neoclassical Synthesis and the Role of Monetary Policy. In *NBER Macroeconomics Annual 1997*, pages 231–296. MIT Press, Cambridge (MA).

Gouvea, S., Minella, A., Santos, R., and Souza-Sobrinho, N. (2008). SAMBA. Stochastic Analytical Model with a Bayesian Approach. Technical report, Central Bank of Brazil. Mimeo.

Hall, R. E. (1976). Note on the Current State of Empirical Economics. Papier non publié, présenté au workshop annuel de l'*Institute of Mathematical Studies in Social Sciences, Stanford University*.

Hammond, G. (2015). State of the art of inflation targeting. Technical Report 29, Bank of England.

Hansen, G. D. (1985). Indivisible Labor and the Business Cycle. *Journal of Monetary Economics*, 16(3):309–327.

Hansen, L. P. and Heckman, J. J. (1996). The Empirical Foundations of Calibration. *Journal of Economic Perspectives*, 10(1):87–104.

Hansen, L. P. and Sargent, T. J. (1980). Formulating and Estimating Dynamic Linear Rational Expectations Models. *Journal of Economic Dynamics and Control*, 2(1):7–46.

Harrison, R., Nikolov, K., Quinn, M., Ramsay, G., Scott, A., and Thomas, R. (2005). *The Bank of England Quarterly Model*. Bank of England, Londres.

Harrison, R. and Oomen, O. (2010). Evaluating and Estimating a DSGE Model for the United Kingdom. Technical Report 380, Bank of England.

Hartley, J. E. (2014). The Quest for Microfoundations. *Œconomia. History, Methodology, Philosophy*, 4(2):237–247.

Hartley, J. E., Hoover, K. D., and Salyer, K. D. (1997). The Limits of Business Cycle Research: Assessing the Real Business Cycle Model. *Oxford Review of Economic Policy*, 13(3):34–54.

Heijdra, B. J. and van der Ploeg, F. (2002). *Foundations of Modern Macroeconomics.* Oxford University Press, Oxford.

Henin, P.-Y., editor (1995). *Advances in Business Cycle Research.* Springer, Berlin.

Hoover, K. D. (1988). *The New Classical Macroeconomics. A Sceptical Inquiry.* Basil Blackwell, Oxford.

Hoover, K. D. (2012). Microfoundational programs. In Duarte, P. G. and Lima, G. T., editors, *Microfoundations Reconsidered*, pages 19–61. Edward Elgar, Cheltenham.

Jääskelä, J. and Nimark, K. (2008). A Medium-Scale Open Economy Model of Australia. Technical Report 2008-07, Reserve Bank of Australia.

Jääskelä, J. and Nimark, K. (2008). A Medium-scale Open Economy Model of Australia. Technical Report RDP 2008-07, Reserve Bank of Australia Research Discussion Papers.

Jahan, S. (2012). Inflation Targeting: Holding the Line. *Finance and Development*, 49(1):0–0.

Johnson, H. G. (1971). The Keynesian Revolution and the Monetarist Counterrevolution. *American Economic Review*, 61(2):1–14.

Jones, C. I. (2014). *Macroeconomics. 3rd Edition.* Norton & Co, London.

Juillard, M. (1996). DYNARE. A Program for the Resolution and Simulation of Dynamic Models with Forward Variables through the Use of a Relaxation Algorithm. Technical Report 9602, CEPREMAP.

Juselius, K. (2010). On the Role of Theory and Evidence in Macroeconomics. In Davis, J. B. and Hands, W. D., editors, *The Elgar Companion to Recent Economic Methodology*, pages 404–436. Edward Elgar, Cheltenham.

Kamber, G., McDonald, C., Sander, N., and Theodoridis, K. (2015). A structural forecasting model for New Zealand: NZSIM. Technical report, Reserve Bank of New Zealand.

Kilponen, J. and Ripatti, A. (2006). Learning to Forecast with a DGE Model. Technical report, Bank of Finland. Mimeo.

Klein, L. R. (1947). *The Keynesian Revolution*. Macmillan, New York.

Klein, L. R. and Goldberger, A. S. (1955). *An Econometric Model of the United States, 1929-1952*. North Holland, Amsterdam.

Kocherlakota, N. R. (2009). Modern macroeconomic models as tools for economic policy. *The Region*, 2009(May):5–21.

Kuhn, T. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago.

Kumhof, M., Muir, D., Mursula, S., and Laxton, D. (2010). The Global Integrated Monetary and Fiscal Model (GIMF). Theoretical Structure. Technical Report 10/34, International Monetary Found.

Kydland, F. E. and Prescott, E. C. (1982). Time to Build and Aggregate Fluctuations. *Econometrica*, 50(6):1345–1370.

Lawson, T. (1987). The Relative/Absolute Nature of Knowledge and Economic Analysis. *The Economic Journal*, 97(388):951–970.

Laxton, D. (2008). Getting to Know the Global Economy Model and Its Philosophy. *IMF Staff Papers*, 55(2):213–242.

Lees, K. (2009). Introducing KITT: The Reserve Bank of New Zealand New DSGE Model for Forecasting and Policy Design. *Reserve Bank of New Zealand Bulletin*, 72(2):5–20.

Leijonhufvud, A. (1972). *On Keynesian Economics and the Economics of Keynes. A Study in Monetary Theory*. Oxford University Press, Oxford.

Long, J. B. and Plosser, C. I. (1983). Real Business Cycles. *Journal of Political Economy*, 91(1):39–69.

Lucas, R. E. (1972). Expectations and the Neutrality of Money. *Journal of Economic Theory*, 4(2):103–124.

Lucas, R. E. (1975). An Equilibrium Model of the Business Cycle. *Journal of Political Economy*, 83(6):1113–1144.

Lucas, R. E. (1976). Econometric Policy Evaluation: A Critique. *Carnegie-Rochester Conference Series on Public Policy*, 1:19–46.

Lucas, R. E. (1977). Understanding Business Cycles. *Carnegie-Rochester Conference Series on Public Policy*, 5:7–29.

Lucas, R. E. (2004). Keynote Address to the 2003 HOPE Conference: My Keynesian Education. *History of Political Economy*, 36(5):12–24.

Lucas, R. E. and Prescott, E. C. (1971). Investment Under Uncertainty. *Econometrica*, 39(5):659–681.

Maes, I. et al. (2011). The Evolution of Alexandre Lamfalussy's Thought on European Monetary Integration, 1961-1993. *Œconomia. History/Methodology/Philosophy*, 1(4):489–523.

Mäki, U. (2005). Models Are Experiments, Experiments Are Models. *Journal of Economic Methodology*, 12(2):303–315.

Mankiw, N. G. (2016). *Macroeconomics. 9th Edition*. Macmillan, London.

Mankiw, N. G. and Romer, D. H., editors (1991). *New Keynesian Economics*. MIT Press, Cambridge (MA).

Marchiori, L. and Pierrard, O. (2012). LOLA 2.0: Luxembourg OverLapping generation model for policy Analysis. Technical Report 76, Central Bank of Luxembourg.

McCloskey, D. (1985). *The Rhetoric of Economics*. The University of Wisconsin Press, Madison (WI).

McNelis, P. D. and Glindro, E. T. (2009). Macroeconomic Model for Policy Analysis and Insight (a Dynamic Stochastic General Equilibrium Model for the Bangko Sentral ng Pilipinas). Technical Report 2009-01, Bangko Sentral ng Pilipinas.

Medina, J. P. and Soto, C. (2006a). Model for Analysis and Simulations (MAS): A New DSGE for the Chilean Economy. Technical report, Central Bank of Chile.

Medina, J. P. and Soto, C. (2006b). Model for Analysis and Simulations: A Small Open Economy DSGE for Chile. In *Conference Paper, Central Bank of Chile*.

Miller, P. J. (1994). *The Rational Expectations Revolution: Readings from the Front Line*. MIT Press, Cambridge (MA).

Morgan, M. S. (1990). *The History of Econometric Ideas*. Cambridge University Press, Cambridge.

Murchison, S. and Rennison, A. (2006). ToTEM: The Bank of Canada's new quarterly projection model. Technical Report 97, Bank of Canada Research Department. Technical Report.

Muth, J. F. (1961). Rational Expectations and the Theory of Price Movements. *Econometrica*, 29(6):315–335.

Nelson, C. R. and Plosser, C. R. (1982). Trends and Random Walks in Macroeconmic Time Series: Some Evidence and Implications. *Journal of Monetary Economics*, 10(2):139–162.

Phelps, E. S. (1990). *Seven Schools of Macroeconomic Thought*. Oxford University, Oxford.

Pierrard, O. and Sneessens, H. R. (2009). LOLA 1.0: Luxembourg OverLapping generation model for policy Analysis. Technical Report 36, Central Bank of Luxembourg.

Plosser, C. I. (2012). Macro Models and Monetary Policy Analysis. `http://www.philadelphiafed.org/publications/speeches/plosser/2012/05-25-12_bundesbank.pdf` (20/02/2017).

Popper, K. (1934). *The Logic of Scientific Discovery*. Routledge, London.

Popper, K. (1963). *Conjectures and Refutations: The Growth of Scientific Knowledge*. Routledge, London.

Qin, D. (2013). *A History of Econometrics: the Reformation from the 1970s*. Oxford University Press, Oxford.

Rankin, N. (1998). How Does Uncertainty about Future Fiscal Policy Affect Current Macroeconomic Variables? *The Scandinavian Journal of Economics*, 100(2):473–494.

Ratto, M., Roeger, W., and Veld, J. (2009). QUEST III: An Estimated Open-economy DSGE Model of the Euro Area with Fiscal and Monetary Policy. *economic Modelling*, 26(1):222–233.

Ratto, M. and Röger, W. (2005). An estimated new Keynesian dynamic stochastic general equilibrium model of the Euro area. Technical Report 220, European Commission.

Renault, M. (2016). *Edmond Malinvaud, entre science et action*. PhD thesis, Université Paris 1 Panthéon Sorbonne, Paris.

Rodano, G. (2002). The Controversies in Contemporary Macroeconomics. In Nisticò, S. and Tosato, D. A., editors, *Competing Economic Theories. Essays in Memory of Giovanni Caravale*, pages 306–325. Routledge, London.

Samuelson, P. A. (1987). Out of the Closet: A Program for the Whig History of Economic Science. *Journal of the History of Economic Thought*, 9(1):51–60.

Sargent, T. J. (1976). A Classical Macroeconometric Model for the United States. *Journal of Political Economy*, 84(2):207–237. Reprint in Lucas, Robert E. and Sargent, Thomas J. 1981. *Rational Expectations and Econometric Practice*, George Allen and Unwin Ltd., London, pages 521-562.

Seneca, M. (2010). A DSGE Model for Iceland. Technical Report 50, Central Bank of Iceland.

Sergi, F. (2016). When "Facts" Matter: New Keynesian Models and the "Real World". Communication au Séminaire Quantitativisme Réflexif, Ecole Normale Suérieur de Cachan, 15/01/2016.

Sergi, F. (2017a). *De la révolution lucasienne aux modèles DSGE. Réflexions sur les développements récents de la modélisation macroéconomique*. PhD thesis, Université Paris 1 Panthéon Sorbonne, Paris.

Sergi, F. (2017b). Models as Laboratories. Robert E. Lucas on Expertise. Communication at the Annual Meeting of the European Society for the History of Economic Thought, 21/05/2017.

Sergi, F. (2017c). The DSGE Models and the Lucas Critique. A Historical Appraisal. Communication at the Annual Meeting of the Association Française d'Économie Politique, Rennes, 04/07/2017.

Sims, C. A. (1980). Macroeconomics and Reality. *Econometrica*, 48(1):1–48.

Sims, C. A. (1996). Macroeconomics and Methodology. *Journal of Economic Perspectives*, 10(1):105–120.

Smets, F. and Wouters, R. (2003). An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area. *Journal of the European Economic Association*, 1(5):1123–1175.

Snowdon, B. (2007). The New Classical Counter-Revolution: False Path or Illuminating Complement? *Eastern Economic Journal*, 33(4):541–562.

Snowdon, B. and Vane, H. R. (2005). *Modern Macroeconomics: Its Origins, Development and Current State*. Edward Elgar, Cheltenham.

Snowdon, B., Vane, H. R., and Wynarczyk, P. (1994f). *A Modern Guide to Macroeconomics. An Introduction to Competing Schools of Thought*. Edward Elgar, Cheltenham.

Spanos, A. (2009). The Pre-Eminence of Theory versus the European CVAR Perspective in Macroeconometric Modeling. *Economics: The Open-Access, Open-Assessment E-Journal*, 2009(3):1–14.

Stähler, N. and Thomas, C. (2012). FiMod—A DSGE model for fiscal policy simulations. *Economic Modelling*, 29(2):239–261.

Steinbach, M., Mathuloe, P., and Smit, B. (2009). An open economy New Keynesian DSGE model of the South African economy. *South African Journal of Economics*, 77(2):207–227.

Štork, Z., Závacká, J., and Vávra, M. (2009). HUBERT: A DSGE Model of the Czech Republic. Technical Report 2/2009, Ministry of Finance of the Czech Republic.

Tanboon, S. (2008). The Bank of Thailand Structural Model for Policy Analysis. Technical Report 12/2008, Bank of Thailand.

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39:195–214.

Vercelli, A. (1991). *Methodological Foundations of Macroeconomics: Keynes and Lucas*. Cambridge University Press, Cambrige.

Walsh, C. E. (2003). *Monetary Policy and Theory*. MIT Press, Cambridge (MA).

Wickens, M. (2012). *Macroeconomic Theory: A Dynamic General Equilibrium Approach. 2nd Edition*. Princeton University Press, Princeton (NJ).

Woodford, M. (1998). Control of the Public Debt: A Requirement for Price Stability? In Calvo, G. and King, M., editors, *The Debt Burden and Its Consequences for Monetary Policy*, pages 117–158. Springer, Berlin.

Woodford, M. (2003). *Interest and Prices. Foundations of a Theory of Monetary Policy*. Princeton University Press, Princeton (NJ).

Woodford, M. (2009). Convergence in Macroeconomics: Elements of the New Synthesis. *American Economic Journal: Macroeconomics*, 1(1):267–279.