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ABSTRACT
Historians of macroeconomics, through the analysis of articles in peer-review journals, pointed out macroeconomists' propensity to elaborate narratives about the history of their discipline. This article extends the analysis of self-produced narratives to a different genre of literature—namely technical reports on DSGE models published by central banks and other policy-making institutions. This literature adopts a narrative displaying two distinctive characteristics: the emphasis on "consensus" (leading to "better microfoundations") and on "technical change" (enhancing the "fit" between theory and "facts"). Relying on these two arguments, the narrative told in technical reports conveys a rhetorical argument to legitimize the use of DSGE models in policy institutions.

KEYWORDS
DSGE models; central banks; history of macroeconomics; microfoundations; bayesian econometrics

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1. Introduction

This article investigates the history of dynamic stochastic general equilibrium (DSGE) models as it has been told in central banks' technical reports between the early 2000s and 2017.

Historians of macroeconomics, through the analysis of articles in peer-review journals and books, have already pointed out macroeconomists' propensity to elaborate narratives about the history of their discipline. These self-produced narratives have been alternatively referred to as "standard narrative", "potted history", "myth", and "fairy tale" (see for instance Duarte and Lima 2012; Backhouse and Boianovski 2013; Hartley 2014). My purpose is to extend the analysis of self-produced narratives about macroeconomics to a specific strain of macroeconomic modelling (i.e. DSGE models) and to a different *genre* of literature—namely "technical reports" published by central banks and other policy-making institutions.

"Technical reports" are occasional working papers or booklets published by national and international organizations providing expertise and advice on economic policies ("policy-making institutions" hereafter).[1] The purpose of technical reports is to present equations and estimation methods for a model that an institution uses to inform policy

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[1] In this paper, policy-making institutions include mostly central banks (since they were the leading producers of DSGE models in the past two decades), but also international organisations (such as the International Monetary Fund, IMF).

debates.[2] Somehow surprisingly, these "technical" pieces always present a historical perspective on macroeconomic modelling, often as an introduction or as a first section of the report. Section 2 of this article presents in more details this *genre* of literature and discusses its boundaries and specificities.

The historical narrative emerging from technical reports on DSGE models shares three common characteristics with other self-produced narratives told by macroeconomists in other *genres* (such as academic articles in peer-review journals):

1. They build a collective story-telling, which is used and spread simultaneously by many authors across different contexts;
2. They rely on the idea of "scientific progress" (a "steady accumulation of knowledge"; Blanchard 2000, 1375); in Samuelson (1987)s words, the narrative is "whiggish";
3. They tend to convey a rhetorical argument legitimizing an approach to macroeconomics, while delegitimizing other approaches.

Given these common characteristics, all these narratives have been qualified as "standard", in a threefold sense: they are "standard" as they are widespread across communities of modellers; they look at the past in a "standard" or "traditional" way (the whiggish perspective); and, finally, they serve the purpose of a "standardisation" of the field.

However, when compared to other self-produced narratives about macroeconomics, the standard narrative about DSGE models in central banks' technical reports (hereafter, in short, "standard narrative") displays two distinctive characteristics.

First, this standard narrative consistently emphasizes "consensus" among macroeconomists (a common ground of questions and methods) as the driving force of "theoretical progress" (an improvement of the conceptual toolbox, or "theory", for macroeconomic modelling). This is in contrast with another widespread narrative, emphasizing "theoretical progress" throughout "scientific revolutions". Section 3 of this article presents the narrative of "consensus", it contrasts "consensus" and "revolutions" narratives, and, finally, it discusses how the "consensus" narrative fits with the needs proper to technical reports, in particular the need for a persuasive rhetoric legitimizing the use of DSGE models.

The second distinctive feature of this standard narrative is to grant a substantial role to "exogenous technical change". "Techniques" and "technologies" (which entails, broadly, mathematical tools, data availability, statistical and econometric methods, software, and computational power) are considered as a crucial driving factor of "scientific progress"—equally crucial as "consensus" about theory. More specifically, the standard narrative claims that "technical change" enhanced the consistency between models and "facts" (i.e. the ability of models to replicate and to forecast aggregate data), therefore enhancing their ability to inform policy debates. Technical change is depicted as

[2] Most technical reports are not officially endorsed by the institution; they are signed by their authors (i.e. those who have been in charge of the development of the model) with the usual caveat ("views expressed in this report are solely those of the authors etc."). In most cases, technical reports have not been peer-reviewed, although they usually result from a collective writing effort *supervised* by a senior officer.

"exogenous" to the DSGE approach: DSGE modellers simply "imported" in their models the new techniques that were "the outcome of constant progress in neighbouring sciences" (Collard 2016, 139). Section 4 of this article presents this second feature of the standard narrative and its originality compared to other self-produced narratives, which usually address exclusively theoretical change.

2. DSGE models and policy-making institutions

2.1. The "theoretical synthesis" and its recent developments

The stabilisation of the DSGE approach, as a theoretical framework and as a label, is usually associated with the seminal contributions by Smets and Wouters (2003), Woodford (2003), and Christiano, Eichenbaum, and Evans (2005).[3] Following these first "canonical" models, one could resume the baseline DSGE model to a "recipe" of five "ingredients" (using Boumans 1999s metaphor):

1. The purpose of the model is to analyse macroeconomics fluctuations ("the business cycle"), i.e. co-movements in aggregate time series around a stochastic trend (Lucas 1977; Nelson and Plosser 1982). The chosen theoretical toolbox is inspired from neo-Walrasian general equilibrium and, more specifically, from optimal growth models (Kydland and Prescott 1982).
2. The model economy is populated by representative (or homogeneous) classes of agents (households, firms). Agents behave "rationally": (i) each class of agents solves an optimization problem (utility/profit maximization, cost minimization), under constraint, and for an infinite number of periods; (ii) each class of agents forms rational expectations on future states of the model economy (Muth 1961); (iii) individual optimal plans are mutually interdependent and compatible. Consequently: all markets clear (simultaneously and interdependently); equilibrium is unique, stable and inter-temporal. The aggregate characteristics of the economy result from the sum of individual behaviours, consistently with the idea of "microfoundation" of macroeconomics, as it was formulated by Lucas.[4]
3. The dynamics of the model results from exogenous stochastic disturbances ("shocks"). Disturbances are "impulses" triggering fluctuations, while changes in optimal behaviour of individual agents are "responses" or "propagation mechanisms" for fluctuations (following the "rocking chair" metaphor inspired by Frisch 1933). Shocks can be real (affecting technologies, preferences, mark-ups) or nominal (affecting nominal interest rates, prices).
4. At the individual level, at least some prices and wages are not immediately reacting to shocks, which implies a price/wage rigidity (or "stickiness") at the aggregate level. The nominal rigidity at the microeconomic level relies on an imperfect

[3] Early developments of DSGE models include Cooley (1995), Henin (1995), Goodfriend and King (1997), and Clarida, Gali, and Gertler (1999). The label "DSGE" appeared for the first time in press in Rankin (1998).

[4] There are actually many microfoundational programs investigating the relationship between individual behaviour and aggregate phenomena (Hoover 2012). Lucas's program is one particular example, characterized by the representative agent hypothesis and market clearing. Since alternative programs are not addressed here, I will simply use the word "microfoundations" instead of "Lucasian microfoundations" or "representative agent microfoundations".

competition framework (monopolistic competition à la Dixit and Stiglitz 1977) and the Calvo (1983) pricing mechanism.

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 from Taylor (1993).

Formally, a DSGE model consists in a three-equation system:[5]

$$x_t = E_t(x_{t+1}) + \frac{1}{\sigma}\left[R_t - E_t(\pi_{t+1})\right] + \varepsilon_t^d \tag{1}$$

$$\pi_t = \beta E_t(\pi_{t+1}) + \theta x_t + \varepsilon_t^p \tag{2}$$

$$R_t = \rho^1 R_{t-1} + \rho^2(\pi_t - \overline{\pi}) + \rho^3 x_t + \varepsilon_t^m \tag{3}$$

Equation (1) describes the goods market equilibrium, as a function of the current (rational) expectation for future output gap x_{t+1}, the elasticity of consumption σ and the expected real interest rate. Equation (2) sets the evolution of aggregate prices, as a function of current (rational) expectations for future inflation and the degree of price rigidity θ. Equation (3) accounts for central bank's behaviour in setting the nominal interest rate R_t in response to changes in the inflation rate and the output gap ($\rho^{i=1,2,3}$ being sensitivity parameters). The dynamics of the model economy around its steady state results from stochastic independent and identical distributed disturbances ("shocks") on demand, supply and monetary policy ($\varepsilon_t^{j=d,p,m}$).

The above presentation helps understanding Goodfriend and King (1997)s claim that DSGE models constitute 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).

A DSGE model looks indeed like an "old" Keynesian model *à la* Klein and Goldberger (1955): a system of three equations, including an equation describing the equilibrium on the goods market, a pricing equation (or Phillips curve) and a policy rule. Among the five ingredients, ingredients 1–3 are an inheritance of new classical and real business cycle (RBC) theoretical framework; ingredients 4–5 have been developed by the new Keynesian approach in the 1980s (Mankiw and Romer 1991). Hence, a DSGE model clearly combines different theoretical and analytical frameworks; or, in short, it constitutes *a synthesis*, as defined also by De Vroey and Duarte (2013).

The five ingredients presented above constituted the basic recipe for building large-scale DSGE models directly inspired from Smets and Wouters (2003) and Christiano,

[5] As traditionally suggested by Clarida, Gali, and Gertler (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).

Eichenbaum, and Evans (2005). These large-scale models integrated further ingredients and variations, including for instance several sources of rigidity (such as consumption habit formation, investment adjustment costs, …) or open economy features. These versions were fashionable before the 2008 crisis, especially in central banks. Nevertheless, since 2008, the DSGE framework evolved significantly: DSGE models (both small-scale and large-scale) started integrating new "ingredients" to the previous ones; also, some models developed alternative recipes without, for instance, representative agents, or without a unique equilibrium. As recently emphasized in a renowned symposium, published by the *Oxford Review of Economic Policy*, these development entailed four lines of work (Vines and Wills 2018; a similar classification is suggested by Christiano, Eichenbaum, and Trabandt 2018): financial frictions, non-rational expectations, heterogeneous agents and "better microfoundations".[6] By developing "financial frictions" (i.e. non-trivial financial intermediation), DSGE modellers try, for instance, to account for individual liquidity or credit constraints and wealth effects, and leveraging and balance sheet effects in the banking system. This aims at building DSGE models that, on the one hand, describe in more details the actual functioning of modern economies; on the other hand, DSGE models including financial frictions can account for financial shocks as impulses to fluctuations or as amplifying mechanisms.[7] Non-rational expectations (including myopic expectations, bounded rationality and heuristic expectations, learning) aim at characterizing agents' behaviour in a rather "realistic" way (see Branch and McGough 2009 for an early example). DSGE models with heterogeneous agents have developed in several directions and areas, including financial frictions (see for instance De Graeve et al. 2010), search and matching frictions for the labour market, strategic interactions for firms, and also attempts to "bridge the gap" between Agent-based models and DSGE (see for instance Salle, Yıldızoğlu, and Sénégas 2013). Finally, the "better microfoundations" line of work identified by Vines and Wills (2018) essentially tackles the ad hocness of rigidities in the baseline DSGE model and calls for integrating other microeconomic approaches to these questions (for instance by replacing Calvo-pricing with state-dependent pricing).

Despite a substantial amount of work engaging with these four lines of development, it is widely acknowledged that no "new core DSGE model" has emerged yet. As for DSGE models in use in policy-making institutions, these recent developments have been integrated to different extents (see *infra*, 2.2).

As the theoretical framework was changing—and it is still changing—the self-produced narratives used by macroeconomists are changing.[8] However, in our analysis below, we consider technical reports over a period (2003–2017) for which no significant change in the narrative occurred.

[6] For an early survey of these issues, see Tovar (2008). It should be noted that indeed most of these developments had started even *before* the 2008 crisis (as stressed by Christiano, Motto, and Rostagno 2008). However, it seems fair to say that since 2008 the DSGE approach devoted a *far greater* attention to effectively develop these research areas.

[7] This line of work seems for the moment the one that has produced the most significant amount of new research. Early contributions are for instance Christiano, Motto, and Rostagno (2003, 2008), Castelnuovo and Nistico (2010), Iacoviello and Neri (2010), and Boissay, Collard, and Smets (2013).

[8] A typical illustration of such a change is the evolution of Blanchard's views, as analysed by Brancaccio and Saraceno (2017).

2.2. DSGE models in policy-making institutions

Few years after the publishing of the seminal contributions by Smets and Wouters (2003), Woodford (2003) and Christiano, Eichenbaum, and Evans (2005), DSGE models became extremely popular in academia—i.e. across universities and other research institutions—as indicated, for instance, by the increasing number of articles published in peer-review journals (Dammski et al. 2018). The outgrowth of DSGE models in academia *coincided* with the proliferation of DSGE models in policy-making institutions.[9] DSGE models became a new, crucial tool for informing policy decisions, in particular through the production of "scenarios" for policy analysis (especially for monetary policy and structural policies, and only later for fiscal policy; see Coenen et al. 2012) and, in some institutions, for producing the baseline scenario forecasting the future evolution of the economy.[10]

Table 1 above provides an overview (non-exhaustive) of the spread of DSGE models in policy-making institutions before 2008. The European Central Bank (ECB) and the IMF played a pioneering role in developing DSGE models for policy analysis and forecasting. Rapidly, the Federal Reserve Board and other Western central banks adopted DSGE models in their expertise processes; then, DSGE models also took roots in central banks in Latin America and Asia. Moreover, policy-making institutions other than central banks adopted DSGE models.[11]

The outgrowth of DSGE models in policy-making institutions came shortly after the changes in monetary policies during the "Great Moderation", when central banks listed in Table 1 switched to "inflation targeting", with nominal interest rates as monetary policy instruments (see Jahan 2012; Hammond 2015). DSGE models have been particularly fit for the purpose of accompanying this change, given their representation of the conduct and mechanism of monetary policy (see *supra*).[12]

By the end of the 2000s, DSGE models became "ubiquitous" in policy-making institutions and mobilized considerable material resources and staff, as emphasized by Olivier Blanchard (former IMF chief economist):

> 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

[9] This is also consistent with the findings by Claveau and Dion (2018), about central banks' increasing engagement with academic research starting from the end of the 1990s. As Douglas Laxton, an IMF official, put it, "Much of the success" of DSGE models in policy-making institutions "has been a result of their strong links to the academic literature" (Laxton 2008, 214).

[10] For a more comprehensive overview of the different uses of DSGE models—policy analysis ("conditional forecasting") or forecasting ("now" or "real-time" or "short term" forecasting)—see for instance the survey by Hammond (2015).

[11] It is beyond the scope of this paper to illustrate how the spread of DSGE models was actually supported by a dense network of modellers, connecting all these policy-making institutions. But cross-fertilization among policy-making institutions did play a crucial role for rise of DSGE models across the world. Modellers building ECB, Fed Board and IMF's first DSGE models were subsequently involved, directly or indirectly (consultancy, co-authoring), with the construction of DSGE models for other policy-making institutions around the world. An early example is Czech National Bank "New Model" (or "G3"), which was designed relying on the structure of IMF's GEM model, with the active support of IMF researchers (Beneš et al. 2005).

[12] For a case study see Clinton et al. (2017). Note also that some DSGE modellers claim that the DSGE approach was able to adapt to the new policy environment of the 2008 crisis, i.e. assessing and advising non-conventional monetary policy that followed the 2008 crisis (forward guidance, quantitative easing; see for instance Lindé 2018, 274–275 for a review). Christiano, Eichenbaum, and Trabandt (2018, 129–130) claim also that DSGE models can be adapted to assess fiscal policy scenarios within a zero-lower-bound-type of environment.

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, Coenen, and Warne (2008)
International Monetary Fund	GEM	2003	Bayoumi (2004)
Federal Reserve Board	SIGMA	2005	Erceg, Guerrieri, and Gust (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, Roeger, and Veld (2009)
International Monetary Fund	GFM	2006	Botman et al. (2006)
Bank of Canada	ToTEM	2006	Murchison and Rennison (2006)
Norges Bank	NEMO	2006	Brubakk et al. (2006); Brubakk and Sveen (2009)
Bank of Finland	AINO	2006	Kilponen and Ripatti (2006)
Banco de España	BEMOD	2006	Andrés, Burriel, and Estrada (2006)
Banco central de Chile	MAS	2006	Medina and Soto (2006)
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, Dellas, and Natal (2009)
French Ministry for the Economy and Finance	Omega3	2007	Carton and Guyon (2007)
European Central Bank	CMR	2007	Christiano, Motto, and Rostagno (2008)

> used to evaluate policy rules, to do conditional forecasting, or even sometimes to do actual forecasting (Blanchard 2008, 24).

Table 2 shows that the 2008 crisis did not significantly interrupt the spreading of DSGE models. New policy-making institutions adopted DSGE models, both in developed countries and in developing countries. Moreover, policy-making institutions that were already using DSGE models developed new versions. This "second generation" of DSGE models integrated some of the developments discussed above.[13]

DSGE modellers at the turn of the 2000s claimed that their models became hegemonic in policy-making and academia. As argued for instance by Varadarajan Chari (a professor at University of Minnesota and an economic advisor for the Minneapolis Fed), during his famous hearing before the U.S. Senate,[14] there was now "no other game in town" for macroeconomics than DSGE models:

> 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" (Chari 2010, 2).

The spread of DSGE over academia and policy-making institutions, as reported in Tables 1 and 2, is indeed an impressive phenomenon. However, this does not always

[13] A significant development occurred with respect to the analysis of the financial and banking sector. The ECB has been leading this process, developing and using very early a version of NAWM including a financial block (McAdam and Lombardo, 2009) and developing an alternative DSGE model focused precisely on the financial sector (the "CMR model", inspired by Christiano, Motto, and Rostagno 2008, 175). See Smets et al. (2010) for a review of these two models.

[14] These hearings were organised in 2010 by the Committee on Science and Technology to investigate "the appropriate roles and limitations of models such as DSGE models" (Broun 2010, 1). Many scholars have been already commenting on these hearings (see for instance De Vroey 2016, chap. 20).

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, Montoro, and Tuesta (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, de Castro, and Félix (2008), Almeida et al. (2013)
South Africa Reserve Bank		2008	Steinbach, Mathuloe, and Smit (2009); Du Plessis, Smit, and Steinbach (2014)
Reserve Bank of New Zeland	KITT	2009	Lees (2009)
Banco de España	MEDEA	2009	Burriel, Fernández-Villaverde, and Rubio-Ramírez (2010)
Czech Ministry of Finance	HUBERT	2009	Štork, Závacká, and Vávra (2009); Alitev, Stork, and Bobkova (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, Kiley, and Laforte (2010)
Bank of Japan	M-JEM	2010	Fueki et al. (2010)
Sedlabanki Islands		2010	Seneca (2010)
European Central Bank	EAGLE	2010	Gomes, Jacquinot, and Pisani 2010
Bank of England	COMPASS	2011	Burgess et al. (2013)
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)
Sveriges Riksbank	RAMSES II	2013	Adolfson et al. (2013)
Bank of Canada	ToTEM II	2013	Dorich et al. (2013)
International Monetary Fund	MAPMOD	2014	Benes, Kumhof, and Laxton (2014)
Swiss National Bank		2014	Rudolf and Zurlinden (2014)
NCAER (India)		2015	Banerjee and Basu 2015
Reserve Bank of New Zealand	NZSIM	2015	Kamber et al. (2015)
Norges Bank	NEMO	2017	Gerdrup et al. (2017)

imply, as claimed by Chari, that DSGE models became "the only game in town" and succeeded in marginalizing and excluding the competing practices. Actually, many policy-making institutions, while introducing DSGE models, continued using also models pertaining to other approaches—like macroeconometric models à la Klein and Goldberger (1955) and statistical-oriented models inspired from Sims (1980)s VAR approach. More recently, some key institutions stated clearly their will to rely on a "set of models" rather than on a "DSGE-only" analysis.[15] This "pluralism" in modelling practices within policy-making institutions could be explained by different factors,

[15] The ECB embraced again "old" structural macroeconometric models (such as the "multi-country" model by Dieppe, Pandiella, and Willman 2011). Also, the ECB is considering the development of alternative approaches (such as agent-based modelling) in the future, as stated by Vitor Constâncio (ECB vice-president) in his opening speech to the second annual ECB research conference (Constâncio 2017). The Bank of England also emphasizes since 2013 a "multiple models" approach, although the DSGE model COMPASS kept a central place in the toolbox for policy analysis and forecasting (Burgess et al. 2013). A similar call for the use of a "set of models" was made famously by Blanchard (2016), and then by most participants to the recent *Oxford Review for Economic Policy* symposium.

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, …). Explaining this is of course far beyond the scope of this article; conversely, the reality of a "struggle for hegemony" between DSGE models and competing modelling approaches in policy-making is key for understanding the *function* of the standard narrative.

2.3. The rhetoric role of the standard narrative

Why macroeconomists do bother in discussing (even briefly) the history of their discipline in technical reports? My claim is that the standard narrative is used in this literature as a tool (among others) for the standardization of the expertise process within policy-making institutions. The standard narrative helps in legitimising DSGE models as a rightful tool for policy analysis and forecasting, while providing a rationale for challenging or excluding competing models.[16] From this perspective, the standard narrative plays a crucial role in the "rhetoric" of the macroeconomists acting as experts or advisors in policy-making institutions. The standard narrative is a tool for persuasion in this "conversation" among macroeconomists (McCloskey 1985), but also between macroeconomists and their audience (policy-makers and other officials, politicians, laymen, the media). The interaction with a non-specialist audience is obviously of a particular importance in the case of technical reports: the credibility and legitimacy of the expertise produced using DSGE models is at stake, together with material resources and jobs devoted to the development of DSGE models within policy-making institutions.

The standard narrative consists in an articulate vision of the historical developments bringing to DSGE models: This articulate vision, and its specificities, are discussed *infra*. However, the rhetorical force of the standard narrative comes down to one bottom line: DSGE models embody "scientific progress" (an "accumulation of knowledge") and therefore they are the rightful tool for policy analysis. Let's examine some examples.

The *Bulletin de la Banque de France* is a quarterly publication from the French central bank and "an information tool for a broad readership [offering] educational insights so that all readers can form their own opinions."[17] In an article published in 2007 and devoted to the history of DSGE models, the authors started by claiming:

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

Many other DSGE modellers working in policy-making institutions follow the same line of argument about "the most advanced tool", incorporating the theoretical and

[16] Since the crisis, we should also acknowledge a rather "defensive" attitude, which tend to legitimize DSGE models while recognizing their limitations, and opening the door to some alternative approaches (see for instance Lindé 2018). This new attitude fits with the general atmosphere of a renewed "plurality of models" as described above (fn. 17).

[17] https://publications.banque-france.fr/en/liste-chronologique/banque-de-france-bulletin [retrieved on 23/04/2019]

technical advances (the "scientific progress") made by macroeconomics over the last decades. In a similar bulletin published by the Reserve Bank of New Zealand (RBNZ), the new DSGE model of the bank (named KITT, for "Kiwi Inflation-Target Technology") is presented as "advanc[ing] our modelling towards the frontier in terms of both theory and empirics." (Lees 2009, 5)

As DSGE models constitute the achievement of "scientific progress" ("the most recent theoretical and econometric developments"), hence they should be considered as the best, the most valuable approach to macroeconomics and to policy-making. In short, adopting DSGE models is simply about "being modern", as pressed by a technical report 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, the National Council of Applied Economic Research (NCAER) undertakes a research initiative to develop a DSGE model for India on an accelerated basis (Banerjee and Basu 2015, 2).[18]

If DSGE models are the "modern" approach to the analysis of macroeconomic policy, other approaches are, by contrast, "archaic" or "outdated". This rhetoric is also used by Chari during his testimony before the U.S. Senate. While considering the criticisms raised by the recent financial and economic crisis, Chari argues that putting into question DSGE models results in a foolish rejection of the "scientific progress" accomplished in the past—a view shared with Christiano, Eichenbaum, and Trabandt (2018, 135)s vision of "substantial progress" vs. "not informed criticisms". To Chari, abandoning DSGE models will be equivalent to "turn over medical research to acupuncturists" or "stop using mathematical models of oil pressure" in oil drilling (Chari 2010, 9–10). These metaphors rely on the positivistic rhetoric about engineering and medicine to qualify the current state of knowledge in macroeconomics as "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). Moreover, this rhetoric plays an important role in justifying the most suitable pattern for future developments in macroeconomics. According to the linear character of the "scientific progress", macroeconomics will keep evolving by perpetuating DSGE models and "devote substantially more resources" to them, "rather than pursuing elusive chimera dreamt up in remote corners of the profession" (*ibid.*). More recent interventions by central bank economists follow the same line of argument, although some of them adopted a rather balanced and nuanced tone.[19] For instance, Jesper Lindé (Riksbank) stated recently that "given that we have few or no alternative approaches today that are more helpful than DSGEs in daily quantitative

[18] A similar use of the adjective "modern" (as opposed to "traditional") macroeconomics could also be found in textbooks (see for instance Chugh 2015, 170).

[19] And some did not: Christiano, Eichenbaum, and Trabandt (2018) famously started with calling criticists of the DSGE approach "dilettants", then continued with arguing that most criticisms against DSGE models were "not informed criticisms", and finally concluded by restating that "There is simply no credible alternative [to DSGE models]". Note that the sentence about "dilettants" disappeared from the published version of the article.

analysis at central banks and treasuries" (Lindé 2018, 271), DSGE models should for the moment continue to play their pivotal role in policy analysis. However, Lindé also recognizes that "other models […] can be important complements and sometimes even substitutes to DSGEs, depending on the question addressed" (*ibid.*).

3. Consensus vs. revolution: Two tales of "scientific progress" for macroeconomic theory

As we have seen, self-produced narratives characterize the current state of knowledge in macroeconomics as "better" or "greater" than the past state of knowledge.[20] One illustration of this claim is Blanchard's article "What Do We Know that about Macroeconomics that Fisher and Wicksell Did Not?":

> the answer [to this question] 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).[21]

This accumulation is not only "steady", but also astonishingly rapid in moving from an early stage of knowledge ("prototypes") to an advanced stage ("complex constructions"):

> 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, Eichenbaum, and Evans 2005). It was similar to jumping from the Wright brothers to an Airbus 380 in one generation (Fernández-Villaverde 2010, 63).

This positivist enthusiasm is widespread across most *genres* of literature (articles, books, textbooks, technical reports, blogs …). As such then, it is not specific to the standard narrative about DSGE models found in technical reports. Quite conversely, the claim about "progress" belongs to an even more general (and long-standing tradition) in the history of natural sciences and in the history of economics (see for instance Samuelson 1987s call for a "whig" history of economics).[22]

[20] This seems the most complete definition of "progress" that can be found in the various self-produced narratives about macroeconomics. It is then a loose definition, almost a commonplace notion; those using it do not seem to have engaged any further with the literature discussing this topic (see for instance Lawson 1987; Backhouse 1997 or Bridel 2005).

[21] Also note the overabundant use by Blanchard of the word "progress" in his textbooks (Blanchard, Giavazzi, and Amighini 2013; Blanchard and Johnson 2013, resp. chap. 24 and chap. 25). The idea of "progress" is mentioned and discussed eight times in four pages—including the emphatic paragraph headline "Progress in all fronts" referring to the evolution of macroeconomics during the first two decades of the post-war period.

[22] Nevertheless, the use of self-produced narrative seems to enjoy a distinctive popularity in macroeconomics with respect to other sub-fields (except maybe for international trade). For instance, if we compare a sample of the most common, recent textbooks on macroeconomics (Heijdra and van der Ploeg 2002; Walsh 2003; Dornbusch, Fischer, and Startz 2007; Wickens 2012; Burda and Wyplosz 2013; Blanchard and Johnson 2013; Blanchard, Giavazzi, and Amighini 2013; Jones 2014; Chugh 2015; Mankiw 2016) with a sample of equally common textbooks on microeconomics (Varian 1992, 2009; Pindyck and Rubinfeld 2008; Ruffin and Gregory 2000; Frank 2006; Mankiw 2017), the comparison outlines the following. We can notice that, of the microeconomic textbooks, none addresses the history of microeconomics. Conversely, all most common macroeconomics textbooks address the history of macroeconomics—although the attention devoted to history is variable (from a whole chapter, as in Blanchard's textbook, to scattered remarks, as in Burda and Wyplosz 2013; Mankiw 2016). This suggests that historical narratives play a greater role in the teaching of macroeconomics. Although this is not the place for conducting an in-depth analysis of this issue, it could be argued that historical narratives could play a similar rhetorical role in technical reports and in textbooks.

However, when compared to other self-produced narratives about macroeconomics, the standard narrative found in technical reports exhibits three distinctive characteristics: first, it builds a specific chronology or lineage for contemporary DSGE models, consisting in five steps or stages (3.1); second, it interprets specifically "progress" through these stages as consisting in building "microfoundations" *that enhanced policy analysis* (3.2); finally, conversely to other *genres*, technical reports consistently emphasizes "scientific consensus" rather than "scientific revolutions" as the main driver of "scientific progress" (3.3). All of these three characteristics are consistent with the specificity of the technical reports' described in the previous section, namely the need for a persuasive rhetoric legitimizing the use of DSGE models in policy-making institutions.

3.1. A specific lineage: the five steps of "scientific progress"

As discussed previously (2.1), DSGE models are frequently characterized as a "synthesis", i.e. the combination of different theoretical and analytical frameworks. According to the standard narrative, such a synthesis results from a linear historical sequence of approaches and not from breakthroughs. The technical report about the Bank of England Quarterly Model (BEQM) starts precisely by emphasizing that the new DSGE model "does not represent a significant shift" (Harrison et al. 2005, 1)."[23] DSGE models are then the final stage of a progressive evolution, usually resumed as consisting in five steps (as for instance in Epaulard, Laffargue, and Malgrange 2008).

The first step corresponds to the rise of Keynesian macroeconometric models *à la* Klein and Goldberger (1955). For Lees (RBNZ), the DSGE model KITT is the subsequent development of a "modelling 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).

The emergence of new classical macroeconomics in the 1970s (Lucas 1972, 1976, 1975; Lucas and Prescott 1971; Sargent 1976) is the second step of "theoretical progress". Despite this approach brought radically different insights with respect to the Keynesian approach (such as rational expectations, dynamic equilibrium, representative agent …), the standard narrative does not consider this 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". The technical report about RAMSES (Riksbank Aggregate Macromodel for Studies of the Economy of Sweden) illustrates this view:

> [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).

Riksbank's modellers implicitly refer to the absence, in Keynesian models, of a systematic theoretical description of the behaviour of individuals in line with the general equilibrium framework—namely, the absence of individual optimizing behaviour. As

[23] See also De Castro et al. (2011, 6) about the "SAMBA" model (Central bank of Brazil).

this shortcoming results from a "lack of technical tools", new classical models represent a "progress" (to the extent they developed such needed tools). The way of modelling expectations constitutes an illustration of this argument. Rational expectations are considered as 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)[24]

The conceptual refinement of macroeconomic models was 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 development of Lucas (1972, 1976) work. Following for instance Avouyi-Dovi, Matheron, and Fève (2007, 44) "RBC models are the best illustration of [Lucas's] methodological recommendations". However, RBC models are also considered, in the standard narrative, as having many shortcomings, namely to ignore monetary phenomena and not tackling policy evaluation ("the pioneers of this new approach thrown the baby out with the bathwater"; Epaulard, Laffargue, and Malgrange 2008, 2).

A further step was needed: new Keynesian models in the 1980s and the early 1990s elaborated the necessary microfoundational apparatus for addressing monetary phenomena. According to the standard narrative, new Keynesian models have been a constructive amendment to RBC models, "attempt[ing] to uncover and understand other potential sources of business cycle fluctuations." (Gabriel et al. 2010, 1).[25] 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 and new classical approaches.

Finally, starting from the mid-1990s, this constructive cooperation between the two approaches has been achieved with the rise of DSGE models. 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).

The five steps of this standard narrative (Keynesian macroeconometric modelling, new Classical macroeconomics, RBC, new Keynesian economics, DSGE) constitute a distinctive lineage when compared to other self-produced narrative about macroeconomics. Keynes and the Keynesian revolution of the 1930s and 1940s, as well as the "old" neoclassical synthesis (and their key actors, such as Modigliani, Hicks, Samuelson) are left out of the standard narrative; whilst the reference to Keynes as "father of macroeconomics" and to the "old" neoclassical synthesis is a *topos* in other *genres* of literature, especially academic articles (see for instance Woodford 1999, 5)

[24] Looking at the past with a retrospective and a teleological standpoint is typical of "rational reconstruction" implied by the "whig history" (Blaug 2001). Hence, 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 also the role granted to history in macroeconomics textbooks: "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." (Jones 2014, 407)

[25] A point also raised in several textbooks, as for instance in 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."

and textbooks (see for instance Blanchard's textbooks).[26] Another surprising characteristic of the lineage established by the standard narrative is the omission of Friedman (1968)s otherwise celebrated criticism against Keynesianism and the "old" synthesis, and the resulting stream of monetarist works (see for instance Johnson 1971, Woodford 1999, 14, or, more recently, Christiano, Eichenbaum, and Trabandt 2018, 115). Finally, the standard narrative ignores other strains of macroeconomics thought these are popular in other self-produced narratives—such as disequilibrium theory (which is presented for instance in Blanchard 2000, 1386)—as well as heterodox approaches—although this is less surprisingly, as they are hardly mentioned in any self-produced narrative (an exception being Snowdon and Vane 2005).

It must be acknowledge that all self-produced narratives (and eventually all macroeconomists) tend to "cherry-pick", i.e. to include or exclude from their tale this or that figure or approach.[27] Hence, every self-produced narrative presents a distinctive lineage and the standard narrative is no exception. What deserves critical attention is to establish the *reasons* or the *rationale* beyond the choice of this specific five-step lineage: What is the teaching of such a tale?

3.2. Microfoundations as theoretical progress for policy analysis

The lineage depicted by the standard narrative relies on a very specific thread or rationale: The different historical steps contributed to the extension of the toolbox of macroeconomic modelling to new concepts and formalisms, resulting in "better *microfoundation*".[28] Obviously, most self-produced narratives—including those that are not proper to technical reports—consider the development of the Lucasian microfoundational program as the distinctive path of progression of "modern macroeconomics"—as emphasized for instance by Duarte and Lima (2012). However, technical reports display their own particular rhetoric about *why* the development of microfoundations has been so crucial: it was because they enhanced the ability of models to provide policy analysis.

First of all, microfoundations are claimed, generically, to ensure the "consistency" and the "intellectual rigour" of policy analysis. Modellers from the Swiss National Bank argue for instance that:

> 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, Dellas, and Natal 2009, 6).

[26] See also Wickens's textbook (Wickens 2012, xiii): "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."

[27] For instance, Woodford peculiarly insists on the role of Wicksell in pioneering the DSGE approach, while most other DSGE modellers (including those writing technical reports) never mention this filiation. Also, authors change their narratives: Lucas, for instance was use to trace back the origins of his approach to Hayek (Lucas 1977), then he abandoned that reference (Lucas in Snowdon and Vane 1998, 121), and, in his Nobel lecture, he granted an important role to David Hume (Lucas 1996).

[28] We could assume that an alternative rationale for the standard narrative is to focus on the history of modelling *within* policy-making institutions—this could for instance explain why Keynes itself is absent from the narrative, while macroeconometric modelling *à la* Klein and Goldberger (1955) are present. However, this assumption is weak, as most of the steps in the standard narrative (new classical macro, RBC, new Keynesian economics) do not correspond at all to modelling practices adopted in policy-making institutions.

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, Jacquinot, and Pisani 2010, 5).

Besides "consistency", technical reports put forward the idea a "rich structure" of DSGE models, i.e. a descriptions of the economic mechanisms at work. For the Bank of England, for instance, their DSGE model's main quality 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).

Even more precisely, a key feature of DSGE models is "to be able to explain the key mechanisms in the model *clearly for senior non-modeller staff and policy-makers*" (Lindé 2018, 278, author's emphasis). The technical report about NEMO (Norwegian Economy MOdel) states more clearly that such a "clear" understanding of the economics mechanisms is associated with microfoundations:

> 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).

One possible interpretation of such claims is to consider them as expressing an underlying conception of models "as laboratories" (as also suggested by Mäki 2005). This means that policy-making institutions "use [DSGE models] as laboratories for the study of business cycles and for the formulation and analysis of monetary policy." (Cuche-Curti, Dellas, and Natal 2009, 39) or that "macroeconomists conduct their experiments inside economic models" (Kocherlakota 2009, 1)—see also the substantial discussion of this issue in Christiano, Eichenbaum, and Trabandt (2018, 113–114). Microfoundations fit the comparison with experiments and laboratories as these assumptions, characterizing individual behaviour, can be seen as isolating "relationships and mechanisms" at work in the real word. Therefore, microfoundations provide a clear interpretative framework for the behaviour of the model, as well as isolation for causality similar to experimental control in field or laboratory experiments. In short, the argument of the standard narrative is that microfoundations were crucial in enhancing the ability of DSGE models to serve as laboratories for policy experiments.

A second argument qualifying the progressive character of microfoundations for policy analysis refers to the link between microfoundations and "structural" or "deep" parameters. This is closely related to the conception of models as laboratories, 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 follows of course Lucas (1976) critique about policy invariance of macroeconometric models. Technical reports follow a particular interpretation of the Lucas (1976) critique, i.e. that, in order to escape the Lucas critique, microfoundations are a sufficient condition:

> 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 underlying claim is that, for instance, parameters characterizing individual optimizing behaviour (such as elasticities of substitution) are *by definition* robust to the Lucas critique (i.e. they are by definition structural, or invariant of policy changes)—for a further discussion, see Sergi (2018).

3.3 . Consensus vs. revolution

We illustrated so far how the standard narrative describes a distinctive five-step lineage of "scientific progress", bringing to better theory (i.e. better microfoundations) for policy analysis. We will now discuss how the driving factor of that "progress" has been "consensus", i.e. a shared vision or agreement, among a majority of macroeconomists, about the "right way" of doing macroeconomics (De Vroey and Duarte 2013). "Consensus" in the standard narrative entails two more specific aspects, one theoretical and the other methodological: it is a consensus about economic mechanisms (i.e. those described by microfoundations, as discussed above), and it is a consensus about the fact that there is *only one* "right way" of doing macroeconomics.[29] The technical report about ToTEM (Terms Of Trade Economic Model, the DSGE model of the Bank of Canada) illustrates this twofold meaning of "consensus":

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

While it is quite common to refer *to DSGE models* both as a "consensus" and as a "synthesis" (De Vroey and Duarte 2013), the specificity of the standard narrative is to identify *each of the steps* paving the way up to DSGE models as a consensus and as a synthesis. Therefore, consensus is not the *outcome* of the historical progress, but its *driving force*. As we have seen *supra* (3.1), each step of the historical lineage leading to DSGE models is seen as a *constructive amendment* to the previous step. At each stage of the process, there is an agreement among macroeconomists about the relevant toolbox for model building and about which new concepts and formalisms should be added to the toolbox. Moreover, new concepts and formalisms are always *compatible*

[29] Or, as Azariadis and Kaas (2007, 14) put it, DSGE models are the "unifying platform" for macroeconomics, playing "a similar role to [the one played] by string theory in modern physics". A similar argument can also be found in a recent macroeconomics textbook by Wickens (2012, xv): "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."

one with another, and can be integrated (synthetized) into unified frameworks. Hence, everyone in the professions has been working toward a common purpose, within a common ground of objects, concepts and methods—namely, the production of "better and better" microfoundations, enhancing "better and better" policy analysis. Above, we discussed two key examples, expectations and rigidities: the introduction of rational expectations is considered as an amendment to the "primitive" way of formalizing expectations in Keynesian models; while rigidities introduced by new Keynesian economics are just adding "other sources of fluctuations" to the RBC baseline model.

The use of "consensus" as the driving factor in the development of the DSGE approach is of course in contrast with another widespread narrative in macroeconomics, which depicts the evolution of the field as the result of fierce struggles among "schools of thought" during "scientific revolutions" (and "counter-revolutions").[30] Since Lawrence Klein (1947)s idea of *The Keynesian Revolution*, macroeconomists liked indeed to refer to "revolutions": think, as a few examples, to the "monetarist counter-revolution" (Johnson 1971), to the "rational expectations revolution" (Begg 1982; Miller 1994) also labelled the "new classical (counter)revolution" (Blinder 1986). The revolution view is today still present in macroeconomics textbooks (see for instance Dornbusch, Fischer, and Startz 2007, 574). Similarly, the idea of "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*.[31] Brian Snowdon and Howard Vane's works (and especially their first, famous book *An Introduction to Competing Schools of Thought*) should also been seen as a bandwagon of this view (Snowdon, Vane, and Wynarczyk 1994; Snowdon and Vane 2005; Snowdon 2007). Similarly, many textbooks refer to competing schools of thought—see for instance Heijdra and van der Ploeg (2002, Introduction) and Chugh (2015, chap. II).

In the standard narrative, there are not such things as competing "schools of thought" and "revolutions". Firstly, because "steps" of progress (which could be associated with "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 seen as coexisting for a long period of time. Secondly, there are no revolutions because, while emerging, new "schools of thought" do not overthrow 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 and synthesis.[32]

The use of the idea of "consensus" to describe the history of macroeconomics is not in itself specific to the standard narrative found in technical reports. Self-produced

[30] As for "progress", the notions of "schools" and "revolution" are loosely defined in these narrative (see Duarte 2016).

[31] Although without 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).

[32] Of course accumulation of knowledge ("progress") can also take place through revolution, as claimed, for instance, by Rodano's in "Contemporary Controversies in Macroeconomics" (Rodano 2002, 307): "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".

narratives in other *genres* also oppose the "revolution view" and emphasize consensus. 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), while the deep truth lies in the "steady accumulation of knowledge" (*ibid.*). However, while in academic literature, as just mentioned, both rhetoric coexist (or follow each other, depending on the state of the field and on the age of the authors), in technical reports we observe a *consistent* use of the rhetoric of consensus, and the total absence of the rhetoric of revolution.[33] This makes the standard narrative a distinctive story, different from other self-produced historical accounts. A first reason for this could be obviously found both in the relatively peaceful state of the field in the 2000s, when this narrative has been produced. But a second reason seems more consistent with the function of the standard narrative in technical reports as a standardizing tool. The need for persuasion of the audience makes the narrative of "consensus" more fit to the purpose of presenting a linear improvement of macroeconomic modelling upon which the whole profession has always agreed upon.[34]

4. The exogenous technical change: Computers and Bayesian econometrics

In his 2009 "Annual Report Essay" as President of the Minneapolis Fed, Kocherlakota claimed:

> According to the media, the defining struggle of macroeconomics is between people: those who like government and those who don't.[35] 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).

Such claim illustrates 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,[36] but by innovations overcoming the earlier "conceptual and computational limitations". In such a "struggle against [the limitations of] technology", macroeconomists ("people") are all on the same side.

[33] In other *genres*, the two rhetoric sometimes even *coexist* within a same paper, as for instance in Vines and Wills (2018).

[34] In a way, the choice of the standard narrative to emphasize consensus can be seen as vindicating Woodford (1999, 2)s claim that progress in macroeconomics "is far from transparent", as "macroeconomics has been famously controversial".

[35] This also echoes Hall (1976)s much quoted "saltwater" and "freshwater" divide: "The freshwater view holds that […] government is essentially incapable of affecting the level of economic activity. The saltwater views […] thinks government policies (at least monetary policy) is capable of affecting demand."

[36] 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. As also noted by De Vroey and Duarte (2013), the "old" neoclassical synthesis was also rather an agreement about policy than theory.

A similar argument can be found in the technical report presenting the DSGE model "ToTEM" (Terms-of-Trade Economic Model, Bank of Canada):

> 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.[37] 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).[38]

Technical change is another form of accumulation of knowledge: in this case, technical knowledge in terms of methods (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. the ability of models to consistently reproduce and/or predict data. Jordi Galì and Mark Gertler, in a NBER technical report, emphasize for instance how the ability of models in "capturing data" has "remarkably" improved over the last years:

> 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. Lindé (2018, 276–277) restated recently that one of the main advantage of DSGE models is the ability to fit data and even to produce forecasts that are in line with those produced by other structural models and, most importantly, by "purely statistical" models.[39]

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 relevant 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, Eichenbaum, and Evans 2005), but some evidence exists that DSGE models may outperform less theoretically oriented forecasting models (Cuche-Curti, Dellas, and Natal 2009, 7).[40]

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

[38] In Christiano, Eichenbaum, and Trabandt (2018, 123) we also read that "technological constraints were real and binding", this time with respect to solving and estimating non-linear models.

[39] Note, however, that this assessment has been challenged many times. To take a recent example, Hendry and Muellbauer (2018, 303–308) pointed out the relatively weaker data-week performance of the Bank of England BEQM DSGE model compared to the previous "MTMM" model.

[40] Pagan (2003) expresses a similar view. Erceg, Guerrieri, and Gust (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, i.e. "data-fit" concerns).

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).[41] The competition between DSGE and VAR is indeed explicit in the "forecasting arena", as for instance in ECB technical report about the NAWM model (Christoffel, Coenen, and Warne 2008, 7; Christoffel, Philipp, Coenen, and Warne 2010), although the outcome of these comparisons is alternatively favourable to VAR or DSGE models. In more recent papers, we also observed a rhetoric about the similar forecasting failure of both approaches with respect to "predicting the crisis" (Christiano, Eichenbaum, and Trabandt 2018, 124–125; Lindé 2018, 272–273)

4.1. The five steps of technical change

This "relative" technical change also involves five steps (see again Epaulard, Laffargue, and Malgrange 2008), mirroring the five steps of "theoretical progress". The story begins 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, since, by calling into question the structural character of parameters in Keynesian models, they opened 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 correctly mimicking the data (e.g. pro-cyclical wages); some values chosen for calibrating the model were implausible (e.g. 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 were solved, first, in a theoretical way: calibrated RBC models incorporating new Keynesian features (nominal and real rigidities on wages and prices) fitted the data much better than the original RBC models. Hence, the first versions of "calibrated DSGE models" embodied 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) supported this idea:

> 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.

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

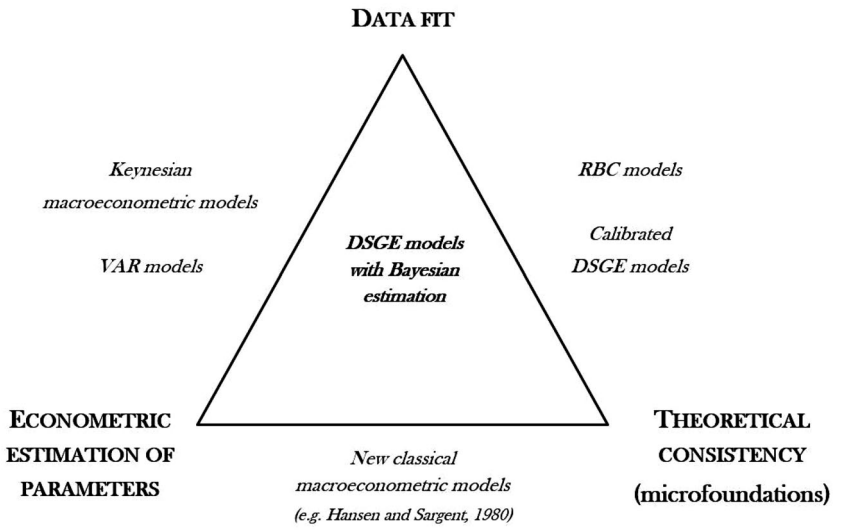

Figure 1. The (im)possible trinity of technical change.

> 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, Guerrieri, and Gust 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, Hoover, and Salyer 1997). On the one hand, the choice of the values for calibrated parameters was considered as allowing too much freedom to the modeller for choosing the "convenient" values for each parameters (i.e. those that will enhance the model data-fit). 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 was 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[42] 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).

This standard narrative on technical change can be summarized by Figure 1 below.

According to the standard narrative, technical change allows DSGE models to combine 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

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

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 by a rigorous methodology based on econometric estimation. Finally, DSGE models are the perfect compromise to this (im)possible trinity.

4.2. Bayesian econometrics and computers as exogenous technical change

The five and last step of technical change corresponds hence to the resolution of the trilemma, thanks to two factors: Bayesian econometrics and increasing 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 (for an overview of the Bayesian "toolkit" for DSGE, see Fernández-Villaverde, Rubio-Ramirez, and Schorfheide 2016). 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).[43] On the other hand, the development of computer power has been crucial to manage increasingly complex models and wide data-sets. A direct consequence of the diffusion of new computers is also the emergence of software dedicated to solving and estimating DSGE models 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 for the 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/). Note that most of the computer tools for DSGE models are open-source and open-access: this is a major turn with respect to the previous generation of macroeconometric models, which were developed under patents, sometime by private corporations (such as Wharton Econometric Forecasting Associates Inc., founded by Lawrence Klein, or Data Resources Inc., founded by Donald Marron and Otto Eckstein). The widespread use of such software made possible an easier and efficient design and

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

estimation of DSGE models, across a wider and wider audience.[44] Technical change in computer sciences has hence been crucial in this development for 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 constitute "the right set of tools", and "more reliable" than past estimation techniques (or "more effective" than older computers).

5. Conclusion: History or narrative?

The paper illustrated how the standard narrative in central banks' technical reports displays two distinctive characteristics when compared to other self-produced narratives about macroeconomics: first, it consistently emphasis consensus as the source of "theoretical progress"; secondly, it grants to technical change a predominant role. These characteristics forged a rhetorical argument to legitimize and grant credibility to the use of DSGE models within policy-making institutions—against criticisms and competing practices.

Given this rhetorical role, the standard narrative should not be seen as a "naïve" view, made-up unmindfully by amateurish historians; nor it is should be seen as a bad or wrong history of macroeconomics *per se*—it is conversely a very good narrative *given its purpose*. However, it should be emphasized how the standard narrative (and other self-produced narratives alike) are, from an historian's perspective, built on shaky foundations, displaying the typical shortcomings of amateurish history. Historical lineages are established by "cherry-picking"; concepts such as "progress" or "consensus" are loosely defined; and, overall, the narrative lacks the reserve, the rational criticism, and the emotional distance that will make a good history.

[44] Although the main audience of such a disclosure remained limited to the academic and policy-making sphere, some authors include this element in their account of the DSGE approach as fostering central banks "transparency", "openess", and "accountability" toward the general public (see e.g. Clinton et al. 2017; Christiano, Eichenbaum, and Trabandt 2018). Open-source models are also praised since they significantly decrease the cost associated with model's "housekeeping" (update, revisions, extensions) and with "transferring" the model to other users within the same institution or across institutions (see for instance Lindé 2018, 277–278).

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