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WHERE MODERN MACROECONOMICS WENT WRONG

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ABSTRACT

This paper provides a critique of the DSGE models that have come to dominate macroeconomics during the past quarter-century. It argues that at the heart of the failure were the wrong microfoundations, which failed to incorporate key aspects of economic behavior, e.g. incorporating insights from information economics and behavioral economics. Inadequate modelling of the financial sector meant they were ill-suited for predicting or responding to a financial crisis; and a reliance on representative agent models meant they were ill-suited for analysing either the role of distribution in fluctuations and crises or the consequences of fluctuations on inequality. The paper proposes alternative benchmark models that may be more useful both in understanding deep downturns and responding to them.

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I. Introduction

Dynamic Stochastic General Equilibrium (DSGE) models, which have played such an important role in modern discussions of macroeconomics, in my judgement fail to serve the functions which a well-designed macroeconomic model should perform. The most important challenge facing any macro-model is to provide insights into the deep downturns that have occurred repeatedly and what should be done in response. It would, of course, be even better if we had models that could predict these crises. From a social perspective, whether the economy grows next year at 3.1 percent or 3.2 percent makes little difference. But crises, when GDP falls and unemployment increases significantly, have large consequences for individual well-being now, as well as for future growth. In particular, it is now well recognized that periods of extended economic weakness such as confronted by the US and Europe after 2008 have significant implications for future potential growth.[1,2]

While the 2008 crisis, and the inability of the DSGE model to predict that crisis or to provide policy guidance on how to deal with the consequences, precipitated current dissatisfaction with the model, the failings are deeper: the DSGE model fails similarly in the context of other deep downturns.

The DSGE models fail in explaining these major downturns, including the source of the perturbation in the economy which gives rise to them; why shocks, which the system (in these models) should have been able to absorb, get amplified with such serious consequences; and why they persist, i.e. why the economy does not quickly return to full employment, as one would expect to occur in an *equilibrium* model. These are not minor failings, but rather go to the root of the deficiencies in the model.[3]

What we seek from "benchmark model" in macroeconomics is not always clear. Vines (written correspondence) suggests that we should be looking for a *simple* model which we could teach to graduate students to provide them with a less misleading framework on which to build whatever research project they are engaged with.

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[1] This implies that macro-econometrics should use a Bayesian loss function with a high weight in explaining/predicting deep downturns. This is markedly different from assessing models by looking at how well they match particular co-variances or moments. Practitioners of DSGE macro-econometrics claim to use Bayesian estimation approaches, by which they mean they include priors (e.g. concerning the values of certain parameters). I emphasize here another aspect: a loss function which puts high weight on being able to predict the events we care about. In terms of priors, the following discussion make clear that I find some of the priors embedded in the standard model less than persuasive.

[2] DSGE models are, of course, not really a model of medium- to long-term growth: that is determined by factors like the pace of innovation and the accumulation of human capital on which they provide little insight. To understand the former, for instance, one needs a much more detailed analysis of technological progress, including investments in basic research and the transmission of knowledge across and within firms, than any standard macro-model can provide.

[3] There are a myriad of versions of the DSGE model, and some versions may have attempted to address one or the other of the concerns I raise. I cannot in the confines of this short article explain why the purported remedies do not adequately address the problems.

Blanchard (2017) suggests:

> The models should capture what we believe are the macro-essential characteristics of the behavior of firms and people, and not try to capture all relevant dynamics. Only then can they serve their purpose, remain simple enough, and provide a platform for theoretical discussions.

Thus, a distinction is often made between the core DSGE model as a benchmark model and the variety of expanded models, which introduces a large number of complexities—more shocks than just technology shocks; and more frictions than just nominal wage and price rigidities.[4] To be sure, as many users of DSGE models have become aware of one or more of the weaknesses of these models, they have "broadened" the model, typically in an *ad hoc* manner.[5] There has ensued a Ptolemaic attempt to incorporate some feature or another that seems important that had previously been left out of the model. The result is that the models lose whatever elegance they might have had and claims that they are based on solid microfoundations are weakened,[6] as is confidence in the analyses of policies relying on them. The resulting complexity often makes it even more difficult to interpret what is really going on.

And with so many parameters, macro-econometrics becomes little more than an exercise in curve fitting, with an arbitrarily chosen set of moments generated by the model contrasted with reality. Standard statistical standards are shunted aside. Korinek (2017) provides a devastating critique:

> First, the time series employed are typically detrended using methods such as the HP filter to focus the analysis on stationary fluctuations at business cycle frequencies. Although this is useful in some applications, it risks throwing the baby out with the bathwater as many important macroeconomic phenomena are non-stationary or occur at lower frequencies. An example of particular relevance in recent years are the growth effects of financial crises.
>
> Second, for given detrended time series, the set of moments chosen to evaluate the model and compare it to the data is largely arbitrary—there is no strong scientific basis for one particular set of moments over another. The macro profession has developed certain conventions, focusing largely on second moments, i.e. variances and

[4] See Smets and Wouters (2003). They introduce a total of ten "shocks"—"two 'supply' shocks, a productivity and a labor supply shock, (…) three 'demand' shocks (a preference shock, a shock to the investment adjustment cost function, and a government consumption shock), three 'cost-push' shocks ((…) to the mark-up in the goods and labor markets and (…) to the required risk premium on capital) and two 'monetary policy' shocks"—and multiple frictions, including "external habit formation in consumption," a "cost of adjusting the capital stock," and "partial indexation of the prices and wages that cannot be re-optimised."

[5] Thus, the Smets–Wouters model introduces individual heterogeneity, but everyone has the same preferences, there are no capitalists or workers, and accordingly no differences in marginal propensities to consume. In this context, redistributions have no effect on aggregate demand. Below, we argue that redistributions may matter.

[6] A claim that is already stretched when it comes to the use of an aggregate production function (see below) and the derivation of the demand for money. There are, of course, assumptions that *seem* to provide microfoundations, e.g. the derivation of the demand for money based on the assumption that there is a "cash in advance" requirement. But credit, not cash, or money as it is usually defined, is typically required. See Greenwald and Stiglitz (2003). Many models embrace a "cop-out," putting money into the utility function. Later, I will explain why one cannot rely for policy analyses on results derived from these "toy" models, or models embracing such *ad hoc* assumptions.

> covariances. However, this is problematic for some of the most important macroeconomic events, such as financial crises, which are not well captured by second moments. Financial crises are rare tail events that introduce a lot of skewness and fat tails into time series. As a result, a good model of financial crises may well distinguish itself by not matching the traditional second moments used to evaluate regular business cycle models, which are driven by a different set of shocks. In such instances, the criterion of matching traditional moments may even be a dangerous guide for how useful a model is for the real world. For example, matching the variance of output during the 2000s does not generally imply that a model is a good description of output dynamics over the decade.
>
> Third, for a given set of moments, there is no well-defined statistic to measure the goodness of fit of a DSGE model or to establish what constitutes an improvement in such a framework. Whether the moments generated by the model satisfactorily match the moments observed in the real world is often determined by an eyeball comparison and is largely at the discretion of the reader. The scientific rigor of this method is questionable.
>
> Fourth, [DSGE models] frequently impose a number of restrictions that are in direct conflict with micro evidence. If a model has been rejected along some dimensions, then a statistic that measures the goodness-of-fit along other dimensions is meaningless.

Korinek's conclusion, that "the scientific rigor" of this methodology is "questionable," must be considered an understatement.[7]

Sometimes, too, a distinction is made between a "policy model," giving practical advice on what to do in different circumstances, and a model with sound theoretical underpinnings. Thus, the standard Keynesian model might (it could be argued) be good enough for telling us whether and how to stimulate the economy, but the fact that its underlying equations are not microfounded makes it theoretically unacceptable; for good theory, we have to turn to DSGE models. These distinctions are, I think, wrong on two accounts. First, as I explain below, I believe the core DSGE models is not good theory: good theory is based on how firms and households actually behave and markets actually work.[8] If credit availability is more important than interest rates, then a model which assumes that there is no credit rationing is bad theory. In the crisis, banks couldn't get access to funds; they were liquidity constrained. Such constraints are not consistent with the underlying

[7] I should emphasize: empirical tests should not be limited to standard statistics. On average, black holes don't exist. They are rare events, but their existence plays a crucial role in confirming the theory. They would not be uncovered through a standard regression. A single experiment (observation) was enough to largely confirm Einstein's relativity theory.

[8] Thus, what is sometimes meant by providing microfoundations is providing foundations based on a particular model of human behavior, rational individuals with perfect information operating in competitive markets, a model which has been widely discredited. Note that in the "microfoundation fundamentalist" view, an analysis of a giraffe's behavior could not include the *assumption* that it had a long neck, because we cannot explain either why it has a long neck or how it can survive, given that it has a long neck (assuming that standard models of circulatory systems could not explain how blood could be pumped that high).

DSGE model. And second, the reason for having a model derived with microfoundations is that a policy change *could* change certain aspects of previously observed reduced form relationships. One has to have a theory to ascertain whether it would. Good policy requires an understanding of the underlying determinants of behavior.

So too, *short-term* policy involves short-term forecasting. As Chairman of the Council of Economic Advisers—established by the US Congress to help ensure that the economy remain at full employment through appropriate macroeconomic interventions—under President Clinton, I had the responsibility for overseeing our forecasts, which were also used in budgetary projections. Though it was before the development of the current generation of DSGE models, many of the considerations upon which we focused are excluded from the standard models. We were, for instance, concerned with changes in expectations. But analyses of expectations were (correctly, in my view) not based on what those might be if it were assumed that individuals had rational expectations, or acted as if they did, but on survey data of what expectations are and have been.[9]

So too, we were concerned with changes in consumption. The determination of consumption is, clearly, a key aspect of any good macro-model. But it is clear that in the short to medium term, the shifts in household savings rates are little related to the considerations on which the intertemporal utility maximization of a representative agent focuses. That model cannot provide accurate predictions of such changes, identifying either shifts in preferences or technology, or even of expectations (especially if those are supposed to be "rational") that give rise to changes in consumption.[10]

Nor has the DSGE model been useful for policy design, e.g. the best way to "deliver" a tax cut. Behavioral economics has provided, I believe, a persuasive case that savings behavior is subject to nudges, in ways that are inconsistent with the standard model.[11] Importantly, differences in responses to the US tax cuts of 2008 and 2009 have more to do with behavioral economics than the determinants of savings behavior incorporated into DSGE models.[12]

But DSGE models seem to take it as a religious tenet that consumption should be explained by a model of a representative agent maximizing his utility over an infinite lifetime *without* borrowing constraints.[13] Doing so is called *microfounding* the model. But economics is a behavioral science.

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[9] Moreover, these surveys show that different groups in the population have distinctly different beliefs (expectations), inconsistent with assumptions of rational expectations and common knowledge. See, for example, Jonung (1981), Jonung and Laidler (1988), and Bruine de Bruin *et al.* (2010).

[10] Of course, *ex post*, one can sometimes interpret changes in consumption *as if* there were a change in intertemporal preferences. The theory of consumer behavior is meaningful, however, only if preferences are stable or change in predictable ways.

[11] See Camerer *et al*. (2011) and the discussion of behavioral economics and savings in the context of macroeconomics. There is ample evidence that individuals' retirement savings cannot be explained within the standard model. See Hamermesh (1984) and Banks *et al*. (1998).

[12] See Parker *et al*. (2013).

[13] The fact that these constraints markedly change savings behavior has been long recognized. See, for example, Newbery and Stiglitz (1982). Deaton (1991), Aiyagari (1994), and Carroll (1992, 1997, 2001) provide empirical support. A major criticism of standard DSGE models provided by Hendry and Muellbauer (2018) is that they ignore these constraints and assume "cash and other liquid assets, stock market and pension wealth minus household debt, and housing wealth as equally spendable."

If Keynes was right that individuals saved a constant fraction of their income, an aggregate model based on that assumption *is* microfounded. Of course, the economy consists of individuals who are different, but all of whom have a finite life and most of whom are credit constrained, and who do adjust their consumption behavior, if slowly, in response to changes in their economic environment. Thus, we also know that individuals do not save a constant fraction of their income, come what may. So *both* stories, the DSGE and the old-fashioned Keynesian, are simplifications. When they are incorporated into a simple macro-model, one is saying the economy acts *as if* . . . And then the question is, which provides a better description; a better set of prescriptions; and a better basis for future elaboration of the model. The answer is not obvious. The criticism of DSGE is thus not that it involves simplification: all models do. It is that it has made the wrong modelling choices, choosing complexity in areas where the core story of macroeconomic fluctuations could be told using simpler hypotheses, but simplifying in areas where much of the macroeconomic action takes place.

The complexities of the DSGE model require drastic simplifications: to analyze the model, strong parameterizations are required. We know that the parameterizations used in the DSGE models (e.g. constant elasticity utility functions[14]) yield predictions that can easily be rejected (e.g. all individuals have exactly the same portfolio of risky assets, and homothetic preferences—unitary income elasticities for all goods and unitary wealth elasticities for all assets[15]). To make matters worse, even with all the implausible parameterizations, the large DSGE models that account for some of the more realistic features of the macroeconomy are typically "solved" only for linear approximations and small shocks—precluding the big shocks that take us far away from the domain over which the linear approximation has validity.[16]

II. The core of the failing: the wrong microfoundations

The core of the failings of the DSGE model can be traced to the attempt, decades ago, to reconcile macroeconomics with microeconomics. There were two approaches. The first was taken by real business cycle (RBC) theory and its descendant, DSGE, which attempted to reformulate macroeconomics by taking the microfoundations of a simplified version of the competitive equilibrium model—just as that model was being discredited by advances in behavioral economics, game theory, and the economics of information. That strand attempted to explain

[14] It is never made clear why we should feel better about a model that assumes a constant elasticity of marginal utility than a model that assumes a constant savings rate.

[15] This is true if there is more than one good or more than one asset—and clearly, "good theory" has to be consistent with that being the case. See Stiglitz (1969). Our toy models shouldn't break down when we move from one good to two goods. See the discussion below.

[16] More recently, techniques have been developed for solving DSGE models with non-linearities. Though some of the models incorporate some of the features that we argue here should be included in any good macro-model, they still leave out many crucial features, make many unreasonable parameterizations, and test their models using unsatisfactory methodologies, as described elsewhere in this paper. For a survey of the advances in non-linear methodologies, see Fernandez-Villaverde and Levintal (2017), and the references cited there.

unemployment and other deviations from predictions of the standard competitive model by looking for the minimal change in that model—assuming (typically nominal) price and wage rigidities.

The second strand (see, for example, Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Greenwald and Stiglitz, 1987*a*,*b*, 1988*a*,*b*, 1993*a*,*b*, 2003) and the references cited there), only entering into the mainstream in the aftermath of the Great Recession, attempted to bring together *modern* micro with macro, incorporating one or more of the ways in which actual markets are far from perfect ("market failures")—besides the possibility of nominal wage and price rigidities, and to which they gave a different interpretation and explanation.[17] In doing so, this strand resurrected the thinking of Irving Fisher (1933), who promulgated a quite different version of macropdynamics than the Hicksian interpretation of Keynes based on wage and price rigidity. Fisher emphasized the consequences of flexibility and debt-deflation. The departures from the standard competitive equilibrium model which play a critical role in these models include incomplete contracts and capital market imperfections, including those associated with imperfect information, incomplete risk markets,[18] and market irrationalities. (Minsky (1986) was particularly influential in the latter.) It is perhaps worth noting that policy-makers in recent downturns—in Japan, Europe, and even the US—have been focused on deflation, on the possibility that prices might fall, not on price rigidities.[19]

In the discussion below, I illustrate the inadequacies of the DSGE framework by focusing on the 2008 crisis. Some advocates of DSGE models say these models were not meant to address "once-in-a-hundred-year floods." There are several responses to this defence. The first is by way of analogy: What would one think of a medical doctor who, when a patient comes with a serious disease, responded by saying, "I am sorry, but I only deal with colds"?

The second is that not only did the model fail to predict the crisis; it effectively said that it could not happen. Under the core hypotheses (rational expectation, exogenous shocks), a crisis of that form and magnitude simply could not occur.

Crises bring out into the open deficiencies in the model that are not so apparent in our smaller and more frequent fluctuations. I believe that most of the core constituents of the DSGE model are flawed—sufficiently badly flawed that they do not provide even a good starting point for constructing a good macroeconomic model. These include (*a*) the theory of consumption; (*b*) the theory of expectations—rational expectations and common knowledge; (*c*) the theory of investment; (*d*) the use of the representative agent model (and the simple extensions to incorporate heterogeneity that so far have found favour in the literature): distribution matters; (*e*) the theory of

[17] Indeed, information economics had identified the possibility of real rigidities—in competitive equilibrium, real wages and interest rates could be set at levels at which markets do not clear. Risk aversion and instrument uncertainty provide an explanation for slow adjustments. See Greenwald and Stiglitz (1989). More recently, Fajgelbaum *et al.* (2017) have provided a simple general model in which information flows more slowly during recessions, and so uncertainty is higher and persists.

[18] The contrast with the Smets–Wouters (2003) model is clear: they assume a complete set of state-contingent securities insuring households against variations in their income.

[19] Greenwald and Stiglitz show that there will be real consequences to unexpected *disinflation*, including through real balance effects. They show that this will be so, whether the resulting redistributive effects are between bank lenders and firms or among firms.

financial markets and money; (*f*) aggregation—excessive aggregation hides much that is of first order macroeconomic significance; (*g*) shocks—the sources of perturbation to the economy; and (*h*) the theory of adjustment to shocks—including hypotheses about the speed of and mechanism for adjustment to equilibrium or about out-of-quilibrium behavior. I cannot review in detail all of these and other failings—such as the failure to include crucial institutional details—in this brief note, and so I am selective, highlighting a few as examples of more general problems. Many of these are related. For instance, the presence of imperfect and asymmetric information leads to credit and equity rationing. Thus, individuals in maximizing their lifetime utility have to take into account credit constraints and, as we have already noted, this gives rise to a markedly different problem than that analysed in the standard DSGE model. One of the reasons that the representative agent model doesn't work well is that some individuals are credit constrained, others are not. Moreover, numerous studies (see, for example, Kim *et al*. (2014); Mian and Suffi (2015); Drehmann *et al*. (2017)) have emphasized the importance of debt for aggregative behavior; but in a representative agent model, debt (held domestically) nets out, and therefore should have no role.[20] At least at times, short-run to medium-term macroeconomic analysis needs to pay careful attention to debt and real debt-dynamics. And here, institutional details can matter. The shift from 30-year fixed-rate mortgages to variable rate mortgages with shorter terms played an important role in the crisis, especially when combined with expectations that were not fully rational and credit constraints: when house prices didn't increase as expected (and it should have been clear that they couldn't increase forever at those rates) and homeowners faced constraints in refinancing, the bubble broke, and the crisis ensued.[21]

As I noted earlier, my approach and that of DSGE models begin with the same starting point: the competitive equilibrium model of Arrow and Debreu. It is clear that that model cannot explain many aspects of the economy, *including* macroeconomic fluctuations. DSGE models begin with the question, What is the minimum deviation from that model required to match macroeconomic behavior *interpreted largely as matching moments*? Their first answer was price and wage rigidities, with unanticipated and not fully insured technology shocks. When that failed to do an adequate job, they added multiple shocks and distortions, in a fairly *ad hoc* way. Standards for what was meant by "microfounding" were similarly *ad hoc*: putting money into a utility function "explains" money holdings, but tells us nothing about what happens if, for instance, credit availability changes or the probability distribution of monetary emissions changes as a result of a change in monetary policy.[22]

[20] The introduction of corporations, with corporate debt owed to households (discussed later), does not address the issues raised here, focusing on *household debt.*

[21] This part of the story of the 2008 crisis is now well accepted. See Stiglitz (2010*b*,*c*) and Financial Crisis Inquiry Commission (2011).

[22] The former might affect the transactions demand for money (credit, not money, is used in most transactions, as noted by Greenwald and Stiglitz (2003)); the latter affects the demand for money as a store of value. See, for example, Tobin (1958), the critique of the portfolio separation theorem (Cass and Stiglitz, 1970), and the implications for monetary and macro-theory (Stiglitz, forthcoming).

III. Explaining deep downturns

The approach that I am advocating begins by ascertaining which of the advances in modern microeconomics are most relevant for understanding the fundamental questions of macroeconomic fluctuations: the source of the shocks; amplification—why seemingly small or moderate shocks can have such large effects on macroeconomic variables and individual well-being; and persistence—why the effects of the shocks persist, with say high levels of unemployment long after the initial shock. The interpretation of these deep downturns should translate into policy, explaining, for instance, why government expenditure multipliers may be quite large (consistent with the earlier amplification analysis) and why monetary policy may be relatively ineffective. In this analysis, information imperfections and asymmetries and behavioral economics often play a central role, as do institutions and distributional effects. As I argue below, for instance, the ineffectiveness of monetary policy is not really attributable to the zero lower bound but to the behavior of banks, the central institution in providing credit to all but the largest firms.[23]

Because the 2008 crisis was a *financial* crisis, the standard DSGE models are particularly poorly designed to analyze its origins and evolution: The central problems of finance—bankruptcy, debt, and asymmetric information—simply cannot arise in a representative agent model.[24] Who is supposed to lend to whom? And only if the representative agent is suffering from acute schizophrenia can there be issues of information asymmetries, and it is hard to reconcile such schizophrenia with the usual assumptions concerning rationality.

Some DSGE models (e.g. Smets and Wouters, 2003) try to introduce rudimentary finance through having a corporate and a household sector. But the 2008 crisis can't be explained within that model: it was some households borrowing from others that gave rise to the crisis. Besides, with a representative agent, with or without firms, finance would always be provided in the form of equity—so there still wouldn't be bankruptcies and debt crises.[25]

(i) The shocks

[23] My argument corresponds closely to that of Hendry and Muellbauer (2018), who note that "A major problem with the claim of 'theory consistency' is the question of 'which theory?' For example, text-book theory, which assumes efficient and close-to-complete markets, well-informed relatively homogeneous agents, little uncertainty, no credit or liquidity constraints, and a stable economy, contrasts with theory that takes account of the asymmetric information revolution of the 1970s and early 1980s associated with Nobel prize winners Stiglitz, Akerlof, and Spence. Relevant theory must incorporate credit and liquidity constraints, incomplete markets with incomplete insurance and high levels of individual and macro uncertainty.'

[24] The Congressional inquiry into the 2008 crisis called itself the Financial Crisis Inquiry Commission and focused on aspects of the financial sector like credit rating agencies and the role of credit default swaps (CDSs), derivatives, and other complex financial instruments. The standard DSGE models have nothing to say about either of these: these are failings related to its inadequate treatment of the financial sector.

[25] There are further criticisms of their particular formulation: with a corporate sector, wealth would have to include the capitalized value of future dividends (they ignore this aspect of wealth). Recent research in macroeconomics has focused on variations in the value of corporations relative to the value of their capital goods, as a result of changes, e.g. in tax laws and market power. See, for instance, Gonzales (2016), Gonzales and Trivin (2017), and Stiglitz (2015, 2016*b*).

The critique of the DSGE models' relevance for deep downturns in general and the 2008 crisis in particular begins with the source of the crisis itself. For instance, in (most) DSGE models, downturns are caused by an exogenous technology shock. In agriculture, we know what a negative technology shock means—bad weather or a plague of locusts. But what does that mean in a modern industrial economy—an epidemic of some disease that resulted in a loss of collective knowledge of how to produce?[26]

By contrast the shocks giving rise to economic fluctuations in many, if not most cases, is clearly endogenous.[27] The 2008 shock was endogenous, caused by the breaking of the housing bubble—something that markets created, and to which misguided policies may have contributed.[28] And to the extent that there are exogenous shocks, the extent to which firms and households are exposed to those shocks is endogenous, affected by the structure of the market.

(ii) Finance: preventing excessive risks and designing stable systems

The main problem in crisis prevention today centers around preventing the financial sector from undertaking excessive risks and ensuring the stability of the financial system. Policy-makers recognize that some of the most important shocks to the economy can come from the financial sector.

In standard models, the money demand equation is supposed to summarize all that is relevant for finance; and, indeed, not even that is very relevant—all that matters is that somehow the central bank is able to control the interest rate.[29] But the interest rate for T-bills is not the interest rate confronting households and firms; the spread between the two is a critical *endogenous* variable.[30] While large firms may turn to capital markets, small and medium-sized enterprises (SMEs) rely on the banking system. Under current arrangements, the links between aggregate credit creation and the levers controlled by the regulatory authorities, including the central bank, are tenuous and

[26] Conceptually, there can be a shock to (beliefs about) the total supply of a critical natural resource—with a belief that, for instance, there was a large supply of oil underneath Saudi Arabia being disproved. While the oil crises of the 1970s were a result of an oil shock, it was politics, not a technology shock of the kind incorporated in DSGE models.
[27] For example, inventory fluctuations. Later, we note that the economy is best described as adjusting to shocks through a decentralized process of wage and price adjustments. Such adjustment processes themselves may give rise to economic fluctuations. See, for example, Stiglitz (2016*a*). The one exception to the view just expressed, that shocks are endogenous, relates to open emerging economies, where there is some evidence that many, if not most, come from abroad. But here, too, the DSGE models fail. The economy's exposure to exogenous risks is endogenous. The "rules of engagement," e.g. the rules governing capital market liberalization, determine the extent to which a country is affected by shocks occurring elsewhere. See Ocampo and Stiglitz (2008) and Stiglitz (2010*a*,*b*).
[28] See, for example, Bernanke (2009), Demyanyk and Von Hemert (2009), Sowell (2009), and Mian and Sufi (2015).
[29] This hypothesis can be directly tested, and rejected. See Fama (2013).
[30] This is one of the central points in Greenwald and Stiglitz (2003), who develop a simple model of banking in which the spread is determined. The importance of this spread has been noted in other papers in this issue. See, for example, Vines and Willis (2018). Gilchrist and Zakrajšek (2012) show that the spread has a predictive power on economic activity.

variable. Among the most important levers are regulations that have typically not been included within the ambit of macroeconomic analysis.[31]

Moreover, finance and the structure of the financial system matter for stability. Understanding the structures that are most conducive to stability, and the central trade-offs (e.g. between the ability to withstand small and large shocks) represents one of the areas of important advances since the crisis.[32] These were questions not even posed within the DSGE framework—they could not be posed because they do not arise in the absence of a well-specified financial sector, and would not arise within a model with a representative financial institution.

One of the key reasons that representative agent models fail in enhancing understanding of macro-fluctuations is the pervasiveness of macroeconomic externalities—the actions of each agent (in the aggregate) have macroeconomic consequences which they do not take into account. These externalities help us understand why markets on their own may be excessively fragile and excessively exposed to risks. Such macroeconomic externalities do not arise in RBC models, and only to a limited extent in standard DSGE models. In the presence of incomplete risk markets and imperfect and asymmetric information, pecuniary externalities matter, and the market equilibrium is in general not Pareto efficient (Greenwald and Stiglitz, 1986; Geanakoplos and Polemarchakis, 1986). Corporations may, for instance, undertake excessive debt (in open economies, excessive dollar-denominated debt), implying that in a downturn there may be fire sales, with the resulting decrease in prices having balance sheet effects, amplifying the downturn (see the next section).[33] Banks engage in contracts with each other that may be individually rational, but result in greater systemic risk, particularly in the face of a large shock.[34] RBC models are structured so that these macroeconomic externalities don't arise, and so markets are always efficient, even in their response to shocks; and in the new Keynesian models with rigid wages and prices that are their successors, they arise only to a limited extent.[35] By contrast, they are at the center of the alternative models for which we are arguing in this paper, and help explain the significant deviations from efficient outcomes.

[31] And again, these levers are typically left out of the standard DSGE model, even though they may be far more effective. The point is simple: if banks are constrained in their lending by capital adequacy or liquidity constraints, changes in those constraints can have large effects, far greater than those generated by the "substitution effects" that arise as returns to T-bills and loans changes. See Greenwald and Stiglitz (2003). Changes in these rules were part of the policy strategy that helped the economy emerge from the 1991–2 recession (Stiglitz, 2003).

[32] While some work had begun in this area before the crisis (see Allen and Gale (2000), Greenwald and Stiglitz (2003), and Gallegati *et al*. (2008)), the crisis itself provided enormous impetus to research in this area: see Allen *et al*. (2010), Roitman *et al*. (2010), Stiglitz (2010*a*,*d*), Gai and Kapadia (2010), Battiston *et al*. (2012*a*), Acemoğlu *et al*. (2016), Haldane (2009), Haldane and May (2011), and Battiston *et al*. (2016). Complexity in financial structures may make it even impossible to ascertain whether a system is systemically stable. See Roukny *et al*. (2017). So too, additional financial instruments can lead to greater economic instability (Brock *et al.* 2008, Caccioli *et al.* 2009), partly because these financial instruments create new betting opportunities, which enhance volatility (Guzman and Stiglitz 2016a, b).

[33] See Korinek (2010, 2011*a*,*b*, 2012), Jeanne and Korinek (2010), and Davila and Korinek (2017). Shleifer and Vishny (2011) provide a partial review of firesale models.

[34] See, for instance, ch. 7 of Greenwald and Stiglitz (2003).

[35] See Farhi and Werning (2016).

In the standard model, issues of systemic risk simply do not arise. The focus was on inflation, as if excessive inflation was the major threat to economic stability. That has not been the case for a third of a century; but the problems posed by financial instability have been recurrent.

One particularly important implication of the kind of models for which I am arguing here, in contrast to the standard DSGE models, is that in the presence of bankruptcy costs, excessive diversification (capital market integration) may result in shocks being amplified, rather than dampened and dissipated—as assumed by the Federal Reserve and predicted by the standard models.[36] Indeed, policy discourse based on assumptions underlying DSGE models had a kind of incoherence: before a crisis, the conventional wisdom called for diversification—as much as possible, e.g. through securitization and financial linkages/risk sharing. After the onset of a crisis, discourse turned to contagion. The word itself, borrowed from epidemiology, suggest the opposite of diversification: were 100 individuals with Ebola to arrive in New York, no one would recommend a policy of diversification, sending two to each state. Contagion arises *because* of such linkages. Unless one has succeeded in eliminating the prospect of future crises, the design of an economic system has to take into account the functioning of the system both before and after a crisis, balancing the benefits of linkages before and the costs afterwards. The conventional wisdom never did that. This is not a minor failing, but a major one.

(iii) Amplification and persistence

Beyond explaining the origins of shocks and the extent to which economies get exposed to shocks, an adequate macro-model needs to explain how even a moderate shock has large macroeconomic consequences. One of the key failures in the 2008 crisis was the prediction that even a large sub-prime crisis would not have large economic consequences because the risks had been diversified. Within the DSGE frame that was being used at the time by key policy-makers, this was a natural conclusion. Other models, however, had predicted otherwise, focusing on important amplifiers within the economy—and, indeed, some of these became part of the standard "explanations" of the crisis.

One source of amplification is "balance sheet effects," the contraction in production and investment that arises when firms suffer a shock to their balance sheets. Providing microfoundations for balance sheet effects requires an analysis of why firms can't replace the lost equity with new equity, i.e. an explanation of equity rationing (see, for example, Greenwald *et al*. (1984)). Modern information-based finance provides such a theory, and these ideas have already been integrated into simple theoretical and applied macro-models, in models in which firms' supply and demand decisions are a function of their balance sheets (see Greenwald and Stiglitz

[36] See, for instance, Bernanke's remarks concerning the risk posed by the collapse of the sub-prime market (see Bernanke, 2009). Bankruptcy costs introduce a non-convexity in the analysis—suggesting a fundamental way in which the mathematics of DSGE models would have to be altered. Recent models with financial linkages and bankruptcy costs have shown that dense networks, with many linkages, while better able to handle small and uncorrelated shocks, perform more poorly in response to large shocks. For analyses of optimal diversification, see, for example, Stiglitz (2010*a*,*d*) and Battiston *et al*. (2012*a*,*b*).

(1993*b*) and Koo (2008)).[37] Greenwald and Stiglitz show, for instance, how a price shock (resulting from, say, a shock to demand for the product) gets amplified through the firm's subsequent decisions on how much to produce, how much labor to hire, and how much to invest.

The effects are amplified still further if there is credit rationing. Not only is there a well-developed theory of credit rationing (e.g. Stiglitz and Weiss, 1981), Calomiris and Hubbard (1989) among others have shown that these constraints are binding in important sectors of the economy, and it appears that they are particularly relevant in those sectors subject to large fluctuations in investment. This played out strongly in the evolution of the 2008 crisis where, by 2010, large firms seemed to be sitting on a couple of trillion dollars of cash, while SMEs remained credit constrained.

At the center of the modern theory of credit rationing, as observed at the macro level, are banks—a critical institution which was missing from DSGE models. This was a particularly peculiar omission because, without banks, there presumably would be no central banks, and it is the central bank's conduct of monetary policy that is central in those models. The fact that credit is allocated by institutions (banks), rather than through conventional markets (auctions) is an important distinction lost in the DSGE framework. Greenwald and Stiglitz (2003) model banks as firms, which take others' capital, in combination with their own, obtaining and processing information, making decisions about which loans to make. They too are by and large equity constrained, but in addition face a large number of regulatory constraints. Shocks to their balance sheets, changes in the available set of loans and their expectations about returns, and alterations in regulations lead to large changes in loan supply and the terms at which loans are made available. Variations in regulations and circumstances of banks across states in the US are helping validate the importance of variation in the supply conditions in banking in the 2008 crisis and its aftermath.[38]

Given how long it takes balance sheets to be restored when confronted with a shock of the size of that of 2008, it is not surprising that the effects persisted.[39] But they seem to have persisted even after the restoration of bank and firm balance sheets. That suggests that this crisis (like the Great Depression) is more than a balance sheet crisis. It is part of a structural transformation, in the advanced countries, the most notable aspects of which are a shift from manufacturing to a service-sector economy and an outsourcing of unskilled production to emerging markets; for developing countries, the structural transformation involves industrialization and globalization. Not surprisingly, such structural transformations have large macroeconomic consequences and are an

[37] One implication of equity-constrained firms is that firms will act in a risk-averse manner—behavior which is markedly different from that assumed in the standard DSGE models. See Greenwald and Stiglitz (1990*a*,*b*, 2003). An important implication of Greenwald and Stiglitz (1993*b*) is that aggregate behavior is not just a function of *averages*, e.g. a shock that increases the balance sheets of some firms (oil exporters) but decreases that of other firms (oil importers) in the same amount will have an adverse effect on aggregate demand and supply. Empirically, it should be possible to incorporate this effect, at least partially.

[38] Hamid Rashid in some recent unpublished analyses has been able to demonstrate this.

[39] Reinhart and Rogoff (2009) emphasize that financial crises tend to be long and persistent. But when the economy experiences a deep real shock, it is inevitable that *eventually* there will be consequences for the financial sector, including banking. The stock market crash of 1929 didn't turn into a full-scale banking crisis until several years later. Italy's current banking crisis is the *result* of its prolonged stagnation. If financial crises are largely the result of deep and prolonged real shocks, then the statement that economic crises associated with financial crises are long lasting says nothing more than that deep and prolonged crises are deep and prolonged.

essential part of growth processes. DSGE models are particularly unsuited to address their implications for several reasons: (*a*) the assumption of rational expectations, and even more importantly, common knowledge, might be relevant in the context of understanding fluctuations and growth in an agricultural environment with well-defined weather shocks described by a stationary distribution,[40] but it cannot describe changes, like these, that happen rarely;[41] (*b*) studying these changes requires at least a two-sector model; and (*c*) a key market failure is the free mobility of resources, especially labor, across sectors. Again, simple models have been constructed investigating how structural transformation can lead to a persistent high level of unemployment, and how, even then, standard Keynesian policies can restore full employment, but by contrast, increasing wage flexibility can increase unemployment (see Delli Gatti *et al*., 2012*a*e *b*).

(iv) Adjustment and equilibrium

One of the reasons that downturns with high levels of unemployment persist relates to the process of adjustment.[42] DSGE models don't address that issue: they simply *assume* that the economy jumps to the new equilibrium path.[43] Though in a model with a single individual, solving for the value of current values of wages and prices which ensures that the transversality condition is satisfied is conceptually clear (the super-smart individual simply thinks through the consequences of choosing any other set of current wages and prices), it is not apparent how that is to be done in the context of a world without common knowledge. If there were a full set of markets extending infinitely far into the future, the problem I described would not occur. But there are not—this is one of the key market failures.[44] That the consequences could be "resolved" by the existence of a representative agent provides no insight into how the absence of these markets is addressed in the actual world. Indeed, this problem arises even if the only difference among individuals is their date of birth; with overlapping generations, and at least some individuals not behaving as if there is a

[40] With global warming, even the assumption that variations in weather are described by a stationary distribution is clearly not correct.

[41] Knight (1921) distinguished between risk and uncertainty. The standard model with rational expectations models risk. Here, there is fundamental uncertainty.

[42] As we have noted, empirical DSGE models have introduced a large number of factors to smooth out behavior, e.g. costs of adjustment in investment and habit formation in consumption. Many of these prolong booms, but some should have the effect of shortening the downturn.

[43] If, of course, there are costs of adjustment, the size of the jump may be affected by the structure and magnitude of those costs. My critique here parallels that of Hendry and Muellbauer (2018, this issue) who noted "the notion that the economy follows a stable long-run trend is highly questionable, despite heroic attempts by policy-makers to stabilize the path." My critique goes further: DSGE models assume that even without government intervention, the economy is on the (unique) convergent path. Hendry and Muellbauer go on to argue:

> The world is usually in disequilibrium: economies are wide-sense non-stationary from evolution and sudden, often unanticipated, shifts both affecting key variables directly and many more indirectly. . . . The assumption made in the business-cycle accounting framework that the economy is never very far from its steady-state trend was simply wrong. These models were unable to capture the *possibility* of without gof financial accelerator that operated in the US sub-prime crisis and the resulting financial crisis. They ignored the shock amplifying, propagating, and potentially destabilizing processes in the financial accelerator.

[44] Discussed long ago by Hahn (1966). See also Shell and Stiglitz (1967).

dynastic utility function extending over infinity, there can not only exist sunspot equilibrium (Cass and Shell, 1983), but there can be an infinity of paths consistent with rational expectations (see Hirano and Stiglitz, 2017).

Indeed, there is a disparity between an analysis based on the assumption of instantaneous adjustment to a new equilibrium, and what actually happens—and what most policy economists assume. There is a decentralized process of wage and price adjustment, with wages and prices in each market responding to the tightness in that market (in the labor market, that is the simple Phillips curve, asserting that wages rise when labor markets become tight). Obviously, adjustment processes may be more complicated in a macroeconomic environment with inflation, where nominal adjustments would be expected to take into account inflationary expectations.

In the short run, such adjustment processes may be disequilibrating: the fall in wages as a result of unemployment may result in a decrease in aggregate demand, increasing the level of unemployment. This is especially true (an implicit assumption in Keynes; an explicit assumption in Kaldor (1957) and Pasinetti (1962)) if the marginal propensity to consume (MPC) differs across groups; the lowering of wages shifts income towards profits, and capitalists' MPC is lower than that of workers.

What matters is, of course, real wages, and that depends on the adjustment of wages relative to prices (see Solow and Stiglitz, 1968). Wages and prices may both be falling, at the same rate, resulting in *real wages being constant*, a kind of real wage rigidity. The increase in real balances (real value of money holdings) would normally be expected to increase spending, but this effect is relatively small, so that the unemployment equilibrium could still persist for a long time. Moreover, the deflation itself has a depressing effect, since it increases the real interest rate (holding everything else constant). In addition, if, as assumed in the previous paragraph, different groups in the economy have different MPCs, the (unexpected) deflation[45] redistributes income from debtors to creditors, and this depresses aggregate consumption even more (see Eggertsson and Krugman (2012) and Korinek and Simsek (2016)). (Even more so, in an open economy, where the creditor is abroad: it is akin to a transfer of income to foreigners, with especially great effect then on demand for non-traded goods.)[46] Similarly, adjustments of prices have balance sheet effects of the kind already discussed, with large macroeconomic consequences.

(v) Financial frictions

Not surprisingly, in the aftermath of the 2008 financial crisis there is a growing consensus that at least one critical failing of the standard model is its (non-)treatment of the financial sector.[47] Financial frictions, as they have come to be called, are important. These include credit and equity rationing and the corollary importance of collateral constraints and of banks, to all of which I have already referred. There are, of course, a variety of information and enforcement problems that can

[45] That is, not incorporated into an adjustment in the interest rate charged. This particular effect would not arise if debt contracts were fully indexed, but arises whenever there is unexpected disinflation.
[46] There can also be balance sheet effects (the financial accelerator), as described earlier.
[47] See Vines and Wills (2018, this issue).

give rise to financial frictions. Those that might provide the simplest textbook treatment—showing their potential importance—may not be the most important. This may matter, because different financial frictions may differ in their policy consequences. In particular, theories based on costly enforcement (e.g. Eaton and Gersovitz, 1981) or costly state verification (Townsend, 1979) differ markedly from those based on adverse selection and incentives, noted earlier. Similarly, though important macroeconomic externalities may arise in any of these models (e.g. with incentive compatibility, self-selection, or collateral constraints), and, typically, the latter are easiest to analyze, that is partly because the constraint is not adequately endogenized.[48]

Still, for purposes of a simple benchmark model, it may be far better to incorporate *some* financial frictions than to ignore them altogether. Indeed, the core teaching model for macroeconomics that I use entails a three-period model. The center of attention is today, but this is linked to the past (decisions and shocks in the past affect current state variables) and the future. Valuation functions summarize the future beyond tomorrow, and individuals, firms, and banks today may engage in intertemporal trade-offs. Aggregate demand is based on reduced form functions for aggregate consumption and aggregate investment, in which credit constraints and net worth play an important role. Firm production and investment decisions are motivated by value-maximizing firms facing equity constraints (in the short run, they can't raise equity), and a rising cost of borrowing as they borrow more (reflecting a higher leverage and an increasing expected value of bankruptcy),[49] with a standard production function. The minimal model incorporating distribution entails two classes of households, workers who consume their income and capitalists who maximize their intertemporal utility function within their borrowing constraints. The central bank sets the T-bill rate, and the loan curve is a function of that rate, bank net worth, regulations, and the state of the economy. An adverse shock shifts the loan curve up (i.e. at any level of borrowing, the representative firm has to pay a higher interest rate). The model can then be expanded, depending on the question being posed. For a more extended description of the model, see the Appendix.

IV. Policy

One of the main reasons we want a good benchmark model is for policy. As we have already noted, short-run forecasting models, even when they conceptually begin within a DSGE framework, add in a variety of variables to increase forecasting accuracy. Having a model which matches moments says little about forecasting accuracy. Especially when there is a deep downturn, governments want to do something. Models constructed for analyzing small fluctuations are likely to provide little guidance.

Governments make decisions about specific expenditures, and there is no reason to believe expenditure multipliers associated with public investment that is complementary to private

[48] That is, plausibly, the constraint may change with changes in policy and should be endogenously derived (see Stiglitz and Weiss, 1986). In the short run, that often does not appear to be the case, so that the standard approach may not be unreasonable for the development of benchmark models.

[49] The limiting case of which is credit rationing—households or firms can't borrow beyond a certain amount.

investment will be the same, e.g. as for public consumption expenditures. The former crowds in private investment. But DSGE models are unlikely to be able to handle this kind of subtlety, which is at the core of public policy discourse.

Conventional wisdom, partly based on the standard model, is that over time public deficits designed to stimulate the economy lead to public debt, which can crowd out private capital accumulation, harming growth. But that depends on a host of assumptions: (*a*) if the public expenditure goes to public capital goods or human capital or technology which are complementary to private capital goods, it can crowd in private capital accumulation; (*b*) in an economy at a zero lower bound, the government can just print money to finance the expenditures. At such times, one is often worried about deflation; any inflationary effects of such money-printing are thus beneficial.

So too, the conventional insight that with rational expectations, multipliers will be low (zero) because of the expectation of future tax increases depends on special assumptions: (*a*) if the expenditures are for productivity-enhancing public investments, the conventional multiplier is actually increased with rational expectations; (*b*) so too, if there had been the expectation of a prolonged economic downturn; some of the "leakages" from spending today are reflected in spending in future demand-constrained periods, increasing incomes in those periods; consumers, taking this into account, spend more today than they otherwise would have spent.[50]

With financial frictions, monetary policy may be relatively ineffective, not because of the zero lower bound (if that were really the problem, changes in investment tax credits and consumption taxes over time could have altered individuals' marginal rates of substitution), but because lowering the T-bill rate (or the Fed discount rate) may not alter bank lending much. If that is the case, policies aimed more directly at increasing credit availability to those borrowers for whom it is constrained may prove more effective than conventional monetary policy.[51]

The central point is that there is a wide range of policies with significant macroeconomic effects that governments consider, and we have to be able to tailor-make models—building off the core model described earlier—to ascertain the effects. Many policies, for instance, may affect a country's exposure to shocks (full capital market liberalization); others may affect the strength of a country's automatic stabilizers. Having a simple model that can analyze these effects is crucial. Building such a model from a DSGE framework is unlikely to be as helpful as building one from the framework described above.[52]

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[50] See Neary and Stiglitz (1983). So, too, the standard result on the inefficacy of debt-financed expenditures does not hold if there are binding credit constraints and/or if there are life-cycle savers, who are unconcerned about tax payments beyond their horizon.

[51] These remarks may provide insight into the relative ineffectiveness of even the so-called non-conventional policies in bringing the economy back to full employment. Without paying due attention to effects on banks' balance sheets, negative interest rates could even lead to reduce lending activity. We have already noted how these ideas did play a role in the response to the 1991–2 recession by the Clinton administration. So, too, behavioral economics played an important role in the design of the tax cut in the Obama administration.

[52] As we have noted, DSGE models begin with the competitive equilibrium model. Variations in that model focused on open economies therefore include an equation assuming uncovered interest parity (UIP). As Hendry and Muellbauer (2018, this issue) point out: "There is strong empirical evidence against UIP. Evidence tends to suggest

The economy today is going through a structural transformation. The result may be that with current levels and forms of government expenditure and taxation and private expenditures, the economy might fall short of full employment. For all the reasons discussed above and others, the adjustment to a full employment equilibrium may be slow. But even with sticky wages and prices, there exists a set of fiscal policy interventions over time (taxes, expenditures) which could bring the economy back to full employment in the short run, or at least bring it back to full employment faster than would otherwise be the case: not just one, but a multiplicity of such paths, differing, for instance, in their levels of public investment and growth in the short run. Even if one were concerned about the level of debt, there is a balanced budget multiplier—and if the taxes and expenditures are chosen carefully, that multiplier can be quite large. Thus, "secular stagnation" associated with persistent unemployment is not a disease that happens to a country: it is a consequence of policies that can be changed. Again, as we noted earlier, building from a DSGE model, with its assumptions of common knowledge and rational expectations, is not likely to be as helpful in designing policies responding to the structural transformation as beginning with a model focusing on financial frictions, as described earlier.[53]

V. Further critiques

One could go through each of the underlying assumptions of the DSGE model, to explain the role they play—and why they result in a model that fails to predict and explain important aspects of macroeconomic fluctuations, and why "reforms" which are supposed to improve economic efficiency may actually increase macroeconomic volatility.

(i) On the importance of differences in beliefs

I have, for instance, alluded to the assumption of rational expectations. I strongly believe that one cannot fully explain the growth of the housing bubble that played such a large role in the recent crisis within a rational expectations framework.[54] But clearly, some of the "reforms" in mortgage markets (strongly supported by the Fed Chair at the time) contributed to the creation of the bubble.

Differences in beliefs, too, can play an important role in macroeconomic fluctuations, through what Guzman and Stiglitz call the creation and destruction of pseudo-wealth. When two individuals differ in beliefs, they have an incentive to engage in a bet (or economic transactions

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that for small deviations from long-run equilibrium in which purchasing power parity plays an important role, the exchange rate is not far from a random walk, but for large deviations, equilibrium correction is important."

[53] In such structural transformation, differences in views are likely to be large, giving rise to the possibility of an increase in pseudo-wealth, as described in the next section, and subsequent volatility. Financial structural reform, allowing for more betting, will increase this volatility, and this should have been taken into account in evaluating the benefits. Again, our critique of the use of rational expectations in such situations parallels that of Hendry and Muellbauer (2018), who note: "Shifts in the credit market architecture are only one example of structural breaks and evolutions, implying that the notion that the economy follows a stable long-run trend is highly questionable. . . . Uncertainty then becomes radical. Structural breaks also make it hard to sustain the possibility of 'rational' or model consistent expectations."

[54] See Shiller (2007) and Stiglitz (2010*b*).

which are similar to bets). Both sides, of course, think that they are going to win, so that the sum of their "perceived" wealth is greater than "true" wealth. Until the bet gets resolved, there is an incentive for both to spend more than they otherwise would, if necessary going into debt. The resolution of the bet (the occurrence of the event) means that one side becomes wealthier, the other side less wealthy; but there is more than just a transfer of income: there is a destruction in aggregate wealth leading to a decrease in aggregate consumption. Pseudo-wealth is being created and destroyed all the time, but certain changes—like the creation of new betting markets, e.g. associated with "improvements" in finance, associated with the creation of markets in derivatives and CDSs—can lead to significant increases in aggregate pseudo-wealth; and certain events, like the collapse of the housing bubble, can lead to its net destruction. Fluctuations in pseudo-wealth help explain one of the paradoxes of macroeconomics: the large fluctuations in the economy in spite of small changes in the *physical* state variables, the stock of capital, labor, and natural capital.[55,56]

(ii) Aggregation

One set of assumptions that is critical, and to which too little attention is given in macroeconomic analyses, concerns aggregation.

Long ago we learned the difficulties of constructing an aggregate production function.[57] The "putty-putty" model provides great simplification, but one should not claim that any analysis based on it is really "microfounded." While earlier analyses provided a critique of the use of the standard model for equilibrium analysis, e.g. when there is production of commodities by means of commodities or when there are production processes involving capital goods of markedly different durability;[58] the use is even more questionable for analyses of dynamics: the dynamics of putty-clay models and vintage capital models, for instance, are markedly different from those of putty-putty models.[59] It would thus be foolhardy to rely on the putty-clay model for any analysis of dynamics in the short to medium term when such vintage effects can be important.

Even more important is perhaps the aggregation of the whole economy into a single sector, particularly when the underlying stress on the economy is one of structural change, requiring the

[55] There is ample evidence that individuals differ in their beliefs. Note these theories are consistent with each individual believing that he has rational expectations—he is forming his expectations on the basis of all information available to him. But they are not consistent with common knowledge, where everyone has the same beliefs. There can also be "negative" pseudo-wealth, where what individuals believe they are going to pay to creditors is greater than the creditor believes he receives. See Guzman and Stiglitz (2016*a*,*b*).

[56] There are, of course, other possible explanations for this, e.g. sunspot theories, where there may be multiple equilibria. In this short note, I cannot explain the relative strengths of these alternative explanations.

[57] See Fisher (1969).

[58] That is, the relationship between the value of capital (*per capita*) and output (*per capita*) may be far different than suggested by the standard production function. For a review, see Stiglitz (1974).

[59] For instance, if, during a period of low interest rates, firms install very capital-intensive machines (with a high output per worker), it will be more difficult for the economy to return to full employment: the necessary increase in aggregate demand will have to be greater than it otherwise would have been. See Morin (2014), Cass and Stiglitz (1969). For a more popular discussion, see Aeppel (2012).

movement of resources from one sector to another (say agriculture to manufacturing), when there are market imperfections (say in access to credit) impeding the reallocation.[60]

Policy analyses are also likely to be misguided. Monetary policy is typically presented as an efficient tool. But monetary policy has disproportionate effects on interest-sensitive sectors, thus inducing a distortion in the economy that simply is not evident in a one-sector model (see Kreamer, 2015).

Finally, the use of a representative agent represents an aggregation of the household sector. It is understandable that macroeconomists attempting to microfound macro-theory would want to impose some restrictions: otherwise, any set of demand functions could be claimed to be microfounded.[61] But assuming a representative agent goes too far, because it eliminates any possibility that distribution matters. There is at least a significant body of thought that argues that the increase in inequality played some, and possibly a critical role, in the build-up to the crisis and to the slow recovery; there are large differences in the marginal propensity to consume between the top 1 percent and the bottom 80 percent and, accordingly, anything that affects distribution significantly affects aggregate demand significantly, i.e. has macroeconomic consequences.[62]

VI. Going still further beyond the standard model

The microeconomics of the basic competitive model—as formulated in Arrow and Debreu—has been shown to be flawed by 40 years of economic research. Why should we expect a macroeconomic model based on such microfoundations to work? Most deeply, the standard model is intellectually incoherent and implicitly encourages society to move in a direction which would undermine both efficiency and well-being. It assumes that all individuals are purely selfish and yet that contracts are always fully honored. Individuals who are fully selfish know that there are enforcement costs, and will not honor their contracts fully, even if the consequence is a loss in reputation. Thus, the Department of Justice and a number of private suits have uncovered the role of pervasive fraud in the securitization process, by many if not most of the credit rating agencies, mortgage originators, and investment banks, consistent with Kindleberger's (1978) analysis of earlier depressions and panics.[63] While incorporating such behavior in a standard economic model is difficult,[64] the prevalence of such behavior is surely out of the spirit of standard DSGE models

[60] Emphasized in the work of Delli Gatti *et al*. noted earlier.

[61] That is, according to the Mantel–Sonnenschein theorem, in the absence of *some* restriction, such as the "representative agent" assumption (where all individuals are assumed identical), virtually any aggregate function can be consistent with the standard competitive model. See Mantel (1974), Sonnenschein (1972), and Kirman (1992). There is also a large literature describing the very restrictive conditions under which such household aggregation can be done.

[62] Thus, the critique is far more than that the conditions allowing for such aggregation are not satisfied. That is obviously the case, and the fact that it is raises, too, questions about claims that DSGE models are well microfounded.

[63] Interestingly, there were provisions of standard contracts in the securitization process designed to mitigate the consequences of moral hazard, but these provisions failed to work as intended, both because of widespread fraud and breach of contract.

[64] Though there have been some attempts to incorporate them and their implications into simple microeconomic models, these have not yet been fully brought into macroeconomic analysis. One important variant of the strand of

and more consistent with those models emphasizing institutional arrangements to prevent such behavior and the exploitation of imperfections of information. Surely, both policies to prevent a recurrence of similar crises and analyses of market dynamics will need to take into account both market and regulatory responses. Most importantly, the inculcation and normalization of a culture of selfishness without moral bounds will lead to an economy that is less efficient with lower individual and societal well-being. Behavioral economics has noted that most individuals systematically behave differently from that model but that embedding individuals within a culture of selfishness (where that is taken as the norm) leads to changes in behavior in that direction.[65] Macroeconomics is supposed to provide us with models of how the economy *actually* behaves, rather than how it might behave in a mythical world of infinitely selfish people but among whom contracts are always honored. Adam Smith, often described as the father of modern "selfish" economics, in his invisible hand conjecture,[66] reminds us in his *Theory of Moral Sentiments* (Smith, 1759):

> How selfish soever man may be supposed, there are evidently some principles in his nature which interest him in the fortunes of others, and render their happiness important to him, though he derives nothing from it except the pleasure of seeing it.

The earlier Smith was fortunately right, and modern macroeconomics should strive to incorporate behavior which is consistent with these impulses, just as it does behavior that is consistent with impulses that may be less noble.[67] One of the critiques of DSGE modelling is that it and its underlying assumptions have become a dogma, with little incentive to call them into question, especially in a context of peer-reviewed publications.

VII. Concluding comments

Assumptions matter. All models make simplifications. The question is, as we have said, what simplifications are appropriate for asking what questions. The danger is that the simplifications *bias* the answers, sometimes in ways that we are not aware of. The DSGE model ignored issues that turned out to be key in the 2008 crisis; not surprisingly, the model neither predicted the most important macroeconomic event in the past three-quarters of a century *nor provided good guidance as to the appropriate policy responses*. Given the way the models are structured, they could not have predicted such an event. In the run-up to the crisis, monetary authorities focused on inflation rather than on what they should have been focusing on—financial stability; and some of their

standard macroeconomics does incorporate insights from one particular variant of financial frictions centring on costly state verification.

[65] For a discussion of some of the recent empirical evidence, see Hoff and Stiglitz (2016).

[66] A conjecture, which we noted, turned out to be false whenever there were imperfect risk markets and asymmetric information, except in the *very* special conditions underlying real business cycle theory and its descendants.

[67] For an excellent discussion of these two contrasting views of human nature and their implications for economics, see Vines and Morris (2015). For an attempt to incorporate some aspects of these considerations into a formal model, see Greenwald and Stiglitz (1992).

(especially deregulatory) actions clearly contributed to financial instability. The DSGE models provided them (false) assurance that they were doing the right thing.

Of course, any good macroeconomic model has to be dynamic and stochastic, and present an analysis of the entire economy. But specific assumptions, as we have noted, went into each of these components. We have already discussed several aspects of the assumed dynamics.

Some of the greatest deficiencies, I believe, relate to the treatment of uncertainty, the stochastic element in DSGE models. We have already questioned the underlying presumption in the model of how risks get dissipated through diversification, and that the underlying shocks are exogenous. Also questionable are the typically unstated assumptions concerning risk management. There is ample evidence that risk has first-order effects on firms, households, and banks that are not adequately incorporated into the standard DSGE models. That is why those models had nothing to say about one of the critical questions confronting policy-makers in the 2008 crisis: how best to recapitalize banks. The objective was to enhance lending, especially to SMEs. The way chosen by the US and some other countries, entailing the issuance of preferred shares, can be shown to be far from optimal. There were other ways of bank recapitalization which would have led risk-averse banks to lend more.

In this paper, we have provided many examples of insights that are revealed by simple macroeconomic models with finite periods—insights that are typically obfuscated by the simplifications required by DSGE modelling.

To me, small and big models should be viewed as complementary: one needs to use each to check the results of the other. Perhaps there is some effect that got lost in the three-period simplification. More often than not, it goes the other way. But it is not really a question of small vs big. It is a matter of the careful choice of assumptions. As I have noted, sectoral aggregation is problematic when the underlying macro-disturbance is that of structural change.

That having been said, our models do affect how we think: DSGE models encourage us to think in terms of the economy always moving along a dynamic equilibrium path, and focus our attention on intertemporal substitution. Neither, I suspect, is at the heart of what is really going on in the short to medium term; and as I have suggested, the DSGE has little to say concerning long-term growth. For instance, the belief in the effectiveness of monetary policy has led to the conclusion that its current obvious ineffectiveness is only because of the zero lower bound: if only we could break through that bound the economy could be restored to full employment.[68] Of course, if there were a large enough negative interest rate—if people never had to pay back their loans—there is little doubt that the economy could be stimulated. The question, though, is whether moderate changes, from a real interest rate of say –2 percent to –4 percent, would have done the trick, when much larger changes have proven ineffective. The reason for the ineffectiveness lies partly in the fact that lowering the nominal interest rate on T-bills may not lead to a lower lending rate or that

[68] This belief encouraged some central banks to move towards negative interest rates, with little success in restoring the economies to robust growth. In some cases, the effects seem negative. Japan's Central Bank was particularly sensitive to the issues raised here (issues, as we have noted, that were not central in the DSGE models): they worked to mitigate any adverse bank balance sheet effects while maintaining substitution effects.

lowering the T-bill rate may not lead to an increase in credit availability, as we have already noted. But, as we have also noted, if one really thought that intertemporal prices were the crucial consideration, one could have changed those through tax policies, through changing consumption tax rates and investment tax credits over time.

In the end, all models, no matter how theoretical, are tested in one way or the other, against observations. Their components—like the consumption behavior—are tested with a variety of micro- and macro-data. But deep downturns, like the 2008 crisis, occur sufficiently rarely that we cannot use the usual econometric techniques for assessing how well our model does in explaining/predicting these events—the things we really care about. That's why, as I have suggested, simply using a least-squares fit won't do. One needs a Bayesian approach—with heavier weight associated with predictions when we care about the answer. Comparing certain co-variances in calibrated models is even less helpful. There are so many assumptions and so many parameters you can choose for your model, many more than the number of moments you can get from the data; so being able to match all moments in the data does not tell you that your assumptions were correct, and thus does not provide much confidence that forecasts or policies based on that model will be accurate.

Defenders of DSGE models counter that other models did little better than the DSGE models. That is not correct. There were several economists (such as Rob Shiller) who, using less fully articulated models, could see that there was clear evidence of a high probability of a housing bubble. There were models of financial contagion (described earlier in this paper, developed further since the crisis), which predicted that the collapse of the housing bubble would likely have systemic effects. The conviction that this would happen would have been even stronger had the data that the Fed had available to it before the crisis also been available to the public. Policy-makers using alternative models of the kind described here would have done far better both in anticipating the crisis and coping with it than those relying on DSGE models.

Models have consequences even when their predictions and explanatory power are less than stellar. For they affect how households, firms, and, most importantly, policy-makers think about the economy. Models which say that the fundamental market failure arises from wage rigidities may be induced to argue for more wage flexibility—to argue that if only we could achieve that, economic performance would be improved.

This essay has argued that the standard DSGE model provides a poor basis for policy, and tweaks to it are unlikely to be helpful. Fortunately, there are alternative frameworks to which modern policy-makers can turn. I have tried here to describe some of the core elements that need to be incorporated into the benchmark *models* with which we teach macroeconomics to our students. The challenge we should be posing to them is how to develop increasingly sophisticated versions of these into models, small and large, incorporating the various insights provided by a range of "partial" models (such as that of the banking sector) that help us understand the important fluctuations in our economy, and what more we might do to reduce their magnitude and frequency and the human suffering that so often results.

Appendix: Core models for macroeconomic policy

The core models for macro-policy today focus on equilibrium today, and incorporate, in reduced form, insights from recent advances in micro- and macroeconomics, taking on specialized form to focus on one issue or another, one set of circumstances or another. Here, we focus only on closed economy models and on the effect of various policies on output and employment.

(i) Constructing a bare-bones model

The bare-bones model begins with a neo-Walrasian model, attempting to incorporate the insights of modern microeconomics into the basic aggregate equations, which are not meant to represent the behavior of a representative individual, but the aggregation of many individuals. Accordingly, a change in, say, a market variable will not only have income and substitution effects, but also distributive effects.

Basic structure

The full model has three periods. Most of the analysis focuses on the middle period, labelled period 1, and how policies in that period affect outcomes in that period, identifying the interdependencies between those policies, and the household, firm, and financial sectors. Thus, the model is a *general equilibrium* model, but with a far richer set of interrelationships than characterizes the standard DSGE model. We outline variants in which wages and prices are fully flexible, completely fixed, and intermediate cases. But even when wages and prices are fully flexible, the market equilibrium may deviate substantially from the "perfect markets" equilibrium because of imperfect capital markets, which lead firms to be risk averse and which result in banks playing a central role. Thus, knowing capital and labor supply in this period does not suffice to determine output and employment.

Each period is linked both to the past and the future, and the other two periods ("zero" and "two") capture these linkages. What matters is not just firms' capital stock but also indebtedness (financial structure) and banks' and households' balance sheets. Thus, we show how shocks at time zero affect these state variables at time 1.

The objective of bringing in period 2 is to more formally analyze households', banks', and corporations' intertemporal decision-making, e.g. as individuals weigh the marginal utility of consuming today vs the value of a dollar in the future. It enables us to isolate, for instance, the effect of an increase in future productivity on consumption today. This intertemporal problem—in particular, the relevant Euler equations—is really at the center of attention in DSGE models. The bare-bones model can be used to study these issues, but as we have suggested in the text, it is almost surely wrong to put them at the center of macro-analysis.

Methodological remarks

The point of the bare-bones model is to help us understand better how changes in the environment (in an agricultural economy, say, bad weather yesterday or today) or policy affect outcomes, and

the channels through which the effects are felt. While one could simultaneously incorporate multiple deviations from the standard competitive model, this is not typically the most insightful way to proceed. Rather, one wants to isolate, say, distribution effects, from balance sheet effects, from the effects of capital constraints, from the regulatory constraints facing banks. We begin by presenting a *general model,* incorporating many, if not most, of the effects discussed in the text (and a few that we touched on only briefly). The real analysis, though, entails specializing this general model.

Underlying the analysis are judgments about the relative importance of different "effects," with some effects being sufficiently small to be ignored—labor supply in the bare-bones models is assumed inelastic at L*; but it is easy to elaborate on the model to incorporate wage effects on labor supply, or even interest rate effects (though that is far-fetched). A key aspect of the analysis is testing for robustness: do results change significantly if, for instance, there is a positive but small labor supply elasticity?

The analysis begins by postulating that the aggregate demand for goods *today*, Y^d, equals the aggregate supply of goods, Y^s, and the aggregate demand for labor, N, equals the aggregate supply of labor, L. It then goes on to focus on key cases considered in the standard literature: for instance, wage and/or price rigidity; and a no-shirking constraint in the labor market.

It focuses on policy, but not just on the effect of interest rates (which monetary policy is assumed to control), but also on regulatory policy, and on government expenditures. But rather than beginning from the hypothesis that consumption and investment demands are separable from government expenditure, it recognizes that the form of government expenditure can affect either variable.

Policy analysis proceeds by first solving the general equilibrium problem in a reduced-form one-period model—the endogenous variables (in particular output and employment) can be solved for as a function of all the policy variables, **P** (given all the other relevant variables describing the economy). It is then a straightforward matter to take the derivative of, say, output or employment with respect to any particular variable, say a particular type of government expenditure. While the resulting expressions are complex and will not be presented here, the analysis can be simplified by assuming that most of the effects are small relative to a few upon which attention is focused. A key difference between the model presented here and the standard DSGE models is that many of the variables that are of first order importance are omitted from that model. The model here, by contrast, pays much less attention to the intertemporal effects upon which the DSGE model focuses. Some of the reasons for this have already been given; others are noted in the final remarks of this Appendix.

The bare-bones model described below incorporates three effects missing from the standard DSGE models: (i) distribution, (ii) banks, and (iii) credit constraints. One has to pay attention to not just the values of average variables and their changes, but also to dispersion, and changes in dispersion. Knowing that, on average, household wealth was large, with home equity sufficiently great that default was not a significant risk, told one nothing about the state of the economy in 2008: large fractions of households were in fact not able to make their interest payments. Thus, in an important

elaboration on the bare-bones model, dispersions in the relevant state variables (which need to be more formally modelled than here) have to be introduced.

But even in the bare-bones model, we recognize that the relevant variables are aggregates among heterogeneous agents, *and that distribution matters.* Thus, a lowering of the interest rate might lower the income of retirees dependent on interest payments, and this distributional income effect may be much larger than any individual substitution effect—including any effect in stimulating investment, except through a collateral effect on credit-constrained firms.

(ii) Period 1

The key ingredients, aggregate demand and aggregate supply, are standard, but their determinants include variables typically left out of DSGE models.

Aggregate demand
As in any standard model, we begin by describing aggregate demand[69]:

$$Y^d = C\,(N, w, p, r, r_L, t, G, c, \mathbb{E}, \boldsymbol{\xi_h}) + I\,(w, r, p, G, c, \mathbb{E}_f, \boldsymbol{\xi_f}) + \mathbf{G} \qquad (1)$$

where in the obvious notation C = consumption, w = wage rate, p = price level, r = T-bill rate, r_L = (nominal) interest rate at which individuals can borrow (about which we will say more below), t = tax rate (assumed fixed), I = Investment, c = credit availability, **G** = government expenditures, and $\mathbb{E}$ represents expectations of the relevant variables (to be described below). **G** is a vector of government expenditures, e.g. investment expenditures that are complements (or substitutes) to private investment, consumption expenditures that are substitutes (or complements) to private consumption. Aggregate demand is the sum of consumption, investment, and government expenditures.

Consumption is affected by a variety of market variables, $\mathbf{m} \equiv \{w, p, N, r_L\}$, wages, prices, employment[70] N and the borrowing rate r_L; a variety of policy variables $\mathbf{P} \equiv \{r, t, \mathbf{G}\}$ set by the government, the interest rate[71] r, the tax rate t, and (a vector of) government expenditures **G**; credit constraints c, itself a function of market and policy variables; other variables $\boldsymbol{\xi_h}$: an individual's wealth, his liquidity, and his risk perceptions, and like c, these can be a function of both market and policy variables; and his expectations of those variables, $\mathbb{E}$. For instance, if individuals own land, an increase in the interest rate, if it is expected to continue into the future, will lower the value of land.[72] If households hold their wealth in stocks and bonds, consumption smoothing is easy; if, as in many countries, much of household wealth is in the form of housing, households

[69] For the moment, we drop time superscripts.
[70] It is not assumed that individuals sell all of the labor they wish to. This is important.
[71] Because some individuals may be lending (say holding government bonds) and others borrowing, both rates are relevant. The standard DSGE model doesn't recognize the distinction, and the fact that the rate at which banks lend is an endogenous variable.
[72] For instance, if T is land holdings, q is the price of land, the value of individuals land wealth is qT. q itself needs to be solved for as part of the general equilibrium, a function of all the policy and state variables.

may suffer from illiquidity, so that even if they would like to smooth their consumption over time by dissaving, it may be difficult for them to do so (except possibly by worsening liquidity in future dates). Expectations are complex—especially in idiosyncratic environments (situations like the Great Depression and Great Recession which have not occurred before, at least in the context of an economy that is very similar to the current economy), and it is always difficult to ascertain whether one is in such an environment. Thus, in a deep downturn, like the Great Recession, it is hard even to know what one would mean by "rational expectations." One might, for instance, reasonably assume that if individuals save, some of the savings will translate into consumption in a demand-constrained period, in which case, future wage incomes will increase, and that in turn will lead to higher future consumption today. In short, it is reasonable to think of expectations as being affected by current variables, but the magnitude (and in some cases even sign) of the effects will not always be clear.[73] All of this can be embraced within the general representation above. To the extent that there is a significant intertemporal substitution effect arising from changes in the real interest rate, one has to model the effect of the market and policy variables on inflationary expectations. In highly reduced form, where expectations themselves are taken to be endogenous, we can write: C = C (**m, P; ξ_h).**

Similarly, the investment function can be related to the usual variables (with Tobin's q being a function of market and policy variables), with two additions: investment is affected by firm balance sheets[74] (including liquidity) and may be credit constrained.[75] The credit constraint itself can be thought of as being a function of the regulatory variables **R** as well as the behavior of banks (or other lenders), itself a function of market and policy variables as well as the net worth, liquidity, and expectations of banks $\{\boldsymbol{\xi_b}, \mathbb{E}_b\}$. More formally, in the absence of credit constraints and the expectation of future credit constraints, investment is given by $I^d = (w, r_L, p, G, \mathbb{E}_f, \boldsymbol{\xi_f})$, and so long as the firm's liquid assets $L \geq I^d - c$, investment is given by I^d. Hence, we can write: I = min $\{I^d, L + c\}$, where L itself may be a function of market and policy variables.[76] For simplicity, it is often useful to focus separately on the cases where the credit constraint is and is not binding. But this misses a key point: firm heterogeneity is important, and some firms may be credit constrained, others not.[77]

Aggregate supply

[73] As an example of a complexity which is typically ignored, a lower interest rate today that leads to higher income today with more savings implies that (everything else being constant) wages in the future will be higher. In a standard putty-clay model, this means that firms will choose a more capital-intensive technology, implying that the increased level of investment is higher than we might have expected using a putty-putty model. Standard DSGE models simplify by assuming fully malleable capital. There are marked differences in dynamics (Cass and Stiglitz, 1969). While there is some *ex post* capital labor substitutability, clearly *ex post* substitutability is much less than *ex ante* substitutability. I have not seen a convincing argument that the economy behaves more like putty-putty than putty-clay.

[74] As in Greenwald and Stiglitz (1993b).

[75] As in Stiglitz and Weiss (1981).

[76] Thus, if there were a liquid land market, the value of land (a function of its market price q) is an endogenous variable.

[77] Thus, in the special cases of this general model focusing on this constraint, we begin with two classes of firms, one liquidity constrained, the other not. But even this misses the more general point: the fraction of firms that are liquidity constrained is an endogenous variable. By assuming a continuum of firms (with different balance sheets) we can endogenously solve for the fraction of firms that are constrained.

Aggregate supply is a function of the same state, market, and policy variables, though it is natural to assume that firms' supply depends on wages relative to prices. The interest rate may be important because it affects the cost of working capital. Again, balance sheets, risk perceptions, liquidity, and expectations of all the relevant variables matter (unlike in the standard neoclassical model). Thus, $Y^s = Y^s\left(\frac{w}{p}, r_L, \mathbb{E}_f, \boldsymbol{\xi_f}\right)$.

Finance

r_L, the rate at which the firm borrows, depends on the T-bill rate, but there is an endogenously determined spread, affected by the state, environmental, and policy variables affecting banks and their expectations:

$$r_L = B(r, \mathbf{R}, \mathbb{E}_b, \boldsymbol{\xi_b}). \quad (2)$$

In particular, banks are a particular kind of firm that takes its capital, borrows additional funds, and with these resources makes, monitors, and enforces loans, with the difference between the lending rate r_L and the rate at which it can get access to funds (here assumed to be r) generating profits; it will charge a lower lending rate if it thinks that there is less risk, if its balance sheet is in better condition, if reserve requirements or capital adequacy requirements are lower, etc.

Period 1 equilibrium with full flexibility

Thus, with full flexibility of wages and prices:

$$Y = Y^s\left(\frac{w}{p}, r_L, \mathbb{E}_f, \boldsymbol{\xi_f}\right) = Y^d \quad (3)$$

where Y is actual output.

(2) can be substituted into (1) and (3) to obtain aggregate demand and supply as functions of the T-bill rate r—but now the financial position of banks, their ability and willingness to make loans, matters too.

With the capital stock fixed, the demand for labor depends on output, Y, and in equilibrium, this equals the supply, which is assumed fixed:[78]

$$N(Y) = L = L^*. \quad (4)$$

Full employment output is determined by (4), and then, for any given set of policy variables, **P,** expectation (functions) and other (state) variables $\boldsymbol{\xi}$, the level of real wages, *w/p* , must be such as to ensure that $Y^* = Y^s$ (note that Y^s depends just on w/p). But given w/p, with $Y^* = Y^d$, equation (1) determines nominal wages and prices. With fixed nominal debt, as wages and prices rise together, aggregate demand increases. The real indebtedness of debtors decreases, and the net

[78] Again, in the more general case, actual employment is the minimum of the amount of labor demanded and supplied. The bare-bones model only considers the case where the demand for labor is equal to or less than the supply.

worth of creditors decreases. If the marginal propensity to consume (from an increase in wealth) of debtors is greater than that of creditors—which we assume—the increase in consumption by debtors more than offsets the decreased consumption of creditors.[79]

There can be output variability in this model only as a result of shocks to the production function. But a slight extension, allowing the labor supply to be a function of, say, the real wage L=L(w/p) means that (2), (3), and (4) *together* solve for w/p, r_L, and N; changes in state variables ξ (both of banks and non-bank firms) affect the endogenous variables {w/p, r_L, N, Y}, and using (1), we can solve for wages and prices separately.

By assumption, there is no unemployment, but shifts in the aggregate supply curve (changes in, say, ξ either of firms or banks) lead to changes in the employment level and output. Economic variability is not just about shocks to the production function. And now policy affects the equilibrium not just through standard Keynesian impacts on aggregate demand, but also through shifting the aggregate supply curve (through (2)). Monetary policy matters, but not just through r, but through regulatory variables, and operating both on demand and supply. What matters are not just intertemporal substitution effects (which may be weak), but impacts on net worth of firms and banks, and through credit constraints.

Specialized versions of the model focus on each of these, and on distribution effects.[80] A simple two-class model (workers with life-cycle saving, and capitalists with long-term saving) can easily bring out these first-order distributional effects.

In short, this bare-bones model can provide insights into the cyclical fluctuations which would occur even in the absence of nominal wage and price rigidities.

Rigid nominal wages and prices

When there is a (nominal or real) rigidity, demand may not equal supply and then it is the short side of the market that prevails:

$$Y = min\{Y^s, Y^d\} . \tag{5}$$

With nominal wages and prices fixed at $\hat{w}$, $\hat{p}$, aggregate demand could either be greater or less than supply.

[79] In the representative agent model, these two effects cancel. There can be other effects, e.g. on expectations. If investors believe that the increased inflation is not matched by an increase in nominal interest rates going forward, then the expected real interest rate will be decreased, and this will stimulate investment. Similarly, an unexpected increase in the price level could lead to more uncertainty about the future, with ambiguous effects on consumption but probably adverse effects on investment (see Rothschild and Stiglitz (1972), Diamond and Stiglitz (1974)). If differences in the marginal propensities to consume are large, and the increases in prices are modest, the consumption effect is likely to dominate. The bare-bones model provides a framework within which one can discuss (and model) the significance of these various effects.

[80] Indeed, much of the recent macro-literature outside of the DSGE/RBC tradition can be seen as doing precisely that.

Assume it is less. Then from (5), $Y = Y^d = \widehat{Y}$, and employment is then $N(\widehat{Y})$. Thus, a temporary decrease in the interest rate could, as we noted, lower consumption, because the distributive effect exceeds the substitution effect. If investment is credit constrained, and the value of, say, land used for collateral does not change (much) in response to an announced temporary change in interest rate (as one would expect), then investment would not change. A regulatory change that resulted in banks making more loans would relax the credit constraint, and be more effective in stimulating the economy and increasing employment.

Assume that there were some policies that could lower wages, without instantaneously lowering prices. In a demand-constrained economy, that would lower consumption, even if it would increase aggregate supply.[81] The effects on investment would be ambiguous, since (*a*) it would make profitable older equipment that might not otherwise have been used; (*b*) it induces the use of more labor-intensive technology, and thus, for every unit of future increased expected output, it induces less investment; but (*c*) it makes investment overall more profitable. If the firm(s) are credit constrained, the effect on investment would be zero. In short, there is some presumption that aggregate demand *and thus output and employment* would be reduced. Even though wages are too high, changing wages *alone* would have an adverse effect—a standard result in the theory of the second best.

There would be long-run supply benefits once the economy was restored to equilibrium (or to a supply-constrained situation.) The gap between aggregate supply and demand might accelerate price adjustments. Whether one views the change as positive or negative then depends on the social discount rate and the pace of adjustment to the full equilibrium.

But even the price adjustments might not (quickly) restore the economy towards equilibrium; in the short run, matters might get worse. The increased indebtedness in real terms (with nominal contracts) lowers both consumption and investment. Again, demand-side effects may dominate.[82]

Efficiency wage unemployment

Efficiency wages put a constraint on the (real) wages that can be offered (the no-shirking constraint). Similar results obtain in bargaining models.

$$\frac{w}{p} \geq \varphi(N), \text{with } \varphi' > 0 \; and \lim_{L-N \to 0} \varphi' = \infty. \tag{6}$$

Assume the product market clears, and that the constraint binds. Then:

$$\frac{w}{p} = \varphi\left(N\left(Y^s\left(\frac{w}{p}\right)\right)\right) \tag{7}$$

[81] In an open economy, to the extent that the lower wages led to lower prices, demand for exports would increase. But even in an open economy, two-thirds of output is non-traded, so that the lowering of (real) wages of workers can significantly lower aggregate demand.

[82] This is modelling the Fisher–Greenwald–Stiglitz debt deflation effect.

yielding the equilibrium real wage (w/p)* and employment levels. Given the policy and state variables, we can solve separately for the market variables {w, p}.

In this model (where we continue to assume aggregate demand equals aggregate supply), the effects of policy again arise out of the aggregate supply function—which translates back into a demand for labor: any change that increases the level of output (and thus the demand for labor) at any real wage leads to lower unemployment. Thus, a lowering of interest rates lowers the cost of working capital and thus increases aggregate supply—the willingness of firms to produce and hire labor—at each value of w/p (given all other variables, such as **ξ)**, and that leads to a higher equilibrium real wage and a higher level of employment.

(iii) Extending the model back in time

The current state variables for households, firms, and banks are affected by what happened in previous periods—including, of course, policies undertaken in previous periods. A model precisely like the one just posited applies to time 0 (the period before the current one). We focus here first not on the decisions in period 0, but on the effects of shocks in period 0 *after* decisions are taken and on government policy responses. We omit the equations describing period 0, focusing only on those linking events in 0 to state variables in period 1. There are two types of firms, those that produce with a one-period lag (denoted by subscript a), and those that produce with no lag but require capital goods (denoted by subscript b). For one type, what is important is working capital, for the other it is physical capital.[83] For the first type,

$$W_{1,a} = p_1 Y_{1,a} - \left(w_0 N_{0,a} - W_{0,a}\right)(1 + r_{0,L}). \qquad (8a)$$

The wealth (balance sheet) of a firm going at time 1 is total sales minus what it has to pay back to the bank, which is the difference between its expenditures on inputs (which in this aggregate model is just labor) minus its own wealth. In effect, in this simplified canonical model the firm takes all of its wealth and uses it for its own production.

For the second type, in this simple model, capital lives only one period.

$$W_{1,b} = p_1 Y_{1,b} - w_1 N_{1,b}\left(Y_{1,b,} K_1\right) - (W_{0,b} - K_1)(1 + r_{0,L}). \qquad (8b)$$

Thus, current prices, past and current wages, the capital stock, previous period's production and investment decisions, and last period's interest rates all affect this period's wealth.

[83] This formulation is important because one wants to have the aggregate supply *curve* depending on the interest rate and balance sheets, which it does in the working capital formulation; but one also wants to have real investment ("I") (and aggregate demand) depending on interest rates and balance sheets.

Equations (8) thus explain how a shock at any date affects wealth and other state variables at later dates. If prices this period are low (e.g. because of a demand shock), wealth will be low. That will affect investment and production, that is, both supply and demand. The interest rate that matters in equations (8) (and in equations (1) and (2) above) will be affected by shocks to the banking system. In real terms, since debt contracts are fixed in nominal terms, banks are better off when the price level is lower than expected; worse off if the default rate is higher, e.g. because of an adverse shock to firms.

Thus, equations (8) give an additional mechanism through which government interventions, like an increase in G, affect the economy: an increase in G increases p, increasing firm wealth and decreasing firm bankruptcies, thus increasing bank wealth. This leads to an increase in firms' willingness to invest and produce (i.e. a shift in the investment and production functions) and banks' willingness to lend (the availability of credit, if they ration, and the terms at which they make credit available).

There are other linkages across time: an increase in investment in public capital increases demand for goods at period t but increases productive capacities at t + 1. But if the public capital goods (like roads) are complements to private capital goods (like railroads), then the increased investment in public capital goods today increases the expected return to private capital goods this period, and hence leads to more private investment at time t. The increased private and public capital stocks then reduce the employment needed to generate any level of production next period, with consequences that can easily be worked out.

One of the important insights of this approach is thus that aggregate demand and supply are intertwined. Shocks to the economy and changes in policy are likely to simultaneously affect both.

(iv) Extending the model forward in time

Individuals and firms are always making intertemporal choices, which were in some sense hidden in equations (1) and (3). As we noted in the text, while their decisions have consequences over time (as the previous subsection illustrates), how they *behave* is an empirical matter, i.e. the extent to which their decisions at any date are based on rules of thumb versus *as if* they solved a more complex maximization problem, is a matter of some dispute.[84] Assume households and firms are forward looking. For instance, in the case of households, we summarize the expected utility of wealth carried forward to the next period (the solution to a complex dynamic programming problem) by $V(W_{h,2}; \ldots.)$. Then households maximize:

[84] Indeed, with households in constant flux, with household formation and dissolution having first order effects on well-being, and with household formation and dissolution both being endogenous variables, affected by economic variables, it is clear that the standard model leaves out much that should be important in any real intertemporal maximization problem.

$$U(C_1) + \mathbb{E}\left[V(W_{h,1}(1+r) + (w_1 N_1 - C_1)(1+r); \ldots.)\right]$$

giving the Euler equation:

$$U' = \mathbb{E}[V_w(1+r)].$$

The heart of the analysis is not so much an enquiry into the effect of changes in r, but of changes in uncertainty, with an increase in uncertainty (e.g. about future wages or employment) generating precautionary savings. A fuller analysis would focus more explicitly on (*a*) aggregating over diverse individuals, with wealth being redistributed as r changes; and (*b*) borrowing constraints and imperfections in capital markets, taking into account the large disparity between borrowing and lending rates. The latter means that for large fractions of individuals, consumption is driven by their budget constraint: $C = wN + r_B B$, where r_B is the borrowing rate charged these individuals, which is very loosely linked with r, if at all; and B is the borrowing limit; and for still others, $C = wN$: because of the kink in the interest rate function, they neither want to be borrowers or lenders.

A similar analysis applies to firms, where again the focus of analysis is on risk and how decision variables affect future risk (including the risk of bankruptcy).

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