Towards a dynamic disequilibrium theory with randomness

Martin Guzman* and Joseph E. Stiglitz**

Abstract:

The 2008 Global Financial Crisis, and the myriad other crises confronting economies around the world, exposed the inadequacies of the Dynamic Stochastic General Equilibrium Models. These models not only hadn't predicted the crisis, its occurrence was completely outside of their framework. The framework assumes there are no macroeconomic inconsistencies—all plans are realized, all budget constraints honored. But after each instance in which that assumption is proved wrong, say in a crisis, the DSGE models assume that kind of event won't happen again. By contrast, our framework explains why these inconsistencies arise and investigates the consequences, shows how large changes in the aggregate demand could trigger inconsistencies, explains the origins of such changes, and explains why decentralized market forces may be *disequilibrating.* We identify the crucial departures from the Arrow-Debreu assumptions underlying our results. We analyze the policy implications of this alternative theory, which typically are distinctly different from those of the standard model.

Keywords: words Macroeconomic disequilibrium; macroeconomic instability; macroeconomic learning; macroeconomics and non-stationarity

JEL classification: codes

* Minister of Economy of the Republic of Argentina; e-mail: mg3463@columbia.edu
** Columbia University; e-mail: jestiglitz@gmail.com; jes322@columbia.edu
We are grateful to Daniel Heymann, Tomohiro Hirano, Jacob Robbins, participants of the XIX Trento Summer School on *Adaptive Economic Dynamics*, and participants of the Institute for New Economic Thinking Taskforce on Macroeconomic Stability and Externalities' 2019 Annual Meeting at Columbia University and the Workshop on *Macroeconomic Coordination and Crises* held at Columbia Global Center in Paris, November 12, 2019 for helpful comments and suggestions, and Christina Laskaridis for her excellent research assistance. We are grateful for the financial support of the Institute for New Economic Thinking. We are also grateful to the participants in the Oxford Policy Review Symposium, and in particular to David Vines and Petr Sedlacek for their thoughtful comments. This work was performed while Guzman was an Associate Research Scholar at Columbia University Business School and a Professor of Economics at the University of Buenos Aires.

I. Introduction

The central problem of macroeconomics is to explain the large, deep, and often persistent downturns, accompanied by high levels of unemployment, that episodically afflict capitalist

economies. Macroeconomic crises are extreme examples of economic fluctuations. But they are the most relevant. They are the events that teach the most about the stability properties of the economic system, in a way that small inventory cycles do not. And they are the events that matter the most for the lives of millions of people.

Some crises are simply the result of external shocks; for instance, a natural disaster that destroys a large part of the country's infrastructure, or an unexpected change in global conditions, or a coronavirus pandemic. But most macroeconomic crises are of a different nature; they are associated with endogenous large changes in beliefs and understandings about the workings of the economy. The 2008 US Great Recession, the crises of Argentina in 2001 and 2018, and the Greek crisis from 2010 and onwards are examples. In none of these cases can there be identified an exogenous technology shock that tripped the economy from prosperity into a deep downturn. All those events show a malfunctioning of the economic system, characterized by bankruptcies and defaults—in some of those cases, even defaults by the sovereign government—as well as by high and persistent unemployment. These are the kind of events that constitute the object of this study.

Such downturns and crises are not consistent with the standard paradigm of a well-functioning competitive economy, and macroeconomic equilibrium models based on that paradigm, including dynamic stochastic general equilibrium (DSGE) models incorporating wage rigidities and other frictions, are widely recognized (except by the practitioners of those models) to have failed to predict the possibility of those downturns, to explain them, or even to design appropriate policy responses.[1] We are forced to think beyond the standard paradigm, to identify which of the many unrealistic assumptions of those models, are the most crucial. Is it rational expectations? The assumption of a representative agent? of the absence of asymmetric information? of perfect competition? that the only, or the most important, shocks giving rise to fluctuations are exogenous technology shocks—rather than those created by the market itself, like (to mention an obvious example) a housing bubble? Or that the economy is always in macroeconomic equilibrium, in

[1] See, for instance, Colander *et al*. (2008), as well as the papers from the *Oxford Review of Economic Policy* issue on *Rebuilding Macroeconomic Theory* (vol. 34 nos 1 and 2), including Blanchard (2018), Haldane and Turrell (2018), Hendry and Muellbauer (2018), Reis (2018), Lindé (2018), McKibbin and Stoeckel (2018), and Vines and Wills (2018*a*,*b*) for criticisms of the benchmark DSGE models, analyses of elements that macroeconomic models should take into account, as well as a defence of at least some of the building blocks of those models for macroeconomic analysis and of current macroeconomic modelling.

which all consistency conditions are satisfied? Some advocates of DSGE models have gone so far as to suggest that changes in any of these assumptions can easily be incorporated into a DSGE model, and that good macroeconomics of necessity must be DSGE.[2] Of course, to the extent that *anything* can be incorporated into a model, it is not a model: a model has to represent a restriction on the set of possible worlds.

As Stiglitz (2018) argued, the criticism of the DSGE approach was not that it simplified the world, but that it made the wrong simplifications; and no Ptolemaic attempts to 'fix' the model were likely to generate one that provides real insights into deep downturns. *Inherent* in any DSGE model is the *assumption* that the economy is always in equilibrium. But the DSGE models themselves do not provide any theory of how that equilibrium is instantaneously attained in spite of the sometimes large shocks which might buffet the economy; the equilibrium hypothesis looks not only inaccurate but, especially outside of representative agent models, simply implausible; and to hold to it requires a high level of cognitive dissonance: it requires believing that, the moment after a crisis, like that of 2008, which showed that the economy was not on an equilibrium trajectory, faith in the equilibrium construct is so strong as to lead all economic agents to believe that, from that date on for evermore, the economy will be on an equilibrium trajectory, never again to experience another off-equilibrium event such as that just encountered.

This paper thus focuses on the 'E' of DSGE: we argue that a better way to understand deep downturns is to think of the economy experiencing a constant evolution, marked by high levels of uncertainty, in which there is continual learning about the economy and the economic system. Occasionally, something happens to make it clear that the beliefs of at least many market participants were wrong—so wrong that there is what we call a significant macroeconomic inconsistency, where contracts are systematically broken and plans get revised in ways that were not fully anticipated. Before that realization, of course, market participants may have believed that they were on an equilibrium trajectory, but it then becomes clear that they weren't. And after that realization, the economy may not return quickly to a new 'equilibrium'. Indeed, we show that there may be strong forces at play that move the economy *away* from equilibrium. Thus, we argue, macroeconomic analysis needs dynamic *disequilibrium* theories with randomness rather than just

[2] For instance, Christiano *et al*. (2018).

DSGE theories. What is also needed is an analysis of real dynamics, including the forces that might either restore the economy to some equilibrium when facing perturbations that reveal that the economy is not in equilibrium or, possibly, move the economy away from "equilibrium"; rather than the hypothesized dynamics along an imaginary dynamic trajectory in which the economy is always in equilibrium *ad infinitum*—until it's not. These crucial events and what happens then are not even conceivable within the ambit of the DSGE model.

In explaining deep downturns, we thus need to understand (*a*) how the market economy generates such large fluctuations in aggregate demand, disproportionate to any exogenous shocks in the 'real variables', large enough that they can result in high unemployment over an extended period of time; and (*b*) the dynamics of adjustment: why they are such that high levels of unemployment can persist.[3] A dynamic disequilibrium theory with randomness provides insights into the underlying economic processes in ways that the DSGE models cannot.

Dynamic disequilibrium with randomness vs DSGE. It is, of course, natural to try to explain the problem of unemployment focusing on the functioning of the labour market, with an emphasis on rigidities which prevent the restoration of full employment when the demand for labour decreases.[4] This view, we believe, is at best incomplete and misleading. While labour market adjustments might work in 'normal' times, they are likely to fail when there are *excessively* large adjustments in aggregate demand. The hypothesis that we pursue in this paper is that to understand economic crises and large fluctuations—both the emergence and propagation of macroeconomic

[3] We have not defined what this means, i.e. what would be a 'quick' restoration of full employment. But clearly, the 10 years it took the US economy to come back to something like normality after the 2008 crisis (though even then the employment ratio remained markedly below what it was before the onset of the crisis), and the long duration of the Great Depression and the euro crisis are beyond what one would have expected of an efficient and stable system. At the very least, the magnitude of the suffering and lost output from the slow return to normality raises the question of whether there might be government interventions that might have reduced both. General theorems concerning economic inefficiencies in the presence of macroeconomic externalities imply that there is a presumption that there exist such interventions. The question is, can we identify them; and to do that, we have to understand better the short-run dynamics, one of the objectives of this paper. (Macroeconomic externalities are simply the macroeconomic representations of the pecuniary and other externalities that almost inevitably arise in the presence of incomplete markets, information imperfections, credit and collateral constraints, search, and efficiency wage effects, noted by Greenwald and Stiglitz (1986, 1988*b*) and Arnott *et al*. (1994). See, for instance, Dávila and Korinek (2017), Korinek (2018a), Jeanne and Korinek (2018).)

[4] Today, these distortions are typically referred to as frictions. Such frictions, of course, mark all economies, whether at or below full employment; asymmetries of information are pervasive, and whenever they exist, markets are not (constrained) Pareto efficient (Greenwald and Stiglitz, 1986). This paper is concerned not with these ever-present market failures, but the much deeper failures associated with crises and deep downturns.

instability—one should focus on the instability of the aggregate demand rather than just on the labour market frictions.

By construction, macroeconomic disequilibria are absent from the standard benchmark frameworks of neoclassical economic theory, like the Arrow–Debreu complete markets framework or the environment postulated by DSGE models. Arrow–Debreu theorems rely on the assumption of the existence of a complete set of markets, which implies that nothing constitutes a perturbation and that there are never situations in which the set of plans turn out to be inconsistent with the set of budget constraints of the market participants—implying that there are never defaults or bankruptcies.[5] While DSGE models do not generally assume a complete set of Arrow–Debreu (AD) securities, they generally assume that transversality conditions hold *in every possible state*, implying a similar result. By contrast, the extreme macroeconomic dysfunctions with which we are concerned are marked by defaults and bankruptcies, sometimes touching large fractions of the economy.[6]

Under incomplete markets, it is not possible to check today that all plans will be consistent in every state at every date in the future, and it is likely that they will be revealed not to be in some state at some date. Because of the absence of futures markets, we simply can't tell whether, given individuals' plans, there would be market clearing in those markets, were they to have existed.

[5] Of course, with representative agent models, apart from the costs of bankruptcy, defaults and bankruptcy don't matter: the individual owes money to himself, and therefore there are no redistributive consequences of his not paying himself. Even HANK models, attempting to incorporate distribution, don't provide a framework for analysing the emergence and propagation of macroeconomic inconsistencies. As we note below, the macroeconomic consequences of costly bankruptcies in a world of interdependent firms, financial institutions, and households entails the analysis large macroeconomic externalities, typically giving rise to multiple equilibria.

[6] We've been tempted to add a 'G' at the beginning: A Dynamic *General* Disequilibrium model with randomness. We want to emphasize that we provide here an approach to the analysis of deep downturns that accounts for *general* interdependencies. Each crisis, each depression, each deep recession is different, and has its own idiosyncratic features. The breaking of the housing bubble was different from the breaking of the tech bubble, which in turn was different from crises at other times and places. Still, there are some commonalities among all of these, most importantly the revelation that previous plans of at least large numbers of individuals were inconsistent with reality; and the increased uncertainty and revised world views associated with that revelation, leading to large decreases in aggregate demand and employment.

We note, however, that like DSGE models, we do take explicitly into account the interdependencies across markets in the economy, and in that sense, our paper entails a *short run* general equilibrium analysis.

Of course, in a representative agent model, there is no problem in ascertaining the consistency of plans—there is no need for markets, and therefore no consequence of the absence of markets.[7] But when agents differ, there may be no way for them to know future plans of other agents, and therefore no way for them to know—in the absence of markets extending infinitely far into the future—that they are consistent. DSGE models assume magically that somehow agents solve this infinitely complicated problem without any coordination mechanism. And, even without knowing production functions and preferences of others, they constantly resolve this problem every moment as the economy experiences different technology shocks. Whether there is a stationary world in which that assumption might make sense is not our concern here:[8] we live in a non-stationary world which is constantly evolving, and it is clear that in such a world the assumption of ever-present equilibrium does not make sense.

Essential ingredients

Thus, the essential ingredients in the analysis to follow are (i) an incomplete set of markets; (ii) individual heterogeneity; and (iii) an evolving economy where individuals are constantly learning, about the structure of the economy and the behaviour of agents within it.[9] This learning, of course, affects behaviour, leading, in turn, to further evolution of the economic system. We'll say more about the evolutionary and learning processes later in the paper,[10] but here, we need to say a bit more about agent heterogeneity. Individuals differ in preferences, endowments, and beliefs. In a complete set of markets, all the relevant information is conveyed through prices; but with an incomplete set of markets, this is not so.[11] With heterogeneity, some individuals are creditors (or

[7] Still, even then additional behavioral assumptions are required: each individual has to know that everyone else is identical, that they have the same beliefs (common knowledge), that they are rational, and that they believe that all others are rational, so that if they ascertain an equilibrium path satisfying the transversality conditions for themselves, they can infer that everyone else will ascertain the same equilibrium path. Even this does not suffice in more general models in which there are multiple equilibria, for then without some coordinating mechanism, each individual doesn't know what the other (otherwise identical) individuals will believe about which of the possible equilibria states the economy will be in.

[8] In particular, a large and important literature by Guesnerie and his co-authors (Guesnerie (1992), Evans and Guesnerie (2003, 2005)) has shown that plausible economic systems do not exhibit what he calls eductive stability.

[9] Our analysis would be relevant even in a stationary stochastic environment, so long as the first two conditions hold: misperceptions are inevitable given the absence of perfect markets into the future; and as we show adjustment after the realization of any misperception is unlikely to be stable.

[10] Our work builds on a wealth of analyses of analyses of evolutionary analyses in economics, including work by Nelson and Winter (1982). For an early review, see Dosi and Nelson (1994).

[11] In particular, Grossman and Stiglitz (1976, 1980b) show that markets are not, in general, informationally efficient, neither fully aggregating not transmitting information from the informed to the uninformed.

otherwise provide capital); others are debtors. There is always counterparty risk: the creditor is never fully sure that the contract will be fully honoured. The debtor may *believe* he will honour the contract, but whether he is willing and able to do so will depend on future contingencies—including whether the contracts he may have made with others are honoured.

Because the economy is always evolving, there is always learning;[12] and because of persistence of incomplete information and information asymmetries—different individuals see and perceive different information and process it differently, so there is persistence in differences in beliefs—we never attain the utopia envisaged by DSGE models of common knowledge.[13] Individuals are exposed to different signals and process the information in different ways.

In the absence of economic evolution, we would presumably eventually learn fully about the economy, but because the economy is always evolving, there is always learning; and large events—crises and other events that reveal that pre-existing assumptions about the economy are not valid[14]—can give rise to large changes in beliefs.[15]

The complexity of the economy[16] makes learning about the structure of the economy all the more difficult and gives rise to complex dynamics; this, combined with differences in beliefs, can easily give rise to situations where *systemically* contracts are not honoured—there is a crisis. While these are not everyday occurrences, they occur with sufficient frequency and have sufficiently adverse

[12] Because there is always uncertainty, because the economy is always evolving (because of changes in technology and changes in beliefs, and because those changes in technology and beliefs may induce further changes in institutional arrangements—inducing further changes in technology and beliefs), and because the economy is so complex that, even in the absence of changes in underlying technology, there is likely to be a process of ever-lasting learning and evolution, but even more so in the presence of such changes. See the discussion in section III.

[13] There is a large literature detailing the stringent conditions required to achieve common knowledge, dating back to Aumann's (1976) work on Common Knowledge. See, for example, Milgrom and Stokey (1982) and Neeman (1996). There is compelling empirical evidence against the hypothesis of common knowledge. See Guzman and Stiglitz (2016*a*).

[14] In particular, in the discussion below we focus on the macroeconomic inconsistencies revealing discrepancies between individuals' plans and what can actually be realized.

[15] With a fixed economic structure, agents' knowledge may converge to full *structural* knowledge. See for instance Boz *et al*. (2011) and Guzman and Howitt (2016). For a general analysis of the conditions under which models with learning for formation of expectations exhibit *expectational stability*, see Evans and Honkapohja (2001).

[16] Battiston *et al.* (2016) explain how complexity gives rise to instability; and Roukny *et al*. (2018) explain that in complex systems, it may simply be impossible to ascertain systemic fragility. Dosi *et al.* (2020) illustrate the difficulties of learning about the structure of an ever-evolving complex economic system in the presence of changes in technology.

consequences that understanding them is, or at least should be, the centre of macroeconomists' attention.

The limitations of market mechanisms to coordinate inter-temporally the actions and decisions of the interacting economic decision-makers onto a stable path of aggregate demand was, of course, a central concern of macroeconomic theory in the years that followed the Great Depression. Keynes wrote before Kenneth Arrow and Gérard Debreu's fundamental theorems of welfare economics, and so he did not have the powerful apparatus provided by Arrow and Debreu that has been so extensively used by the mainstream literature since the mid-1950s to pin down what deviations from the perfect markets benchmark could lead to the observed frequent and persistent macroeconomic dysfunctions. Unfortunately, the mainstream macroeconomics literature that followed from the late 1970s on, by assuming that the system is always in a state of macro-consistency, simply assumed away the most important questions of the field. Under that assumption, it became natural to find in frictions like price rigidities[17] a culprit for the malfunctioning of the economic system. While even analyses of the Great Depression documented very large adjustments in wages and price, the single-minded focus on wage and price rigidities became increasingly untenable as policy-makers in the aftermath of the Great Recession became preoccupied with the risks of deflation, suggesting that they at least did not believe that wage and price rigidity was the crucial issue.[18] In this paper for a special issue on 'Towards Better Macroeconomic Theory and Policy-making', we analyse what we consider to be the fundamental premises that macroeconomic theories that intend to shed light on the most important problems of macroeconomics need to take into account, doing so in the language of modern mainstream macroeconomics.

Outline

[17] Typically explained in an *ad hoc* way, such as that there are large 'menu costs'. Uncertainties, including those associated with the revelation of macroeconomic inconsistencies discussed below, provide a more plausible explanation. See Greenwald and Stiglitz (1989).

[18] Greenwald and Stiglitz (1988*a*) present data for the Great Depression suggesting that wage and price rigidity were not the critical issue in that episode. Greenwald and Stiglitz (1993*a*) explained why increased wage and price flexibility might exacerbate economic downturns. See the more extensive discussion of Fisherian dynamics below, and the analysis of Solow and Stiglitz (1968).

This paper tackles themes that we consider fundamental for a research programme for macroeconomics. The rest of the paper is organized in six sections besides this introduction and the conclusion. Section II describes the benchmark models which have informed thinking about macroeconomics and macroeconomic dysfunctions, explaining the critical role of incomplete markets and the macroeconomic inconsistencies which result. Section III provides a more precise characterization of the concept of macroeconomic inconsistencies. Section IV asks: Is the market economy stable? Section V focuses on macroeconomic uncertainty, formation of expectations and learning, and macroeconomic forecasting. Section VI focuses on policy, asking: What determines the effectiveness of the different macroeconomic policies? And are there macroeconomic interventions to stabilize the system that are welfare-enhancing? Finally, section VII offers the conclusions of our analysis.

II. Macroeconomics in traditional benchmark models

Thinking about macroeconomy *dysfunctions* over the past third of a century has been greatly influenced by two benchmark models.

For the general equilibrium theorist, the Arrow–Debreu model is the lodestone for understanding all deviations from perfection, from the ideal world with no unemployment, no credit rationing, and in which observed fluctuations in the momentary equilibrium can be related to changes (fundamentally, fully anticipated as one of the possible states of nature) in underlying parameters of the economy (e.g. technology shocks). In a world of complete markets,[19] in which all individuals live within their individual budget constraints in all states of nature, there cannot be macroeconomic inconsistencies—i.e. states in which plans become inconsistent in the aggregate with the relevant resource constraints. There are no broken contracts, as every contingent Arrow–

[19] A complete market is one in which there are contracts for every state of nature at every date—a complete set of Arrow–Debreu securities. There are several other characteristics of this ideal world: perfect information, no externalities, no market power, and a costless adjustment of market prices. Note that there can exist costly adjustments of physical quantities. A well-functioning economy takes such costs into account. The price system is supposed to coordinate and take into account these adjustment costs. Impediments to the adjustment of prices means that they cannot perform these roles, or at least not as well as assumed in traditional models.

Debreu contract stipulates payoffs that satisfy all the resource constraints in every possible state. The transversality conditions hold in every possible trajectory of states of nature.

(i) Contrasting reality with the implications of benchmark models

The reasons why there is not a complete set of markets should be obvious. There would have to be an infinite set of markets, and even if the costs of establishing a market were small, the total costs would be disproportionate to the benefit. The assumption of complete markets requires that market participants have full knowledge of the space of states, from now on *ad infinitum*. In a deep sense, it assumes an economy in which there are no innovations. Everything that can ever happen is considered as a possibility from the moment when the market is completed. One has to have a market for the creation of atomic energy before the concept has been *conceived*.[20,21]

As we have already noted, when a full set of Arrow–Debreu markets is lacking, there is no way to be sure that plans are consistent except in very peculiar circumstances, to be delineated below; indeed, it would take a miracle to ensure that they are consistent for all states and dates. In general, moreover, the discrepancies between previously formed expectations/plans and realities are such that plans are not consistent in the aggregate. Changes in perceptions about the sustainability of the financial relations may then switch the economy from one path in which, for instance, there is willingness to rollover loans, to another, where solvency may become an even more dubious proposition and relatedly liquidity gets squeezed, triggering a financial crisis that includes widespread bankruptcies and defaults.[22]

[20] Moreover, the states as conceived by Arrow and Debreu were supposed to be *exogenous.* States that are based on innovation are endogenous, so for the Arrow–Debreu model to apply, it has to be the case that the 'arrival' of these ideas is totally exogenous, and we have to have Arrow–Debreu securities based on the arrival of a particular (still unknown) idea at any particular date.

[21] It requires, too, either a system of enforcement with unlimited capacity but a low cost, or some other way of achieving unlimited commitment to honour promises—the structure assumes not only that all promises can be honoured, but that they will be honoured.

[22] In this paper, we do not develop a full-blown theory of expectations formations, and therefore do not explain why there often appears to be a sudden realization of macroeconomic inconsistencies (highlighted in the sudden-stop literature (Calvo, 1988)), rather than a more gradual realization, which might afford more time for adjustment, thereby avoiding a crisis. Clearly, herding behaviour and the fact that beliefs are interdependent form part of the answer (see Banerjee (1992) for an analysis of herding behaviour in financial economics).

While we noted earlier that the large majority of economic crises were not associated with major changes in the underlying *physical* state variables—there have been no discoveries of new technology or major wars or exogenous events (famine or crop failure) that precipitated most of the major fluctuations and macroeconomic crises over the last century in industrial economies—many of the major macroeconomic events are characterized by large changes of the dominant social beliefs about the future of the economy, as for instance about the returns on particular classes of assets or about future output. These changes in beliefs, in turn, have large effects on contemporaneous aggregate demand, which, in turn, have typically reinforced both the changes in beliefs and the downturn.

The 2008 US financial crisis, for example, was not based on a sudden negative total-factor productivity shock.[23] Rather, it was based on a change of beliefs of investors and lenders, for instance, a changed subjective distribution of changes in housing prices and, relatedly, of the likelihood of mortgages going into default.[24]

So too, many of the sudden stops associated with capital flows in emerging markets are not predictable—that's why they're called sudden stops—and, beliefs aside, typically there is no identifiable exogenous event representing a changed 'state of nature' that can account for the dramatic behavioural changes that in turn have enormous impacts for the aggregate economy.

(ii) Beliefs and macroeconomic consistency

Simple benchmarks are useful, but they must be used wisely, with awareness of the limitations that their assumptions imply. While intertemporal general equilibrium models most often do assume that markets are incomplete, they most often also impose the condition that solvency will hold in every possible state at all dates (or equivalently that in every state of nature, no individual can consume more than the present discounted value (PDV) of his income by borrowing and not

[23] On the contrary, it has been shown that the behaviour of productivity clearly excludes the possibility that a negative shock to technology could have been the initial cause of the recession (Jermann and Quadrini, 2012).
[24] Similarly, in the more than 30 years since the 23 per cent fall in the in the Dow Jones on 18 October 1987 (Bernhardt and Eckblad, 2013), it has proven impossible to identify a 'real shock' that could account for the changes in valuations anywhere near this magnitude. But standard economic theory makes clear that a change in wealth or wealth perceptions of that magnitude should lead to marked changes in aggregate demand.

repaying what is owed). This is equivalent to imposing the condition that macroeconomic consistency will always hold (including that the transversality condition holds in every state of nature). In the simplest versions, assumptions are made so that default simply cannot arise.[25]

In the class of models where there are defaults, a default is never the consequence of a change in the understanding of market participants about the functioning of the economy (with the resulting change in behaviour), but simply the realization of a shock the occurrence of which everyone knew *ex ante* would result in a default. In a deep sense, then, even in variants of equilibrium models that allow for defaults there are no problems of macroeconomic consistency. When there is a default, someone will have a PDV of consumption larger than the PDV of her income and someone else will experience the opposite situation, and there may be a limited impact on aggregate demand associated with differences in, say, marginal propensities to consume out of wealth. But in those models, this risk is *ex ante* rationally anticipated and reflected in market prices. [26] It is *as if* there had been an implicit bet on a (set of) state of nature occurring, and the occurrence of that event triggers a payment. Formulated that way, there is in fact no macro-inconsistency.[27]

Furthermore, and most importantly, the realizations of different states of nature do not teach anything deep about the way the economy works. There is no change in beliefs. In the extreme case of rational expectations, all reduced-form structural parameters of the actual data generating process are known. Former Fed chairman Greenspan's *mea culpa* in the aftermath of the 2008 US financial crisis provides a useful illustration of the learning associated with a crisis. In his comments at a hearing at the US House of Representatives, he explained that he was 'in a state of

[25] This is the case, for instance, in the representative agent model. An economy in which there is a single individual is not really an economy and cannot be the basis of understanding a financial crisis, simply because an economy with a single individual can't have a meaningful financial market. Some of the problems with the representative agent approach are analysed by Kirman (1992). See also Stiglitz (1992, 2011). Some of the standard intertemporal models invoke collateral constraints. But collateral is required precisely because lenders are worried that borrowers will not fulfil their contracts. Thus, intellectual consistency requires that the structure of the economy is consistent with the possibility of defaults. In practice collateral typically does not fully compensate lenders in the event of a default: discontinuities associated with default are still important, as we show below. (That defaults give rise to discontinuities, and that therefore the standard assumptions of the AD model won't be satisfied, has long been recognized. See Stiglitz (1972)).

[26] See for instance Aguiar and Gopinath (2006), Arellano (2008), as well as the review of the literature of equilibrium models of sovereign default by Aguiar and Amador (2014).

[27] See Guzman and Heymann (2015).

shocked disbelief' about his prior view of the world 'because I have been going for 40 years or more with very considerable evidence that it was working exceptionally well' (Greenspan, 2008).[28]

Furthermore, in an evolving system it takes time for market participants to understand the full implications of the ongoing changes. For instance, prior to the Great Recession market participants seemed to have believed that the new financial products that resulted from financial innovation had fundamentally transformed the economy. But a few short years of data under the new regime was insufficient to provide full knowledge of the behaviour of the economy in this new regime. So market participants and regulators turned to earlier data to make inferences—inferences that turned out to be terribly wrong. Our criticism is not that they made bad forecasts, but concerns the pervasive cognitive dissonance: they simultaneously argued that the new financial products had fundamentally changed the economy, yet they relied on data from before the advent of these products to make their forecasts.[29]

But it's not just technology that's evolving. So is our system of social organization, such as the legal frameworks and their interpretation. This means that when the inconsistencies arise, there is often no clarity for market participants about how they will be resolved—a feature of actual market economies that in reality plays a key role for the dynamic adjustment process. Big events like macroeconomic crises have large consequences for our understanding of and for the workings of the systems that determine how such inconsistencies actually get resolved.[30]

---

[28] He went further to explain in greater detail what he learned, including about banks' management of risk. His remarks cast light as well on what one means by learning. For him (a key regulator and interpreter of the economic system), the failure of banks to manage risk came as a surprise, even though for many *microeconomists* who looked more carefully at individual or organizational incentives, it was not. There was clearly not "common knowledge." See the discussion in the next paragraph.

[29] More generally, relying on rational expectations models that assume that there is no change in structure is inconsistent with the beliefs (and profits) of those engaging in the innovation processes that drove those changes in the economy and who believed that their innovations had made a fundamental contribution to the workings of the economy. Such cognitive dissonance is not unusual, and is more consistent with macro-modelling based on behavioural economics than on that predicated on full rationality. Of course, the 2008 crisis and the inconsistencies which it revealed forced most rational observers to conclude that such modelling was wrong, but there were still not enough data to know what the correct model was, let alone to estimate all the parameters of such a model. (The fact that some did not revise their beliefs in the DSGE model may provide further evidence of the limitations of the rational actor model.) Indeed, the issue in which this paper appears is testimony to the fact that there is not agreement about the underlying structure of the model, with some arguing that the behaviour of the economy can be described *as if* such structural uncertainty could be ignored, while others contend that such uncertainty is fundamental to understanding macroeconomic changes, at least in certain critical periods.

[30] That is, the events themselves may alter the way the social-economic-political system functions. In the aftermath of the 2008 crisis, it was not clear whether there would be changes in the legal and economic framework facilitating the

Accordingly, in moments of high distress in which pre-established perceptions are questioned, and in which everyone is learning not just about how the economy works but also about how others think that the economy works and about how the inconsistencies that get triggered or revealed after large changes in beliefs will be resolved, uncertainty may grow and discrepancies of beliefs may become more acute, as it becomes less clear for market participants which 'model' best represents the workings of the economy. The premise that the revelation of macroeconomic inconsistencies increases uncertainty is no more than the recognition of well-known principles of statistics. When individuals have flat priors, even small changes in information can have large effects. They can make us realize that we are in a world about which we know very little. In recent years, for instance, events have led many market participants to become less convinced that what was broadly understood as the neoclassical benchmark, in which neoliberal policy prescriptions are appropriate, provides a good description of the world; but the discrediting of the models that constituted that benchmark has not led to confidence in an alternative. There is now more uncertainty about the consequences of policy.

When individuals are risk averse, an increase in uncertainty--more disperse posteriors-- can simultaneously lead to large increases in precautionary savings and reductions in investment.[31] These effects, in the context of a macroeconomy in distress, may be destabilizing.

(iii) Say's Law

restructuring of mortgages; it happened in some countries (like Iceland), but not in others. Even when there appears to be a clear legal framework, courts may refuse to enforce the law as written, for instance when that law is viewed as unjust. When American banks tried to enforce claims in Thailand against Thai citizens in the East Asia crisis, some judges (rightly in the judgement of many) refused, perceiving the banks as having played a central role in the creation of the crisis in the first place. So too, American banks tried to enforce mortgages that were not duly registered, as required by the law, and lied to the courts, in the famous robo-signing scandal. There was accordingly ambiguity about whether such claims were enforceable, with some courts removing people from their homes *even though they didn't owe any money*, while others were refusing to do so, even though they did. American banks have exploited such ambiguity, refusing to honour contract provisions guaranteeing that the mortgages that they had originated were as represented. More than a dozen years after the financial crisis, litigation over these claims continues.

[31] This is especially so in 'putty clay' models (i.e. models of *real* investment), where investments have to take a concrete form. In the presence of increased uncertainty, there is an increased option value in postponing investment.

A second traditional benchmark for economic analysis is provided by (Keynes's (1936) characterization of) Say's law, according to which there is never a problem with unemployment as supply gives rise to its own demand. This can be viewed, in its simplest representation, as a one-period version of the Arrow–Debreu model. Individuals would not supply labour unless there were goods which they wanted in exchange; the process of generating income is associated with a commensurate demand for goods.

Say's law seems in marked conflict with what we see in modern industrial economies which often experience large changes in aggregate demand even with low variability of supply shocks, and the two change in ways that often result in a gap between them. Changes in aggregate demand that are not driven by changes in aggregate supply capacity (technology shocks) are central for explaining large fluctuations in output and employment.

There is a simple explanation for the failure of Say's Law, an aspect of which Keynes noted: we live in a world with multiple periods, and individuals are willing to supply labour today in return for goods tomorrow. Today's purchasing power can be put into a store of value which is a non-produced good, like land or money.[32] Sudden and large changes in the demand for the store of value can result in correspondingly large changes in the aggregate demand for *produced goods*. This paper suggests that one of the explanations for these sudden changes in the demand for stored goods is the revelation of macroeconomic inconsistencies.

III. Macroeconomic inconsistencies

Credit–debt relations are promises of future transfers of resources, but those promises may or may not be fulfilled. The economic decisions of market participants depend on the constraints they face, and as the perceptions about the fulfilment of financial promises affect those constraints, changes in those beliefs may have large effects on economic behaviours—with consequences for the stability of the system.[33] Those beliefs may change dramatically when there is change in the

[32] Keynes focused on government-issued money, but most of the problems to which he called attention could as well have arisen in a model without government, where there was an alternative non-produced store of value.

[33] The failure of large numbers of debt contracts to be honored is but one example of an event which reflects and induces macroeconomic inconsistencies. If individuals believe that they can sell at future dates all the labor services

perceived consistency of the structure of financial promises. Thus, a macroeconomic theory that intends to address the most relevant macroeconomic problems needs to study the problem of macroeconomic (in)consistency.

(i) Elements and definitions

Macroeconomic consistency is essentially a question of whether previously established individual plans are consistent in the aggregate under circumstances and expectations that differ from the ones that prevailed when those plans were formulated. Thus, the study of macroeconomic consistency must account for the following elements:

- **the set of pre-established plans** for all market participants;
- **the set of constraints** for all market participants, which are state- and beliefs-dependent. For example, credit constraints will depend on the lender's expectation of being repaid; similarly, creditors' expected wealth will depend on the perceived probability that the loans they have granted will be repaid;
- **the sets of circumstances in which market participants find it desirable to adjust plans** rather than to face a disruption of financial relations that triggers legal disputes, such as those associated with bankruptcies.[34] There are some disturbances that create discrepancies between expectations and realizations that the system can absorb without triggering a wave of bankruptcies and defaults, while sufficiently large disturbances cannot be similarly absorbed.[35] We are particularly interested in the latter.

We say that plans formulated in a period t for the time range $[t, t+T]$ are *consistent* in the aggregate if they satisfy all constraints for the same time range $[t, t+T]$. In the presence of

that they would like at the going market wage, but then it turns out that they can't, that too reflects and induces macroeconomic inconsistencies. Much of the earlier Keynesian literature emphasized the difference between Walrasian and Keynesian demand curves, and the general equilibrium which arises when, in fixed wage and price models, individual and firm behavior is constrained, e.g. by effective demand.

[34] As the discussion below will make clear, not all bankruptcies are associated with macroeconomic inconsistencies.

[35] As the discussion below will clarify, sometimes the macroeconomic inconsistencies are so large and the uncertainties about their resolution so great that a wave of bankruptcies and defaults is all but inevitable. In other cases, it may be the result of decisions of agents about whether to accommodate the changes in circumstances through contract renegotiations. Obviously, public policy can affect whether a given set of macroeconomic inconsistencies results in a crisis.

changes to beliefs in period $h \in (t, t+T]$ that affect the constraints, the original plans may become inconsistent with the new set of constraints. There then obviously have to be adjustments. Sometimes, the changes in the budget constraints are so large that there will necessarily be broken 'promises' and defaults that will force a restructuring process. When this is so for a significant number of individuals we say there is a macroeconomic inconsistency. In the absence of a complete set of markets, it is likely that the plans of at least some individuals cannot be fulfilled—it is simply unlikely that prices and plans are such that demands equal supplies in all markets in all states, so that it is almost inevitable that at some date, in some state, macroeconomic inconsistencies will be revealed. Debt, financial, and foreign exchange crises are moments in which such macroeconomic inconsistencies make themselves evident in a dramatic way.

Momentary equilibrium, disequilibrium, and equilibrium and disequilibrium trajectories

At any moment of time, the economy will display certain outcomes. We refer to that as the *momentary equilibrium*. That momentary equilibrium may, of course, not satisfy the central conditions of competitive equilibrium theory, that demand for all goods and factors equal supply.[36] In particular, the momentary equilibrium may be characterized by unemployment. The standard DSGE models with wage rigidities recognize this kind of situation, which is often referred to as a type of 'disequilibrium', but assume that market participants take this and other similar constraints, say in the capital market, into account in formulating their plans. The 'equilibrium' in DSGE models refers to the fact that these (state contingent) plans are always realized; this paper, and the concept of macroeconomic inconsistency, suggests otherwise: in the absence of a complete set of markets extending infinitely far into the future, the equilibrium assumption underlying DSGE models—that all markets in all states at all dates going infinitely far into the future clear—is hard to justify. It is empirically falsifiable and falsified; and there has never been a theoretical justification, outside the overly simplistic representative agent models. The most important and interesting circumstances are those in which plans are not realized for large portions of the population, giving rise to our dynamic disequilibrium with randomness analysis.[37]

[36] In the presence of imperfect and asymmetric information, that condition will not necessarily be satisfied even in a competitive equilibrium (Stiglitz, 2002*a*, Stiglitz and Weiss, 1981).

[37] Later, we refer to the peculiar notion of equilibrium in DSGE models as 'pseudo-equilibrium' to remind us that at the moment prior to the shock, plans were based on beliefs that at least for many individuals are inconsistent, with each other, and with economic reality. We have repeatedly emphasized the cognitive dissonance pervasive in DSGE

(ii) An illustration: macroeconomic (in)consistency in the intertemporal consumption decision problem

Suppose that an economy consists of a representative consumer and a lender. The consumer in period t has a time horizon of T periods ahead, and makes consumption plans at t for the time range $[t, t+T]$. The consumer and the lender have common beliefs about the space of states, described by $S(t+T,t) = \{s_{t+j}^{k}\}_{\{j=0,1,\dots T\},\{k=1,2,\dots,K\}}$; that is, both agents think that in every period from t to $t+T$ there are K possible states and they agree about what those states are.

There are five cases of interest for our analysis of macroeconomic consistency.

Case 1. Suppose that $S(t+T,t)$ represents the full space of states and that markets are complete. In this case, there will be not be a macroeconomic inconsistency at any time. At time t, the consumer will formulate state-dependent plans that satisfy the budget constraints in each possible state, and the lender's expectation of the return in each state will be validated. The consumer and the lender might have different beliefs about the probabilities of each state, and given the realization of states there may be disappointments or pleasant surprises for each agent,[38] but in all states the aggregate plans will be consistent with the budget constraints.

Case 2. Suppose that $S(t+T,t)$ represents the full space of states but markets are incomplete—suppose that the only type of financial asset is a bond that promises a fixed payment, but given the stochastic nature of the environment, there is a probability of default that is compensated by a risk premium. Suppose that the states in which less than the full promised payment will occur are well-specified and contemplated in the consumption and lending plans. In this case, the economy operates *as if* the relevant contracts were 'complete', i.e. specified a payment in each state of

models: though individuals recognize that they have just experienced something that is inconsistent with their plans, going forward they assume that will never happen again.

[38] In the sense that a state that, for instance, one agent thought unlikely actually occurs; but, of course, the agent will have no way of knowing whether his judgement about the likelihood of that event was correct or not: we only observe one out of the possible evolutions of the universe. (This would not be the case in the simplistic world in which the 'state' referred to a recurrent event, e.g. rainfall, distributed with a stationary distribution. In reality, with climate change, even such a simple event can no longer be described by a stationary distribution.)

nature. Thus, there are again no macroeconomic inconsistencies. When the realized state is sufficiently bad, there will be a default, but that will be an event that does not create any surprise—it was perfectly anticipated by agents that there would be a default in that state, and the sum of the consumer's planned consumption and the lender's expected return that correspond to that state will not violate the budget constraint in that state. It is still possible that, with an incomplete set of (insurance) markets, the realization of that state has significant effects on aggregate demand, e.g. as a result of the failure of certain transfers of resources (purchasing power) from one party to the other that otherwise would have occurred.

Case 3. As before, suppose that $S(t+T,t)$ represents the full space of states but markets are incomplete—and again that the only type of financial asset is a bond that promises a fixed payment. Now, however, suppose that even though agents know that default may occur with some probability, the states in which default is supposed to occur are not fully specified—instead, suppose that a default in some state reveals an inconsistency of expectations: the plans of the consumer and the lender in that state cannot be satisfied at the same time given the budget constraints in that state. In this case, the default *triggers* (as opposed to just revealing) a macroeconomic inconsistency and a distributive conflict over a pie that is smaller than what is needed to ensure the aggregate consistency of individual plans—the lender does not want to simply accept the default but the consumer is not willing to pay in full, and there will be uncertainty about the relevant budget constraints for each of the agents until the dispute is resolved, which may take considerable time.

Case 4. Suppose that $S(t+T,t)$ does not represent the full space of states, but agents do not know it—they think it does represent the full space of states.[39] Agents still have access to a set of contingent assets but contingent only on the states that they conceive as possible—not aware of their incomplete knowledge of the space of states, they believe that markets are complete. They make state-contingent plans over the space $S(t+T,t)$.

[39] For instance, there are refinements about which the individual is unaware. He assumes that if it rains tomorrow, the crop will be of a given size; he is unaware that there may be a whole probability distribution, depending not just on rainfall but on temperature. The set of states about which individual *i* is informed may not coincide with the set about which *j* is informed, and it will not then be possible to have AD securities on those states. See Radner (1968). Obviously, with the evolution of time, there will be learning about the set of states of nature, and such learning can have large effects on aggregate demand.

Suppose that at time $t+h$ a state $s_{t+h}^{K+1} \notin S(t+T,t)$ that had not been conceived at time t is realized. In that case, none of the state-contingent plans formulated at time t may be consistent with the relevant budget constraints at time $t+h$. If s_{t+h}^{K+1} entails a more positive outcome for the consumer than was anticipated in all of the conceived states in $S(t+T,t)$, that will not create distress. But if s_{t+h}^{K+1} is a sufficiently bad state, such that the sum of the borrowers' planned consumption and the lenders' expected recovery in all future states is larger than what is available in the realized state, there will be distress, and restoring macroeconomic consistency will require adjustments. Those adjustments might occur voluntarily (but even then, the resolution might not have been known *ex ante*), or there could be a dispute with an unclear resolution that, while it lasts, makes uncertain what are the relevant budget constraints for each of the agents.

There is a fifth case, where we depart from the assumption made so far that both agents think that in every period from t to $t+T$ there are K possible states and they agree about what those states are.

Case 5. Suppose that $S(t+T,t)$ does not represent the full space of states, and agents know it. This is, perhaps, the most relevant case: they know their information is incomplete, but because obtaining information is costly, it does not pay them to obtain information about all the possible states of nature.[40] The revelation of a macroeconomic inconsistency results in a realization of a greater sense of ignorance—previously held beliefs were shown to be incorrect; and that in turn leads to more precautionary behaviour, with potentially large effects on aggregate demand.

Default and macroeconomic inconsistencies

This analysis highlights that not every default reveals a macroeconomic inconsistency, though crises where there are systemic defaults typically do. A broken contract could just be the

[40] We develop the analysis more extensively in section V. As we explain there, individuals may know that there are two states, S_1 and S_2, occurring with probability p and 1 – p, and may know that there are multiple substates, say S_{21}, S_{22},….S_{2n}, but don't know either the characteristics or probabilities of those substates, and given that S_2 is unlikely, don't make the investments required to obtain that information. But if they obtain information that the economy is, or is likely to be in, S_2, they do so. In short, the 'state space' as formulated by the individual is (necessarily) incomplete, the individual knows this, and the revelation of certain information (the occurrence of a particular event) leads individuals to realize that there may be substates (i.e. refinements of the state) with significant probability where there will be significant macro inconsistencies.

consequence of the realization of a bad state that everyone knew *ex ante* was possible. The transfer from the debtor to the creditor stipulated in the contract will just not occur in that state, and if there were no legal conflicts following the event, this would be the end of the story. The outcome would be the same as if the contract were not a debt but an equity contract with the amount transferred between the two parties stipulated to be the amount actually transferred.[41] There would be nothing fundamental to learn about the way the economy works—the default would just represent the unfolding of history, and things will continue just as they were before the event.

But legal frameworks are incomplete, just as contracts and markets are incomplete. The legal framework cannot specify how each possible contingency will be dealt with. Thus, when the debtor defaults, disputes that have to be resolved in a court of law often arise.[42] This aspect of defaults is not modelled even in equilibrium models in which defaults are possible. Those models assume a clear way forward after a default occurs—the debtor typically gets excluded from credit markets,[43] there may be a well-defined cost of default besides the cost of operating without access to credit, and there could be a probability of 'redemption' such that the debtor is allowed to re-enter the credit markets with a clean balance-sheet.[44]

(iii) Defaults and the meanings of macroeconomic consistency

[41] Thus, debt contracts, seemingly promising to pay a given amount in all states of nature, are in reality partial equity contracts, paying the given amount when the debtor can, and paying a lower amount in other states—an amount that would be determined by the application of bankruptcy laws. This formulation assumes, in other words, that there is no ambiguity within bankruptcy laws, and that there is full knowledge of what other debt obligations the debtor has (or at least a well-defined distribution of those obligations, with clarity about the relative seniorities of each). As the discussion below emphasizes, there is often ambiguity.

[42] In practice, when it comes to the resolution of sovereign debt defaults, there is a particularly high level of uncertainty, as there is not a multinational formal framework for the resolution of the disputes that arise after a default (see Guzman *et al*. (2016); Guzman and Stiglitz (2016*b*,*c*)). There is often substantial litigation in the aftermath of sovereign defaults (Schumacher *et al*., 2018). But the extensive discussions after the East Asia crisis and repeated changes in bankruptcy legislation, say in the US, show the existence of significant problems and uncertainties even at the national level. If there were no ambiguities, then bankruptcy courts would never have to adjudicate: all parties would know the outcome, and could save themselves the costs of litigation by undertaking payments in accord with what the bankruptcy court would have ruled. See Stiglitz (2000, 2001), Cooter and Rubinfeld (1989), Spier (2007). Earlier, Stiglitz (1972) had suggested how bankruptcy fundamentally changed the nature of market equilibrium.

[43] Whether defaulting debtors do or should (in a rational equilibrium model) get excluded, even temporarily, from the debt market is a subject of some controversy. Early literature (e.g. Eaton and Gersovitz, 1981) as well as a class of contemporaneous models on sovereign defaults *assumed* that they would be, but later literature (Eaton *et al*. (1986), and Stiglitz (2010*a*)) suggested that this might not be the case in 'rational' competitive markets.

[44] See Aguiar and Gopinath (2006), Arellano (2008), Eaton and Gersovitz (1981), and Stiglitz (2010*a*).

Defaults sometimes simply *reveal* a macroeconomic inconsistency. But more generally, the possibility of avoiding a default depends on the debtor's access to liquidity in every period in which his own income is insufficient to service debt. But the access to liquidity (both its quantity and its price) depends on lenders' beliefs about the probability that the lending they provide will be serviced in the future—which in turn depends in part on the lenders' belief that the debtor will have access to more financing when that future becomes the present, and so forth.[45]

This means that from an *ex ante* viewpoint, macroeconomic consistency cannot be unambiguously determined. Defaults themselves are a result of expectations of others, and changes in those expectations. Many market participants may believe that there is no problem; some that there is or may be: witness the discussions concerning whether there was a bubble in the years leading up to the 2008 crisis. Those with optimistic beliefs will hold that the debtors' transversality conditions are being respected—that in essentially all relevant states of nature they will be able and willing to fulfil their promises, and aggregate plans are consistent. When those who are optimistic dominate the market, the debtor will have access *today* to the necessary liquidity to 'honour' its promises of payment; even if his current cash flow is insufficient, (common) beliefs about future cash flows ensures that he can gain access to funding to fulfil his obligations. On the other hand, if beliefs are pessimistic, liquidity will be a binding constraint and the debtor may be forced (or choose) to default.[46]

Thus, in practice, macroeconomic inconsistency is both objective and subjective: an individual may not be able to meet his obligations, because he cannot get access to credit (an objective condition) and in the aggregate, planned spending may exceed the economy's resource constraints; but the aggregate consistency of plans (which determines each individual's ability to get access to

[45] That's why the standard distinction between solvency and liquidity (e.g. as a criterion for central bank bailouts) is somewhat confused: if it were unambiguous that a debtor was solvent, it would generally not face a problem of illiquidity. Illiquidity arises out of a concern for insolvency. And perceptions of solvency depend in turn on the price of liquidity. (Obviously, matters are somewhat more complicated in the presence of strategic defaults, especially associated with sovereigns, where 'solvency' is not well-defined.)

[46] The credit rationing literature makes clear that there may be no interest rate at which the consumer can get access to credit. But even if there is some interest rate at which he can do so, the consumer may choose to default, or to threaten to default.

funds) also depends on perceptions of multiple agents, perceptions that are themselves subjective.[47]

(iv) Changes in expectations, perturbations, and macroeconomic inconsistencies

The fact that the occurrence of a macroeconomic inconsistency is partly a subjective matter centres attention on the beliefs of market participants. A change in beliefs is a perturbation that is not really a 'shock' in the standard sense, but the consequence of a social process of formation of beliefs about the economy in an evolving environment with limited knowledge and information, in which there are feedback effects in the learning process between the reality and what the agents think they know about the economy. In fact, the word 'shock' is not helpful here. The most meaningful changes in beliefs—the ones we focus on—are endogenous. So too are the major perturbations that have afflicted capitalism—the breaking of a credit bubble, a tulip bubble, a housing bubble, the tech bubble. Even when there is an exogenous shock, like the COVID-19 shock, an important part of understanding the economic consequence is taking into account the massive change in beliefs—and the disparities in those beliefs-- provoked by the shock that led to radical changes in the organization of the economic system that had not been even envisioned as a possibility.

In the benchmark model with which we began the previous section, nothing constitutes a perturbation. And because every possible state has already been contemplated in the Arrow–Debreu securities from the origin of time and is known to everyone, and because all markets at all dates in all states clear, there will never be a violation of consistency conditions.[48]

When we move away from those benchmarks, there can be large sudden changes in beliefs, in the uncertainty with which beliefs are held, and in the disparity of beliefs, giving rise to large changes in aggregate demand. This is especially so when we take into account the social dimensions of belief formation, and the possibility of (rational) herding. What we have in mind here is more than

[47] The only situation in which there is full congruence between the objective and subjective is when there is rational expectations and common knowledge. Beliefs about the future obviously matter and differ; since such beliefs typically are subjective probability distributions over non-repeated events, there is no way of ascertaining the validity of those judgments.

[48] Under rational expectations, not only is there full knowledge of the relevant space of states but also full knowledge of the model that determines the probability of each state. Conditional on the set of information, all that can be known is known. Uncertainty is irreducible. More realistically, in general, when one state out of a possible large number has occurred, there typically is a change in posterior probabilities.

the seemingly inexplicable changes in beliefs due to 'animal spirits'[49]—instead, these are changes that are inherent to the functioning of an evolving non-stationary market economy in which it is simply impossible to have full knowledge of the space of states, and impossible to know the 'actual' probability distribution of all the variables and processes that are relevant for the economic decisions of market participants, and so individuals are always revising their beliefs. Such revisions are likely to be particularly significant when significant unanticipated events occur—and crises are by their nature significant and (at least generally) unanticipated. Moreover, the change in beliefs may itself affect the functioning of the economic system—there can be large feedback effects in the learning process, between what agents think they know about how the market economy works and how it actually works.[50] The change in beliefs about the ability of residential mortgage-backed securities (RMBS) to disperse risks has had, for instance, a profound effect on the working of the mortgage and housing markets, continuing to today, more than a decade after the housing bubble broke.

The change in beliefs that precipitates a crisis that both gives rise to and reveals macroeconomic inconsistencies may arise in many ways. The realization of any state of nature may change the *ex post* probability distributions of future states; such changes can be large, and when that is the case, a macroeconomic inconsistency can arise. But beliefs can have a life of their own, and as we have already noted, there can be changes in beliefs that cannot be easily traced to any *real* set of events. In complex networks, the beat of the wings of a butterfly can give rise to a cascade of events all out of proportion to and disconnected from the initiating event; and the social and economic system is a very complex network. It may be as simple as an article expressing scepticism regarding some government policy or a set of financial instruments that goes viral and changes perceptions and beliefs.

[49] Which are usually interpreted to be related to the psychology of the investor, with some economists suggesting that that may be manipulable. President Obama's economic team hoped that talking about green shoots would lead everyone to see green shoots—as might happen in a sunspot equilibrium. It didn't work. See the discussion below for how our analysis differs from that associated with those of sunspots and multiple equilibria.

[50] This, of course, is the notion of reflexivity emphasized by Soros (1987), and is incorporated in models such as that of Dosi *et al.* (2020).

The study of the origins of belief changes is important. The analysis of this paper, however, focuses on (*a*) the consequences, which are largely independent of these origins; and (*b*) why beliefs are likely to change dramatically *once* a macroeconomic inconsistency is revealed.

(v) Crises as revealing and inducing macroeconomic inconsistencies

At the centre of our analysis is the contention that crises have large effects on aggregate demand not just because of the (unanticipated) distributive effects (e.g. creditors who had thought that they would get repaid suddenly realizing that they won't be), but because macroeconomic crises typically entail large revisions in understanding of the workings of the economy and give rise to a large increase in uncertainty. True, there are some crises that are triggered by extreme events, such as a large natural disaster, that do not necessarily lead to substantial revisions of the views that determine how markets work, including how participants make their plans, or of what is the space of the states.[51] But most macroeconomic crises feature changes to formation of expectations that are incompatible with the premise that all that could have been known about the structure of the economy was actually known. The US 2008 crisis illustrates this phenomenon.[52]

The macroeconomic inconsistencies that are the object of our study here are of this type. In *normal* times, when the prevailing opinion in markets is that debt contracts will, with a few exceptions, be honoured, there is a perception of relative certainty about how the economy works and about the budget constraints that each market participant faces. But, occasionally there may be large changes in expectations[53] that in turn trigger changes in the perceptions about the sustainability of the credit

[51] Though there can still be learning, e.g. about how the economy responds to extreme events, including how the macroeconomic inconsistencies that emerge with such extreme events are resolved.

[52] In each crisis, one can identify the 'learning' that occurred. The East Asia crisis, for instance, 'taught' that crises could occur even in economies with high savings rates and fiscal surpluses, contrary to what economists thought that they had learned in the Latin American crisis of the 1980s. The S&L crisis taught the risks of under-regulated financial institutions (a lesson that seemingly was soon forgotten) and the risks of undiversified financial institutions, providing a rationale for universal banks. The 2008 crisis has exposed the risk of 'too correlated to fail' and the advantages of more specialized financial institutions (the disadvantages of universal banks.) See Furman and Stiglitz (1998), Griffith-Jones *et al*. (2010).

[53] As we noted earlier, we do not fully explore what triggers such expectational changes, or why they take the form they do. In the run-up to the US 2008 crisis, there were strong a priori reasons to believe that there was an unsustainable bubble; but economic leaders, like Greenspan and Bernanke, discouraged such thinking, helping the economy to coordinate on an optimistic perspective—we were living in a new economy. But eventually conventional arithmetic took hold—risk-averse homebuyers were unable or unwilling to pay inflated bubble prices—and the bubble broke.

relations. Such changes in perceptions often then trigger a reassessment of understandings of the economic and social system, in ways (as we explain more fully in the next section) that can lead to or deepen or prolong a crisis. This, for instance, is a typical characteristic in financial crises—sudden changes in the sets of beliefs of market participants lead to the revelation of large individual and aggregate wealth misperceptions.[54] All of a sudden, those who could lend become unwilling to do so;[55] those with outstanding loans refuse to roll them over; potential lenders do not find counterparties that they perceive as solvent with high probability, and it becomes optimal to hoard savings or invest in a non-produced store of value—a type of behaviour similar to what Keynes defined as liquidity preference. At the same time, those who thought that they had easy access to funds at reasonable rates suddenly discover that they have no access to funds at any interest rate. These sudden changes have further consequences, both today and in the future. For instance, while under other circumstances an act of saving may signal an increase in demand in the future—that in an equilibrium model would be satisfied by the increase in supply that the increase in savings-financed investment generates—the increase in savings that occurs after the revelation of macroeconomic inconsistencies does not generate an offsetting increase in investment today; the increased savings is precautionary, held in non-produced assets.

As we discuss in section V, the endogenous increase in uncertainty that gets triggered when the macroeconomic inconsistency is revealed *amplifies* the decrease in aggregate demand, a force that is destabilizing.

IV. Macroeconomic stability

Eventually, even the cheerleading from officials and the media could not offset the reality of macroeconomic inconsistency.

[54] The change in wealth perception may be due to the creation or destruction of pseudo-wealth, discussed more extensively later in this paper. arising.

[55] Some of these responses are consistent with a modicum of rationality: the revelation of the macroeconomic inconsistency means that some individuals who previously (were thought to be) able to repay their debts may no longer be able to do so. But typically, these events suggest that prior to the crisis, many individuals acted in a way that would be hard to reconcile with even a modicum of rationality, as revealed by absurd risk premiums on Greek debt or absurd assumptions about the evolution of house prices. Modern behavioural economics has provided insights into such behaviour, including the social determination of beliefs. On the latter, see, for example, Hoff and Stiglitz (2016).

Earlier, we argued that understanding large economic fluctuations, especially those associated with significant increases in unemployment, required understanding the large and often rapid changes in aggregate demand that sometimes afflict market economies, and that in turn requires an identification of the perturbations that affect agents' spending decisions. Central to that analysis is the exploration of economic structures and processes which amplify those perturbations entailing large changes in beliefs without significant changes in the physical state variables.[56] Here we focus on the systemic responses to revealed macroeconomic inconsistencies. The revelation of such inconsistencies inevitably leads to changes in beliefs about budget constraints. But the revelation of an inconsistency typically also induces a change in beliefs about the structure of the economy. Belief formation is a social process, in which there can be large changes in the aggregate state of beliefs even when there are seemingly small changes in observables.[57]

Financial crises are events in which there are large changes in observables, and so it is hardly surprising that they engender large revisions of priors, including both the mean and dispersion. Individuals had beliefs about the world that are shown to be wrong and, normally, that induces a rethinking about the underlying model. Recently, the US Great Recession was one of those instances. When debtors could not roll over their debts, models which simply assumed away the possibility of such events occurring should rightly have been discredited. If they had any relevance, they certainly didn't have much relevance in describing the economy at that moment. Both policy-makers and academics had to admit that the dominant model did not work.[58] By contrast, our 'dynamic disequilibrium theory with randomness' provides an intellectual framework for

[56] Earlier literature highlighted how credit and equity rationing could give rise to financial amplifications of changes in firm, bank, and household balance sheets (Greenwald and Stiglitz, 1993*a*,*b*). (Equity rationing is simply the notion that firms cannot raise additional equity at times that they would like to, or that were they to do so, the dilution in the value of the equity claims of existing equity owners is so great that they would not want to raise additional equity. See Greenwald and Stiglitz (2003*a*) and the references cited there.)

[57] Our earlier discussion highlighted two especially relevant features of the economy: the presence of herding behaviour, and the fact that in many circumstances, individuals have relatively flat priors. The presence of these large changes in aggregative beliefs when beliefs are interdependent is sometimes referred to as a social multiplier. See Hoff and Stiglitz (2016).

[58] The crisis was defined by some as a 'rollover crisis', but that is an event that is nothing else than a liquidity crisis, a large change in the extent of credit rationing (Christiano *et al*. (2018)). The standard DSGE models precluded credit rationing, and were unable to explain how a system *in equilibrium* could find itself suddenly in a state of macro inconsistency in which liquidity is squeezed. The 'trick' of invoking a *deus ex machina,* something totally outside the model, like an exogenous supply shock, this time called a rollover crisis, is obviously unsatisfactory.

We might better have written: Both policy-makers and academics should have admitted that the dominant model did not work, because many did not. See, e.g. Bernanke (2010).

understanding what happened. Such a crisis is in fact a stark example of non-market clearing in a context of severe doubts about agents' solvency; the macroeconomic system is put into an inconsistent state, as those who had counted on being repaid in order to fulfil their plans find out that they must now recalibrate[59]—a possibility that by construction had been left aside in equilibrium models.

While moments when macroeconomic inconsistencies get revealed are also times when economic agents lose confidence in their old economic model, there may not be a new model that quickly replaces the old: these are moments of increased uncertainty not only about the future but about the governing economic, political, and social model. This increase in dispersion itself has direct effects to which we have already alluded: it increases precautionary behaviour, leading to reduced demand for produced goods (consumption and investment).

This is part of what often is the unstable dynamics of adjustment. The standard 'story' of a shock leading to unemployment centres on the equilibrating force of (real) wage adjustments, leading to an increase in employment, ensuring that the unemployment is only transitory. But there may be simultaneously other stronger disequilibrating forces. We have just identified one: the shock changes beliefs in ways that increase precautionary behaviour, lowering aggregate demand. The resulting reduced demand for labour may exceed the increased demand generated by lower real wages. Worse: the lowering of real wage—something that previously had not been contemplated—may lead to even more precautionary behaviour, in which case the lowering of real wages exacerbates the deficiency in aggregate demand, leading to an *increase* in unemployment. The disequilibrating forces that we have just identified (and the further forces that we discuss below) are quite different from those typically associated with Keynes and Fisher, where falling wages

[59] The basic insight of the credit rationing (illiquidity) literature is that there may be no interest rate at which the lender is willing to lend and the borrower willing to borrow, even when the borrower (say, the bank facing a potential crisis) has a great need for funds. The higher the interest rate offered by the borrower, the more likely (in the beliefs of the lender) is it that the borrower will not make the promised payments (either because of adverse selection, or incentive effects, or because of costly enforcement), so much so that the expected return (especially, the risk-adjusted expected return) is lowered. Alternatively, at some interest rate lower than that at which the lender believes he is appropriately compensated for the risk of lending, the borrower concludes that he would be better off defaulting. This may be especially true, as we note below, if there is ambiguity about what happens in the event of a default—and the borrower (here a bank) believes that there is a reasonable chance it will be rescued, as actually happened during the US financial crisis of 2008. (Goldman Sachs did obtain some funds from the private market, but once the crisis was in full swing, it obtained funds from the government on much more favourable terms, as part of the bank rescue.)

leads to falling prices, and thus to an increase in the real interest rate (at a given level of nominal interest rate), which can depress investment.

Thus, understanding the persistence of unemployment requires taking a closer look at the dynamics of adjustment. As we have observed, in standard equilibrium models the economy is just *assumed* to be dynamically stable—following any perturbation, it *somehow* reaches the new equilibrium — without specifying the adjustment process. Moreover, it is simply assumed that the dynamic adjustment processes would, in the absence of wage rigidities, lead quickly (instantaneously) to a new equilibrium in which all markets, including the labour market, *today* clear. At the most relevant times for macroeconomic analysis such assumptions are inappropriate and unpersuasive. There is neither theory or evidence that current markets quickly return to equilibrium (with all markets clearing) after a perturbation. Most importantly, the failure of the labour market to clear cannot just be blamed on wage rigidity. Wages do adjust—but at times in ways that move the economy away from a full employment equilibrium rather than towards full employment. Here, we explain why the natural adjustment processes at work in a decentralized economy often do so. But first, we review the standard results about stability in perfect markets.

(i) Stability under perfect and imperfect markets

The fundamental theorems of welfare economics depict an ideal world where the decentralized market economy produces the best possible outcomes. Because there never is really a perturbation—every possible shock has already been contemplated and optimally taken into account in all plans—the question of whether the market forces will restore equilibrium when the system is perturbed is not even considered. Those who have enquired into the subject, making what might seem natural assumptions about adjustment processes beginning with an initial set of 'proposed' prices, have found it hard to find robust conditions for stability—and for good reason (to be discussed more fully below).[60]

[60] Scarf (1960) demonstrated that price-adjustment in a Walrasian general-equilibrium setting does not always converge to a general equilibrium; on the contrary, adjustments in one market may be continually counteracted by independent adjustments in other related markets. Howitt (1994) explains that the literature on the stability of general equilibrium, which flourished in the 1950s and 1960s, did not in any way establish a presumption of stability, and that

While even in a world with perfect markets we have no general theory of stability, the real world is, of course, not one of perfect markets, and in this real world, stability is even less likely. Earlier work (e.g. Solow and Stiglitz (1968)) showed formally that a natural decentralized process need not lead to the elimination of unemployment and that, if it did so, it might be a very slow process. As wages fall, prices fall, and markets may adjust so that they fall at the same rate—with real wages and unemployment unchanged. Fisherian dynamics (Greenwald and Stiglitz, 1993*a*) suggested things may be worse: as wages and prices fall, bankruptcies increase and so too does unemployment.[61]

(ii) Market adjustment forces

Earlier, we explained how the absence of a complete set of markets gives rise to the possibility of macroeconomic inconsistencies, the revelation of which can lead to large changes in beliefs without any large perturbation to the physical state variables or the state of technology. These changes in beliefs in turn induce large changes in aggregate demand. We now show that the revelation of a macroeconomic inconsistency triggers market forces that may be destabilizing, and that can be stronger than the stabilizing forces that might have prevailed when the consistency of the system had not been violated.[62] Thus, while economic theory provides little presumption that the benchmark model economy is stable, there is some presumption that real economies are not,

all that it has shown is that there are hypothetical sufficient conditions for stability, such as universal gross substitutability. He adds that 'when theorists discovered what a messy subject they had on their hands they just dropped it, although they had hardly begun to deal with expectations'. On the other hand, the standard DSGE models simply assume the matter away: the economy mystically, somehow, gets to the equilibrium. While there are plausible arguments that one might put forward for how this might happen in an economy in which there is a representative individual (who knows that all other individuals are identical to himself), in a more general model, there is no such mechanism. Enquiries into the stability of intertemporal market economies have been even more disappointing, showing that even if there are rational expectations ensuring that the no-arbitrage condition among assets is satisfied for any finite number of periods, no matter how large, unless there are futures markets going *infinitely* far into the future (or somehow expectations are such to be macroeconomically consistent going *infinitely* far into the future, *as if* there were such futures markets, an assumption that begs disbelief outside of the representative agent model) the economy is not stable. (See Hahn (1966), Shell and Stiglitz (1967)).

[61] These bankruptcies result in the loss of informational and organizational capital, a kind of negative technology shock—but one which is endogenous, and engendered by the decentralized dynamics.

[62] Even a small change in the state of the economy could, in principle, trigger large redistributions, which, if individuals differ significantly, could have large consequences. This may happen, for instance, in the models of pseudo-wealth discussed in the next paragraph. For example, in those models, small differences in beliefs with low levels of risk aversion can imply that an occurrence of a seemingly small event could have large consequences.

at least at the critical moments when macroeconomic inconsistencies occur, e.g. when there is a significant economic disturbance.

Suppose that there is a change in the beliefs about the future states of the economy that acts as a negative wealth shock.[63] There is a variety of ways in which a shock of that type can occur. For instance, the general opinion about the capacity of the economy for generating incomes could become more pessimistic, e.g. because prospects for future innovations are less than had previously been thought,[64] the society suddenly realizes that there was a misperception of the economy's wealth, the PDV of future income.

Or it could just be that agents were making trades based on heterogeneous beliefs—and whenever there are heterogeneous beliefs that are incentives to engage in bets-- that had led all sides of the trade to an expectation of future income that, in the aggregate, was not consistent with the capacity of the aggregate economy for generating incomes, and the economy is then hit by a shock that suddenly eliminates those differences in beliefs. Guzman and Stiglitz (2016*a*,*d*) refer to the difference between the sum of perceived wealth and actual wealth as pseudo-wealth That shock will destroy pseudo-wealth, leading to a fall in the aggregate perceived wealth.

Following any shock that reduces perceived wealth, normally aggregate demand will fall. If the shock does not simultaneously reduce the real capacity of the economy by the same amount, an economy that was in a momentary equilibrium in which all markets cleared today moves out of that *pseudo-equilibrium*—aggregate demand today falls, reducing also the demand for labour. We introduce the terminology 'pseudo-equilibrium' to remind us that at the moment prior to the shock, while markets may have cleared, plans were based on beliefs that may well have been inconsistent, with each other, and with the new (perceived) reality. Indeed, before the shock not only may the economy have been in a momentary equilibrium with markets clearing, all market participants might have believed that they were on equilibrium trajectories, in which all their plans would be fulfilled.

[63] That is, for instance, with any given supply of inputs (say labour), the value of incomes will be lower, and this affects life-time budget constraints.
[64] As a result, for instance, of the publication of an influential work such as that of Gordon (2016).

Rational expectations

Earlier, we explained that in a world with incomplete markets, episodic crises revealing macroeconomic inconsistencies, and an ever evolving economic, political, and social system, it was not rational to have 'rational expectations', to believe that the economy is always in equilibrium, that one knows fully everything relevant to how the economic system behaves, and that there accordingly is nothing to learn from what has happened. Large macroeconomic shocks cannot be appropriately analysed within models of rational expectations simply because they reveal that previously held beliefs were wrong. In analysing what happens then, one has to focus on how individuals respond to the changes—including how their beliefs change. Their behaviour might be described as 'reasonable' and even rational—but not in the narrow sense of the rational expectations literature. Thus, it was 'rational' for banks to respond to the unfolding events in the 2008 financial crisis by not lending to others, as they realized that their previous beliefs, e.g. about the ability of diversification to insulate financial institutions from a financial crisis, were wrong; and this is so whether their previous beliefs were fully rational or not. These second round expectations effects may clearly be destabilizing. This is just one example of a multiplicity of 'forces' which a crisis unleashes; as we will see, many of these exacerbate the downturn, rather than returning the economy back to a full employment equilibrium.

A taxonomy of stabilizing and destabilizing forces in a world of decentralized adjustment and learning

The critical question for our analysis is whether the market forces will quickly return the economy to a state of full equilibrium—or even just to a (pseudo-)momentary equilibrium in which all markets clear today. The general answer, as we will see, is 'it depends'. It will depend on the structure of markets (the types of market failures) that prevail and the assumptions about the structure of knowledge.

Following the change in beliefs that creates a negative wealth effect, there are multiple forces that determine the nature of the market adjustment. We can distinguish nine of these. In each case, we attempt to ascertain whether the effects are stabilizing or destabilizing, and the conditions under

which they might arise, e.g. the extent to which the particular effect is linked to market incompleteness.

(i) *Substitution effects*: market forces will change prices for both goods and labour, both today and in the future. The standard price mechanism ensures that a sufficient fall in prices (wages) equalizes supply and demand, provided that demand curves are negatively sloped. The presence of this effect does not rely on any specific assumption about market completeness or the process of expectation formation.[65] The working of this mechanism may, however, be limited by wage or price rigidities; these rigidities may arise from adjustment costs, from uncertainties (some of which are described below) of the consequences of adjusting, or from efficiency wage effects in labour markets or customer-market effects in product markets.[66]

(ii) *Income effects that come from distributional consequences of price changes*: changes in prices have distributional consequences that may affect aggregate demand. The implication, as demonstrated by the Sonnenschein–Mantel–Debreu theorem, is that the response of the aggregate demand to the fall in prices could go in any direction.[67] Similar to the substitution effects, these effects do not rely on any specific assumption about market completeness or the process of expectation formation.

[65] Although the sign and magnitude of the substitution effects depend on the expectational path: if there are, for instance, expectations that prices in the future are going to fall even more than those today, then the *net* substitution effect will decrease demand today. Similarly, there can be decreases in demand today because of complex complementarities across products, especially given expectations about the future. In general models, after a shock which at existing prices for goods and factors results in a deficiency of demand for a particular good, in the new full equilibrium, the price of that good may have risen. Partial equilibrium analysis provides an imperfect guide for general equilibrium. These general equilibrium effects were largely responsible for the difficulties in establishing stability in the literature discussed earlier.

[66] See Greenwald and Stiglitz (1989), Shapiro and Stiglitz (1984), Greenwald and Stiglitz (2003*b*), Phelps and Winter (1970). In contrast to real adjustment costs (which would slow adjustment in the context of an optimal response to a shock), the rigidities arising from uncertainty, efficiency wage, or customer-market effects may be more socially costly. In any of these cases, however, incomplete adjustment may give rise to macroeconomic externalities.

[67] Early studies of stability of general equilibrium (with origins in Walras) focused on a process of *tatonnement*, an iterative adjustment process in which capital gains and losses along the way were left aside. This was done to avoid the potentially destabilizing consequences of these income effects. Even so, as discussed earlier, it proved difficult to establish general plausible conditions under which the equilibrium was stable. These are not just theoretical niceties. The lowering of interest rates, which on the basis of substitution effects would lead to an increase in consumption and aggregate demand today, may have the opposite effect, if those who are dependent on interest income cut back their consumption more than those who are induced to consume more increase it. Here and elsewhere, the extent to which the occurrence of an event (say a change in price or in technology) has distributive consequences and induces a change in aggregate demand depends on the set of insurance policies in place. See, for example, Korinek and Stiglitz (2019).

(iii) *Fisher–Greenwald–Stiglitz balance sheet effects*: deflation will affect the income and wealth of market participants. Market participants who have not purchased insurance to fully insulate themselves from such shocks—almost everyone in all markets—will respond. Of particular relevance are the real balance effects that arise because debt contracts are not sufficiently indexed to the relevant prices.[68] These effects are typically destabilizing: while creditors are better off, *if* the borrower repays, Greenwald and Stiglitz (1993*a*) show that the decrease in consumption and investment by those whose balance sheets have been worsened will be greater than the increase on the part of those whose balance sheets have improved.

(iv) *Incentive effects from debt overhang*: the increase in the real value of debts also affects economic performance.[69] A large debt burden acts as a high marginal tax rate on the debtor's effort—thus blunting debtor incentives to produce. Moreover, with equity rationing, increased production is typically financed out of increased debt, inducing an increased probability of bankruptcy, so that deflation discourages production. It also discourages investment. Together, with adverse effects both on the demand and supply side, employment can fall. This effect can only arise under incomplete markets and/or incomplete information, and exacerbates the downward movement of the economy.

(v) *Income effects as the consequence of bankruptcy*: wage and price decreases may increase bankruptcies, and because of the significant costs associated with bankruptcy, net incomes may fall.[70] These costs include those associated with the uncertainty about the outcome of the bankruptcy process (to be discussed more fully below); and the dissipation of economic resources in the period of limbo, as those temporarily controlling the resources attempt to divert as much of

[68] Most debt contracts are not indexed at all. Greenwald and Stiglitz (1993*a*) emphasize that what matters is not so much a fall in prices, but a lower level of prices relative to what was expected. Hence disinflation can have analogous effects. Theories of asymmetric and imperfect information help explain the absence of insurance and the imperfections of indexation.

[69] See, for instance, Krugman (1988).

[70] If there were a single creditor, he would obviously renegotiate rather than bear the consequences of a Pareto inferior default. But when there are multiple creditors, bargaining among different creditors and the debtor, in the presence of asymmetric information, often does lead to defaults in which creditors are worse off.

those resources to their own welfare.[71,72] Macroeconomic crises are typically associated with large numbers of bankruptcies, so these income effects take on macroeconomic significance. These effects can only arise under incomplete markets, and these effects are typically destabilizing.[73]

(vi) *Distributional effects as consequence of the settlement of the macroeconomic inconsistency*: the way in which the consistency of the system is restored will have distributional consequences that can affect aggregate demand.[74] These effects can only arise under incomplete markets, and could be either stabilizing or destabilizing.[75]

(vii) *Uncertainty effects as a result of undefined budget constraints*: if it were perfectly clear how the macroeconomic inconsistency is going to be resolved, then there would not be uncertainty about the budget constraints that the economic agents will face after the shock. In the absence of

---

[71] Uncertainties about the outcome of the bankruptcy process and the extent to which resources will be dissipated in the periods before resolution imply that there may be large costs of delay in achieving a settlement. Credit is likely to be rationed in the interim (more rationed than it otherwise would have been). More generally, the actions which firms can undertake in the interim may be severely curtailed, and this too may generate high costs. Court attempts to limit diversion of assets while ownership and control are unsettled are both costly and inevitably incomplete. Note that the period between the revelation of the macroeconomic inconsistencies and the resolution of the inconsistencies is one of heightened uncertainties, the effects of which are described below. For analyses of the consequences of systemic bankruptcy and implications for the design of bankruptcy codes, see Miller and Stiglitz (2010) and Stiglitz (2000, 2001).

[72] There can also be general equilibrium price effects (both as a result of the delays prior to the resolution of bankruptcy and the changes in production patterns after the resolution as a result of a change in control), which in turn induce further distributional and income effects.

[73] That is, with a complete set of markets, these effects would have been anticipated and insured against.

There is another income effect associated with bankruptcy, noted earlier in fn. 65: the loss of organizational and informational capital.

There is still another aspect of incomplete markets associated with bankruptcy that can be important, but whose impact on stability is hard to ascertain. In complete markets, control is not important. In incomplete markets, it is. (Grossman and Stiglitz (1977, 1980a). Bankruptcy is typically associated with a change in control, and a change in control is associated with a change in decisions, affecting differentially the incomes of different individuals. (Stiglitz, 1972).

[74] The relevant distributional consequences of the settlement are not only those in relation to the pre-shock scenario, when the perception was one of macroeconomic consistency, but also in relation to the expectations that are formed about how the inconsistencies will be resolved after the inconsistencies get revealed. Consider a sovereign debt crisis. At times, the market expectation is that the settlement will include a large haircut on the creditors—a force that is generally stabilizing (because it is a redistribution from those with a low marginal propensity to consume living outside the country to those with higher propensities to consume living within the country)—but the actual settlement sometimes ends up involving less relief for the debtor than was previously anticipated—an outcome that is generally destabilizing. (In a sense, if market participants had 'reasonable' expectations, then at least some of the time, debtors will be disappointed about the amount of debt relief.) A recent example of such a case was the settlement of Puerto Rico's defaulted COFINA bonds, what included a level of relief for the country that was substantially lower than what market prices were anticipating a year before the settlement.

[75] Under rational expectations, the possibility of these effects would be anticipated and correctly priced. Defaults would just be the consequence of bad random draws from a perfectly known and correct probability density function—agents endowed with rational expectations but operating in incomplete markets can get unlucky or lucky. And the distributional consequences of default settlements would be anticipated and priced ex-ante. Nonetheless, the realization of this particular 'draw' of the lottery could lower aggregate demand, destabilizing the economy.

such predictability, the increased uncertainty following the revelation of a macroeconomic inconsistent will tend to increase precautionary savings by risk-averse agents and depress aggregate demand.[76] Indeed, aggregate demand will become depressed even earlier, before the actual occurrence of the crisis, as evidence mounts that there might be a crisis, thereby making such an occurrence more likely. These effects will be amplified if, as prices fall in response to the decrease in aggregate demand, the increase in the real value of debts increases the size of the macroeconomic inconsistency. Moreover, as we noted in the previous paragraph, the resolution of bankruptcies, especially in deep downturns, often takes a long time, leading to an extended period during which uncertainty effects may prevail. Again, these effects can only arise under incomplete markets.[77]

(viii) *Uncertainty and learning effects as a result of learning about the economic system—that it is different from what had previously been thought*: Under rational expectations, where by definition the 'true' model that describes the workings of the economy is known, the occurrence of any specific event itself does not affect beliefs about how the economy actually works. But in an environment in which the economy is constantly evolving in ways that cannot be anticipated, the occurrence, or even the perception of an increasing likelihood, of a macroeconomic inconsistency can reveal or at least induce the perception that the economy does not work as agents previously thought. This means that economic agents suddenly face an increase in perceived structural uncertainty. Learning from what happened entails possibly a large change in the perceived probability distributions, say of future states,[78] significantly affecting aggregate demand. There is some presumption (since the macroeconomic inconsistencies on which we are focusing occur as a result of not fully anticipated unfavourable events such as those associated with debt crises) that this is destabilizing.[79]

---

[76] There is a large literature explaining how, in general, an increase in uncertainty leads to more precautionary behaviour. See Rothschild and Stiglitz (1971).

[77] The uncertainties are especially great when there is systemic bankruptcy, i.e. where the bankruptcy of one enterprise affects the viability of others. See Miller and Stiglitz (2010) and Stiglitz (2001). Only recently has there been an adequate resolution of the mathematical problem of the solution of systematic bankruptcy in the presence of extensive bankruptcy interdependencies. That analysis highlighted the possibilities of multiple equilibria, and therefore the importance of the uncertainties that arise in the presence of systemic default. See Roukny *et al*. (2018).

[78] The event could alternatively provide more insights about how the economy works, leading to a decrease in uncertainty, although not under the assumption of rational expectations and not likely in the contexts upon which we focus here, the occurrence of a crisis.

[79] This is especially so because typically such events give rise to an increased dispersion of beliefs, with the adverse effects of those who are more pessimistic more than offsetting the responses of the more optimistic, as suggested, for instance, by the analysis of Greenwald and Stiglitz (1993*a*).

(ix) *Uncertainty and learning effects as a result of learning about the socio-political system*: crises typically reveal macroeconomic inconsistencies, where some parties' *ex ante* plans have to be revised. Typically, too, the sum of individuals' perceived 'just' claims on societal resources exceeds the available resources. And typically, there is not a system to deal with those inconsistencies which specifies how the macroeconomic inconsistencies are resolved in a fully pre-determined way.[80] This will give rise to negotiations and disputes that will at least in part be resolved by the socio-political system. The way in which the inconsistencies are dealt with may also entail learning about the true nature of the socio-political system. Learning about the social/economic/political system includes learning how legal frameworks work, revising views of those who judge over disputes, and obtaining greater insights into the power structure within the system. The system itself is always evolving, as, for instance, underlying technologies change and the economic consequences of those evolutions become apparent. While it is possible that we may learn that the social-political system is better at dealing with macroeconomic inconsistencies than was previously thought to be the case, just the opposite may be true, so these effects may be either stabilizing or destabilizing.[81]

Table 1 summarizes the effects that get triggered after the beliefs shock, each of which must be analysed comprehensively in order to draw conclusions about the stability properties of a market economy.[82] If there were a complete set of markets, the large income effects that we identify would not occur, because individuals would have insured against them.[83] And with a complete set of markets, there are not bankruptcies,[84] precisely because contracts are designed in ways that the budget constraints are satisfied without a bankruptcy or default in *any* state of nature. That's why

[80] For instance, earlier we discussed the ambiguities that arise in bankruptcy laws. As we also noted, such problems are heightened in the presence of systemic bankruptcies.

[81] In addition, there may be a dispersion in the changes in beliefs, with those who perceive the system is unfair—who believe that they have experienced a large loss in wealth—dominating over those who believe otherwise, and the losers may have a higher marginal propensity to consume than the (relative) winners. In that case, the change in beliefs resulting from learning about how the economic and social system works will depress aggregate demand.

[82] The change in beliefs gives rise to second-round effects that may make matters even worse, including through price adjustments that in the standard theory were simply hypothesized to help restore equilibrium.

[83] Richer individuals would, on average, provide insurance to poor individuals, so that the realization of a negative wealth shock would in such a world lead to a transfer of resources from individuals with a low marginal propensity to consume to a high marginal propensity to consume, and so the payment of the insurance would be stabilizing.

[84] As we have noted, even without a complete set of markets, 'complete contracts' can be designed to avoid bankruptcy. The fact that so many debt contracts are written in ways that clearly anticipate the possibility of default implies that contracts are far from complete. This takes on particular importance in the events upon which we focus, such as debt crises.

our stability analysis so much richer, complex, and we would argue more realistic than that of standard competitive analysis (as reflected in, say, Arrow and Hahn's *General Competitive Analysis* (1971).

Table 1: Types of adjustment forces

Type of adjustment force	**Direction**	**Required market failures**
Substitution effects	Stabilizing	None. Limited by price rigidities
Income effects from distributional consequences of price changes	Stabilizing or destabilizing	None. Limited by price rigidities
Fisher–Greenwald–Stiglitz debt deflation effects	Destabilizing	Incomplete markets/contracts
Incentive effects from debt overhang	Destabilizing	Incomplete markets/contracts
Income effects from distributional consequences of the settlement of the macroeconomic inconsistency	Stabilizing or destabilizing	Incomplete markets/contracts
Income effects as the consequence of bankruptcy costs	Destabilizing	Incomplete markets/contracts
Uncertainty effects as a result of undefined budget constraints	Destabilizing	Incomplete markets/contracts

Uncertainty and learning effects from learning about the economic system	Destabilizing	Incomplete markets/contracts
Uncertainty and learning effects from learning about the socio-political system	Destabilizing or stabilizing	Incomplete markets/contracts

(iv) Assessing stability under imperfect markets

The stability of the market economy will depend on the relative strength of the dis-equilibrating and equilibrating forces that are put in motion when the system is perturbed. There is no presumption that the equilibrating forces always dominate over the dis-equilibrating forces. It is possible that the adjustment forces are overall stabilizing under some circumstances, e.g. for a small perturbation, but destabilizing under other circumstances, e.g. in the context of a large disturbance.[85] An example of such a non-linearity is the discontinuity in the adjustment forces if dis-equilibrating forces get activated under some circumstances but not others. We have argued, for instance, that the revelation of macroeconomic inconsistencies typically will put in motion dis-equilibrating forces associated with uncertainty, wealth, distributional, and incentives effects that are not present when the prevailing perception is that the system is in a state of consistency. Discontinuities in belief formation too give rise to a discontinuity in the strength of destabilizing adjustment forces.[86]

Importantly, the adjustment forces that we have described are market determined. None are dependent on the *existence* of government, let alone a particular view about how the government

[85] See Howitt (1978) and Leijonhufvud (1981) for a related discussion on the limits to the stability of a full-employment equilibrium.

[86] That is, for small deviations from what was expected, individuals do not revise their beliefs about how the economic system functions, but for large beliefs they do. (See the discussion in the next section.) Alternatively, even if there is continuity in belief formation—with the size of the revision in beliefs a continuous function of the size of the revealed macroeconomic inconsistency—there can be a critical threshold—a big enough crisis—such that for crises of that size or larger, at least in the short run, the dynamics are destabilizing. This may be especially so in the presence of herding behaviour and social multipliers, as discussed earlier in fn. 61.

behaves. On the other hand, the belief that government is committed to maintaining the economy at or near full employment and that it has the tools to do so may affect the behaviour of market participants in ways that are stabilizing.[87]

Our discussion of stability enables us to further clarify the distinction between the concepts of equilibrium and disequilibrium to which we alluded in the introduction to this paper.

Disequilibrium vs equilibrium with stagnation

The macroeconomic phenomena that are at the core of our analysis have to do with the malfunctioning of the economy. We have argued that the deepest forms of malfunctioning arise in situations of disequilibria where a disturbance reveals the inconsistency of plans. Given the new state of the economy, there will be equilibrium conditions—for instance, the transversality conditions—that will be violated. Even the standard momentary equilibrium conditions (full employment) may be violated, even with considerable flexibility of wages and prices, because the decentralized adjustment processes (described earlier) may not work quickly and forcefully enough to restore the economy to full employment and, indeed, may move the economy in the opposite direction.

There are other strands of recent macroeconomic research analysing the malfunctioning of the economy—reflected, for instance, in the persistence of unemployment—as *equilibrium* outcomes. Our analysis of disequilibrium must be distinguished from those related literatures. For instance, one approach that became popular in the aftermath of the Great Recession invokes rigidities in wages to ensure that the labour market can't be restored to full employment after a shock to aggregate demand.[88] The analysis employs the standard intertemporal general equilibrium model. The increased uncertainty after the crisis induces more precautionary behaviour, lowering

[87] For instance, it may lead to reduced precautionary behaviour, and this belief itself can help stabilize the economy. On the other hand, in some circumstances, government behaviour may be destabilizing. Prior beliefs about government intervention to stabilize the economy may have been undermined in the summer of 2020, as the US government was unable to extend unemployment benefits and provide assistance to states and localities in the midst of the pandemic, leading to an increase in precautionary savings.

[88] In the absence of any constraints on market prices, there would still be a vector of prices that would satisfy the market clearing conditions. The assumption of fixed wages is, of course, extreme; all that is required is that they are not fully flexible. We have emphasized, however, that if there is some flexibility, the direction of adjustment may be dis-equilibrating rather than equilibrating.

aggregate demand.[89] However, while previous assumptions about the economy being on an equilibrium path were falsified, the economy nonetheless behaves as if such an occurrence will not occur in the future. Moreover, it puts under the rug some of the fundamental aspects of the behaviour of the macroeconomic system that get manifested in the aftermath of the disequilibrium to which the previous section called attention. A robust analysis of the macroeconomic dynamics that follow a perturbation must account for how the system responds to the perturbation, including how the size of the inconsistencies responds to price changes and how uncertainty *evolves* endogenously when inconsistencies get revealed.

Another important strand in macroeconomics notes how coordination failures can lead to a bad, inefficient equilibrium—but the focus is still on 'equilibrium'.[90] The key ingredients of those theories include strategic complementarities—still generally in an environment of agents endowed with rational expectations. For instance, suppose that signing a labour contract is costly: the process of search and matching consumes resources, both for the employer and the potential employees; and suppose that there is a 'thin-market externality' in the search and matching process: the return of the search for the employer is larger when the potential employee exerts more search effort, and vice versa. In this context, there will be two equilibria: one with low intensity of search and low employment, and another with high intensity of search and high employment. The low effort and low employment equilibrium is inefficient.[91] The dysfunction is often referred to as a coordination failure; if everyone would become more optimistic about the efforts that the others would exert, the system would reach a superior, well-coordinated, solution. Absent a mechanism for bringing about such a coordinated change in expectations, the economy will stay trapped in a low-employment equilibrium. This equilibrium is of a non-Walrasian type: it is not just determined by price variables but also by (expectations of) non-price variables—the expectations about the intensity of search of others. However, this is a different type of

[89] Not just precautionary savings will be higher, but real investment will be lower. There is an 'option value' in not investing, and this is especially so in a world of 'putty-clay'. To reiterate what we emphasized earlier: if there were no non-produced asset into which agents could put their precautionary holdings, the precautionary demand would only increase the composition of the demand for produced goods, not the overall level.

[90] For example, Diamond (1982), Howitt (1985), Cooper and John (1988), Cooper (1999), Benhabib and Farmer (1994, 1999), and Cass and Shell (1983). See also Howitt (2003) for a review of the literature on coordination failures.

[91] In such models, even with a unique equilibrium, the level of search will in general not be efficient. See Greenwald and Stiglitz (1988*b*). The inefficiencies that arise in the case can be thought of as simply associated with macroeconomic externalities.

coordination failure than the one associated with the inconsistency of plans in the aggregate that we have emphasized. No equilibrium conditions are violated in the decentralized market outcome. There is no shock that puts the economy off-course and to which it has to adjust. Thus, there is, within this literature, no discussion of dynamics of adjustment—the dis-equilibrating forces associated with macroeconomic inconsistencies that we have discussed in this section are simply absent.[92]

But still, there is an important link between multiplicity of equilibria and the possibility/likelihood of the occurrence of macroeconomic inconsistencies, a link which can be present even with rational expectations,[93] and especially so in the presence of bankruptcy costs. Without knowing which of the dynamic trajectories will characterize the future, one cannot know whether a path is dynamically consistent, and we won't know for sure until the dynamic path is fully revealed.[94] While such multiplicity of equilibria naturally gives rise to macroeconomic inconsistencies in the absence of futures markets, they can arise more generally—our analysis focuses on this more general situation. On the other hand, as we previously observed, it is typically not unambiguous how the inconsistencies will be resolved; there may in fact be multiple alternative trajectories going forward, depending on the resolution of the macroeconomic inconsistencies—all consistent with the pre-existing legal framework.[95]

[92] More precisely, this literature, like the DSGE literature, focuses on the macroeconomic equilibrium, with no attention to how the economy attains that equilibrium. Typically, the models are simple enough that standard game-theoretic approaches suffice, with market participants knowing the pay-off functions of the other relevant participants, and therefore being able to infer their behaviour. See, however, our discussion above of how heterogeneity undermines the plausibility of that approach more generally.

[93] Hirano and Stiglitz (2019) show that in a rational expectations model with overlapping generations, there can be an infinity of trajectories. The large literature on sunspots (Cass and Shell, 1983; Benhabib and Farmer, 1999) focused on multiplicity of macroeconomic equilibria. Similarly, in debt markets there may be a low interest rate equilibrium, associated with and justified by low default rates; and another equilibrium with high interest rates, marked by high default. See Calvo (1988) and Greenwald and Stiglitz (2003*a*). For a general equilibrium discussion focusing on defaults in financial contracts, see Roukny *et al*. (2018).

[94] That is, different individuals (given the observables) may believe that the economy is on different paths; on the trajectory they each believe the economy is on, there is full macroeconomic consistency; but their beliefs are inconsistent. In this case, the macroeconomic inconsistencies are sometimes described as arising out of a 'coordination failure'. But, of course, such coordination failures are to be expected in the absence of a full set of markets.

[95] There can even be multiple momentary equilibrium and multiple trajectories, *given* any specific resolution of the macroeconomic inconsistencies. And the fact that there are multiple possible trajectories *post* crisis means that there is a corresponding multiplicity before the crises, with market participants differing even in their beliefs about the likelihood of a crisis along and across trajectories

V. Beliefs, uncertainty, and learning

This section focuses on one set of effects identified in the previous section, the interaction between formation of beliefs, uncertainty, and learning in an environment of incomplete markets in which macroeconomic inconsistencies can arise.

(i) Uncertainty effects as a result of learning about the economic and socio-political system

The increase in subjective uncertainty arising out of learning about the economic and socio-political system can be founded on reasonable assumptions about the structure of learning and its costs. Suppose that agents understand that there may be more than one model that represents how the economy works—there are multiple possible worlds. Suppose that understanding the workings of the economy in each of the possible worlds (including in each of the possible substates) is costly.[96] Furthermore, suppose that the agents of the economy have a common prior that suggests that with very high probability the true world is world A. For a sufficiently high learning cost, it is optimal for the agents not to learn about how the economy works in world not-A. They act as if there were a single not-A state. They may form beliefs about the average value of relevant variables in not-A (but if not-A occurs with small enough probability they may not even do that); but it does not pay to 'refine' one's thinking about what happens in a world of type not-A. Under those circumstances, sufficiently small updates of priors would not have large effects on the state of knowledge and beliefs about not-A. But a sufficiently large disparity between priors and posteriors will trigger an entirely new learning process. Now, the perceived probability of being in world not-A is large enough as to pay the learning cost. While they learn, uncertainty will reign. They now not only know that they don't know, they act accordingly.

An example that fits this learning process is the idea of thinking through categories (Mullainathan, 2002) in the presence of non-convexities. The structure of costs of processing information and learning may be such that it becomes optimal for the economic agents to use coarse categories to make inferences. Rather than engaging in continuous Bayesian updating, agents update their views of the world only when they see enough data that suggest that a different view is a better fit to the

[96] And that there are natural non-convexities to learning—it is better to learn a lot about a few things than a little (say almost nothing) about a lot. And even if ignorance isn't bliss, it's a local optimum. See Radner and Stiglitz (1984).

realities they have been experiencing—and that it pays to make the investment in information to refine one's views. Once a category is chosen, other categories are not considered in making predictions—until another refinement or categorization seems desirable.

The same process that governs the evolution of beliefs may endogenously create uncertainty about the workings of the socio-political-economic system. Suppose that world A is one represented by a typical DSGE model, in which the possibility of macroeconomic inconsistencies is ruled out. As long as the signals that the economy receives do not lead to a significant discrepancy between priors and posteriors, it will be optimal for the agents not to figure out how the socio-political system under which a macroeconomic inconsistency (that reveals that the world is not-A) would be resolved. But a sufficiently large discrepancy between priors and posteriors will entail learning. They now know that they are living in a different world than they had thought, and they know that they don't know much about this world. They (rightly) perceive themselves as facing more uncertainty—and this induces still more learning. Note that there is a subtlety here with respect to the issue of uncertainty: agents knew less about the workings of world not-A before the shock, and in that sense the distribution of probabilities over world not-A was more disperse—if it were defined at all. But the probability that they were assigning to that world was low enough as to act *as if* that world could not happen. This means that *perceived* uncertainty increases after the shock, and, of course, *perceived* uncertainty, is what actually matters for economic decisions.[97]

Heterogeneous beliefs

If different agents follow different processes for formation of expectations, uncertainty may grow even larger. Take an economy that has had a long period of stability, and that has led to a low dispersion of beliefs about the nature of the economic system. For instance, before the Great Recession there was convergence to a shared perception of common knowledge, in particular a

[97] There is an additional element of uncertainty associated with differences in beliefs: 'learning' may mean different things for different agents, creating not only more dispersion in beliefs about the correct model but also more disagreement about the structural parameters of what is believed to be the correct model for those who share that belief. (See, for instance, Acemoglu *et al*. (2006).) Take the example of learning about macroeconomic theory after the Great Recession. It is clear that some hold to the prior that the world is described by a DSGE model far more firmly than others, but there is uncertainty about what fraction of market participants will change their beliefs, and for those who change their beliefs, what their new beliefs will be. Among those who continue to believe in the DSGE model, some may believe that the crisis changed their estimates of the structural parameters, others that there is no reason for revision, given that one has just observed a once-in-a-hundred-year flood, an event ('a rollover crisis') that, while recognized to be outside the model, does not alter one's views of possible future courses of history.

shared belief that we live in a world of the Great Moderation. The switch from the shared belief of being in world A, the Great Moderation, to world not-A, created significant heterogeneity of beliefs, in particular, because the world not-A can include many different worlds. There is no reason a priori why all the agents would have the same posterior distribution of probabilities over all those alternative worlds,[98] or even employ the same sets of categorizations. And the evidence is that they did not. Accordingly, the crisis was associated with a discontinuous jump from the shared belief of being in world A, the Great Moderation, to world not-A; and this led to a large increase in uncertainty—not only had prior beliefs been destroyed, now individuals knew that they didn't know what others believed and how the increased dispersion of beliefs would affect the performance of the economy.

COVID-19

The COVID-19 pandemic—that broke out about a year after we started to write this paper—constitutes a salient example of a change from world A to world not-A that triggers an endogenous large increase in uncertainty and a new learning process. The pandemic led to lockdowns that massively affected the workings of the economic system, leading to significant macroeconomic inconsistencies, of the kind that constitute the object of our study, as economic plans—and economic systems all over the world in general—had not accounted for the possibility of such a contingency.

An extreme event like the COVID-19 pandemic can be analysed through the lens of the framework for dynamic macroeconomic disequilibrium with randomness that we present in this paper in two different ways. The first is to think of COVID-19 as an event that economic agents knew was possible but thought had such a low probability that it was not worth learning about its implications—despite the costs that not knowing much about it would entail in case it was realized.[99] The second possibility is to think of it as an event that could not be foreseen, that was the consequence of evolutionary forces that could not be anticipated—thus, there was no chance

[98] We would expect such dispersion, for instance, if the agents follow different processes for formation of expectations, including choosing different categories.

[99] The earlier SARS and MERS epidemics had made clear—to a few—the possibility of a hard-to-anticipate pandemic, inducing the White House to set up an office within the National Security Council to deal with the threat. But few economic agents incorporated the possibility into their planning, and it is now clear that there will be major macroeconomic inconsistencies. Twice in a dozen years the standard equilibrium model has failed.

of even making economic plans that were contingent on such a state of nature. In either case, its realization would trigger a change in economic and social constraints, a new learning process (including learning about the substates within the state of nature 'COVID-19') in which time acts as a constraint, and in which macroeconomic inconsistencies get revealed that act as an accelerator of the increases in uncertainty.

(ii) Forecasting and subjective expectations

In the aftermath of the 2008 North-Atlantic financial crisis, the difficulties of macroeconomic forecasting became evident, with large and systematic errors in forecasting, even by 'blue chip' forecasters. There were also large divergences in forecasts, contradicting the standard assumptions about common knowledge and rational expectations, but consistent with the analysis of this paper. Figures 1 and 2 provide two telling examples. Figure 1 shows the comparison between the actual GDP growth of the US and the Federal Open Market Committee (FOMC) forecasts, and figure 2 shows the comparison between the actual GDP of Greece and the International Monetary Fund (IMF) forecasts, in both cases from the origins of their respective crises.

Figure 1: US: Actual GDP growth and the Federal Open Market Committee (FOMC) forecasts

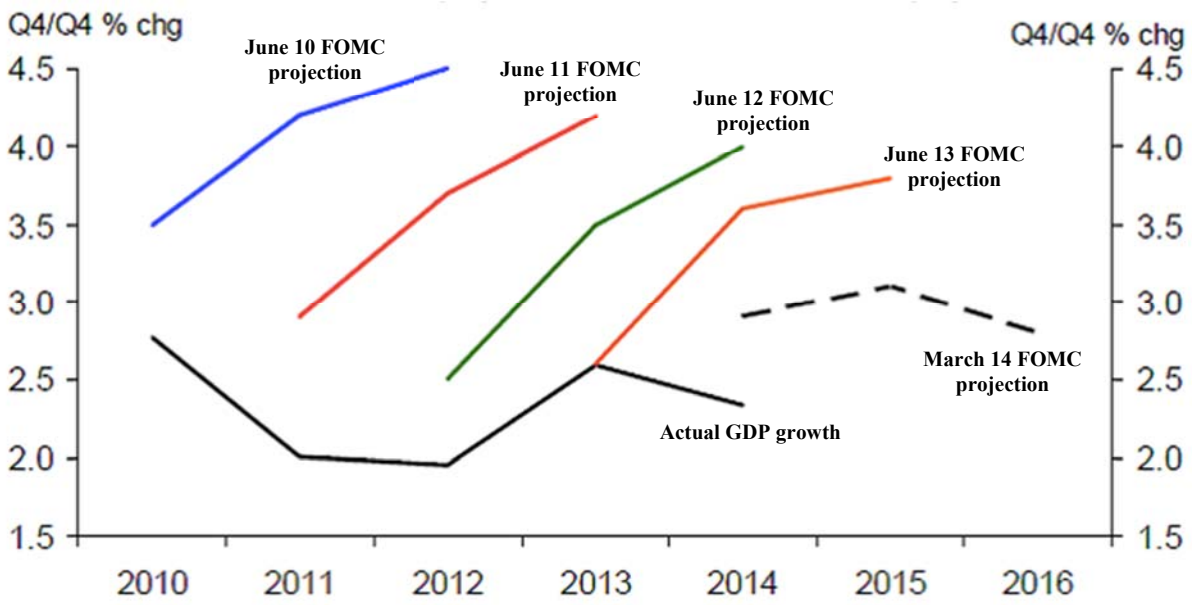
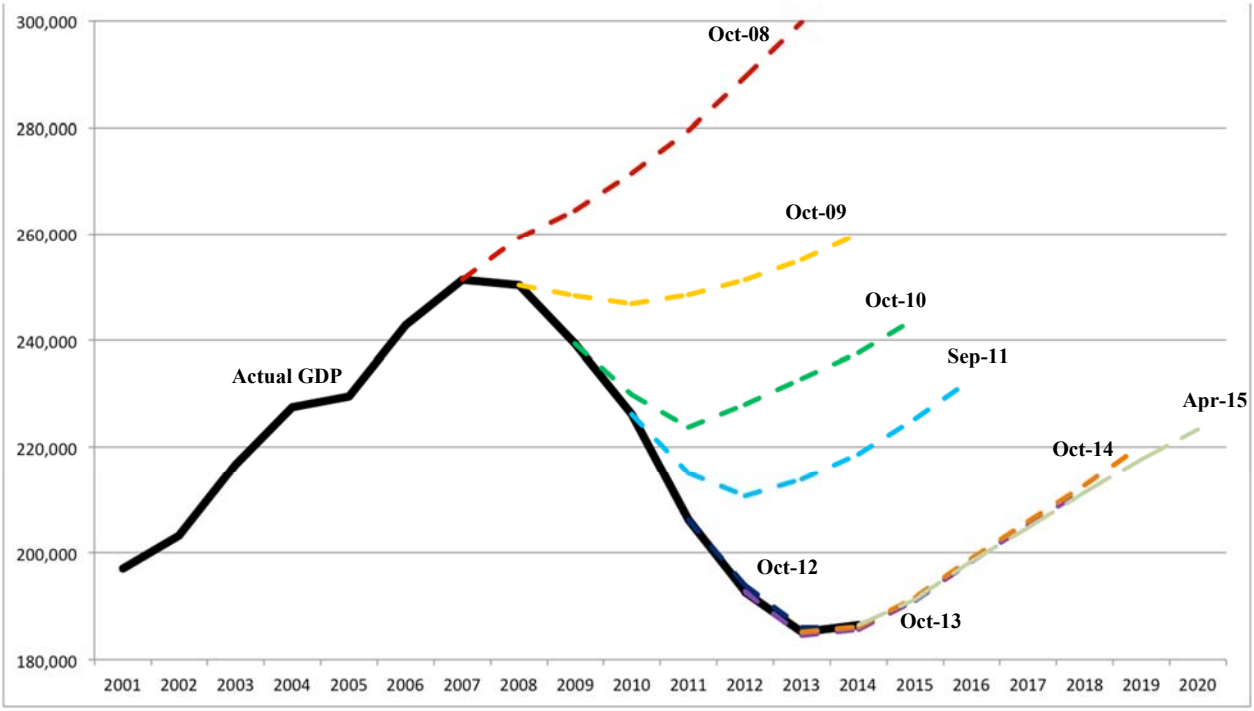


Figure 2: Greece: Actual GDP and IMF's WEO Forecasts (in billions of euros)



What is striking in both cases is both the magnitude of the failures and the absence of learning: as the error in the previous forecast was revealed, future trajectories were simply shifted down. Rationally, they should have inferred that something was wrong with their model. The learning seems to have been limited.[100] (But, of course, market participants were learning; their beliefs about the world were changing.)

Quantitative macroeconomics has relied for model validation on matching moments.[101] The approach involves calibrating the model so that the 'theoretical' or predicted moments of chosen variables matches the 'empirical' or observed moments. In effect, it imposes the assumption that the subjective probability distribution of outcomes believed by agents within an economic system is the same as the frequency distribution from a sufficiently large sample of past realizations. Such a methodology, while it may be useful for forecasting in *stable* times—if there is a long enough period of stability without structural or policy changes—is likely to fail in unstable times, or if the

[100] In the case of the Greek crisis, for instance, the models did not take adequately into account the effects of the crisis on the banking system and credit availability. For a more extensive critique of the models employed in that crisis, see Stiglitz (2016b)

[101] For a telling critique of this methodology and a discussion of alternatives, see Korinek (2018*b*), and the articles in the *Oxford Review of Economic Policy*, vol. 34 nos. 1–2 (2018) and vol. 36 no. 3 (2020) (in particular the work of David Hendry and John Muellbauer, 2018), and Fair (2019).

underlying stochastic processes are non-stationary. It is also likely to fail in ascertaining the consequences of contemplated policy changes, if those changes are large. In these conditions, changes in perceptions about how the economy works are likely to be paramount—market participants now realize that that old model was wrong, or is at least now obsolete. Accordingly, their behaviour will change, and even if the model worked well in describing economic outcomes before, it may not do so now. In an evolving world there is by definition insufficient data to construct a reliable posterior distribution based solely upon sample frequencies—in a world in which the space of states evolves, the limits to what is learnable about the future from any number of past empirical observations makes such simplistic methodologies unreliable. In times in which there are massive revisions to beliefs, it may become optimal for agents to put lower weight on objective data-evidence from the past and more weight on highly uncertain judgments. We may be able to make inferences about the future direction of the economy under alternative policies, but the recognition that what is learnable falls short of full structural knowledge implies that such inferences will require a different methodology; one cannot rely on a model calibrated to match moments using past data. It is, in particular, a poor way of assessing *ex ante* the effects of economic policies.

Puzzles in economics

In fact, when the standard model proves incapable of matching the reality, the situation is often characterized as a 'puzzle'.[102] Our analysis provides a way of understanding these puzzles. The puzzles represent contradictions between real-life data and that predicted by a model in which agents have confidence in the model of the economy, believe it is stationary, and accordingly have sure expectations of objective frequencies generated by an already known stochastic structure (about which nothing remains to be learned), as the rational expectations hypothesis assumes.[103] But in reality, agents behave with not-so-sure expectations about an evolving economic structure. Those 'puzzles' tell something about the subjective expectations that agents implicitly hold and that lead them to behave in the ways that generate those data patterns. An alternative, more sensible, approach for macroeconomics entails making inferences about processes of expectation

[102] Like the asset-return pricing puzzles of the finance literature, such as the equity-risk premium puzzle.
[103] Our perspective does not, of course, resolve all puzzles: behavioural finance has provided ample evidence of a wealth of 'irrationalities'.

formation and subjective uncertainty from the observation of reality, including from survey data on beliefs, and modelling beliefs based on those observations. Belief formation may implicitly be very non-linear, with selective emphasis on particular pieces of information. Models employing data on subjective beliefs have the potential in an evolutionary world to 'beat' models relying on objective non-expectations data-evidence in forecasting actual behaviour. And this is especially important for macroeconomic analyses whose objective is—like Keynes's—the improvement in the short-run performance of the economy.

VI. Macroeconomic policy

The 2008 economic crisis was also a crisis of mainstream macroeconomics, whose models had not contemplated even the possibility of such an event happening, and accordingly, hadn't predicted it, and had a hard time explaining it and providing guidance on how to respond (Stiglitz, 2018). Critically, many of the 'experts' providing advice did not seem to realize that macroeconomic crises are times in which the crucial assumptions of the benchmark DSGE models are violated. While those benchmarks might have been reasonable for assessing the effects of policies in times of Great Moderation, they became unhelpful, even misleading, in times of crisis.

The choice of assumptions (models) obviously has implications for policy. In this section, we compare the macroeconomic policy prescriptions that are implied by a model that recognizes that the market economy may produce outcomes that are inter-temporally inconsistent versus one that doesn't. We show in particular that an analytical framework that, by assumption, precludes the possibility that policies might exacerbate macroeconomic inconsistencies and uncertainties—moving the economy in the opposite direction from what they would do in a full equilibrium model and from what policy-makers want—will likely have trouble in assessing the impact of policy at precisely those times in which policy guidance is most needed.

(i) Implications of costly adjustment of wages and prices

In general equilibrium models that assume away the problem of macroeconomic inconsistencies, unemployment is typically attributed to problems in the structure of labour markets, never to the broader and more fundamental problems in the macroeconomy. As we have already noted, at first glance this seems natural: if there is unemployment, there must be a failure in the labour market. No matter what the cause and magnitude of the source of fluctuations in the demand for labour, a fully flexible labour market would restore the economy to full employment. The first remedy, if available, is to remove 'frictions' in the labour market—for instance, by weakening the bargaining power of workers' unions in order to eliminate downward wage rigidities.

But this policy perspective is partial[104] and at times incorrect, as it misses the fundamental issues that we discussed earlier: lowering wages in response to unemployment may lead to increased unemployment, for all the reasons discussed in section IV.[105]
Most importantly from our perspective, more flexible wages may simply increase the size of the macroeconomic inconsistencies, lowering aggregate demand even more, and possibly causing more individuals to rethink the appropriateness of their previous sets of beliefs, in an ongoing downward spiral.[106] Thus, once we open the door to the possibility of macroeconomic inconsistencies and the associated endogenous evolution of structural uncertainty and beliefs, policies encouraging greater wage flexibility may be counterproductive, as the decentralized process of adjustment may actually move the economy *away* from the kind of full equilibrium with full employment contrary to what is envisaged in standard models.

[104] For instance, it fails to take into account efficiency wage effects: unemployment can persist even in economies without effective labour legislation or unions. We note the presence of high levels of unemployment in developing countries, where workers have little bargaining power. It is simply wrong to assert that the seeming 'distortions' in the labour market that give rise to unemployment are due to government or to collective action by workers.
[105] The failure of lowering wages to reduce unemployment can be looked at in another way: The theory of the second best that tells us that removing one distortion, in the presence of others, may make matters worse.
[106] As a result of a downward wage–price spiral of the kind described by Solow and Stiglitz (1968), with adverse Fisherian debt-deflation (or disinflation) dynamics (Greenwald and Stiglitz, 1993*a*). If individuals fully understood the model, they would understand how the change in policy affected the default rate, and the change in the default rate (from what was previously expected) would convey no information. Instead, if individuals do not have full confidence in their model, there will be learning from the change in policy and the consequent change in default rates. The policy *experiment* (and any change in policy can be viewed as an experiment) gives them a different set of data from which to make inferences from those that they otherwise would have had. Even this discussion may put excessive emphasis in assuming individuals act 'rationally'. More plausibly, seeing a rash of defaults, they may conclude that the mortgage market is much riskier than they had previously thought. Originally, they hadn't thought through an entire model, nor do they do so in the aftermath of the crisis. Responses may not be well-described by a model formulated on the basis of rational Bayesian updating.

So, too, a perspective that focuses on labour market rigidities will likely fail at identifying the deeper set of market failures giving rise to the high and persistent unemployment associated with macroeconomic crises. The important market failures—the ones requiring a policy 'fix'—may be those giving rise to disproportionately large fluctuations in aggregate demand. If those markets failures hadn't existed, even less than fully flexible labour markets might suffice to maintain full or near-full employment.

The implication is that analyses of optimal *ex ante* and *ex post* (that is, in anticipation of the possibility of large changes in aggregate demand and after those changes occur) policies that omit an analysis of how those policies affect the macro consistency of the system and how in turn the inconsistencies endogenously affect the perceived structural uncertainty and behaviour will not in general be robust. In situations of large macroeconomic inconsistencies, prescriptions based on such analyses may go badly awry.

The next subsection illustrates these principles in the context of monetary policy.

(ii) The effectiveness of monetary policy

Monetary policy occupied the centre of the policy debate in the aftermath of the 2008 US financial crisis. It proved ineffective in quickly restoring levels of aggregate demand compatible with full employment.[107] Some of the conventional literature attributed this to the inability to lower the nominal interest rate below zero (the zero lower bound, ZLB). Given the ZLB on the nominal interest rate and the lack of commitment of the monetary authorities to deliver inflationary policies that would make the real interest rate negative, the economy (according to this theory) is prevented from achieving an equilibrium in which all (current) markets clear—and in particular, today's labour market remains in surplus. In this view, if somehow the real interest rate could fall enough, the economy would be in a situation of (at least momentary) equilibrium with full employment.[108]

[107] For analyses on the effectiveness of monetary policy in the crisis, see for instance Borio (2014), Reichlin (2014), Goodhart (2015), Borio and Hofmann (2017).

[108] Situations where at a zero interest rate, there is still an excess supply of labour are sometimes referred to as exhibiting secular stagnation (see Hansen,1938; Eggertsson and Krugman, 2012; Eggertsson and Mehrotra, 2014; Summers, 2016; and Eggertsson *et al*., 2019).We argue below (as Hansen did earlier) that changes in fiscal policy can resolve such situations. The term secular stagnation is used in another, markedly different, way: 'secular stagnation'

We find the ZLB explanation of the persistence of an insufficiency of aggregate demand unpersuasive: if that view was correct, one could in general achieve the full employment equilibrium by, for instance, changing intertemporal prices through time dependent consumption taxes and investment credits.[109]

An alternative analysis focuses on how unresolved *disequilibria* create large structural uncertainty. In such situations, market participants are aware of the uncertainty surrounding the budget constraints that they face. In these circumstances, characteristic of an economy in a state of high macroeconomic distress, it is not really the ZLB that constrains the effectiveness of monetary policy. Rather, monetary policy is ineffective because, when there is too much uncertainty, lending, investment, and consumption decisions are highly insensitive to the interest rate, so the elasticity of aggregate demand to the interest rate becomes small.[110] Indeed, at moments of crises, credit rationing becomes more pervasive; and with credit rationing, it is not the interest rate that matters so much as bankers' willingness to lend (Greenwald and Stiglitz, 2003*a*). When lenders have a hard time finding solvent counterparties, changes in the interest rate will hardly affect the lenders' willingness to lend. In short, a decrease in the real interest rate from, say, 1 per cent to –1 per cent, or even –5 per cent, will hardly boost aggregate demand, and this makes the standard mechanisms of transmission of monetary policy to economic activity ineffective (Stiglitz, 2018). Worse, if it were possible to implement large changes in real interest rates, to say –20 per cent, it is likely that doing so would be counterproductive. Such a large change would undoubtedly have saved some enterprises from default, but pushed other enterprises into default. Creditors that had counted on receiving positive returns from their lending would suddenly be in difficulty. Those

is a state of the economy in which productivity growth is low. This interpretation focuses on the rate of change of productivity, and centres on whether that can be affected by economic policy (see, for example, Gordon (2015).)

[109] See Stiglitz (2016a) and Correia *et al*. (2013). Of course, a sufficiently large 'money rain' would also restore full employment.

[110] That is, estimates of elasticities based on 'normal' times, where macroeconomic inconsistencies are not the centre of attention, are of limited relevance in such times. An important aspect of this, emphasized in Greenwald and Stiglitz (2003*a*) and strongly evident both in the East Asian crisis and in the 2008 crisis, is bank behaviour. Normally, banks do not like to keep excess reserves: the risk-adjusted expected returns to lending out money far exceed the (often zero) returns to keeping reserves at the central bank. Lowering reserve requirements and lowering the returns on government bonds induces more lending. But in the presence of the extremes of uncertainty that arise in the presence of the revelation of macroeconomic inconsistencies and the realization that one's model of the economy was wrong, banks' demand for 'precautionary' balances increases.

depending on these creditors for a supply of funds would, in turn, be in difficulties.[111] Similarly, negative interest rates will affect the balance sheet of banks and their ability and willingness to lend. Firms and households that formerly were not subject to credit rationing may well be now. A whole new range of uncertainties would have opened up: most enterprises have a complex portfolio of assets (typically imperfectly known to those outside the enterprise), all of which have to be revalued because of the large effect that the change in the interest rates would have had on asset prices; and each enterprise depends on a complex network of suppliers (including suppliers of credits) and customers, whose solvency probabilities have now changed dramatically.[112] The new constraints and increased uncertainty may have large effects on spending and saving behaviour, and thus on the aggregate demand—effects that would not be well-captured in consumption and investment models estimated in more normal times.[113]

Thus, the change in intertemporal prices may plausibly have just the opposite effect of that intended, especially as it may exacerbate macroeconomic inconsistencies. The relevant discussion for policy guidance should not be about the ZLB—as if to say, if only we could get rid of this artificial barrier (which one might conceivably do if all money became digital). Rather, it should be about how to more directly increase aggregate demand, e.g. through fiscal policies, debt restructuring, or government insurance programmes that might reduce the extent of macroeconomic uncertainties.

(iii) The effectiveness of fiscal policy

[111] Because the extension of credit is dependent on very specific information, it is typically difficult if not impossible to switch sources of credit, especially for small enterprises (see Jaffee and Stiglitz, 1990). Creditors include, of course, not just banks, but suppliers and, in some instances, customers.

[112] The large recent literature on networks has shown how uncertainties in one part of the network can get passed on to, and amplified in, others. Complex derivatives have increased these uncertainties, to the point where it may not even be possible to ascertain systemic stability. See, for example, Battiston *et al.* 2012*a*,*b*; Battiston *et al.* 2016; and Roukny *et al.*, 2018.

[113] This is exemplified by the result that an increase in domestic interest rates can actually lead to a decrease in a country's exchange rate, contrary to the usual 'partial equilibrium' analysis which has traditionally played a central role in international policy guidance. The failure was particularly evident (and predicted) in the East Asia crisis. Increases in interest rates increased the macroeconomic inconsistencies that had already been revealed, increased uncertainties as large fractions of productive enterprises were thrown into bankruptcy, and thereby discouraged capital inflows. See Greenwald and Stiglitz (2003*a*), Stiglitz (2002*b*), and Furman and Stiglitz (1998).

Failure to recognize the importance of macroeconomic inconsistencies in times of crisis can also lead to incorrect *ex ante* evaluations of the macroeconomic effects of fiscal policies. One of the standard arguments against using fiscal policy is Ricardian equivalence: that the increased indebtedness on the part of the government as a result of increased spending will lead to an exactly offsetting reduction in spending by households, making fiscal policy ineffective. But whether such Ricardian equivalence holds in more normal times (already an unlikely outcome given the restrictive assumptions under which it holds),[114] it is not likely to do so in moments such as we are considering here.

Individual risk—the consequences for particular individuals of their inability to fulfil their obligations—can be markedly different from collective or aggregate risk. There may be a high level of uncertainty about which individuals are at risk of going into default—and so all individuals may face credit constraints and/or may increase their precautionary savings—but less uncertainty about aggregate resources. The fact that the higher taxes that might have to be levied in the future will be levied on those whom the outcome of the resolution of the inconsistencies treats well, means that the government is in effect providing some state insurance. The provision of such insurance reduces the need for precautionary behaviour, and thus expands aggregate demand.[115]

Of course, to ascertain whether a budget trajectory exhibits macroeconomic consistency, the government, like the private sector, also faces the difficult challenge of identifying output trends—a task that becomes particularly complex in times of crises. In fact, the idea that debt crises are the *consequence* of reckless spending—in what is often referred to as 'fiscal indiscipline'—needs to be re-examined. It is wrong to classify spending as 'excessive' on the basis of *ex post* performance, instead of in reference to what were the prevailing expectations at the time in which the fiscal

[114] For example, the absence of credit constraints (see, e.g., Stiglitz, 1988).

[115] These results are, of course, consistent with those showing that there are in fact higher multipliers associated with government spending in deep downturns. But there are other reasons as well to expect multipliers to be smaller when the economy is near full employment: the scope for the expansion of output is limited, and central banks are less likely to engage in offsetting measures, and such measures are more likely to be effective. Moreover, if it is expected that the economy will be operating below full employment next period, spending deferred to future dates has multiplier effects in later periods, and that redounds to increase consumption this period: the full multiplier is thus larger than a simple one-period analysis suggests (see Neary and Stiglitz, 1983). Just as estimates of interest elasticities based on 'normal' times, where macroeconomic inconsistencies are not the centre of attention, are of limited relevance in less normal times, so too for multipliers. See, for instance, Auerbach and Gorodnichenko (2012*a*,*b*), Blanchard and Leigh (2013), Nakamura and Steinsson (2014), and Canzoneri *et al*. (2016).

policies were implemented. The problem becomes even more complex when we recognize that the cycle affects the trend, as theoretical and empirical literature suggests (see, for instance, Cerra and Saxena (2008, 2017), Aguiar and Gopinath (2007)). There are plausible circumstances under which *more* countercyclical spending could have made the debts sustainable: the problem may have been that the government spent too little, not too much.

Our identification of the increased uncertainty following the revelation of a macroeconomic inconsistency, and the resulting increased precautionary behaviour which reduces aggregate demand, suggests a set of policies which might stabilize the economy: the provision of macroeconomic Arrow–Debreu securities, providing compensation to investors, for instance, should it turn out that the macroeconomic downturn lasts longer than expected; such insurance would remove a major impediment to investment in a recession and might increase the responsiveness of investment to monetary policy.

(iv) The importance of debt policies

Macroeconomic crises are situations in which there are not enough resources to fulfil all plans. Inevitably, something has to adjust. The restoration of macroeconomic consistency becomes a necessary condition for the resolution of the crisis. The most direct way that this might be done is through a restructuring of liabilities, a process that determines how the 'losses' (the difference between what was planned (or 'promised') and what will happen) are distributed. Such a process, in the absence of a *complete legal framework*, entails conflict. And the resolution of conflict is essentially a political process.

Ultimately, when monetary and fiscal policies are insufficient to restore the economy to full employment and, as a result, macroeconomic inconsistencies get revealed—many credit contracts cannot be fulfilled—governments need to contemplate the possibility of debt restructurings. And to provide guidance on the appropriate debt policies, macroeconomic models must account for the effects of such restructurings on economic performance.

These effects are sometimes ambiguous, with considerable controversy surrounding judgements. Consider a debt restructuring involving a write-down of foreign debts. Reducing the net outflow of funds out of a country provides more fiscal space for expansionary policies. Those in the financial markets, who obviously wish to discourage such debt restructurings, argue that there is a high risk of losing access to financial markets. But when the flow of funds is systematically out of the country (to service the debt) for the foreseeable future, access to capital is largely irrelevant. Moreover, competitive markets are supposed to be forward looking: the main insight that rational markets should make from a default is that earlier lenders failed to do due diligence to check the macro consistency of the country's plans. Accordingly, a country with less debt burden is in a better position to get greater access to funds.[116]

The failure to account for the effects of debt restructurings on economic performance represents an important lacuna in the mainstream macroeconomics literature on debt crises resolution, and is especially noticeable in the literature on sovereign defaults.[117] Because the problem of macroeconomic inconsistency and what it implies for adjustment is not even contemplated in these strands of work, the destabilizing consequences of not restructuring debt that we have emphasized in this paper—including the endogenous increase in uncertainty that depresses aggregate demand and thus deteriorates even more debt sustainability-- is absent from the analyses.[118]

VII. Conclusions

[116] Empirically, countries that had deep restructurings, such as Russia in 1998, very quickly returned to the capital markets. See, for instance, Stiglitz (2010*a*).

[117] Much of which emphasizes the problems of limited commitment and the importance of the reputation of sovereign debtors—to some extent understandable, given the enforceability problems for sovereign debt payments. See, for example, Eaton and Gersovitz (1981). The issue, however, is equally important with private, including domestic, debt. Many argued, for instance, that a debt restructuring in the US mortgage market would have facilitated recovery. Iceland's quick recovery from the 2008 recession is widely attributed to its extensive debt restructuring. See Stiglitz (2010*b*).

[118] The degree of uncertainty associated with a debt crisis and debt restructuring would be reduced if there were a more widely agreed set of principles guiding such restructuring; and that in turn might reduce the adverse effects on aggregate demand and accordingly the depth of the subsequent downturns. This is part of the reason that virtually every country has adopted a bankruptcy law to guide restructuring; but the US and a few other countries have thwarted the adoption of international guidelines along the lines endorsed by the UN General Assembly in 2015.

The 2008 US financial crisis posed a challenge to macroeconomic theory in many ways similar to that posed by the Great Depression. The 2008 crisis revealed the inadequacies of the prevailing macroeconomic doctrines. The standard DSGE models neither anticipated the possibility of the Great Recession—nor could they have done so;[119] nor would they have done any better 80 years ago in accounting for the possibility of the Great Depression; nor have they provided a framework for understanding how to prevent another such occurrence or how to respond to such crises. These deficiencies suggest the need for an alternative macroeconomics. But there has yet to be reached a consensus on a new overarching framework for macroeconomic analysis. This paper, and this issue of the *Oxford Review*, are intended to help fill in the lacuna.

We have followed the traditional approach of identifying the critical failure in the standard Arrow–Debreu paradigm that might account for market dysfunctions of the magnitude observed; here, we argue for the crucial role of the incompleteness of markets, heterogeneity, and an evolving economy where individuals are constantly learning about the structure of the economy and the behaviour of agents within it. We focus in particular on a key consequence of these assumptions: the presumption that the economy is not necessarily on an equilibrium trajectory, the almost inevitable macroeconomic inconsistencies which emerge, giving rise episodically to crises.

It has long been recognized that Keynes's static approach to understanding persistent unemployment is unsatisfactory. But, we argue here, so too is the pseudo-equilibrium dynamics of DSGE models, which assume that there are no macroeconomic inconsistencies—and which assume that when they inevitably occur (as they did in the Great Depression and in 2008, and in the myriad of other crises over the past century), the economy miraculously instantaneously gets restored to the new equilibrium, and blithely plunges ahead again, assuming that there will never again be such an event. Our approach provides a more intellectually coherent way forward.

We argue that the centre of attention should be explaining the large changes in aggregate demand, well beyond the level that can easily be explained by the exogenous technology shocks buffeting the economy; and in understanding the *real time* adjustment processes. We have shown, in particular, that these may be destabilizing; rather than quickly restoring the economy to full

[119] Simply because that event entailed a 'disequilibrium' of a kind that the model itself ruled out.

employment, they move the economy away from it. Those destabilizing forces are just absent in the benchmark macroeconomic models that assume that consistency conditions are always satisfied and that simply *assume* that the economy constantly re-equilibrates to move along an equilibrium trajectory.[120]

The Arrow–Debreu model provides a powerful apparatus for economic analysis. Keynes wrote before Arrow and Debreu, and hence he did not have access to that formal apparatus to identify what were the differences between the perfect markets benchmark and actual economies that lead to persistent unemployment and unstable macroeconomic dynamics. Other leading macroeconomists in the era before the 'rational expectations revolution' and DSGE models came to dominate the field, for instance Leijonhufvud (1968, 1981) and Clower (1965),[121] focused, as we have, on the analysis of disequilibrium and intertemporal coordination failures, but perhaps one of the barriers for the communication with the mainstream literature was that they did not conduct their analyses sufficiently in reference to the Arrow–Debreu benchmark that quickly became a cornerstone of the language of economic theory.

We learned in the four decades that preceded the 2008 US financial crisis that the Arrow–Debreu theorems were not robust to small changes in assumptions—in a large number of papers, one of the authors of this paper, Joseph Stiglitz, and his co-authors, demonstrated, first, that small changes to the assumptions of the perfect markets benchmark implied that the free-markets solution was no longer in general Pareto optimal—on the contrary, there could be large inefficiencies, and there were policy interventions that would improve the outcomes delivered by markets; second, that even with tiny costs of acquiring information, perfect information would become an impossibility, meaning that the benchmark of perfect markets was largely irrelevant; and third, that with imperfect information, even competitive markets could be characterized by non-market

[120] Thus, this paper can be thought of as complementing and extending earlier work on shock amplification (e.g. as a result of the financial accelerator) and shock creation (e.g. work on instability arising from pseudo-wealth creation and destruction and Minsky credit cycles) by focusing on the volatility associated with the revelation of macro-inconsistencies and the destabilizing dynamics to which that can give rise. Even without a crisis, there can be large and sudden changes in aggregate demand, beyond the ability of labour and other markets to instantaneously adjust to restore full employment.

[121] For a detailed account and analysis of the evolution of macroeconomic thinking, see De Vroey (2016).

clearing.[122] The micro-inefficiencies to which this literature called attention have been shown to have their macroeconomic counterparts, as demonstrated in the large and growing literature on macroeconomic externalities. But one aspect that was not analysed by that literature was the implications of the possibility of macroeconomic inconsistencies in an environment of incomplete markets for the stability of the system. We have shown under plausible conditions that the revelation of a macroeconomic inconsistency gives rise to a myriad of effects, a few stabilizing, many destabilizing, with an overall consequence that, say, unemployment increases and that the decentralized adjustments move the economy further away from any "equilibrium." Indeed, an initial macroeconomic inconsistency can lead to further changes in aggregate demand that could trigger even larger inconsistencies. In short, the market solution can be very unstable. (Obviously, along these unstable paths, with persistent unemployment, there may be massive inefficiencies.)

Our framework for macroeconomic analysis provides, in turn, a different perspective of the effectiveness of alternative macroeconomic policies, suggesting, in particular, that the ineffectiveness of monetary policy may not be due to the zero lower bound, that fiscal policy may be more effective than in the traditional equilibrium theory, and that there are situations in which a restructuring of debt is desirable.[123] Better institutions for resolving inconsistencies, e.g. better legal frameworks for debt restructuring, may accordingly improve macroeconomic performance. Our analysis also suggests that interventions that stabilize beliefs *ex ante* contribute to a more stable environment—the belief that the government can stabilize the economy reduces precautionary behaviour and is thus itself stabilizing. There are a number of interventions that should be considered. For instance, those that reduce the magnitude of the shocks experienced by an economy, such as capital account or macro-prudential regulations; and those that increase the

[122] There were a host of other ways in which the standard model was shown not to be robust, e.g. equilibrium often did not exist; markets were not, in general, competitive; and a competitive equilibrium was not, in general characterized by a single price for a given good. For a survey, see Stiglitz (2002*a*). Unfortunately, much of modern macroeconomics is based on the 'perfect markets' model, with various 'frictions' thrown into the analysis, often in a relatively *ad hoc* manner—in spite of the pretence of 'micro-founding' macroeconomics. See, for example, Greenwald and Stiglitz (1987).

[123] In the aftermath of crises, macroeconomic analysis needs to identify whether the environment that is under scrutiny corresponds to a new 'normal' of low growth, or if the observed stagnation is a result of the abnormality of the environment—one featured by disequilibria with unresolved inconsistencies. The answer to that question is crucial for identifying the right policy course.

ability of the economy and those within it to absorb risk and to respond to it in ways that stabilize the economy, such as the automatic stabilizer provided by income or unemployment insurance.[124]

There is a well-defined model of a perfectly functioning economy; but economic dysfunction can take many different forms. This is especially so for deep downturns: one may be the result of a trade war, another of a housing bubble, another of a tech bubble, another of an overexuberant response to inflationary fears, another to oil politics, still another to a pandemic.[125] None of these is well described by a random technology shock with a known distribution; in all of them there is great uncertainty about subsequent events and their implications for the evolving economy. But we can nonetheless develop an intellectual frame for thinking about these never fully anticipated events, which give rise to macroeconomic inconsistencies with all the untoward follow-on effects that we have described: the revealed inconsistencies lead in turn to the recognition of future possible disequilibrium, to momentary equilibrium where the markets do not clear, and to adjustment processes which may move the economy further away from equilibrium.

While there are many threads to the complex framework we have laid out, two are essential: misperceptions are inevitable given the absence of perfect markets into the future, and trouble arises simply when the misperception become obvious; and adjustment after the realisation of any misperception may well not be stable. The results we have obtained hold under a variety of micro-foundations—indeed, there is a case that precisely under the circumstances upon which we focus standard frameworks, e.g. concerning Bayesian updating of subjective priors, may either be misleading or unhelpful.[126] Behavioral economics may provide better insights into how individuals and firms behave in the presence of the revelation of macro- economic inconsistencies, with its possible undermining of pre-existing world views.

[124] There is a limit to what the government can do to prevent macroeconomic inconsistencies. It may be as difficult for the government as for the private sector to understand what will be the consequences of certain innovations for the future of wealth creation—like the private sector, the government may have incomplete knowledge about the full space of states. Thus, in the absence of complete markets, governments are not immune to the possibility of mis-identification of wealth that matters for ensuring macroeconomic consistency. But while government may face the same limitations of knowledge that the private sector faces, it can do more to resolve them once they appear; indeed, in one way or another, the resolution of macroeconomic inconsistencies almost always entails some government actions.

[125] The evidence on macroeconomic crises reviewed in Heymann and Montero (2019) constitutes a clear testimony of this fact.

[126] There is, for instance, a large literature questioning the axioms underlying Savage subjective utility.

In this paper, there are, of course, many important questions we have not been able to address. Capital market imperfections, for instance, give rise to imperfect labour market mobility: individuals may not be able to move from a declining sector to a growing sector; and such 'real' rigidities can give rise to dysfunctional macroeconomic equilibria—including those associated with high levels of defaults.[127]

Nor have we identified the conditions under which macroeconomic inconsistencies are likely to be especially large or the revelation of such inconsistencies is likely to be sudden. Loose financial market regulation may give rise, for instance, to Minskyian excessive credit expansion which likely leads to a large macroeconomic inconsistency. Excessive fears of inflation too may lead monetary authorities to suddenly increase interest rates in an unanticipated way, exposing if not creating a macroeconomic inconsistency. What is clear, however, is that the associated large macroeconomic fluctuations that are the object of our study are typically induced not by a large exogenous technology shock, but by endogenous processes.[128]

We have also not had much to say about the kinds of underlying economic circumstances in which these problems are most likely to arise: central is the notion of the non-stationarity of the underlying stochastic processes describing the economy, and that is most likely to be particularly relevant in periods of rapid and unpredictable changes in technology and/or economic structure, such as those associated with the move from agriculture to manufacturing in the earlier part of the last century or the move from manufacturing to a service-sector economy, accompanied by rapid globalization, including the integration of the emerging markets and developing countries into the global economy, that marks the current era. (Our perspective is thus consistent with the findings of Kindleberger and Aliber (2011), who observes the booms and bubbles are typically associated with large technology changes.)

[127] See Delli Gatti *et al.* (2012*a*,*b*).
[128] As we have also noted, we have not identified the conditions under which there is a slow gradual evolution of beliefs, including about the existence of macroeconomic inconsistencies, versus the kind of sudden change often associated with a crisis.

While there is a rich agenda ahead, even in its current state of development, our dynamic disequilibrium theory with randomness helps us understand the fundamental failures of DSGE, which no Ptolemaic attempts at repair, no tweaking of the model, can address. It makes clear the sense in which the standard model is not really general, emphasizes that the standard model is intellectually incoherent, has no theory (outside of the representative agent model) for how equilibrium is attained,[129] and does not provide a framework for addressing the most important macroeconomic challenges, which appear when macroeconomic inconsistencies appear. Most importantly, the dynamic disequilibrium theory with randomness points the way towards a better macroeconomics, focusing in particular on situations where macroeconomics really matters. It explains why decentralized market forces may be *disequilibrating*, provides a framework for thinking about how to do better forecasting, and provides a distinctly different policy framework—which had it been employed in 2008, might have led to a more robust recovery.

The evolutionary nature of the environment that we have described means that it is not just that societies need to develop institutions to deal with the macro inconsistencies that are inherent to the functioning of market economies, but they also need to build institutions that are adaptable—that can evolve with the understanding of the society in a world that also evolves in ways that cannot always be conceived at the time that those institutions are designed. Learning and adaptation is the key. This is true for macroeconomic thinking as well. We hope these notes contribute to that.

[129] Advocates of DSGE models might say: 'Never mind that we don't have a theory explaining how equilibrium is attained. All we are claiming is that the economy behaves *as if* it somehow instantaneously achieved the equilibrium.' Such a response, of course, runs counter to the thrust of modern macroeconomics, which is to provide micro-foundations to the assumptions. But even more to the point, we have repeatedly shown here that the economy does not function as if it is instantaneously restored to an equilibrium trajectory, once perturbed.

References

Acemoglu, D., Chernozhukov, V., and Yildiz, M. (2006), 'Learning and Disagreement in an Uncertain World', National Bureau of Economic Research Working Paper No. 12648.

Aguiar, M., and Gopinath, G. (2006), 'Defaultable Debt, Interest Rates and the Current Account', *Journal of International Economics*, **69**(1), 64–83.

Aguiar, M., and Gopinath, G. (2007), 'Emerging Market Business Cycles: The Cycle is the Trend', *Journal of Political Economy*, **115**(1), 69–102.

Aguiar, M., and Amador, M. (2014), 'Sovereign Debt', in G. Gopinath, E. Helpman, and K. Rogoff (eds), *Handbook of International Economics* 4, Elsevier, 647–87.

Arellano, C. (2008), 'Default Risk and Income Fluctuations in Emerging Economies', *The American Economic Review*, **98**(3), 690–712.

Arnott, R., Greenwald, B., and Stiglitz, J. E.. (1994), 'Information and Economic Efficiency', *Information Economics and Policy*, **6**(1), 77–88.

Arrow, K. and Frank Hahn (1971) *General Competitive Analysis,* North Holland.

Auerbach, A. J., and Gorodnichenko, Y. (2012*a*), 'Fiscal Multipliers in Recession and Expansion', in *Fiscal Policy after the Financial Crisis*, Chicago, IL, University of Chicago Press, 63–98.

Auerbach, A. J., and Gorodnichenko, Y. (2012*b*), 'Measuring the Output Responses to Fiscal Policy', *American Economic Journal: Economic Policy*, **4**(2), 1–27.

Auman, R. J. (1976), 'Agreeing to Disagree', *The Annals of Statistics*, **4**(6), 1236–9.

Banerjee, A. V. (1992), 'A Simple Model of Herd Behavior', *The Quarterly Journal of Economics*, **107**(3), 797–817.

Battiston, S., Delli Gatti, D., Gallegati, M., Greenwald, B. C., and Stiglitz, J. E. (2012*a*), '*Liaisons Dangereuses*: Increasing Connectivity, Risk Sharing, and Systemic Risk', *Journal of Economic Dynamics and Control*, **36**(8), 1121–41.

Battiston, S., Delli Gatti, D., Gallegati, M., Greenwald, B. C., and Stiglitz, J. E. (2012*b*), 'Default Cascades: When Does Risky Diversification Increase Stability?', *Journal of Financial Stability*, **8**(3), 138–49.

Battiston, S., Caldarelli, G., May, R. M., Roukny, T., and Stiglitz, J. E. (2016), 'The Price of Complexity in Financial Networks', *PNAS (Proceedings of the National Academy of Sciences of the United States of America)*, **113**(36), 10031–6.

Benhabib, J., and Farmer, R. E. A. (1994), 'Indeterminacy and Increasing Returns', *Journal of Economic Theory*, **63**(1), 19–41.

Benhabib, J., and Farmer, R. E. A. (1999), 'Indeterminacy and Sunspots in Macroeconomics', in J. B. Taylor and M. Woodford (eds), *Handbook of Macroeconomics*, 1A, Elsevier, 387–448.

Bernhardt, Donald., and Eckblad, M. (2013), 'Stock Market Crash of 1987', *Federal Reserve Bank of Chicago*.

Bernanke, B. ——, 2010, "On the Implications of the Financial Crisis for Economics," address delivered September 24, 2010 at Princeton University, available at http://www.federalreserve.gov/newsevents/speech/bernanke20100924a.htm, (accessed January 5, 2010).

Blanchard, O. (2018), 'On the Future of Macroeconomic Models', *Oxford Review of Economic Policy*, **34**(1–2), 43–54.

Blanchard, O. J., and Leigh, D. (2013), 'Growth Forecast Errors and Fiscal Multipliers', *The American Economic Review*, **103**(3), 117–20.

Borio, C. (2014), 'Monetary Policy and Financial Stability: What Role in Prevention and Recovery?', *Capitalism and Society*, **9**(2).

Borio, C., and Hofmann, B. (2017), 'Is Monetary Policy Less Effective When Interest Rates are Persistently Low?', Bank of International Settlements Working Papers 628.

Boz, E., Daude, C., and Durdu, C. B. (2011), 'Emerging Market Business Cycles: Learning about the Trend', *Journal of Monetary Economics*, **58**(6–8), 616–31.

Brunnermeier, M. K., Simsek, A., and Xiong, W. (2014), 'A Welfare Criterion for Models with Distorted Beliefs', *The Quarterly Journal of Economics*, **129**(4), 1753–97.

Calvo, G. A. (1988), 'Capital Flows and Capital-market Crises: The Simple Economics of Sudden Stops', *Journal of Applied Economics*, **1**(1), 35–54.

Canzoneri, M., Collard, F., Dellas, H., and Diba, B. (2016), 'Fiscal Multipliers in Recessions', *The Economic Journal*, **126**(590), 75–108.

Cass, D., and Shell, K. (1983), 'Do Sunspots Matter?', *Journal of Political Economy*, **91**(21), 193–228.

Cerra, V., and Saxena, S. C. (2008), 'Growth Dynamics: The Myth of Economic Recovery', *The American Economic Review*, **98**(1), 439–57.

Cerra, V., and Saxena, S. C. (2017), 'Booms, Crises, and Recoveries: A New Paradigm of the Business Cycle and its Policy Implications', International Monetary Fund Working Paper 17/250.

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

Clower, R. W. (1965), 'A Keynesian Counter Revolution: A Theoretical Appraisal', in F. H. Hahn and F. Brechling (eds), *Theory of Interest Rates*, New York, International Economics Association, Macmillan, 103–25.

Colander, D., Howitt, P., Kirman, A., Leijonhufvud, A., and Mehrling, P. (2008), 'Beyond DSGE Models: Toward an Empirically Based Macroeconomics', *The American Economic Review*, **98**(2), 236–40.

Cooper, R. (1999), 'Coordination Games: Complementarities and Macroeconomics', New York, Cambridge University Press.

Cooper, R., and John, A. (1988), 'Coordinating Coordination Failures in Keynesian Models', *The Quarterly Journal of Economics*, **103**(3), 441–63.

Cooter, R. D., and Rubinfeld, D. L. (1989), 'Economic Analysis of Legal Disputes and their Resolution', *Journal of Economic Literature*, **27**(3), 1067–97.

Correia, I., Farhi, E., Nicolini, J. P., and Teles, P. (2013), 'Unconventional Fiscal Policy at the Zero Bound', *The American Economic Review*, **103**(4), 1172–211.

Dávila, E., and Korinek, A. (2017), 'Pecuniary Externalities in Economies with Financial Frictions', *The Review of Economic Studies*, **85**(1), 352–95.

De Vroey, M. (2016), *A History of Macroeconomics from Keynes to Lucas and Beyond*, Cambridge, Cambridge University Press.

Delli Gatti, D., Gallegati, M., Greenwald, B., Russo, A., and Stiglitz, J. E. (2012*a*), 'Mobility Constraints, Productivity Trends, and Extended Crises', *Journal of Economic Behavior & Organization*, **83**(3), 375–93.

Delli Gatti, D., Gallegati, M., Greenwald, B., Russo, A., and Stiglitz, J. E. (2012*b*), 'Sectoral Imbalances and Long Run Crises', in F. Allen, M. Aoki, J.-P. Fitoussi, N. Kiyotaki, R. Gordon, and J. E. Stiglitz (eds), *The Global Macro Economy and Finance*, IEA Conference Volume No. 150-III, Houndmills, UK and New York, Palgrave, 61–97.

Diamond, P. (1982), 'Aggregate Demand Management in Search Equilibrium', *Journal of Political Economy*, **90**(5), 881–94.

Dosi, G., and Nelson, R. R. (1994), 'An Introduction to Evolutionary Theories in Economics', *Journal of Evolutionary Economics*, **4**(3), 153–72.

Dosi, G., Napoletano, M., Roventini, A., Stiglitz, J. E., and Treibich, T. (2020), 'Rational Heuristics? Expectations and Behaviorism Evolving Economies with Heterogeneous Interacting Agents', *Economic Inquiry*, **58**(2) (also NBER Working Paper No. 26922).

Eaton, J., and Gersovitz, M. (1981), 'Debt with Potential Repudiation: Theoretical and Empirical Analysis', *The Review of Economic Studies*, **48**(2), 289–309.

Eaton, J., Gersovitz, M., and Stiglitz, J. E. (1986), 'Pure Theory of Country Risk', *European Economic Review*, **30**(3), 481–513.

Eggertsson, G. B., and Krugman, P. (2012), 'Debt, Deleveraging, and the Liquidity Trap: A Fisher–Minsky–Koo Approach', *The Quarterly Journal of Economics*, **127**(3), 1469–513.

Eggertsson, G. B., and Mehrotra, N. R. (2014), 'A Model of Secular Stagnation', National Bureau of Economic Research Working Paper No. 20574.

Eggertsson, G. B., Mehrotra, N. R., and Robbins, J. A. (2019), 'A Model of Secular Stagnation: Theory and Quantitative Evaluation', *American Economic Journal: Macroeconomics*, **11**(1), 1–48.

Evans, G. W., and Guesnerie, R. (2003), 'Coordination on Saddle-path Solutions: The Eductive Viewpoint—Linear Univariate Models', *Macroeconomic Dynamics*, **7**(1), 42–62.

Evans, G. W., and Guesnerie, R. (2005), 'Coordination on Saddle-path Solutions: The Eductive Viewpoint—Linear Multivariate Models', *Journal of Economic Theory*, **124**(2), 202–29.

Evans, G. W., and Honkapohja, S. (2001), *Learning and Expectations in Macroeconomics*, Princeton, NJ, Princeton University Press.

Fair, R. (2019), 'Some Important Macro Points', Cowles Foundation Discussion Paper No. 2165R.

Furman, J., and Stiglitz, J. E. (1998), 'Economic Crises: Evidence and Insights from East Asia', *Brookings Papers on Economic Activity*, 2, 1–114.

Galiani, S., Heymann, D., and Tommasi, M. (2003), 'Great Expectations and Hard Times: The Argentine Convertibility Plan', *Economia*, **3**(2), 109–47.

Goodhart, C. (2015), 'Why Monetary Policy Has Been Comparatively Ineffective?', *The Manchester School*, **83**(S1), 20–9.

Gordon, R. J. (2015), 'Secular Stagnation: A Supply-side View', *The American Economic Review*, **105**(5), 54–9.

Gordon, R. J. (2016), *The Rise and Fall of American Growth*, Princeton, NJ, Princeton University Press.

Greenspan, A. (2008), Hearing before the Committee on Oversight and Government Reform House of Representatives, One Hundred Tenth Congress, Second Session, 23 October, available at https://www.govinfo.gov/content/pkg/CHRG-110hhrg55764/html/CHRG-110hhrg55764.htm

Greenwald, B. C., and Stiglitz, J. E. (1986), 'Externalities in Economies with Imperfect Information and Incomplete Markets', *The Quarterly Journal of Economics*, **101**(2), 229–64.

Greenwald, B. C., and Stiglitz, J. E. (1987), 'Keynesian, New Keynesian and New Classical Economics', *Oxford Economic Papers*, **39**, 119–33.

Greenwald, B. C., and Stiglitz, J. E. (1988*a*), 'Examining Alternative Macroeconomic Theories', *Brookings Papers on Economic Activity*, 1, 207–70.

Greenwald, B. C., and Stiglitz, J. E. (1988*b*), 'Pareto Inefficiency of Market Economies: Search and Efficiency Wage Models', *The American Economic Review*, **78**(2), 351–5.

Greenwald, B. C., and Stiglitz, J. E. (1989), 'Toward a Theory of Rigidities', *The American Economic Review*, **79**(2), 364–9.

Greenwald, B. C., and Stiglitz, J. E. (1993*a*), 'Financial Market Imperfections and Business Cycles', *The Quarterly Journal of Economics*, **108**(1), 77–114.

Greenwald, B. C., and Stiglitz, J. E. (1993*b*), 'New and old Keynesians', *Journal of Economic* Perspectives, **7**(1), 23–44.

Greenwald, B. C., and Stiglitz, J. E. (2003*a*), *Towards a New Paradigm in Monetary Economics*, Cambridge, Cambridge University Press.

Greenwald, B. C., and Stiglitz, J. E. (2003*b*), 'Macroeconomic Fluctuations in an Economy of Phelps–Winter Markets', in P. Aghion, R. Frydman, J. Stiglitz, and M. Woodford (eds),

Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps, Princeton, NJ, Princeton University Press, 123–36.

Griffith-Jones, S., Ocampo, J. A., and Stiglitz, J. E. (eds) (2010), *Time for a Visible Hand: Lessons from the 2008 World Financial Crisis*, Oxford, Oxford University Press.

Grossman, S., and Stiglitz, J. E. (1976), "Information and Competitive Price Systems," American Economic Review, 66(2), May, pp. 246-253

Grossman, S., and Stiglitz, J. E. (1977), 'On Value Maximization and Alternative Objectives of the Firm', *Journal of Finance*, **32**(2), 389–402.

Grossman, S., and Stiglitz, J. E. (1980a), 'Stockholder Unanimity in the Making of Production and Financial Decisions', *Quarterly Journal of Economics*, **94**(3), 543–66.

Grossman, S., and Stiglitz, J. E. (1980b), On the Impossibility of Informationally Efficient Markets," *American Economic Review*, 70(3), June, pp. 393-408.

Guesnerie, R. (1992). 'An Exploration of the Eductive Justifications of the Rational-expectations Hypothesis', *The American Economic Review*, **82**(5), 1254–78.

Guzman, M., and Heymann, D. (2015), 'The IMF Debt Sustainability Analysis: Issues and Problems', *Journal of Globalization and Development*, **6**(2), 387–404.

Guzman, M., and Howitt, P. (2016), 'Learning, Expectations, and the Financial Instability Hypothesis', in J. E. Stiglitz and M. Guzman (eds), *Towards a General Theory of Deep Downturns*, IEA Conference Volume, 155-VI, Houndmills, UK and New York, Palgrave Macmillan, 50–60.

Guzman, M., Ocampo, J. A., and Stiglitz, J. E. (eds) (2016), *Too Little, Too Late: The Quest to Resolve Sovereign Debt Crises*, New York, Columbia University Press.

Guzman, M., and Stiglitz, J. E. (2016*a*), 'Pseudo-wealth and Consumption Fluctuations', National Bureau of Economic Research Working Paper No. 22838.

Guzman, M., and Stiglitz, J. E. (2016*b*), 'Creating a Framework for Sovereign Debt Restructuring That Works', in M. Guzman, J. A. Ocampo, and J. E. Stiglitz (eds), *Too Little, Too Late: The Quest to Resolve Sovereign Debt Crises*, New York, Columbia University Press.

Guzman, M., and Stiglitz, J. E. (2016*c*), 'A Soft Law Mechanism for Sovereign Debt Restructuring Based on the UN Principles', *Friedrich–Ebert–Stiftung International Policy Analysis*.

Guzman, M., and Stiglitz, J. E. (2016*d*), 'A Theory of Pseudo-Wealth', in J. E. Stiglitz and M. Guzman (eds), *Towards a General Theory of Deep Downturns*, IEA Conference Volume, 155-VI, Houndmills, UK and New York, Palgrave Macmillan, 21–33.

Hahn, F. (1966), 'Equilibrium Dynamics with Heterogeneous Capital Goods', *The Quarterly Journal of Economics*, **80**(4), 633–46.

Haldane, A. G., and Turrell, A. E. (2018), 'An Interdisciplinary Model for Macroeconomics', *Oxford Review of Economic Policy*, **34**(1–2), 219–51.

Hansen, A. (1938), *Full Recovery or Stagnation?*, New York, W.W. Norton, 1st edn.

Hendry, D. F., and Muellbauer, J. N. J. (2018), 'The Future of Macroeconomics: Macro Theory and Models at the Bank of England', *Oxford Review of Economic Policy*, **34**(1–2), 287–328.

Heymann, D. (2008), 'Macroeconomics of Broken Promises', in R. E. A. Farmer (ed.), *Macroeconomics in the Small and the Large*, Cheltenham, Edward Elgar.

Heymann, D., and Sanguinetti, P. (1998), 'Business Cycles from Misperceived Trends', *Economic Notes*, **27**(2), 205–32.

Heymann, D., and Montero, G. (2019), 'Notes on Expectations, Coordination Failures, and Macro Crises', Working Paper.

Hirano, T., and Stiglitz, J. E. (2019), 'The Wobbly Economy', Working Paper, Columbia University.

Hoff, K., and Stiglitz, J. E. (2016), 'Striving for Balance in Economics: Towards a Theory of the Social Determination of Behavior', *Journal of Economic Behavior and Organization*, **126**, 25–57.

Howitt, P. (1978), 'The Limits to Stability of a Full-employment Equilibrium', *The Scandinavian Journal of Economics*, **80**(3), 265–82.

Howitt, P. (1985), 'Transaction Costs in the Theory of Unemployment', *The American Economic Review*, **75**(1), 88–100.

Howitt, P. (1994), 'Adjusting to technological change', *The Canadian Journal of Economics* 27, no. 4: 763–775.

Howitt, P. (2003), 'Coordination Failures', in B. Snowdown and H. R. Vane (eds), *An Encyclopedia of Macroeconomics*, Cheltenham, Edward Elgar, 140–4.

Jaffee, D. and J. E. Stiglitz (1990), "Credit Rationing," *Handbook of Monetary Economics*, B. Friedman and F. Hahn (eds.), Amsterdam: Elsevier Science Publishers, pp. 837-888.

Jeanne, O., and Korinek, A. (2018), 'Managing Credit Booms and Busts: A Pigouvian Taxation Approach', *Journal of Monetary Economics*, **107**, 2–17.

Jermann, U., and Quadrini, V. (2012), 'Macroeconomic Effects of Financial Shocks', *The American Economic Review*, **102**(1), 238–71.

Keynes, J. M. (1936), *The General Theory of Employment, Interest and Money*, Kessinger Publishing.

Kindleberger, C. P., and Aliber, R. Z. (2011), *Manias, Panics and Crashes: A History of Financial Crises*, Palgrave Macmillan.

Kirman, A. P. (1992), 'Whom or What Does the Representative Individual Represent?', *Journal of Economic Perspectives*, **6**(2), 117–36.

Korinek, A. (2018*a*), 'Regulating Capital Flows to Emerging Markets: An Externality View', *Journal of International Economics*, **111**, 61–80.

Korinek, A. (2018*b*), 'Thoughts on DSGE Macroeconomics: Matching the Moment, But Missing the Point?', in M. Guzman (ed.), *Toward a Just Society*, New York, Columbia University Press.

Korinek, A., and Stiglitz, J. E. (2019), 'Artificial Intelligence and Its Implications for Income Distribution and Unemployment', in A. Agrawal, J. Gans, and A. Goldfarb (eds), *The Economics of Artificial Intelligence: An Agenda*, NBER/University of Chicago Press, 349–90 (also National Bureau of Economic Research Working Paper No. w24174 (2017)).

Krugman, P. (1988), 'Financing vs Forgiving a Debt Overhang', *Journal of Development Economics*, **29**(3), 253–68.

Leijonhufvud, A. (1968), *On Keynesian Economics and the Economics of Keynes*, Oxford, Oxford University Press.

Leijonhufvud, A. (1981), *Information and Coordination: Essays in Macroeconomic Theory*, Oxford, Oxford University Press.

Lindé, J. (2018), 'DSGE Models: Still Useful in Policy Analysis?', *Oxford Review of Economic Policy*, **34**(1–2), 269–86.

Lorenzoni, G. (2008), 'Inefficient Credit Booms', *The Review of Economic Studies*, **75**(3), 809–33.

McKibbin, W. J., and Stoeckel, A. (2018), 'Modelling a Complex World: Improving Macro-models', *Oxford Review of Economic Policy*, **34**(1–2), 329–47.

Milgrom, P., and Stokey, N. (1982), 'Information, Trade, and Common Knowledge', *Journal of Economic Theory*, **26**(1), 17–27.

Miller, M., and Stiglitz, J. E. (2010), 'Leverage and Asset Bubbles: Averting Armageddon with Chapter 11?', *The Economic Journal*, **120**(544), 500–18.

Mullainathan, S. (2002), 'Thinking Through Categories', Working Paper.

Nakamura, E., and Steinsson, J. (2014), 'Fiscal Stimulus in a Monetary Union: Evidence from US Regions', *The American Economic Review*, **104**(3), 753–92.

Neary, P., and Stiglitz, J. E. (1983), 'Toward a Reconstruction of Keynesian Economics: Expectations and Constrained Equilibria', *Quarterly Journal of Economics*, **98**(Supplement), 199–228.

Neeman, Z. (1996), 'Common Beliefs and the Eexistence of Speculative Trade', *Games and Economic Behavior*, **16**(1), 77–96.

Nelson, R. R., and Winter, S. G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA, Harvard University Press.

Phelps, E. and S. Winter (1970), "Optimal Price Policy Under Atomistic Competition," in E. Phelps, Ed., *Microfoundations of Employment and Inflation Theory, pp. 309-337, W. W. Norton, New York.*

Radner, R. (1968), 'Competitive Equilibrium under Uncertainty', *Econometrica*, **36**(1), 31–58.

Radner, R., and Stiglitz, J. E. (1984), 'A Nonconcavity in the Value of Information', in M. Boyer and R. Khilstrom (eds), *Bayesian Models in Economic Theory*, Elsevier, 33–52.

Reichlin, L. (2014), 'Monetary Policy and Banks in the Euro Area: The Tale of Two Crises', *Journal of Macroeconomics*, **39B**, 387–400.

Reis, R. (2018), 'Is Something Really Wrong with Macroeconomics?', *Oxford Review of Economic Policy*, **34**(1–2), 132–55.

Roukny, T., Battiston, S., and Stiglitz, J. E. (2018), 'Interconnectedness as a Source of Uncertainty in Systemic Risk', *Journal of Financial Stability*, **35**, 93–106.

Scarf, H. (1960), 'Some Examples of Global Instability of the Competitive Equilibrium', *International Economic Review*, **1**(3), 157–72.

Schumacher, J., Trebesch, C., and Enderlein, H. (2018), 'Sovereign Defaults in Court', European Central Bank Working Paper No. 2135.

Shapiro, C., and Stiglitz, J. E. (1984), 'Equilibrium Unemployment as a Worker Discipline Device', *The American Economic Review*, **74**(3), 433–44.

Shell, K., and Stiglitz, J. E. (1967), 'Allocation of Investment in a Dynamic Economy', *The Quarterly Journal of Economics*, **81**(4), 592–609.

Solow, R., and Stiglitz, J. E. (1968), 'Output, Employment and Wages in the Short Run', *The Quarterly Journal of Economics*, **82**(4), 537–60.

Soros, G. (1987), *The Alchemy of Finance: Reading the mind of the Market*, Hoboken, John Wiley & Sons.

Spier, K. E. (2007), 'Litigation', in A. M. Polinsky and S. Shavell (eds), *Handbook of Law and Economics*, vol. 1, Elsevier, 259–342.

Stiglitz, J. E. (1972), 'Some Aspects of the Pure Theory of Corporate Finance: Bankruptcies and Take-overs', *Bell Journal of Economics*, **3**(2), 458–82.

Stiglitz, J. E. (1988), 'On the Relevance or Irrelevance of Public Financial Policy', in K. Arrow and M. Boskin (eds), *The Economics of Public Debt, Proceedings of the 1986 International Economics Association Meeting*, London, Macmillan Press, 4–76.

Stiglitz, J. E. (1992), 'Methodological Issues and the New Keynesian Economics', in A. Vercelli and N. Dimitri (eds), *Macroeconomics: A Survey of Research Strategies*, Oxford, Oxford University Press, 38–86.

Stiglitz, J. E. (2000), 'Some Elementary Principles of Bankruptcy', in *Governance, Equity and Global Markets: Proceedings from the Annual Bank Conference on Development Economics in Europe, June 1999*, Paris, Conseil d'Analyse Economique, 605–20.

Stiglitz, J. E. (2001), 'Bankruptcy Laws: Basic Economic Principles', in S. Claessens, S. Djankov, and A. Mody (eds), *Resolution of Financial Distress: An International Perspective on the Design of Bankruptcy Laws*, Washington, DC, World Bank, 1–23.

Stiglitz, J. E. (2002*a*), 'Information and the Change in the Paradigm in Economics', *The American Economic Review*, **92**(3), 460–501.

Stiglitz, J. E. (2002*b*), *Globalization and Its Discontents*, New York, W.W. Norton.

Stiglitz, J. E. (2010*a*), 'Sovereign Debt: Notes on Theoretical Frameworks and Policy Analyses', in B. Herman, J. A. Ocampo, and S. Spiegel (eds), *Overcoming Developing Country Debt Crises*, Oxford, Oxford University Press, 35–69.

Stiglitz, J. E. (2010*b*), *Freefall: America, Free Markets, and the Sinking of the World Economy*, New York, W. W. Norton.

Stiglitz, J. E. (2011), 'Rethinking Macroeconomics: What Failed and How to Repair It', *Journal of the European Economic Association*, **9**(4), 591–645.

Stiglitz, J. E. (2016a), *Towards a General Theory of Deep Downturns*, IEA Conference Volume, 155-VI, Houndmills, UK and New York, Palgrave Macmillan, also available as National Bureau of Economic Research Working Paper 21444 (August 2015).

Stiglitz, J. E. (2016b), *Euro: How a Common Currency Threatens the Future of Europe,* New York: WW Norton.

Stiglitz, J. E. (2018), 'Where Modern Macroeconomics Went Wrong', *Oxford Review of Economic Policy*, **34**(1–2), 70–106.

Stiglitz, J. E., and Weiss, A. (1981), 'Credit Rationing in Markets with Imperfect Information', *The American Economic Review*, **71**(3), 393–410.

Summers, L. (2016), 'The Age of Secular Stagnation', *Foreign Affairs*, March/April, 2–9.

Vines, D., and Wills, S. (2018*a*), 'The Rebuilding Macroeconomic Theory Project: An Analytical Assessment', *Oxford Review of Economic Policy*, **34**(1–2), 1–42.

Vines, D., and Wills, S. (2018*b*), 'The Financial System and the Natural Real Interest Rate: Towards a "New Benchmark Theory Model"', *Oxford Review of Economic Policy*, **34**(1–2), 252–68.

Weitzman, M. L. (2007), 'Subjective Expectations and Asset-return Puzzles', *The American Economic Review*, **97**(4), 1102–30.

Weitzman, M. L. (2009), 'On Modeling and Interpreting the Economics of Catastrophic Climate Change', *The Review of Economics and Statistics*, **91**(1), 1–19.