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The Benefits of International Policy Coordination Revisited

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Abstract

This paper uses two of the IMF's DSGE models to simulate the benefits of international fiscal and macroprudential policy coordination. The key argument is that these two policies are similar in that, unlike monetary policy, they have long-run effects on the level of GDP that need to be traded off with short-run effects on the volatility of GDP. Furthermore, the short-run effects are potentially much larger than those of conventional monetary policy, especially in the presence of nonlinearities such as the zero interest rate floor, minimum capital adequacy regulations, and lending risk that depends in a convex fashion on loan-to-value ratios. As a consequence we find that coordinated fiscal and/or macroprudential policy measures can have much larger stimulus and spillover effects than what has traditionally been found in the literature on conventional monetary policy.

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I. Introduction

International policy coordination has played a major role in the global policy response to the Great Recession, with a focus particularly in the early years on the worldwide joint implementation of fiscal stimulus measures[1], and more recently on the worldwide implementation of harmonized financial market regulations (e.g. Basel III), which have an important macroeconomic stabilization dimension that is generally referred to as macroprudential policy.[2]

In the theoretical literature, the term international policy coordination describes a situation where, due to well-designed incentives or penalties, a group of countries manages to move away from individual Nash policies to a set of policies that internalizes some cross-border externalities, and that is therefore Pareto superior. In practice a distinction is sometimes drawn between policy coordination and policy cooperation, where the latter describes a non-binding sequence of steps that removes some disagreements and uncertainty between countries, and that eventually results in policies that, due to their simultaneous implementation, increase each country's policy effectiveness, measured for example by the size of fiscal multipliers. However, for the purpose of describing the simulation experiments in this paper, the distinction between coordination and cooperation is not important. Instead we use the term international policy coordination loosely, following Horne and Masson (1988), to mean the joint planning or setting of at least some macroeconomic policies. Cooper (1985) and Bryant (1987) have proposed a similar terminology. For a recent discussion of the obstacles to international policy coordination, see Ostry and Gosh (2013).

Our paper studies the stimulative and stabilizing effects of fiscal and macroprudential policies, both in normal times and at crisis times, but with an emphasis on the latter. The ultimate objective is an evaluation of the ability of joint stimulus measures across a number of countries to enhance the domestic effects of such policies.

The economics literature has now produced a number of studies on the benefits and costs of fiscal stimulus, and also on the benefits and costs of macroprudential policies, and these will be discussed in more detail in Section II of this paper. But, despite the above-mentioned trends in policymaking, there has been almost no literature on international policy coordination in these two fields. It is therefore probably correct to say that the profession's intuition on the subject of international coordination is still shaped by an older, pre-crisis literature that dealt exclusively with coordinating conventional monetary policies, in other words interest rate policies, during normal economic times. A key paper is Obstfeld and Rogoff (2002), and a recent summary can be found in Taylor (2013).[3] The conclusions of that literature, based on empirical estimation of multi-country New Keynesian monetary models, are however squarely at odds with the policymaking experience of the last five years, in that it suggests that countries should pursue policies

[1] See Group of Twenty (2009), whose leaders' statement, made at the height of the crisis, proclaims "By acting *together* ... we will bring the world economy out of recession ..." and "We are undertaking an unprecedented and *concerted* fiscal expansion, which will save or create millions of jobs which would otherwise have been destroyed ..."

[2] For Basel III, see the information available at http://www.bis.org/bcbs/basel3.htm. European Central Bank (2012) summarizes work on the analytical foundations of macroprudential policymaking.

[3] See also Oudiz and Sachs (1984) and Taylor (1985, 1993b).

that are optimal for their domestic circumstances, because the benefits from international policy coordination would be negligible. In this paper we will suggest that translating this result to fiscal and macroprudential policies is likely to be very misleading. The reasons include the presence of quantitatively important economic nonlinearities and asymmetries, especially in the financial system during times of severe economic stress, and the fact that fiscal and macroprudential policies, unlike monetary policy, can have very large short-run and long-run effects on the real economy.[4]

The tool of monetary policy is the nominal policy interest rate. Taking as given foreign interest rates and inflation, its primary objective is the stabilization of inflation around a long-run target, with output stabilization as a secondary objective. Conflicts between these two objectives, and therefore policy trade-offs, arise principally following supply shocks. Due to these conflicts, as illustrated by Taylor (2013), monetary policy aims at jointly minimizing the volatility of output and inflation, with the best achievable outcomes found along an efficiency frontier, and with the selected outcome determined by policy preferences. Taylor (2013) argues that international policy coordination has almost no effects on the position of that frontier. The reasons include: (i) Policy interest rates, even domestically, have only a small and temporary effect on output. (ii) Policy errors are generally not costly unless monetary policy drifts persistently off course and allows inflation expectations to become unanchored. (iii) International goods market spillovers in the class of models studied by this literature are very small because a large part of the adjustment to shocks consists of relative price changes. (iv) The economic model environment studied by this literature is generally some variant of a linear model, which means that the effects of shocks are small, and more importantly that the economy can smoothly adjust to shocks of any size. In other words, this literature never studies environments that resemble severe economic crises, and it is precisely in such environments, characterized by quantitatively important nonlinearities (and asymmetries in the response of the economy to negative and positive shocks), where policymakers have recently found coordination to be desirable. Furthermore, that coordination, while it had an important monetary policy dimension, centered on fiscal policy, and recently also on macroprudential policy.

Our paper will study the role of three different nonlinearities, all of which are found in financial rather than goods markets, and all of which become much more important at times of economic crises. They include the zero interest rate floor that limits the ability of government to keep lowering the policy rate to stimulate the economy, the minimum capital adequacy floor that limits the ability of banks, after lending losses, to make further loans and thereby create purchasing power, and high loan-to-value ratios that, through fast increasing lending spreads, limit the ability of borrowers to spend.

The models used in this paper are built around a basic structure where conventional monetary policy (CMP) plays the same role as in Taylor (2013) and the entire New Keynesian literature. We will not revisit the question of international monetary policy coordination during normal times, where we expect our model to yield the same results as the above-mentioned literature. Instead we focus on fiscal policies (FP) and

[4] Early versions of the work presented in this paper did play an important role in the international policy debates at the outset of the Great Recession. The argument was that, at least for fiscal policy, internationally coordinated national stimulus measures would, due to spillovers, produce larger output gains than isolated national implementations of such measures. See the above-mentioned Group of Twenty (2009) statement.

macroprudential policies (MPP), with monetary policy operating in the background in the usual way, except that we emphasize the importance of the zero interest rate floor for nominal interest rates. Table 1 contains a comparison of CMP, FP and MPP. We will argue that fiscal and macroprudential policies exhibit fundamental differences from monetary policy, and similarities with each other, in three dimensions. First, in the multiplicity of possible policy instruments, second, in the nature of the long-run objectives that are targeted, and third, in the nature of the effect of these policies on the real economy. We begin with policy instruments, and then turn to objectives and real output effects.

For fiscal policy, there are many possible policy instruments, including spending on goods and services, spending on transfers, and several different kinds of taxes. There is no substitute for analyzing these one at a time, because the effectiveness of fiscal stimulus, including the international coordination of such stimulus, depends critically on the instrument used. We will therefore study four different fiscal instruments in this paper, under different assumptions about conventional monetary policy and about the financial sector of the economy. For macroprudential policy, there is also a variety of possible instruments, including most importantly different variants of capital adequacy and liquidity requirements. In this paper we will mainly focus on capital adequacy requirements, which have so far been most extensively studied in the literature, but it should be clear that future analysis will have to be as exhaustive as for fiscal policy. We expect to find that, as for fiscal policy, the effectiveness of the countercyclical aspects of macroprudential policies, including the international coordination of such policies, depends critically on the instrument used. The foregoing of course differs fundamentally from conventional monetary policy where, with the exception of fixed exchange rates, there is only one possible policy instrument, the nominal interest rate. Unconventional monetary policy, which we will discuss briefly, works through similar channels to macroprudential policy, but is generally designed as a short-term emergency measure rather than a longer-term systematic policy.

The long-run primary objectives of both fiscal and macroprudential policies are the stabilization of financial balance sheet ratios. For fiscal policy there is little controversy that a rule should stabilize government debt by targeting the government debt-to-GDP ratio, either directly or, as in our model, by targeting the interest-inclusive government deficit-to-GDP ratio. For macroprudential policy, a consensus is beginning to emerge that an important long-run objective is the stabilization of the private credit-to-GDP ratio.[5] These objectives are fundamentally different from the inflation objective of monetary policy, and reflect a concern with much longer-term issues of financial stability, either of the government or of the entire private credit system. In other words, they reflect a concern with the possibility of crises. As we will discuss, this is not just reflected in the long-run objective, but also in the way these policies can be used once a crisis has happened.

The final similarity between fiscal and macroprudential policies, and difference to monetary policy, concerns their effect on real output. With monetary policy there is a very long-standing consensus that it can only affect the volatility of output rather than its level or growth rate, barring extreme but of course not impossible scenarios where

[5] See the survey in European Central Bank (2012).

inflation expectations have become unanchored. This is clearly different for fiscal and macroprudential policy, where the stabilization of output and the prevention of crises can be achieved by setting policy instruments at permanently different levels that however also have permanent effects on the level of output. Two examples should suffice to illustrate this. First, fiscal policy, by choosing a very high level of government spending as a share of GDP and then stabilizing government spending, can clearly directly contribute to stabilizing output. But permanently higher government spending requires permanently higher taxes, and if these are distortionary, this implies a permanently lower level of output. Second, macroprudential policy, by setting a very high level of minimum capital adequacy requirements, can clearly directly contribute to reducing the probability of financial crises and thus of extreme output fluctuations. But such a policy may make lending more expensive, which could also imply a permanently lower level of output. By the same token, once a crisis, or at least a recession, has already arrived, the fact that fiscal and macroprudential policy tools can have permanent output effects has a corollary in that short-run variations of such tools can have potentially powerful short-run effects on the volatility of output. For fiscal policy, this has been studied in Freedman et al. (2010), Christiano et al. (2011) and Coenen et al. (2011), who find potentially large fiscal multipliers of short-run fiscal stimulus across a range of models, which become even larger once monetary policy has mostly exhausted its potential, at the zero interest rate floor. Also, Bi and Kumhof (2011) find that, in a model with liquidity-constrained households, countercyclical fiscal policy can have far larger welfare effects than countercyclical monetary policy. And for macroprudential policy, Benes and Kumhof (2011) show that, in response to financial sector shocks, countercyclical macroprudential policy can have far larger welfare effects than countercyclical monetary policy.

The model we use to study the domestic and cross-border stimulative effects of fiscal and macroprudential policies is the Global Integrated Monetary and Fiscal (GIMF) model, a dynamic general equilibrium model that is frequently used by the IMF for the purpose of policy and scenario analyses. GIMF is a multi-region model of the world economy, with 5 regions in this paper's application. For the effects of fiscal stimulus the critical component of GIMF is the household sector, which has two non-Ricardian features that determine the effectiveness of fiscal stimulus. First, a share of households is liquidity-constrained as in Galí et al. (2007), that is, these households are constrained to consume their after-tax income in every period. Second, the remaining households have finite horizons as in Blanchard (1985). Furthermore, our preferred version of GIMF incorporates a financial accelerator mechanism similar to Bernanke, Gertler and Gilchrist (1999), in which a financial sector, corporate balance sheets and lending risk premia play a key role. By contrasting the results of two model versions, one with and one without the financial accelerator, we will be able to demonstrate that the nonlinearities present in the financial sector, in this case principally due to the convexity of lending risk premia in loan-to-value ratios, significantly increase the effects of fiscal policies. Because the model also incorporates a conventional New Keynesian model of monetary policy that allows for the possibility of a zero interest rate floor, or of monetary accommodation of fiscal or macroprudential stimulus, we will also be able to illustrate the interactions of these policies. We find that the zero interest rate floor combined with the nonlinearities of the financial system, rather than simply goods market interactions, is the principal reason why internationally coordinated stimulus policies lead to very sizeable output spillovers. Perhaps even more importantly, they can take the participating economies into a region where fiscal stimulus pays for itself, by generating multipliers that are so large that government debt-to-GDP ratios decline despite an increase in spending or a reduction in taxes.

The model we use to illustrate more detailed arguments concerning macroprudential policy is taken from the IMF Modeling Division's suite of banking models.[6] These models share the following features, some of which are unique in the literature. *First*, banks are not simply intermediaries between savers and borrowers, but rather creators (and destroyers, as the case may be) of purchasing power. This point is of fundamental importance, because it implies that banks' only constraint on their ability to lend is the perceived profitability of lending. Banks are not constrained by the availability of savings, and instead create their own deposit liabilities ex nihilo in the act of lending. In terms of the business cycle, this implies that banks can rapidly, indeed discontinuously, increase or decrease the quantity of lending, that their main response to adverse shocks is not as much the raising of interest rates as it is quantity rationing of lending, and that capital adequacy does not necessarily drop dramatically in crises because lending losses are matched by sudden contractions in lending. *Second*, banks have their own net worth, and are exposed to non-diversifiable aggregate risk determined endogenously on the basis of optimal debt contracts. *Third*, banks are lenders rather than holders of risky equity. *Fourth*, bank lending is endogenously risky, by making some terms of the lending contract non-contingent on future aggregate outcomes. *Fifth*, bank capital is subject to minimum capital adequacy regulations that do not result in a continuously binding constraint, but rather in endogenous regulatory capital buffers that arise from the interaction of optimal debt contracts and regulation. The regulatory minimum on bank capital represents an additional nonlinearity, in that following large losses banks need to aggressively raise lending rates to avoid the penalties payable on falling below the minimum. *Sixth*, acquiring fresh capital is subject to market imperfections, as otherwise bank losses would be of little or no consequence for banks' ability to meet capital adequacy requirements. The implication is that banks need to replenish their capital exclusively, or at least to a very significant extent, through higher lending margins. We use this model to generate and study several simulations.

The first simulation, a temporary but persistent 400 basis points increase in the foreign exchange risk premium faced by the economy, illustrates the role of the two principal nonlinearities in the financial system, the disproportionately large increase in spreads near the regulatory capital minimum and at very high loan-to-value ratios. It does so by comparing the results of simulating the effects of this shock using two different methods, simple log-linearization and a globally nonlinear method. For an identical shock size, the second method generates far larger real effects than the first.

The second simulation compares two different types of credit expansion, one based on an erroneous expectation of a sizeable improvement in economic fundamentals (bad credit expansion), and the other on a correct expectation of the same improvement (good credit expansion). These scenarios end with the economy suffering an adverse shock that exposes the lack of improved fundamentals under the bad credit expansion. This again illustrates

[6] See Benes and Kumhof (2011), which first discusses some of the principles of our modeling philosophy, and then goes on to study the properties of a small-scale closed economy DSGE model. Benes et al. (2013) presents a more recent small open economy prototype model that is designed for illustrative policy simulations. The simulations in this paper are based on that model.

the role of nonlinearities, this time with a focus on the fact that dangerous financial fragilities can remain hidden until the economy is exposed to an adverse shock that takes financial ratios into the regions where nonlinearities become an issue.

The third and fourth simulations deal with policies concerning the level and variability of bank minimum capital adequacy ratios (MCAR). The third simulation exposes the economy to a permanent increase in the level of MCAR. This obviously makes it less likely that any given shock will cause banks to become insolvent, which avoids the extreme volatility associated with financial crashes, but on the other hand it reduces the long-run level of output. This possibility of affecting long-run output levels, and the trade-off with short-run stabilization, is one of the features that make macroprudential policy similar to fiscal policy. The fourth simulation adds the possibility of countercyclical variations in MCAR, by studying the response of the economy to a boom-bust cycle induced by partially disappointed expectations of higher future growth. It shows that countercyclical MCAR can have powerful beneficial effects on the risk-taking behavior of banks following shocks, and thereby on business cycle fluctuations and the volatility of asset prices.

The rest of the paper is organized as follows. Section II provides a more detailed review of the literature on policy activism. Section III presents an overview of the multi-regional model GIMF. Section IV assesses how the introduction of macro-financial linkages in the form of a financial accelerator affects the model simulations of key shocks. Section V uses GIMF to examine the short-run multipliers of four different types of stimulative fiscal measures, under a variety of different assumptions about monetary accommodation and about the financial environment. Section VI presents the simulated effects on the world economy of the actually announced G20 fiscal stimulus measures, with an emphasis on their output spillover effects and the resulting effects on government debt-to-GDP ratios. Section VII presents counterfactual simulations that study how the world economy might have fared if coordinated expansionary fiscal and financial sector policies had not been adopted around the onset of the Great Recession. Section VIII studies the illustrative simulations produced with our banking model. Section IX concludes.

II. The Literature on Policy Activism

The ultimate objective of this paper, as discussed in the introduction, is an analysis of the benefits of international policy coordination, in other words of the joint implementation of stimulative or stabilizing fiscal or macroprudential policy measures. But this presumes that such policies are desirable domestically. While the existing literature on the international dimension of this problem is so far very small, the literature on the domestic dimension is much larger. This section provides a brief overview.

There is a long history of debate in economics on the virtues or otherwise of policy activism. Historically that debate centered mostly on the desirability of ongoing fine-tuning of the business cycle, but the recent debate took place against the background of an exceptionally severe financial and economic crisis, where even many staunch opponents of the active and continuous use of fiscal policy have accepted that fiscal stimulus could be used as a one-off emergency measure.

Keynesian demand management through fine-tuning of monetary and fiscal policy was popular among economists of the 1950s and 1960s.[7] But fiscal activism started to be challenged by the emerging neoclassical school in the 1960s.[8] There was a simultaneous challenge to the systematic use of monetary policy (Lucas, 1972), but here the pendulum started to swing back in favor of activism in the early 1980s, based on much improved theoretical[9] and empirical foundations. But the presumption was still that policy activism should be left to monetary policy. It was argued (Gramlich, 1999) that it is difficult for fiscal policy to deliver its stimulus in a "timely, targeted and temporary" manner. But Solow (2005) and Wyplosz (2005) argue that this problem can be overcome through institutions and procedures that would allow fiscal policy to adopt the core principles of monetary policy.

Fiscal rules are one way to formalize the use of fiscal policy for fine-tuning the business cycle. Taylor (2000) discusses the desirability of a fiscal rule in which the budget surplus depends on the output gap, but he argues against its use because the central bank would only suffer from having to forecast the fiscal stance. He therefore argues, along with many other commentators at that time, that the role of fiscal policy should be limited to minimizing distortions and to "letting automatic stabilizers work". Automatic stabilizers describe the channels through which fiscal policy can be countercyclical even if fiscal instruments are not varied in any discretionary way in response to the business cycle.[10]

Taylor (2000) makes two exceptions to this assessment. The first is fixed exchange rate regimes, where monetary policy deliberately gives up its stabilizing role. The second is the type of situation that the world economy has been facing during the crisis, where nominal interest rates are very close to their zero lower bound so that further conventional discretionary monetary policy is much more problematic.[11] This, and the exceptional gravity of the current crisis, are the major reasons for the renewed interest in fiscal policy.[12]

Interest in the deliberate and systematic use of macroprudential policy only arose much more recently. The reason is that, amazingly, for practically the entire post-war period the private financial system, as opposed to the central bank, was not seen as an important part of the macroeconomic transmission mechanism. This is in stark contrast to the preoccupation of the leading macroeconomists of the 1920s, 1930s and 1940s with the problems of banking[13], which began to disappear after the second world war, except for the work of Minsky (1986) and the Post-Keynesian economics tradition. As a consequence almost all interest in prudential banking regulation before 2008 was of a microeconomic

[7] See Phillips (1954), Musgrave (1959) and Tobin (1972), and also Seidman (2003).

[8] See Eisner (1969), which was based on Friedman (1957), and Barro (1974).

[9] See Taylor (1980), Rotemberg (1982), Calvo (1983), Taylor (1993a) and Bernanke and Mishkin (1997).

[10] This, however, begs the question of how strong automatic stabilizers should be to achieve a desirable degree of countercyclicality. And this question can in turn be formalized as a search for the optimal design of a fiscal rule. See Bi and Kumhof (2011) and Kumhof and Laxton (2013).

[11] We would add that in an economy with many liquidity-constrained agents fiscal activism may be desirable even away from the zero bound and under flexible exchange rates. This is because monetary policy operates mainly through an intertemporal substitution channel that is absent for liquidity-constrained agents, while fiscal policy can directly affect these agents' income. See Kumhof and Laxton (2013).

[12] For examples, see Freedman et al. (2010), Christiano et al. (2011) and Coenen et al. (2011).

[13] A list of examples includes Douglas (1935), Fisher (1935), Graham (1936), Knight (1933), Simons (1946, 1948) and Schumpeter (1954).

nature. The Great Recession changed that dramatically, culminating in the recent debates over the Basel III framework, which were very much concerned with the macroeconomic rather than just the prudential implications. Academic work has also increasingly paid attention to the macroeconomic consequences of prudential banking regulation.[14]

III. The Global Integrated Monetary and Fiscal Model

This section, to conserve space, contains only a brief overview of the model, followed by some details that are critical to understanding its fiscal policy implication. A complete description can be found in Kumhof, Laxton, Muir and Mursula (2010), henceforth KLMM.[15] Time periods represent years. To simplify the exposition we present the perfect foresight version of the model.

A. Overview of GIMF

The world consists of 5 regions, the United States (US), the euro area (EU), Japan (JA), emerging Asia (AS)[16] and remaining countries (RC). The regions trade with each other at the levels of intermediate and final goods. International asset trade is limited to nominal non-contingent bonds denominated in U.S. dollars. We refer to U.S. variables by a superscript asterisk. The world economy's technology grows at the constant rate $g = T_t/T_{t-1}$, where T_t is the level of labor augmenting world technology, and world population grows at the constant rate n.

Each country is populated by two types of households, both of which consume final retailed output and supply labor to unions. Liquidity-constrained households are limited to consuming their after-tax income in every period, as in Galí et al. (2007).[17] The share of these agents in the population equals ψ. Overlapping generations households have finite planning horizons as in Blanchard (1985). Each of these agents faces a constant probability of death $(1-\theta)$ in each period, which implies an average planning horizon of $1/(1-\theta)$.[18] In addition to the probability of death, households also experience labor productivity that declines at a constant rate $\chi < 1$ over their lifetimes.[19] Households of both types are subject to uniform labor income, consumption and lump-sum taxes. We will denote variables pertaining to these two groups of households by OLG and LIQ.

[14] For examples, see Angeloni and Faia (2013), Benes and Kumhof (2011), Christiano et al. (2013), Curdia and Woodford (2010), Gertler and Karadi (2010), Meh and Moran (2010), Milne (2002) and van den Heuvel (2008).

[15] This paper is available at http://www.imf.org/external/pubs/cat/longres.cfm?sk=23615.0.

[16] For calibration purposes, AS comprises China, Hong Kong S.A.R. of China, India, Indonesia, Korea, Malaysia, Philippines, Singapore, and Thailand.

[17] We follow Galí et al. (2007) in referring to these households as liquidity-constrained. Other terms used in the literature are rule-of-thumb or hand-to-mouth agents.

[18] Galí et al. (2007) interpret the complete inability to smooth consumption of their model's liquidity-constrained households as (among other possible interpretations) extreme myopia, or a planning horizon of zero. We adopt the same interpretation for the average planning horizon of the finite-horizon model. We therefore allow for the possibility that agents may have a shorter planning horizon than what would be suggested by their biological probability of death. See KLMM for a more detailed discussion.

[19] Due to the absence of explicit demographics in our model, we only need the assumption of declining labor productivity to be correct for the average worker.

Firms are managed in accordance with the preferences of their owners, finitely-lived OLG households, and they therefore also have finite planning horizons. Except for capital goods producers, entrepreneurs and retailers, they are monopolistically competitive and subject to nominal rigidities in price setting.[20] Each country's primary production is carried out by manufacturers producing tradable and nontradable goods. Manufacturers buy capital services from entrepreneurs and labor from unions. Unions buy labor from households. Entrepreneurs buy capital from capital goods producers. They are subject to an external financing constraint and a capital income tax. Capital goods producers are subject to investment adjustment costs. Manufacturers sell to domestic and foreign distributors, the latter via import agents located abroad that price to their respective markets. Distributors combine a public capital stock with nontradable goods and domestic and foreign tradable goods, subject to an import adjustment cost. Distributors sell to domestic and foreign consumption and investment goods producers, via import agents for foreign sales. Consumption and investment goods producers combine domestic and foreign output, again subject to an import adjustment cost. Consumption goods are sold to retailers and the government, while investment goods are sold to capital goods producers and the government. Retailers face real sales adjustment costs, which together with habit persistence in preferences generate inertial consumption dynamics.

Asset markets are incomplete. There is complete home bias in domestic government debt and in ownership of domestic firms. Equity is not traded, instead households receive lump-sum dividend payments.

In our derivations, per capita variables are only considered at the level of disaggregated households. When the model's real aggregate variables, say x_t, are rescaled, we divide by the level of technology and by population to obtain $\check{x}_t$, with the steady state of $\check{x}_t$ denoted by $\bar{x}$.

B. Overlapping Generations (OLG) Households

A representative OLG household of age a derives utility at time t from consumption $c_{a,t}^{OLG}$ relative to the consumption habit $h_{a,t}^{OLG}$, and from leisure $(1-\ell_{a,t}^{OLG})$ (where 1 is the time endowment). The lifetime expected utility of a representative household has the form

$$\sum_{s=0}^{\infty}(\beta\theta)^s\left[\frac{1}{1-\gamma}\left(\left(\frac{c_{a+s,t+s}^{OLG}}{h_{a+s,t+s}^{OLG}}\right)^{\eta^{OLG}}\left(1-\ell_{a+s,t+s}^{OLG}\right)^{1-\eta^{OLG}}\right)^{1-\gamma}\right], \tag{1}$$

where β is the discount factor, $\theta<1$ determines the planning horizon, $\gamma>0$ is the coefficient of relative risk aversion, and $0<\eta^{OLG}<1$. As for money, we assume the cashless limit advocated by Woodford (2003). Consumption $c_{a,t}^{OLG}$ is given by a Dixit-Stiglitz CES aggregate over retailed consumption goods varieties. The (external) consumption habit is given by lagged per capita consumption of OLG households.

A household can hold domestic currency bonds, which are either issued by the domestic government, $B_{a,t}$, or by banks lending to nontradables and tradables entrepreneurs,

[20] We assume quadratic inflation adjustment costs as in Ireland (2001) and Laxton and Pesenti (2003), meaning that inflation rather than the price (or wage) level is sticky.

$B^N_{a,t} + B^T_{a,t}$. They can also hold U.S. dollar denominated foreign bonds $F_{a,t}$. The nominal exchange rate vis-a-vis the U.S. dollar is E_t, and the corresponding gross depreciation rate is ε_t. Gross nominal interest rates on domestic and foreign currency denominated assets held from t to $t+1$ are i_t and $i^*_t(1+\xi^f_t)$, where i^*_t is the U.S. dollar nominal interest rate and ξ^f_t is a foreign exchange risk premium.

Participation by households in financial markets requires that they enter into an insurance contract with companies that pay a premium of $\frac{(1-\theta)}{\theta}$ on a household's financial wealth for each period in which that household is alive, and that encash the household's entire financial wealth in the event of his death.[21]

OLG households' pre-tax nominal labor income is $W_t\Phi_{a,t}\ell_{a,t}$. The productivity $\Phi_{a,t}$ of an individual household's labor declines throughout his lifetime, with $\Phi_{a,t} = \kappa\chi^a$ and $\chi < 1$. OLG households also receive lump-sum remuneration for their services in the bankruptcy monitoring of entrepreneurs, $P_t rbr_{a,t}$. Lump-sum after-tax nominal dividend income received from firms/unions in sector j is denoted by $D^j_{a,t}$. OLG households' labor income and consumption are taxed at the rates $\tau_{L,t}$ and $\tau_{c,t}$. In addition there are lump-sum taxes $\tau^{ls,OLG}_{a,t}$, and transfers $\Upsilon^{OLG}_{a,t}$ paid to/from the government.[22] The consumption tax $\tau_{c,t}$ is payable on the price P_t at which retailers purchase final consumption goods from distributors.

We choose P_t as our numeraire. Gross inflation is given by $\pi_t = P_t/P_{t-1}$, the real interest rate is $r_{t+1} = i_t/\pi_{t+1}$, the real wage is $w_t = W_t/P_t$, and retailers' real sales price is $p^R_t = P^R_t/P_t$. Real domestic bonds are $b_t = B_t/P_t$, real internationally traded bonds are $f_t = F_t/P^*_t$, and the real exchange rate vis-a-vis the United States is $e_t = (E_t P^*_t)/P_t$. The household's budget constraint in nominal terms is

$$P^R_t c^{OLG}_{a,t} + P_t c^{OLG}_{a,t}\tau_{c,t} + P_t\tau^{ls}_{a,t} + B_{a,t} + B^N_{a,t} + B^T_{a,t} + E_t F_{a,t} \tag{2}$$

$$= \frac{1}{\theta}\left[i_{t-1}\left(B_{a-1,t-1} + B^N_{a-1,t-1} + B^T_{a-1,t-1}\right) + i^*_{t-1}E_t F_{a-1,t-1}\left(1+\xi^f_{t-1}\right)\right]$$

$$+W_t\Phi_{a,t}\ell^{OLG}_{a,t}(1-\tau_{L,t}) + \sum_j D^j_{a,t} + P_t rbr_{a,t} + P_t\Upsilon^{OLG}_{a,t}\ .$$

The household maximizes (1) subject to (2). We obtain a standard first-order condition for the consumption/leisure choice. Uncovered interest parity is given by $i_t = i^*_t\left(1+\xi^f_t\right)\varepsilon_{t+1}$.

A key condition of the model is the optimal aggregate consumption rule of OLG households.[23] Consumption is a function of real aggregate financial wealth fw_t and human wealth $hw^L_t + hw^K_t$, with the marginal propensity to consume out of wealth given by $1/\Theta_t$, with hw^L_t representing the present discounted value of households' time endowments evaluated at the after-tax real wage, and hw^K_t representing the present discounted value of dividend income net of lump-sum government transfers. After rescaling by technology we have

[21] The turnover in the population is assumed to be large enough that the income receipts of the insurance companies exactly equal their payouts.

[22] It is convenient to keep these two items separate in order to account for a country's overall fiscal accounts, and to distinguish targeted and untargeted transfers.

[23] Aggregation takes account of the initial size of each age cohort and the remaining size of each generation.

$$\check{c}_t^{OLG}\Theta_t = \check{f}w_t + \check{h}w_t^L + \check{h}w_t^K \ , \tag{3}$$

where

$$\check{f}w_t = \frac{1}{\pi_t gn}\left[i_{t-1}\left(\check{b}_{t-1} + \check{b}_{t-1}^N + \check{b}_{t-1}^T\right) + i_{t-1}^*\varepsilon_t(1+\xi_{t-1}^f)\check{f}_{t-1}e_{t-1}\right] \ , \tag{4}$$

$$\check{h}w_t^L = (N(1-\psi)(\check{w}_t(1-\tau_{L,t}))) + \frac{\theta\chi g}{r_{t+1}}\check{h}w_{t+1}^L \ , \tag{5}$$

$$\check{h}w_t^K = \left(\Sigma_j \check{d}_t^j + r\check{b}r_t - \check{\tau}_t^{ls,OLG} + \check{\Upsilon}_t^{OLG}\right) + \frac{\theta g}{r_{t+1}}\check{h}w_{t+1}^K \ , \tag{6}$$

$$\Theta_t = \frac{p_t^R + \tau_{c,t}}{\eta^{OLG}} + \frac{\theta j_t}{r_{t+1}}\Theta_{t+1} \ , \tag{7}$$

and where j_t is discussed in KLMM. The intuition is as follows: Financial wealth depends on the government's current financial liabilities, which are serviced through different forms of taxation. These future taxes are reflected in the different components of human wealth, as well as in the marginal propensity to consume. But unlike the government, which has an infinite horizon, a household with finite planning horizon attaches less importance to higher tax payments in the distant future, by discounting future tax liabilities at the rates r_{t+1}/θ and $r_{t+1}/\theta\chi$, which are higher than the market rate r_{t+1}. Government debt is therefore net wealth to the extent that households, due to short planning horizons, disregard the future taxes necessary to service that debt.

A fiscal stimulus through initially lower taxes, and accompanied by a permanent increase in debt, represents a tilting of the tax payment profile from the near future to the more distant future. The present discounted value of the government's future primary deficits has to remain equal to the current debt $i_{t-1}b_{t-1}/\pi_t$ when future deficits are discounted at the market interest rate r_{t+1}. But for households the same tilting of the tax profile represents an increase in human wealth because an increasing share of future taxes becomes payable beyond the household's planning horizon. For a given marginal propensity to consume, this increase in human wealth leads to an increase in consumption.

C. Liquidity-Constrained (LIQ) Households and Aggregate Households

The objective function of liquidity-constrained households is assumed to be identical to that of OLG households. These agents can consume at most their current income, which consists of their after-tax wage income plus net government transfers. After rescaling by technology, their budget constraint is given by

$$\check{c}_t^{LIQ}(p_t^R + \tau_{c,t}) = \check{w}_t\ell_t^{LIQ}(1-\tau_{L,t}) + \check{\Upsilon}_t^{LIQ} - \check{\tau}_t^{ls,LIQ} \ . \tag{8}$$

This group of households has a very high marginal propensity to consume out of income (equal to one), so that fiscal multipliers of revenue based stimulus measures (taxes and transfers) are particularly high whenever such agents have a high population share. Aggregate consumption and labor supply are given by $\check{C}_t = \check{c}_t^{OLG} + \check{c}_t^{LIQ}$ and $\check{L}_t = \check{\ell}_t^{OLG} + \check{\ell}_t^{LIQ}$.

D. Firms

To conserve space we only describe here the financial accelerator or entrepreneur/bank sector. KLMM contains the complete details for the other sectors. Each firm in each sector maximizes the present discounted value of net cash flow or dividends. The discount rate it applies includes the parameter θ so as to equate the discount factor of firms θ/r_{t+1} with the pricing kernel for nonfinancial income streams of their owners, OLG households. The first-order conditions for optimal price setting and input choices are standard.

The entrepreneur/bank sector is based on the models of Bernanke et al. (1999) and Christiano et al. (2013). Entrepreneurs rent capital stocks to manufacturers. Each entrepreneur finances his capital with a combination of his net worth and bank loans. Loans are risky because the productivity of an entrepreneur's capital is subject to idiosyncratic risk. The entrepreneur is risk-neutral and therefore bears all aggregate risk. The loan contract specifies a loan amount and a state-contingent schedule of gross interest rates to be paid if productivity is above a cut-off level. Entrepreneurs below the cut-off go bankrupt and must hand over their entire capital stock to the bank. Due to bankruptcy monitoring costs rbr_t the bank can only recover a fraction of the value of such firms. The bank finances its loans to entrepreneurs by borrowing from households. It pays households a nominal rate of return i_t that is not state-contingent. The parameters of the entrepreneur's debt contract are chosen to maximize entrepreneurial profits, subject to zero bank profits in each state of nature. Due to the costs of bankruptcy, entrepreneurs must pay an external finance premium, which equals the difference between the rate paid by entrepreneurs to banks and the rate paid by banks to households. There is an upward-sloping and convex relationship between entrepreneurs' leverage and the external finance premium. Entrepreneurs accumulate profits over time. To rule out net worth accumulation to the point that entrepreneurs no longer need loans, we assume that they regularly pay out dividends to households according to a fixed dividend policy.

E. Government

Fiscal policy consists of a specification of consumption and investment spending $G_t = G_t^{cons} + G_t^{inv}$, lump-sum taxes $\tau_{ls,t} = \tau_t^{ls,OLG} + \tau_t^{ls,LIQ}$, lump-sum transfers $\Upsilon_t = \Upsilon_t^{OLG} + \Upsilon_t^{LIQ}$, and tax rates $\tau_{L,t}$, $\tau_{c,t}$ and $\tau_{k,t}$, while monetary policy is described by an interest rate rule.

Government consumption spending is unproductive, while government investment spending augments a stock of publicly provided infrastructure capital that depreciates at the rate δ_G. Tax revenue τ_t is endogenous and given by the sum of labor, consumption, capital and lump-sum taxes. Denoting the primary surplus by $\check{s}_t$, the government budget constraint is

$$\check{b}_t = \frac{i_{t-1}}{\pi_t gn}\check{b}_{t-1} + \check{G}_t + \check{\Upsilon}_t - \check{\tau}_t = \frac{i_{t-1}}{\pi_t gn}\check{b}_{t-1} - \check{s}_t \quad . \tag{9}$$

A fiscal policy rule stabilizes deficits and the business cycle. First, it stabilizes the interest inclusive government-deficit-to-GDP ratio gd_t^{rat} at a long-run target (structural) government-deficit-to-GDP ratio $gdss^{rat}$. Second, it stabilizes the business cycle by letting the deficit fall with the output gap. We have

$$gd_t^{rat} = gdss^{rat} - d^{gdp} \ln\left(\frac{g\check{d}p_t}{g\check{d}p_{pot}}\right) \quad . \tag{10}$$

Here $g\check{d}p_{pot}$ is potential output, $d^{gdp} \geq 0$, and gd_t^{rat} is given by

$$gd_t^{rat} = 100\frac{\frac{(i_{t-1}-1)\check{b}_{t-1}}{\pi_t gn} - \check{s}_t}{g\check{d}p_t} = 100\frac{\check{b}_t - \frac{\check{b}_{t-1}}{\pi_t gn}}{g\check{d}p_t} \quad . \tag{11}$$

We denote the current value and the long-run target of the government-debt-to-GDP ratio by $\check{b}_t^{rat}$ and $\check{b}ss^{rat}$. The relationship between bss^{rat} and $gdss^{rat}$ follows directly from the government's budget constraint as

$$bss^{rat} = \frac{\bar{\pi}gn}{\bar{\pi}gn - 1} gdss^{rat} \ , \tag{12}$$

where $\bar{\pi}$ is the inflation target of the central bank. In other words, for a given trend nominal growth rate, choosing a deficit target $gdss^{rat}$ implies a debt target bss^{rat} and therefore keeps debt from exploding. We note that the implied long-run autoregressive coefficient on debt, at $1/(\bar{\pi}gn)$, is close to one.

Our model allows for permanent saving and technology shocks, which have permanent effects on potential output $g\check{d}p_{pot}$. The latter is therefore modeled as a geometric moving average of past actual values of GDP to allow for the gap to close over time. Fiscal policy can be characterized by the degree to which automatic stabilizers work. This has been quantified by the OECD, who have produced estimates of d^{gdp} for a number of countries.[24]

The rule (10) is not an instrument rule but rather a targeting rule. Any of the available tax and spending instruments can be used to make sure the rule holds. The default setting in this paper is that this instrument is general transfers $\check{\Upsilon}_t$, meaning transfers that are not specifically targeted at one of the two household groups.

Monetary policy uses an interest rate rule to stabilize inflation. The rule is similar to a conventional inflation forecast based rule that responds to one-year-ahead inflation, but with the important exception that the equilibrium real interest rate needs to be formulated as a geometric moving average, similar to potential output above.

F. Calibration

We comment only on the most important features of the calibration, including updates made since the publication of KLMM.

The real per capita growth rate is 1.5 percent, the world population growth rate is 1 percent, and the long-run real interest rate is 3 percent.

Household utility functions are equal across countries. The intertemporal elasticity of substitution is 0.5, or $\gamma = 2$, and the wage elasticity of labor supply is 0.5. The

[24] See Girouard and André (2005).

parameters ψ, θ and χ are critical for the non-Ricardian behavior of the model. The shares of liquidity-constrained agents ψ are 25 percent in US, EU and JA, and 50 percent in AS and RC, reflecting less developed financial markets in the latter two regions. The average remaining time at work is 20 years, or $\chi = 0.95$. The planning horizon is also equal to 20 years, or $\theta = 0.95$. The main criterion used in choosing θ and χ is the empirical evidence of Laubach (2009), Engen and Hubbard (2004) and Gale and Orszag (2004). They find that a one percentage point increase in the government-debt-to-GDP ratio in the U.S. leads to an approximately one to six basis points long-run increase in the U.S. (and therefore world) real interest rate. Our calibration is at the lower end of that range, at around one basis point.

As for technologies, elasticities of substitution equal 1 between capital and labor, 1.5 between domestic and foreign goods, and 0.5 between tradables and nontradables. Steady state gross markups equal 1.2 in manufacturing, 1.1 in wage setting, 1.05 in retailing, investment and consumption goods production, and 1.025 for import agents.

Steady state GDP decompositions, trade flows and debt ratios are based on recent observed values. For the public capital stock accumulation we adopt Kamps' (2004) 4 percent per year estimate. Ligthart and Suárez (2005) estimate the elasticity of aggregate output with respect to public capital at 0.14. This is reproduced by our model through specifying the productivity of public capital in the distribution sector's technology.

The calibration of monetary rule parameters is based on our own estimates using annual data. For fiscal rule parameters the calibration assumes target deficit-to-GDP ratios consistent with recent average observed government-debt-to-GDP ratios. We use OECD estimates of output gap coefficients d^{gdp}.

The structure and calibration of the two model variants that exclude and include a financial accelerator are kept identical in all but the entrepreneur/bank sector. Leverage, defined as the ratio of corporate debt to corporate equity, equals 100 percent in all sectors and regions, and the steady state external finance premium equals 2.5 percent. The model version without a financial accelerator can be thought of as an otherwise identical model where bankruptcy monitoring costs are zero.

IV. The Role of the Financial Accelerator

We begin by illustrating the importance of including a financial sector in the model. We do so by simulating[25] two shocks that in our view reflect important aspects of the Great Recession, a decline in the potential growth rate and an increase in the riskiness of the corporate sector. The latter shock is only present in the model with a financial accelerator. We assume that both shocks are temporary but highly persistent. The shocks are stylized, they are not designed to quantitatively match features of the Great Recession.

[25] The programs used to generate the results in this paper use TROLL to generate the model structure and simulations. A temporary version of TROLL can be obtained from Peter Hollinger at INTEX Solutions at <troll@intex.com>.

The key feature of the financial accelerator is that, following a contractionary shock to corporate net worth, the real interest rate faced by the corporate sector increases persistently, as it takes several years to rebuild lost net worth. During this time dividend distributions are reduced, which negatively affects consumption. Corporate net worth is equal to the market value of the firm's physical capital minus the value of the firm's financial liabilities. The former falls in the presence of negative technology shocks and of higher riskiness of corporate borrowers. The latter rises when there is a decline in the price level.

The monetary policy response to adverse shocks, and also to any fiscal stimulus response that follows such shocks, has played a key role in the recent policy debate.[26] Several of the world's main central banks reached the zero lower bound on nominal interest rates during the course of the financial crisis. On the downside, they were therefore unable to respond to further negative shocks through lower rates. This means that further falls in inflation caused real interest rates to rise far more quickly than in ordinary circumstances. On the upside, in response to the expansionary fiscal measures that were adopted to mitigate the crisis, they nevertheless chose to hold interest rates constant to amplify the expansionary effects of the stimulus, a policy that we will refer to as monetary accommodation. Stimulus increases inflationary pressures (or at least reduces disinflationary pressures), which under constant nominal interest rates lowers the real interest rate, thereby giving rise to further increases in consumption and investment. Our simulations reflect these policy choices by comparing three sets of environments, ranging from an ordinary monetary policy response that follows an interest rate reaction function, to a situation where the central bank keeps nominal interest rates unchanged for one or two years.

A. Decline in Productivity Growth

Figure 1 illustrates the simulated effects on the U.S. and rest of the world economies of a temporary but persistent reduction in productivity growth. The shock involves a reduction in the rate of productivity growth of 0.2 percentage points for 5 years in both the tradables and non-tradables sectors in each region of the world economy.

In Figure 1 and in all subsequent figures, the dotted line shows the effects of the shock when the policy interest rate can respond immediately, in line with a monetary policy interest rate reaction function. The dashed line scenario leaves policy rates unchanged for one year following the shock, either because the rate is at the zero interest rate floor (ZIF) or because of a delay in the policy response. The solid line scenario leaves policy rates unchanged for two years.

We first discuss the model without a financial accelerator in the bottom half of Figure 1. The short-run to medium-run effects of the decline in productivity growth are a reduction in real GDP and a decline in inflation. The latter indicates that aggregate demand falls by more than aggregate supply over the time period shown, as households consume less in anticipation of lower lifetime income, and as businesses reduce investment in response to anticipated lower growth. The central bank, if it follows its reaction function (dotted line), gradually reduces the policy interest rate, and the real interest rate eventually falls below

[26] See, for example, Freedman et al. (2009).

baseline. If interest rates are left unchanged for one year (dashed line), real interest rates in the first year are above those in the previous case, so that real GDP, inflation, consumption and investment are slightly lower than in the previous case. If interest rates are held fixed for two years (solid line), we observe larger declines in real GDP, inflation, consumption and investment.

Now consider the model with a financial accelerator. For the cases in which interest rates are able to adjust or are fixed for only one year, introducing the financial accelerator causes the negative effects of the shock to be only slightly larger. But in the case of interest rates fixed for two years, the differences are more substantial. Two principal mechanisms are responsible for this outcome.

First, the external finance premium increases by more. The reason is that leverage increases due to lower net worth, which in turn results from a combination of the negative effect of lower productivity growth on the market value of physical capital with the positive effect of the unanticipated fall in the price level on the real value of outstanding debt. Investment is negatively affected by the higher external finance premium, while consumption falls in response to lower dividend distributions from the corporate sector, due to both lower earnings and the effort to rebuild lost net worth.

Second, the larger decline in domestic demand results in a larger decline in inflation, which raises the riskless real interest rate still further, especially for the case of nominal interest rates fixed for two years. This further reduces investment and consumption.

The interaction of these factors results, in years two and three and for the case of interest rates unchanged for two years, in a decline in U.S investment of well over 4 percent in the model with a financial accelerator versus around 2.5 percent in the model without a financial accelerator. The corresponding GDP contractions are 1.4 percent versus 1.1 percent. Effects in the rest of the world, which is assumed to suffer a productivity shock of the same size as the United States, are at comparable or slightly larger magnitudes.

B. Increase in Borrower Riskiness

Figure 2 presents the simulated effects of a temporary but persistent increase in the idiosyncratic risk of U.S. corporate borrowers, in both the tradables and non-tradables sectors, with the rest of the world not suffering a comparable shock. The magnitude of the shock is such that, under a monetary policy response that follows a conventional interest rate reaction function the U.S. external finance premium increases by 100 basis points on impact. Thereafter the shock gradually tapers off, with an annual decay factor of 0.95.

For the case of an immediate interest rate response, the increase in financing costs has a very considerable and persistent effect on U.S. investment, which drops by around 5 percent, while U.S. GDP drops by around 0.7 percent. But the effects are much larger, with a more than 1.5 percent drop in GDP, in the case of unchanged interest rates for two years. Part of the larger effects in the latter case can be attributed to a larger initial movement in the external finance premium, which increases by an additional 15 basis points on impact, but much more is attributable to the greater increase in the riskless real interest rate, which increases by around 100 basis points more for this policy.

Output spillovers to RW are small for the cases of interest rates able to adjust immediately or fixed for one year, but are very significant, at over 0.6 percent, for the case of interest rates unchanged for two years. This is not the direct result of demand spillovers from lower spending in the United States, which are fairly small, as is common in this type of model. Rather, they are the result of much stronger propagation through real financing costs. Specifically, the decline in U.S. demand reduces inflation not only in the United States but also in RW. This is due to the behavior of the exchange rate which, while dampening the real effect of the goods trade channel, amplifies the real effect of the financial channel. With interest rates held unchanged, this drives up RW real interest rates, thereby negatively affecting that region's corporate balance sheets and external finance premia.

V. Short-Run Effects of Fiscal Policies

This section turns to a simulation-based evaluation of the effectiveness of the fiscal policy measures adopted in the wake of the Great Recession. We discuss simulations for four types of temporary fiscal stimulus measures—(i) an increase in government investment; (ii) an increase in general lump-sum transfers to all households; (iii) an increase in lump-sum transfers targeted specifically at liquidity-constrained households; and (iv) a decrease in the tax rate on labor income.[27] In all cases, the fiscal shock involves discretionary stimulative actions equal to 1 percent of pre-shock GDP for two years. The resulting government deficits are smaller than the size of the shock because automatic stabilizers ($d^{gdp} > 0$) react to the positive movements of GDP that result from the discretionary fiscal actions.

In our discussions of the results we will use the terminology "fiscal multiplier" to describe the sizes of the instantaneous GDP effects of the four stimulus measures. Given that the stimulus equals exactly one percent of baseline GDP in the first two years, the fiscal multiplier equals simply the percentage change in GDP for those same years.[28]

Fiscal stimulus has effects on both the demand and supply sides of the economy. The demand effects come from the fiscal action feeding directly into aggregate demand (in the case of government investment), or from increasing real disposable incomes that are partly used to increase spending (in the case of increases in general or targeted transfers and decreases in labor income taxes). Demand effects have the usual secondary multiplier effects, as higher spending increases labor incomes and dividends, and the recipients in turn increase their own spending. For some stimulus measures there are important supply-side effects. Specifically, higher government investment and lower labor income taxes increase potential output, thereby reducing the inflationary effects of fiscal stimulus.

[27] See Freedman et al. (2010) for a more detailed discussion of fiscal multipliers that also includes government consumption, consumption taxes and corporate income taxes.

[28] We therefore limit our discussion to instantaneous or short-run multipliers. The distinction between instantaneous and cumulative or long-run multipliers is discussed in Coenen et al. (2011).

A. Increase in Government Investment

Figure 3 shows the simulated effects of an increase in government investment. The average effects on U.S. GDP over the two years of fiscal stimulus in the model without a financial accelerator are sizeable, ranging from a just under 1.0 percent increase in GDP without monetary accommodation, to 1.1 percent for one year of monetary accommodation, to 1.3 percent for two years of monetary accommodation. The corresponding effects in the model with a financial accelerator are 1.0 percent, 1.2 percent, and 1.9 percent.

There are a number of reasons for these relatively large multipliers. First, government investment feeds directly into aggregate demand. Second, it has a small but not insignificant effect on aggregate supply, by making private production more efficient. Third, under monetary accommodation, the substantial increase in inflation leads to a substantial decline in real interest rates. For example, with two-year monetary accommodation and a financial accelerator, riskless real interest rates are below baseline by around 50 basis points in years 1 and 2. This supports and greatly increases, by around 50 percent, the direct effects of the fiscal action on GDP.

With a financial accelerator, corporate net worth increases as the strengthening economy raises the market value of physical capital, and as higher inflation reduces the real value of corporate debt, thereby causing a reduction in the external finance premium, especially in the case of two-year monetary accommodation. This leads to an additional reduction in interest rates faced by corporate borrowers, beyond that from the decline in the riskless real interest rate, and therefore to even larger investment.

A notable feature of Figure 3 is that the effect of the shock on GDP nearly dies out as soon as the shock ends. The main reason is the highly temporary nature of the stimulus measure. This implies that OLG households will largely, although not completely, smooth their consumption by saving the additional income, while investors have no incentive to engage in sustained higher investment because the effect of temporarily higher demand is more than outweighed by the anticipation of higher real interest rates. In the absence of a sustained increase in demand from these sources, wage income does not increase significantly beyond the stimulus period, and therefore neither does LIQ households' post-stimulus consumption.

Another reason for the rapid drop in output following the stimulus could in principle be that annual averaging in GIMF can give the appearance of less dynamics. But quarterly models do in fact produce very similar impulse responses around the end of the stimulus period. This is shown in Coenen et al. (2011), which compares fiscal multipliers for temporary stimulus measures across seven large DSGE models (five of which are quarterly) used by policymaking institutions. In that comparison GIMF typically generates as much persistence as estimated models such as the Federal Reserve's FRB-US and the European Central Bank's NAWM.

The effects of fiscal stimulus on realized fiscal deficits are of course also a matter of great interest to policymakers. We find that the direct effects are offset to a considerable extent by automatic stabilizers. For example, for two years of monetary accommodation and a financial accelerator, the fiscal accounts move back into balance in year 3, and the government-debt-to-GDP ratio is below baseline for several years, as the effect of the relatively small net deficits in the first two years is offset by the increase in real GDP, and by the effect of the rise in prices on the real value of government debt.

The effects on the rest of the world of the U.S. fiscal stimulus are generally small, but not for the case of two years of monetary accommodation, where real interest rate effects lead to a large increase in real GDP (about 0.7 percent on average over the two years) in the model with a financial accelerator, which is more than four times larger than in the model without a financial accelerator. We have here a first indication that the cross-country spillover effects of stimulus can be so large that they significantly increase multipliers when countries jointly implement fiscal stimulus. The conditions that make this likely in our simulations are monetary accommodation, a model that takes account of the financial sector, and the use of a fiscal instrument with high multiplier effects even if used only in a single country.

B. Increase in General Lump-Sum Transfers

As shown in Figure 4, the simulated effects on GDP of an increase in general lump-sum transfers are small, even in the case of monetary accommodation. In the model without a financial accelerator and without monetary accommodation, GDP increases by around 0.1 percent. With two-year monetary accommodation, the results are somewhat larger, but with real GDP still only rising by 0.15 percent. There are virtually no spillovers to the rest of the world.

The main reason for these small multipliers is that the increase in general lump-sum transfers only has a significant effect on the spending of liquidity-constrained households, who comprise only one quarter of the U.S. household population. The remaining households treat most of the increase in income as a windfall, and spend only a small proportion. The indirect effect from the decline in real interest rates under monetary accommodation is minimal since the increase in inflation is small.

Adding a financial accelerator generally results in only small increases in the multiplier. In the case of two-year monetary accommodation, there are somewhat larger effects on corporate net worth and the external finance premium, and real GDP rises by about 0.25 percent on average over two years. Spillovers to the rest of the world are also more noticeable in this case.

C. Increase in Targeted Lump-Sum Transfers

Targeted transfers are aimed directly at liquidity-constrained households, who have a marginal propensity to consume out of current income of almost one.[29] When such households, who account for one quarter of all households in the United States, receive 100 percent of the increase in transfers, the aggregate increase in consumption is much higher than when they receive only 25 percent.

[29] There can be leakages out of additional income, due for example to consumption taxes or to a decision to work less.

Figure 5 shows the simulated results. The effects on U.S. GDP are almost four times larger than the effects of an increase in untargeted lump-sum transfers. In the case of two-year monetary accommodation, they equal 0.6 percent compared with 0.15 percent in the model without a financial accelerator, and 0.9 percent compared with 0.25 percent in the model with a financial accelerator. The larger increase in U.S. demand results in significantly higher inflation not only in the United States but also in RW. This relatively limited spillover is however propagated much more strongly in the presence of monetary accommodation and financial accelerator effects, as higher RW inflation drives down the riskless real interest rate, which in turn positively affects corporate balance sheets and external finance premia. The result is an almost four times larger increase in GDP in the rest of the world than in the case of general lump-sum transfers.

D. Decrease of the Labor Income Tax Rate

The simulation results for fiscal stimulus implemented via lower labor income taxes are presented in Figure 6.[30] The effect on U.S. GDP is significantly larger than in the case of general lump-sum transfers for no monetary accommodation and one-year monetary accommodation, and smaller in the case of two-year monetary accommodation, especially in the model version with a financial accelerator. The reduction in labor income taxes increases households' labor supply. This has two effects that operate in opposite directions. First, the increase in labor supply directly increases potential and actual output, and by more than in the case of general transfers. Second, as a result of the increase in potential GDP, there is less upward pressure on inflation and therefore less downward pressure on real interest rates in the presence of monetary accommodation, which implies less monetary stimulus to aggregate demand than in the case of general transfers. For example, in the case of two-year monetary accommodation and no financial accelerator, U.S. real interest rates fall on average by more than 5 basis points over the two years when the fiscal instrument is general lump-sum transfers, but they increase by more than 5 basis points in the case of a reduction in labor income taxes. A similar result holds in the model with a financial accelerator and two-year monetary accommodation. Given the much smaller drops in real interest rates, there is also less propagation due to financial accelerator effects.

VI. Effects of Coordinated G20 Fiscal Stimulus Packages

Table 2 sets out the simulated effects on regional and global GDP of the actual G20 fiscal stimulus packages of 2009 and 2010.[31] We assume two years of monetary accommodation. We emphasize that these simulations do not represent an ex-post evaluation of the actual impacts of the policy packages, but rather an ex-ante simulation of what the model predicts for their effectiveness.

[30] A reduction of about 1.7 percentage points in the tax rate on labor income is needed to achieve an increase of 1 percent in the government-deficit-to-GDP ratio.

[31] Regional decompositions of stimulus measures are based on data collected by IMF staff.

Japan, emerging Asia and the United States implemented the largest fiscal packages, while the G20 countries in the euro area, Africa and Latin America had smaller packages. In terms of their composition, general and targeted transfers dominated in Japan, government investment dominated in emerging Asia, general and targeted transfers and labor income taxes dominated in the United States, while in the euro area and other countries there was a relatively large role for corporate income tax cuts in 2010.[32] It is interesting to note that increases in government consumption did not play a predominant role in any of the regions.

Simulations of both versions of the model show a considerable impact of the announced packages on GDP. The regional differences reflect both the different sizes of the announced packages and the higher multipliers of government investment and targeted transfers based measures. Consistent with the earlier results on fiscal multipliers, the effects in the model with a financial accelerator are larger by around 50 percent, and in some cases by considerably more than that.

But the most striking result is that the GDP effects of any given country are very considerably larger when all countries implement stimulus simultaneously (the left column), compared to one country implementing its stimulus program in isolation (the bold figures in the five right columns).[33] In the model without a financial accelerator the increase in GDP effects averages almost 50 percent, while in the model with a financial accelerator it averages around 80 percent. This can make a critical difference, because with sufficiently high multipliers the stimulus can pay for itself, both by increasing GDP sufficiently and by increasing tax revenue sufficiently, to reduce rather than increase government debt-to-GDP ratios.

This effect is illustrated in Table 3, which shows the effects on debt ratios corresponding to the GDP effects shown in Table 2. In the model without a financial accelerator, stimulus implemented in isolation increases government debt, but with a joint stimulus the increase is much smaller. In the model with a financial accelerator the increases in debt ratios are much smaller even if stimulus is implemented in isolation. But when stimulus is implemented jointly, the simulations show an across-the-board and significant *decrease* in government debt-to-GDP ratios. The reason is that in this version of the model the inflation generated by stimulus has spillover effects to other countries that work through financial markets and real interest rates, rather than primarily through goods prices.

This behavior of debt in the immediate crisis period is clearly crucial, because it affects market perceptions of the sustainability of the stimulus program. Lower debt helps to forestall increases in lending spreads, which would otherwise feed back to higher fiscal deficits.

[32] Transfers that fall under the social safety net heading are treated as targeted transfers for simulation purposes.

[33] On the other hand, the multipliers for simultaneous worldwide stimulus are somewhat smaller than the sum of the multipliers for stimulus in each region at a time. The reason is that stimulus in one region can expand output at a comparatively low cost by drawing on foreign output and therefore labor. The world as a whole faces a much less elastic labor supply curve.

VII. Counterfactual Simulation: The Great Recession without Coordinated Policies

The onset of the Great Recession was a period characterized by acute financial stress. As shown in Figure 8, output declined precipitously, and this was accompanied by significant downward revisions to the growth rate of potential output. Furthermore, as shown in the top panel of Figure 7, following the Lehman bankruptcy interest rate spreads on risky debt increased by several hundred basis points, which posed severe problems for the cash flow of borrowers, especially because this was accompanied by a severe slowdown in the granting of new credit facilities. The output collapse and the tightening in financial conditions led to a crash in asset prices, as exemplified by the equity price indices shown in the middle panel of Figure 7. And finally, the initially extremely disorderly nature of the collapse led to a massive increase in uncertainty, as exemplified by the VIX data shown in the bottom panel of Figure 7. Collapses in confidence of this order of magnitude lead to the large-scale postponement of investment and consumption decisions that are very hard to capture by conventional economic models, but that are nevertheless very real.

At such junctures there is virtually no support to the economy from private sources of aggregate demand. Fiscal stimulus, and support measures for the financial system, are therefore the only measure that can prevent the economy from descending into a downward spiral that can destroy far larger amounts of output and productive capacity than what would seem justifiable on the basis of measurable economic fundamentals. And this is exactly what policy attempted to do, starting with conventional monetary policy in the form of lower policy interest rates, unconventional monetary policy (QE1) in November 2008, then moving on to the G20 fiscal expansion policies in April 2009, and also a large set of additional financial sector support measures.

The simulation in Figure 8 constructs a counterfactual simulation that illustrates what the outcomes might have been if these policies had not been adopted, and the world economy had been left to its own devices. The figure is divided into two panels, with the top panel showing cumulative GDP growth, in percent relative to 2008, for the U.S. economy, and the bottom panel showing the same information for the rest of the world. The thin solid line shows the pre-crisis forecast of the 2007 IMF World Economic Outlook (WEO), with stronger growth in the bottom panel reflecting the fact that the growth rate of potential GDP in many emerging economies exceeds that of the mature U.S. economy. The second, bold solid line shows the actual performance in 2009, followed by the dramatically revised forecast of the 2010 IMF WEO. The remaining three lines add to this a set of counterfactual simulations.

The dashed line uses the same fiscal stimulus information that was used to construct Tables 2 and 3, which were discussed in the previous section. Specifically, the bold solid line is assumed to reflect the fiscal stimulus actually implemented, and also the financial sector support measures actually implemented. The dashed line simulates how the economy would have behaved without any fiscal stimulus (but with financial sector support). Consistent with the information in Table 2, the simulation finds that GDP in 2009 and 2010 would on average have been 1.8 percent lower in the United States, and 2.3 percent lower in the rest of the world. Given the highly temporary nature of fiscal stimulus, the simulation shows that subsequent differences in output due to fiscal stimulus would have been slight.

The dotted line removes not only fiscal stimulus, but also policies supporting the financial sector. This simulation is, for the purpose of this paper, our only attempt to quantify the effects of international coordination in macroprudential or financial sector support policies. The statement of the Group of Twenty (2009) supports our contention that there was a significant element of international coordination in this domain, and not just for fiscal policy.[34] Our simulation assumes that in the absence of support to the financial sector external finance premia would have been higher by 200 basis points in 2009, with the underlying shock thereafter decreasing at a fairly slow rate, specifically with an annual autoregressive coefficient of 0.95. The magnitudes in this simulation are of course harder to quantify than in the previous one, which was based on the observed size of fiscal stimulus measures. But at the same time, given the extremely high spreads observed at the outset of the Great Recession (see again Figure 7), combined with great levels of uncertainty, a 200 basis points effect of financial sector support policies appears far from extreme. The simulation finds that GDP in 2009 and 2010 would on average have been 2.7 percent lower than in the previous simulation (the dashed line) in the United States, and 3.6 percent lower in the rest of the world. Given the more persistent nature of this shock, and the fact that it has significant endogenous propagation effects through reductions in bank and borrower net worth, post-2010 differences in output remain sizeable until 2013.

The dash-dotted line removes fiscal stimulus and policies supporting the financial sector, and furthermore it assumes a sizeable additional demand shock, of a more transitory nature, due to confidence effects. This is meant to represent the idea of a downward spiral in the absence of fiscal and financial sector support, but of course this shock is hardest to quantify. This simulation finds that GDP in 2009 and 2010 would on average have been 2.2 percent lower than in the previous simulation (the dotted line) in the United States, and 3.2 percent lower in the rest of the world. Subsequent differences in output due to the confidence shock are much smaller than for financial sector support measures.

To summarize, our illustrative simulation finds that, in the complete absence of fiscal and financial sector support, and taking into account how this might have impaired confidence, the world economy could have experienced much lower output levels in 2009 and 2010, by almost 7 percent in the United States, and by around 9 percent in the rest of the world. These are very large numbers, and we do not believe that they are unrealistic.

VIII. Macrofinancial Scenarios

In this section we report more detailed macrofinancial scenarios that were generated using the model of Benes et al. (2013). The simulations allow us to study special features of the financial sector, most importantly its nonlinearities, and macroprudential policies that, as discussed in the introduction, share many features with fiscal policies.

[34] Note the following extract from the Group of Twenty (2009): "G-20 governments committed themselves to strengthening national and global institutions for oversight, supervision and regulation of financial markets and institutions, at the same time they transformed the highly transatlantic-centric Financial Stability Forum in Basel composed of financial authorities into a new Financial Stability Board with greater authority and with all G-20 now present as full members."

A. The Effects of Nonlinearities

We begin by illustrating the effects of financial sector nonlinearities when the model economy suffers a large adverse shock. Specifically, the foreign exchange risk premium, in other words the difference between foreign and domestic nominal interest rates, increases by 400 basis points over a period of four quarters, and thereafter returns to its original value with a quarterly autoregressive coefficient of 0.8. The profile of this shock is shown in the top left subplot of Figure 9. Half of all bank loans in this economy are denominated in foreign currency, while all bank deposits are in local currency.[35] The zero lower bound on the policy interest rate is assumed to not be binding. The shock is nevertheless magnified through the other two nonlinearities, the convexity of lending spreads at low capital adequacy ratios and at high loan-to-value ratios.

We report two results for each variable. One is based on a first-order perturbation solution (log-linearized), the other is based on a globally non-linear solution algorithm that is essentially the same as the one used for our TROLL-based simulations of GIMF, namely a perfect foresight stacked-time Newton algorithm.

An increase in the foreign exchange risk premium entails a very large increase in the nominal interest rate at which the country can borrow from the rest of the world. This results in immediate and large negative wealth and intertemporal substitution effects that dramatically reduce domestic demand. The nominal exchange rate depreciates by around 10 percent on impact, with the trade balance correspondingly moving into surplus. Subsequent gradual exchange rate appreciation equalizes ex-ante real interest rates in the periods following the shock. Postponed consumption and investment plans lead to a large drop in real asset prices. This in turn has a highly damaging effect on borrower balance sheets, with large increases in loan-to-value ratios then also leading to a deteriorating performance of bank loans, and thus to bank net worth losses and deteriorations in capital adequacy ratios. Deteriorating bank balance sheets lead banks to charge higher spreads on loans in order to shore up their capital position, and deteriorating household balance sheets also lead banks to charge higher spreads, in this case in order to compensate them for the higher risk of borrower default. This increase in bank lending spreads makes the economic contraction significantly deeper, and also more persistent, because it takes time for bank and borrower balance sheets to recover from the shock.

The differences between the linearized and nonlinear simulations are very large, with the largest difference seen in lending spreads, which increase by less than three percentage points for the linearized solution, but by more than twelve percentage points on impact for the nonlinear solution. The effects are also very pronounced for real asset prices, which decline by almost twice as much for the nonlinear solution. The reason for these differences is that a linearized solution approximates impulse responses around a steady state with benign capital adequacy ratios for the banking sector, and benign leverage ratios for borrowers. But when, following a large shock, capital adequacy ratios approach their legal minimum, and loan-to-value ratios increase to levels that make bank lending far more risky, the behavior of the economy changes fundamentally, with spreads increasing in a highly nonlinear fashion. The resulting differences in the response of GDP are very

[35] This is motivated by the recent experience of Hungary, whose banks exhibited a similar balance sheet composition.

large, with a contraction of well under four percent for the linearized model turning into a contraction of around six percent. While the linearized solution suggests an initial substantial increase in inflation driven by the depreciating exchange rate, the nonlinear solution generates an almost immediate decline in inflation, because the domestic contraction is so deep that it offsets the effect of the depreciation on inflation. Real bank loans also decline by more in the nonlinear simulation, but this effect is less pronounced.[36]

This simulation once again highlights the fundamental differences between macroprudential (and also fiscal) policies on the one hand, and conventional monetary policy on the other hand, and therefore the danger of deriving policy advice for macroprudential policy, most importantly for our purposes on the question of international policy coordination, from studies of conventional monetary policy. The extremely nonlinear behavior of the economy in this simulation, which can clearly be traced back to financial sector nonlinearities and their effects on spreads, is very different from the linear-quadratic world that is typically studied in models of conventional monetary policy. The objective of macroprudential policy is to a very large extent to keep the economy out of this danger zone, and this is very different from the inflation-stabilizing objective of conventional monetary policy.

B. Good and Bad Credit Expansions

Financial cycles are distinct from regular business cycles, in that they are typically more prolonged and more asymmetric (Borio (2012)). In the upside phase, risks gradually accumulate on the balance sheets of financial institutions and non-financial agents. This is typically followed by a sudden and large downswing, triggered often by adverse events unrelated to the upside developments. We develop a scenario that exhibits these features. Specifically, banks gradually reduce their estimate of the dispersion of the distribution of the future prices of collateralizing assets. In the good credit expansion scenario, shown as the solid line in Figure 10, this reduction in banks' estimates is fully justified by subsequent actual developments. In the bad credit expansion scenario, shown as the dashed line, these same estimates of risk used by banks in evaluating their lending supply decisions do not correspond to subsequent actual developments. While banks make the same assumptions concerning risk as in the first scenario, the actual risk decreases by only half of that scenario - see the dashed line in the top left subplot. In other words, the risk on bank balance sheets becomes increasingly underpriced. This discrepancy between the ex-ante estimates and the ex-post actual values of risk is assumed to persist for several years. We can interpret such an episode as deliberate efforts by banks to increase their market share, chase for higher returns, herding or myopia. After an initial three-year period of credit expansion, we subject the two economies to a large adverse shock unrelated to the original developments in banks' risk perception, specifically a terms of trade deterioration of 5.25 %, with a subsequent gradual return of the terms of trade to their original value, with a quarterly autoregressive coefficient of 0.75. During the same period, banks in the bad credit expansion scenario also gradually correct their incorrect assessment of risk. The scenarios reveal two distinct features of credit cycles, one related to the period prior to the terms of trade shock, and the other to the period after that shock.

[36] The initial increase in real bank loans is due to a valuation effect, as a depreciated nominal exchange rate increases the domestic currency value of foreign currency bank loans.

With regard to the pre-shock period, until the economy is subjected to a large negative shock (the shaded area of the plots), the two scenarios are observationally indistinguishable. A credit expansion that is based on underpriced risk can therefore not be detected from casual observations of macroeconomic and macrofinancial outcomes. In each case, banks reduce their lending spreads by more than a full percentage point, and increase their lending volume by six percent by the end of the third year. Their capital buffer is reduced by around 35 basis points as the perceived need to guard against bad lending outcomes decreases. The increase in lending and reduction in spreads leads to a more than 5 percent expansion of domestic demand, a real appreciation, and trade deficits. The policy rate is raised in response to the resulting inflation, and this starts to dampen the boom in domestic demand, and GDP, during the second year following the shock.

As for the post-shock period, we observe that, while the timing and persistence of the terms of trade shock are exactly the same for both scenarios, outcomes are now very different. Banks' previous lending decisions were based on their expectations of how resilient their borrowers would be to shocks, including the realized terms of trade shock. When banks correctly judge that resilience under the good credit expansion scenario, the shock leads to only very modest lending losses, a minimal reduction in capital adequacy ratios, and an increase in spreads of less than 1.5 percentage points. This does contribute to a GDP contraction of around 2 percent by the end of year 4, but this contraction is not only due to the behavior of banks. Rather, the terms of trade shock itself, and the sluggish reduction of the policy rate inherited from the previous expansion, also play a major role.

By contrast, when banks underestimate the resilience of their borrowers, defaults on loans occur at far higher rates than they had previously anticipated. This leads to very large lending losses that reduce banks' capital adequacy ratios by almost a full percentage point. In order to recover from these losses, and also in response to banks' gradual realization of the true state of their borrowers' riskiness, spreads rise by over 8 percentage points, and lending stalls and then contracts. This contributes to a far deeper GDP contraction of around 5 percent, and an even deeper contraction of domestic demand. The direct consequence of this contraction in demand is a steep decline in real asset prices of around 8 percent. As in the previous scenario, the initial increase in the loan-to-value ratio at the end of year 3 is due to the large nominal depreciation, which increases the real value of foreign currency denominated bank loans. This damage to borrower balance sheets feeds back to lending losses and bank balance sheets in a vicious spiral.

To summarize, this scenario highlights two critical facts. First, it is difficult to distinguish sustainable and unsustainable credit expansions ex ante by looking only at macroeconomic indicators. Indeed, an important lesson from the crisis is that familiarity with what is really happening in the banking sector at the microeconomic level will be needed to identify instances of unsustainable lending expansions. Even without such knowledge, to insure against particularly bad outcomes it may be justified to apply macroprudential measures to prevent an excessively fast credit expansion. We will study this in the next subsection. Second, adverse aggregate shocks can rapidly reveal that a lending expansion has not been sustainable, as weakened borrower and thus bank balance sheets are not able to effectively absorb such shocks, especially because of the nonlinearities discussed in the previous subsection.

C. Bank Capital Adequacy Requirements

In this section we study an essential aspect of macroprudential policy that was mentioned in the introduction, the fact that the choice of policy instruments can involve a trade-off between better short-run stabilization and worse long-run output performance. The specific policy choice that we will study is minimum capital adequacy requirements (MCAR).

1. Steady State Effects of Higher MCAR

Figure 11 shows the steady-state effects of changing MCAR, using the current 8% of the Basel regime as the baseline. The benefit of increasing MCAR is of course that it increases the loss-absorption capacity of banks, and thereby makes collapses of major financial institutions and the resulting financial and real crashes, like Lehman in 2008, less likely. The cost, which is the sole focus of Figure 11, is a reduction in steady state output.[37]

Figure 11 shows that a 1 percentage point increase in MCAR, by increasing the cost of making loans, permanently raises lending spreads by around 15 basis points, and reduces bank loans by just under 1 percent. The reduction in bank loans is accompanied by a similar contraction in the physical capital stock, with the loan-to-value ratio falling only very slightly. A lower capital stock and higher spreads lead to a reduction in GDP of around 0.4 percent per percentage point increase in the MCAR.

There is however another aspect of MCAR policies that goes beyond the output and crisis probability effects of permanent MCAR changes already mentioned. We turn to this next.

2. Dynamic Effects of Countercyclical MCAR

Macroprudential policy can be designed to deal much more effectively with financial cycles, by making MCAR countercyclical so as to prevent or at least reduce asset price bubbles or lending booms.[38] Such countercyclical policies should be designed to minimize the cost of large macrofinancial meltdowns under very adverse, yet plausible, scenarios.

In the experiment illustrated in Figure 12, we simulate a future anticipated permanent improvement in the productivity of exporting industries. The improvement is expected to start occurring three years into the future, and to lead to an approximately 10 percent increase in domestic demand and real output over the subsequent three years. However, at the end of the third year, when the improvement was originally expected to start materializing, its final size is revised downwards by half, and furthermore the speed at which it arrives slows down considerably.

The solid line in Figure 12 illustrates this scenario under a constant 8% MCAR. The initial expectation of future higher productivity growth leads to an expansion in bank

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[37] The comparison of precisely these benefits and costs, in this case in the context of new financial markets derivatives regulations rather than higher MCAR, was the objective of the recent MAGD exercise organized by the BIS. See Bank for International Settlements (2013).

[38] See Benes and Kumhof (2011).

lending and also, over the first year, a reduction in spreads. Asset prices rise amid the anticipation of higher future productivity, and loan-to-value ratios drop. GDP expands by over 3 percent by the end of year 3, with inflation dropping due to a sizeable nominal appreciation.

The downward revision of expectations at the end of year 3 causes large lending losses, with banks experiencing a roughly 1 percentage point reduction in their capital adequacy ratio. Their main response to this is to sharply increase spreads by well over 10 percentage points, with lending stalling rather than remaining on its steeply increasing path.[39] This leads to a large drop in asset prices and, due to a nominal depreciation, an increase in loan-to-value ratios, which feeds back to even higher loan losses. GDP contracts by around 5 percent almost instantaneously, with the policy rate dropping further to support the rapidly weakening economy. The fact that banks were not prepared for this shock ends up driving the economy into a painful three-year contraction period.

As shown in the dashed line in Figure 12, countercyclical MCAR can be highly successful at dampening such fluctuations. This simulation assumes that the regulatory authority imposes an asymmetric rule that mirrors the asymmetry of macrofinancial cycles. Specifically, the minimum capital adequacy ratio γ_t is never allowed to fall below 8%, but during periods of high lending volumes banks have to follow the rule

$$\gamma_t = 0.8\,\gamma_{t-1} + (1 - 0.8)\,\frac{1}{2}\log\frac{L_{X,t+4}/P_{C,t+4}}{L_{X,t}/P_{C,t}}\ , \tag{13}$$

where $L_{X,t}$ is a measure of bank credit net of valuation effects in economies with foreign currency lending[40] and $P_{C,t}$ is the consumer price index. Furthermore, at the time when a risk event materializes, capital requirements are reset to 8 % and banks are allowed to draw down the additional capital buffers accumulated during the upturn phase.

This experiment again illustrates the basic trade-off discussed in the previous subsection. Increased capital surcharges reduce output in good times, but result in extra capital buffers that can be drawn down in times of financial distress, when they may be extremely valuable due to the nonlinear behavior of the financial sector following large shocks. Specifically, with the rule (13) banks still respond to increased optimism about future productivity by increasing lending. But to do so they have to put additional capital aside, and this requires higher lending spreads and therefore a slower increase in lending. As a result the increases in domestic demand and GDP are only about half as large as in the case of constant MCAR during the initial three-year period.

When the disappointing news about technology arrive at the end of year 3, banks have accumulated a comfortable capital cushion, which they draw down to absorb their lending losses. Spreads immediately start to decline rather than increase, as banks instead contract lending. This can be seen in the behavior of real bank loans, which decline despite the fact that a discrete nominal depreciation increases the domestic currency value of foreign currency loans. In other words, when valuation effects are stripped out there is a discrete downward jump in lending at this time. This, incidentally, is only possible in a

[39] The increase in lending that has already materialized is partly justified by fundamentals, which do improve at that time, only not be as much as anticipated.

[40] Note that the valuation effect is negative in times of credit booms, where the exchange rate appreciates. Not correcting for the valuation effect would therefore underestimate the true extent of credit growth

model where banks are not simply intermediaries between savers and investors, but rather creators of purchasing power, because only in such a model can banks instantaneously create or destroy purchasing power by making or calling loans. The result is very familiar from the Great Recession, which in many countries was initially not so much characterized by massive increases in lending spreads, but rather by a significant element of credit rationing. The much more moderate behavior of real interest rates of course implies a much reduced incentive for intertemporal substitution on the part of domestic consumers and investors, so that the contraction in domestic demand remains much milder than for the case of constant MCAR, and the contractions in GDP and asset prices are close to zero.

IX. Conclusion

This paper uses the IMF's family of DSGE models to study the effectiveness of fiscal and macroprudential stimulus and stabilization policies, with an emphasis on the benefits of internationally coordinated policies. We contrast those benefits with the small benefits of internationally coordinated conventional monetary policies claimed by the literature. Our motivation and analysis focuses on times of crises, when the benefits of fiscal and macroprudential policies, and of their coordination, are particularly large.

The IMF's family of models has been developed with questions of precisely this nature in mind, GIMF for the analysis of fiscal and macroprudential policies, and our family of banking models for a more detailed analysis of macroprudential policies. Both sets of models represent monetary policy, including the possibility of zero interest rate floors, in precisely the same way as the New Keynesian literature. They are therefore consistent with Taylor (2013), in that they produce only small benefits of international monetary policy coordination under non-crisis conditions, although we have not included a specific exercise to demonstrate this once more in the present paper.

The comprehensive nature of GIMF has a major advantage for the type of policy analysis undertaken in this paper – it allows us to explore the sensitivity of our conclusions to many different combinations of policies and structural features. First, unlike monetary policy, fiscal policy can use a large number of different instruments, and there is no substitute for exploring them one at a time. Second, the simultaneous modeling of monetary and fiscal policies allows us to study their interactions, most importantly at the zero interest rate floor. And third, the incorporation of a model of the financial sector allows us to study the interaction of fiscal stimulus with the nonlinearities in the financial system, and also the possibility of stimulus from macroprudential policy in addition to fiscal policy.

Our model of the financial sector features banks that have a critical role in the monetary transmission mechanism, but as creators of the economy's purchasing power rather than as intermediaries of real savings. Other critical features of this model are that banks can make lending losses which are endogenously determined rather than exogenously imposed, the fact that bank net worth and balance sheets, rather than just the price of credit, are critically important for the transmission mechanism, and the fact that the incentive mechanisms of bank capital adequacy regulations, including their interaction with optimal lending contracts, are part of the model.

For fiscal policy, we find that the multipliers of a two-year stimulus package with no monetary accommodation and no financial accelerator mechanism range from 1.0 for government investment to 0.1 for general transfers, with targeted transfers closer to the upper end of that range and labor income tax cuts closer to the lower end. In the presence of monetary accommodation and a financial accelerator mechanism multipliers are 50 percent larger, and in some cases up to twice as large. The reason is that accommodation lowers real interest rates, which is directly stimulative but which also has a favorable effect on corporate balance sheets and therefore on firms' external finance premium. Finally, and most importantly for the purpose of this paper, we find that the combined nonlinearities of the zero interest rate floor and the financial system not only directly increase domestic fiscal multipliers, they also increase spillovers to other countries, and mostly through financial rather than goods market channels. As a consequence, internationally coordinated fiscal stimulus packages, such as the ones implemented in the early years of the Great Recession, can expand output to such an extent that the stimulus pays for itself, in the sense that it reduces, rather than increases, countries' debt-to-GDP ratios, despite the increase in spending or the reduction in tax rates. This is not only because of the large increase in GDP, but also because of automatic stabilizers whereby the additional tax revenue (and transfer reductions) generated by the expansion reduce the increase in the deficit and thus in debt, and finally also because of higher inflation that reduces the real value of inherited debt.

For macroprudential policy, we find that policies that prevent external finance premia from rising to extremely high levels can have output effects that are as large as or larger than the effects of the 2009/2010 fiscal stimulus measures, particularly if they contribute to preventing a loss of confidence. We also find that countercyclical capital adequacy requirements can be a powerful tool to stop vulnerabilities in the financial system from developing before they are exposed by adverse shocks.

The foregoing suggests that a carefully chosen package of fiscal and supporting monetary and macroprudential stimulus measures can provide a very significant contribution to supporting domestic and global economies during a period of acute stress. The international spillover effects of such policies are, unlike for conventional monetary policy, very sizeable, and can be large enough to lead to reduction in debt-to-GDP ratios despite an increase in spending or a reduction in tax rates. Given that sustainability of public finances has become a matter of concern in many countries, this has important implications for the conduct of policy around the time of major crises. It suggests that it may indeed be possible to spend your way out, particularly if this is coordinated across countries, and supported by accommodative monetary policy and by macroprudential measures that encourage lending, and thus the creation of purchasing power, by banks.

Nonlinearities at times of crises play a major role in these results. Crises are characterized by multiple nonlinearities, including the zero interest rate floor that limits the ability of government to use the policy rate, the minimum capital adequacy floor that limits the ability of banks to create purchasing power, and high loan-to-value ratios that limit the ability of borrowers to spend. Fiscal policy can be used much more effectively at such junctures, as stressed recently by Blanchard and Leigh (2013), not only by directly increasing demand but also by creating more inflation and thereby lowering real interest rates. And macroprudential policies can also contribute, for example by temporarily relaxing capital requirements, either through set rules or in a discretionary fashion, to facilitate the creation of purchasing power by banks.

We should therefore not be led to premature conclusions concerning the general undesirability of international policy coordination, based only on the simple linear-quadratic frameworks that have been used in the literature on monetary policy. International fiscal and macroprudential policy coordination around crisis times differs fundamentally from the international coordination of conventional monetary policy during normal times. This is not only because economies become much more sensitive to any stimulus, including cross-border stimulus, in the presence of nonlinearities and crises. More fundamentally, the international transmission channels of fiscal or macroprudential stimulus are primarily found in financial markets, while the older literature on international policy coordination stressed the role of goods market transmission. Real exchange rate effects typically reduce the direct goods market spillovers of stimulus measures, but they translate into inflationary effects that reduce real interest rates and relax borrowing constraints. This can produce outcomes that are superior along all dimensions, including most critically public debt sustainability. As far as the arsenal of policymakers during the worst economic times is concerned, this is a message of hope rather than gloom.

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Table 1. Policies and Stabilization Objectives

	Policy Instrument	**Primary Objective**	**Secondary Objective**
CMP	Nominal Interest Rate	Rate of Inflation	Output Volatility
FP	Taxes, Spending, Transfers	Government Debt/GDP	Output Level and Volatility
MPP	Capital or Liquidity Ratios	Private Credit/GDP	Output Level and Volatility

Table 2. GDP Effects of G-20 Fiscal Stimulus

	Stimulus in:					
	All	U.S.	Euro Area	Japan	Em.Asia	RoW
Model without Financial Accelerator (percent deviations from baseline)						
Effects on GDP Level in 2009						
World	1.3	0.3	0.1	0.1	0.5	0.3
United States	1.0	**0.7**	0.0	0.0	0.1	0.1
Euro Area	0.7	0.0	**0.4**	0.0	0.1	0.1
Japan	1.4	0.1	0.0	**1.1**	0.3	0.0
Emerging Asia	2.2	0.3	0.0	0.1	**1.8**	0.1
Remaining Countries	1.1	0.1	0.1	0.0	0.2	**0.7**
Effects on GDP Level in 2010						
World	1.0	0.2	0.1	0.1	0.4	0.2
United States	0.9	**0.7**	0.0	0.0	0.1	0.1
Euro Area	0.5	0.0	**0.3**	0.0	0.1	0.1
Japan	1.3	0.1	0.0	**1.0**	0.2	0.0
Emerging Asia	1.7	0.2	0.0	0.0	**1.4**	0.1
Remaining Countries	0.8	0.1	0.0	0.0	0.2	**0.4**
Model with Financial Accelerator (percent deviations from baseline)						
Effects on GDP Level in 2009						
World	2.3	0.6	0.2	0.2	1.0	0.6
United States	1.8	**1.1**	0.1	0.1	0.4	0.3
Euro Area	1.1	0.1	**0.6**	0.0	0.3	0.3
Japan	2.6	0.3	0.1	**1.6**	0.7	0.2
Emerging Asia	3.6	0.8	0.1	0.1	**2.5**	0.3
Remaining Countries	2.4	0.4	0.2	0.1	0.8	**1.2**
Effects on GDP Level in 2010						
World	2.1	0.6	0.2	0.2	0.9	0.5
United States	1.7	**1.1**	0.1	0.1	0.4	0.2
Euro Area	1.0	0.2	**0.4**	0.0	0.3	0.2
Japan	2.4	0.3	0.1	**1.5**	0.7	0.2
Emerging Asia	3.1	0.7	0.1	0.1	**2.1**	0.3
Remaining Countries	2.1	0.5	0.2	0.1	0.8	**1.0**

Table 3. Debt-to-GDP Effects of G-20 Fiscal Stimulus

	Stimulus in:					
	All	U.S.	Euro Area	Japan	Em.Asia	RoW
Model without Financial Accelerator (percentage point deviations from baseline)						
Effects on Debt/GDP in 2009						
World	0.2	0.1	0.0	0.0	0.1	0.1
United States	0.5	**0.9**	0.0	0.0	-0.2	-0.1
Euro Area	-0.1	0.0	**0.2**	0.0	-0.1	-0.1
Japan	-0.9	-0.1	0.0	**-0.1**	-0.5	-0.1
Emerging Asia	0.5	-0.2	0.0	0.0	**0.9**	-0.1
Remaining Countries	0.1	-0.1	0.0	0.0	-0.1	**0.4**
Effects on Debt/GDP in 2010						
World	0.9	0.4	0.1	0.0	0.3	0.1
United States	1.7	**2.2**	0.0	0.0	-0.2	-0.1
Euro Area	0.5	-0.1	0.9	0.0	-0.1	-0.1
Japan	-0.5	-0.2	0.0	**0.6**	-0.6	-0.1
Emerging Asia	1.9	-0.2	0.0	0.0	**2.5**	-0.1
Remaining Countries	0.1	-0.1	0.0	0.0	-0.2	**0.7**
Model with Financial Accelerator (percentage point deviations from baseline)						
Effects on Debt/GDP in 2009						
World	-0.9	-0.2	-0.1	-0.1	-0.3	-0.2
United States	-0.7	**0.3**	-0.1	-0.1	-0.5	-0.4
Euro Area	-0.7	-0.1	**0.1**	0.0	-0.3	-0.3
Japan	-3.4	-0.5	-0.1	**-1.2**	-1.3	-0.3
Emerging Asia	-0.4	-0.5	-0.1	-0.1	**0.4**	-0.2
Remaining Countries	-0.9	-0.2	-0.1	-0.1	-0.4	**0.0**
Effects on Debt/GDP in 2010						
World	-0.9	-0.1	0.0	-0.2	-0.2	-0.3
United States	-0.2	**1.3**	-0.1	-0.1	-0.7	-0.5
Euro Area	-0.7	-0.2	**0.6**	-0.1	-0.5	-0.4
Japan	-4.4	-0.7	-0.2	**-1.0**	-1.8	-0.5
Emerging Asia	0.4	-0.7	-0.1	-0.1	**1.8**	-0.3
Remaining Countries	-1.6	-0.4	-0.2	-0.1	-0.6	**0.0**

Figure 1. U.S. Persistent Productivity Growth Shock (Deviation from Baseline)

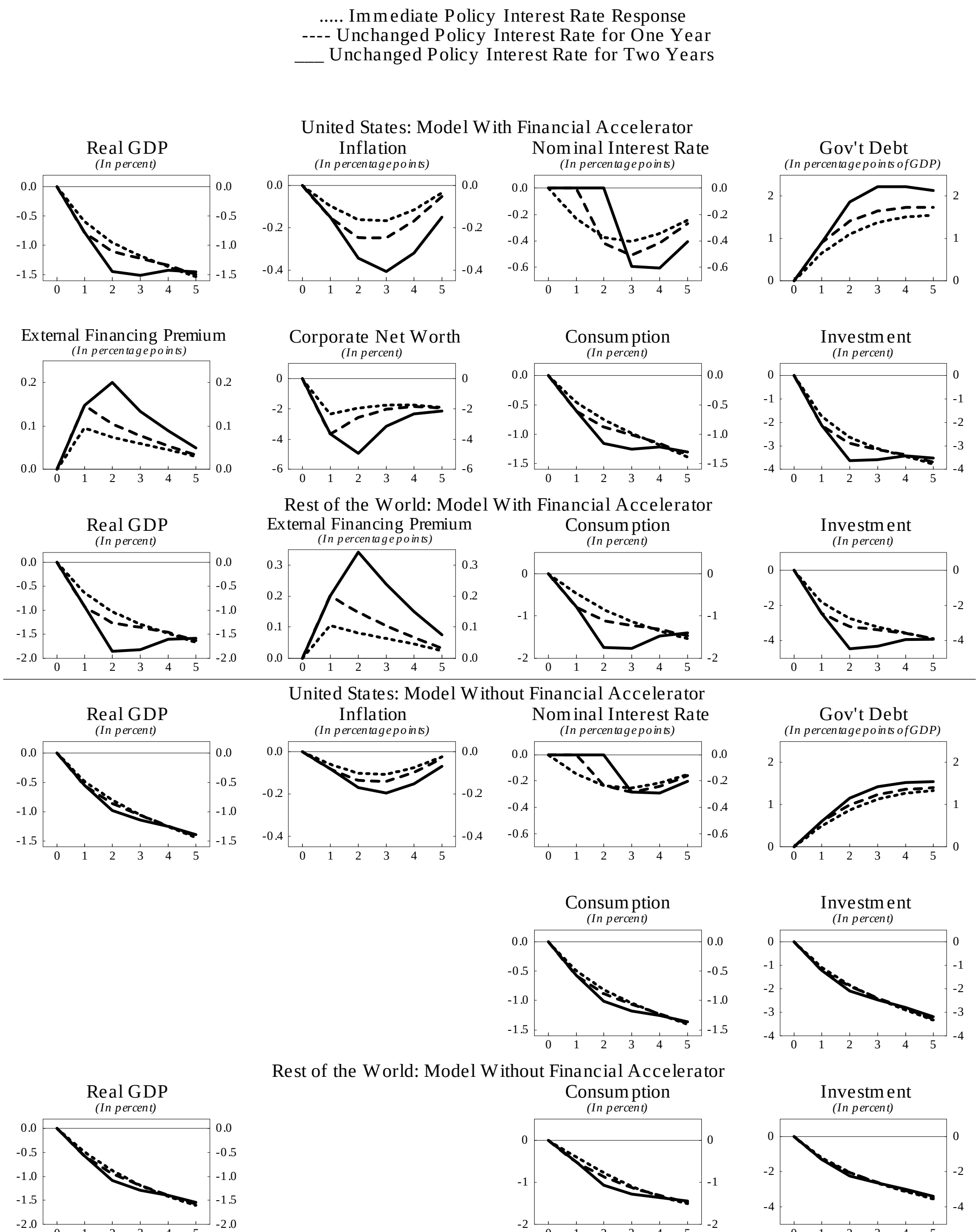

Figure 2. U.S. Persistent Increase in Borrower Riskiness (Deviation from Baseline)

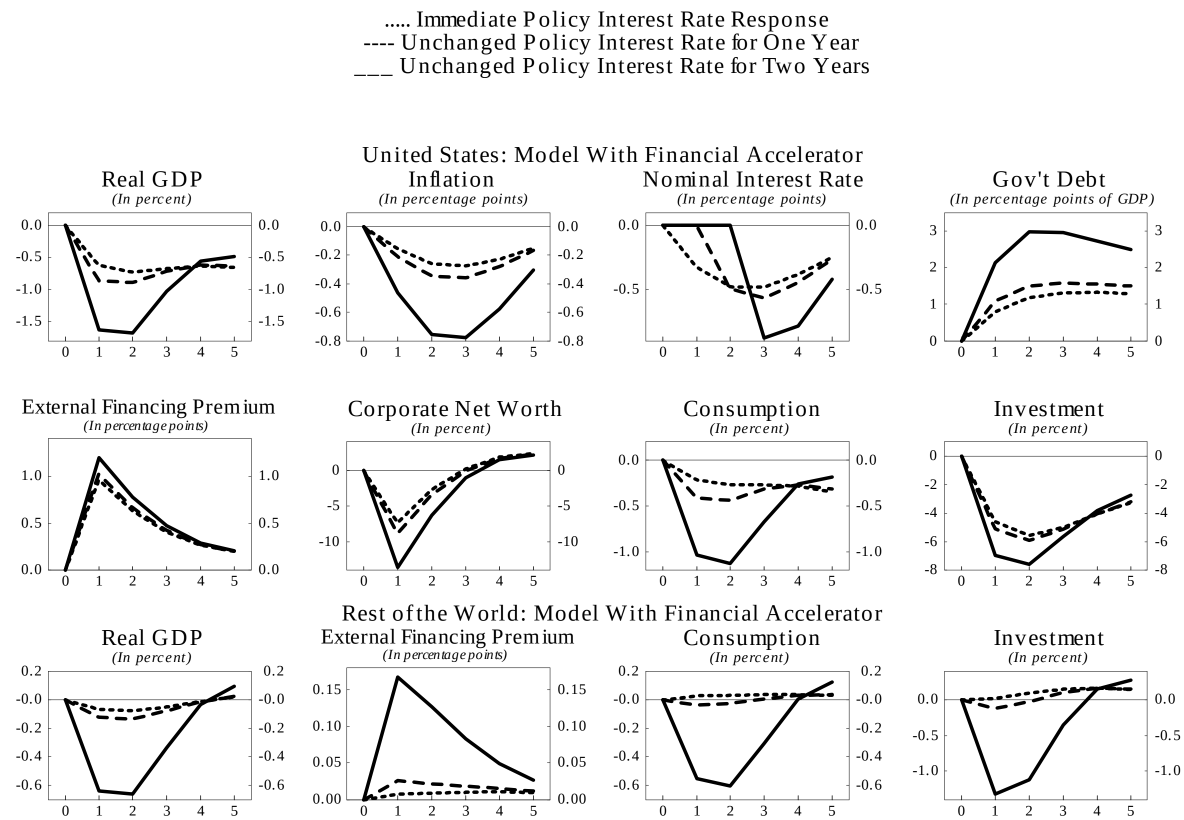

Figure 3. U.S. Fiscal Stimulus, Instrument=Gov't Investment (Deviation from Baseline)

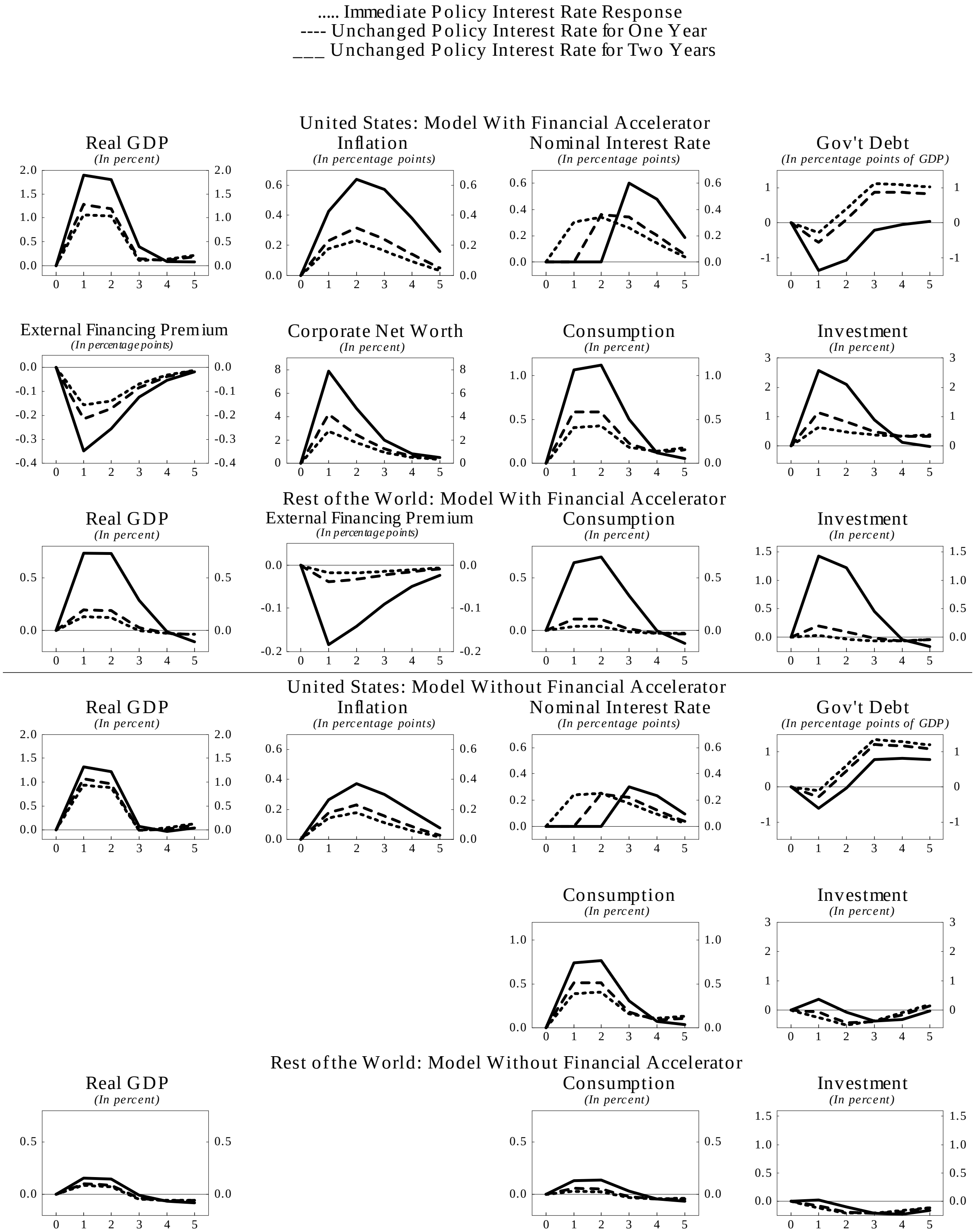

Figure 4. U.S. Fiscal Stimulus, Instrument=General Transfers (Deviation from Baseline)

..... Immediate Policy Interest Rate Response
---- Unchanged Policy Interest Rate for One Year
___ Unchanged Policy Interest Rate for Two Years

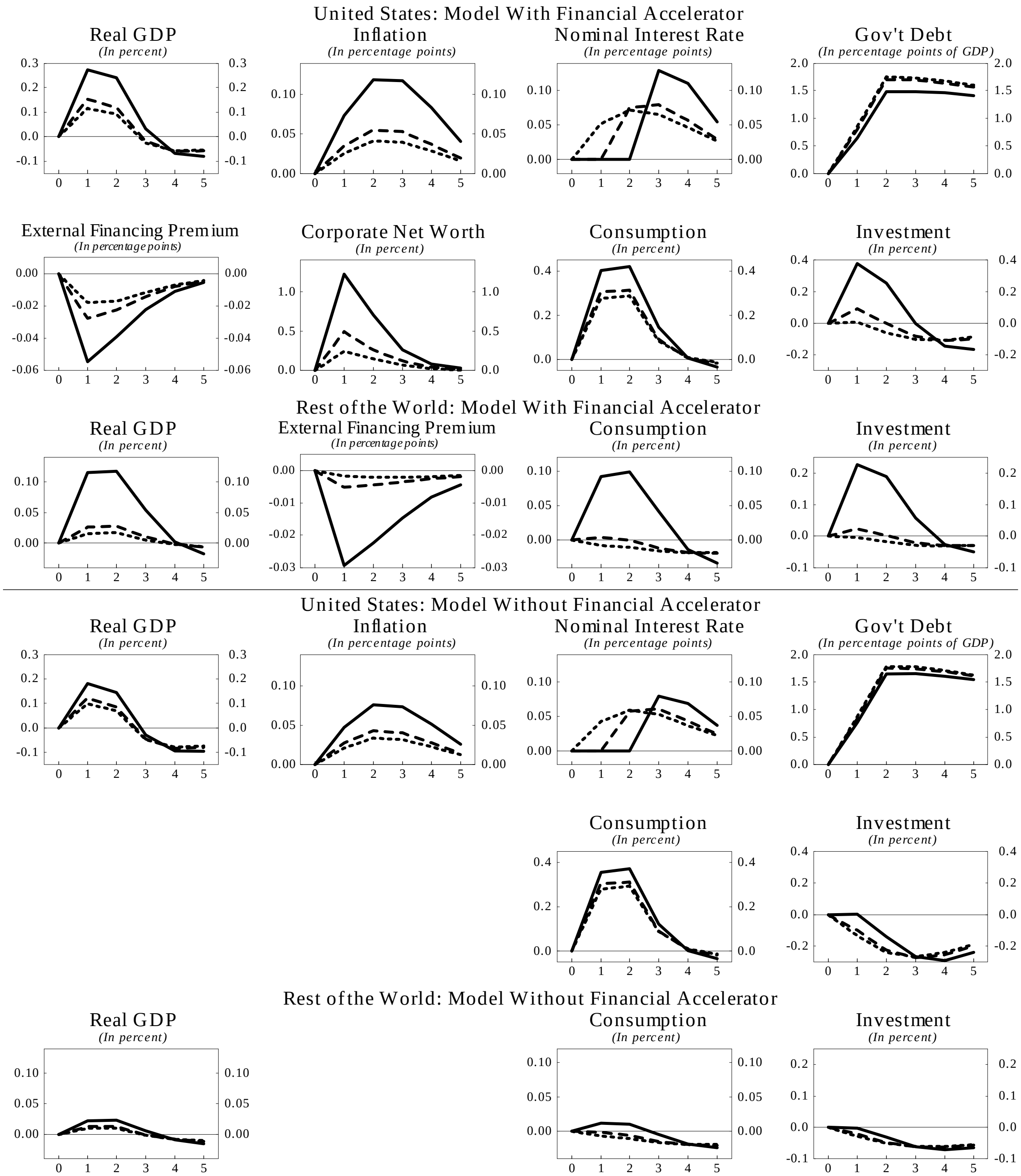

Figure 5. U.S. Fiscal Stimulus, Instrument=Targeted Transfers (Deviation from Baseline)

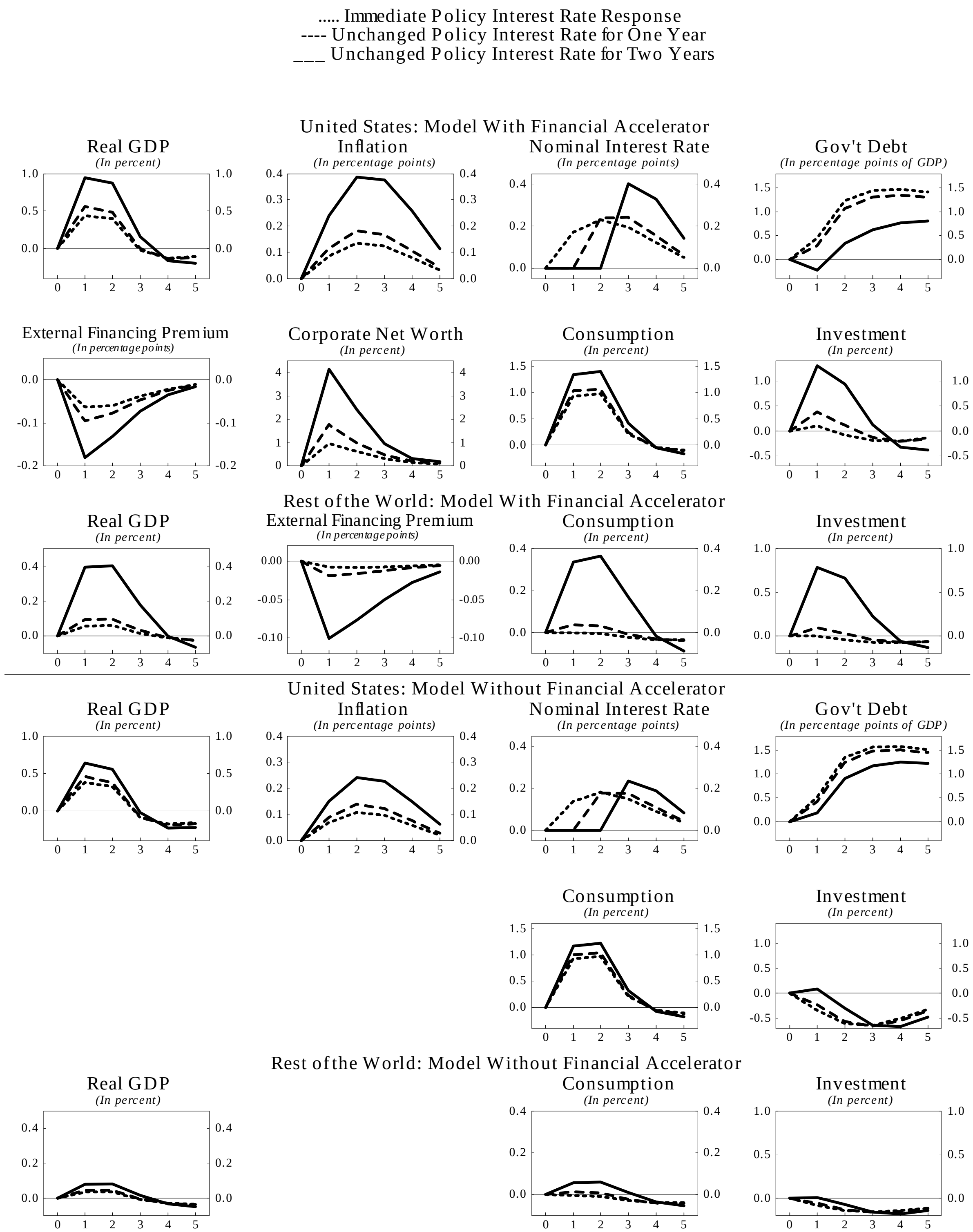

Figure 6. U.S. Fiscal Stimulus, Instrument=Labor Income Tax (Deviation from Baseline)

..... Immediate Policy Interest Rate Response
---- Unchanged Policy Interest Rate for One Year
___ Unchanged Policy Interest Rate for Two Years

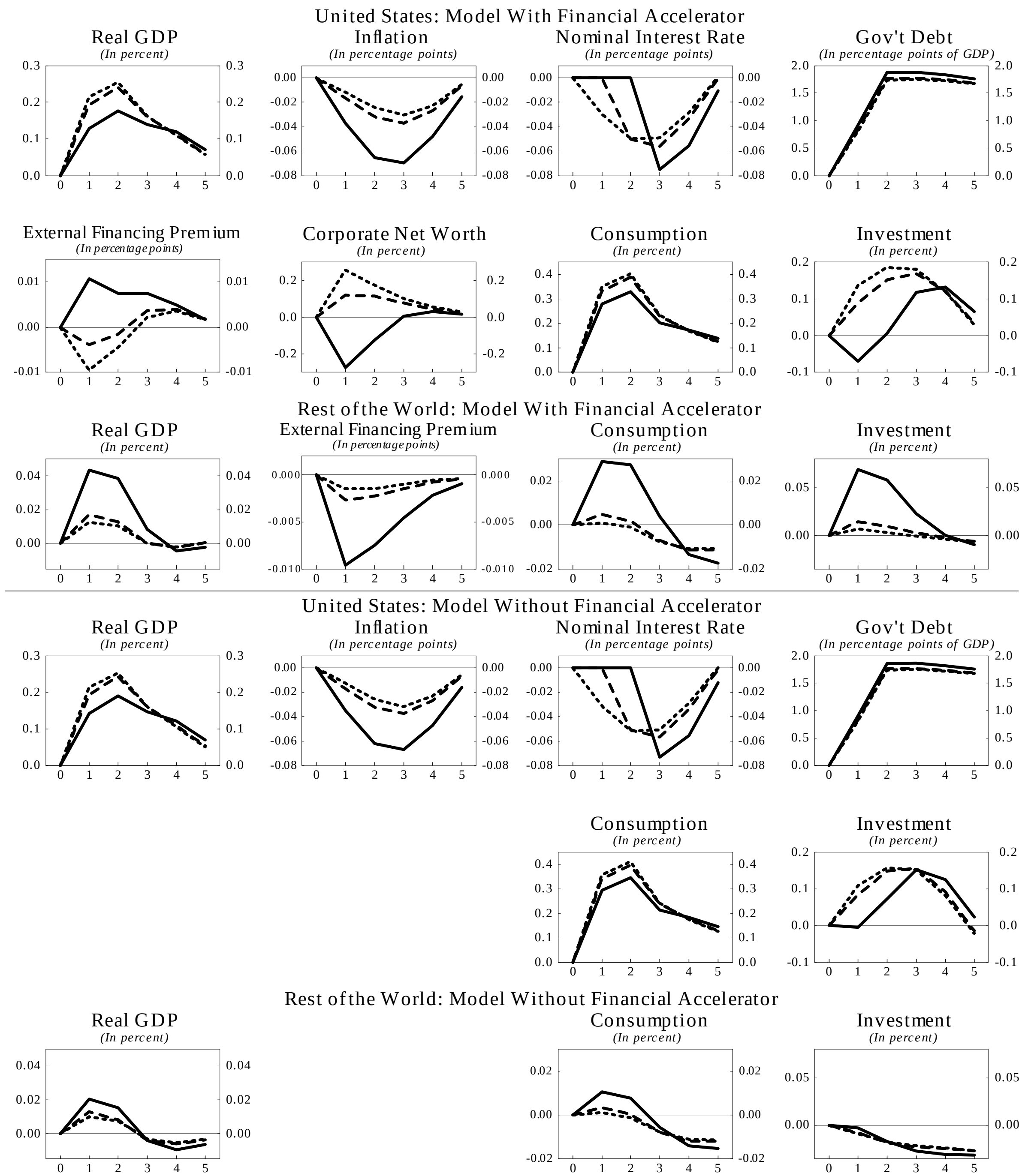

Figure 7. Key Macroeconomic Stress Indicators Around the Time of the Great Recession

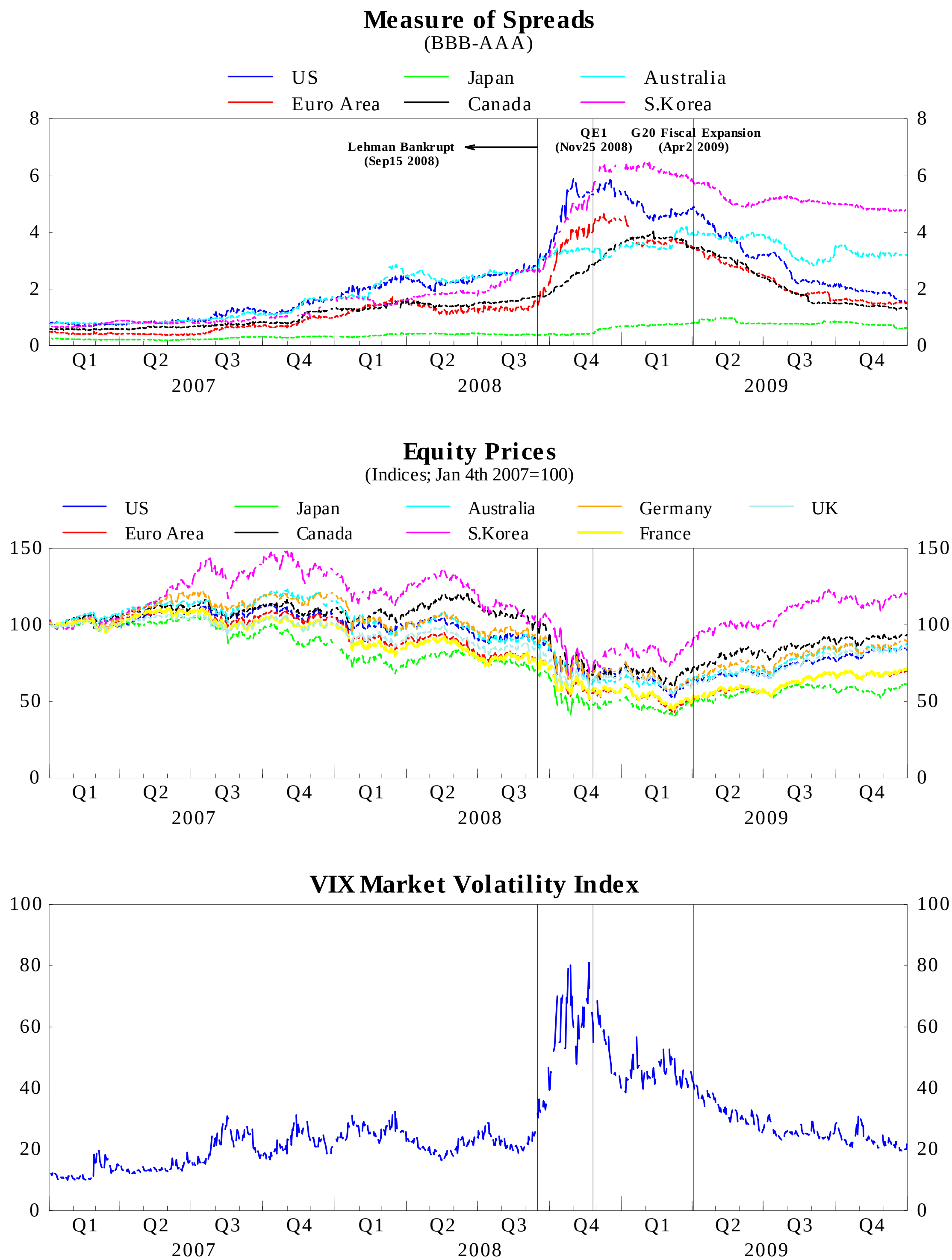

Figure 8. Counterfactual Simulations - Real GDP Indices (100*log)

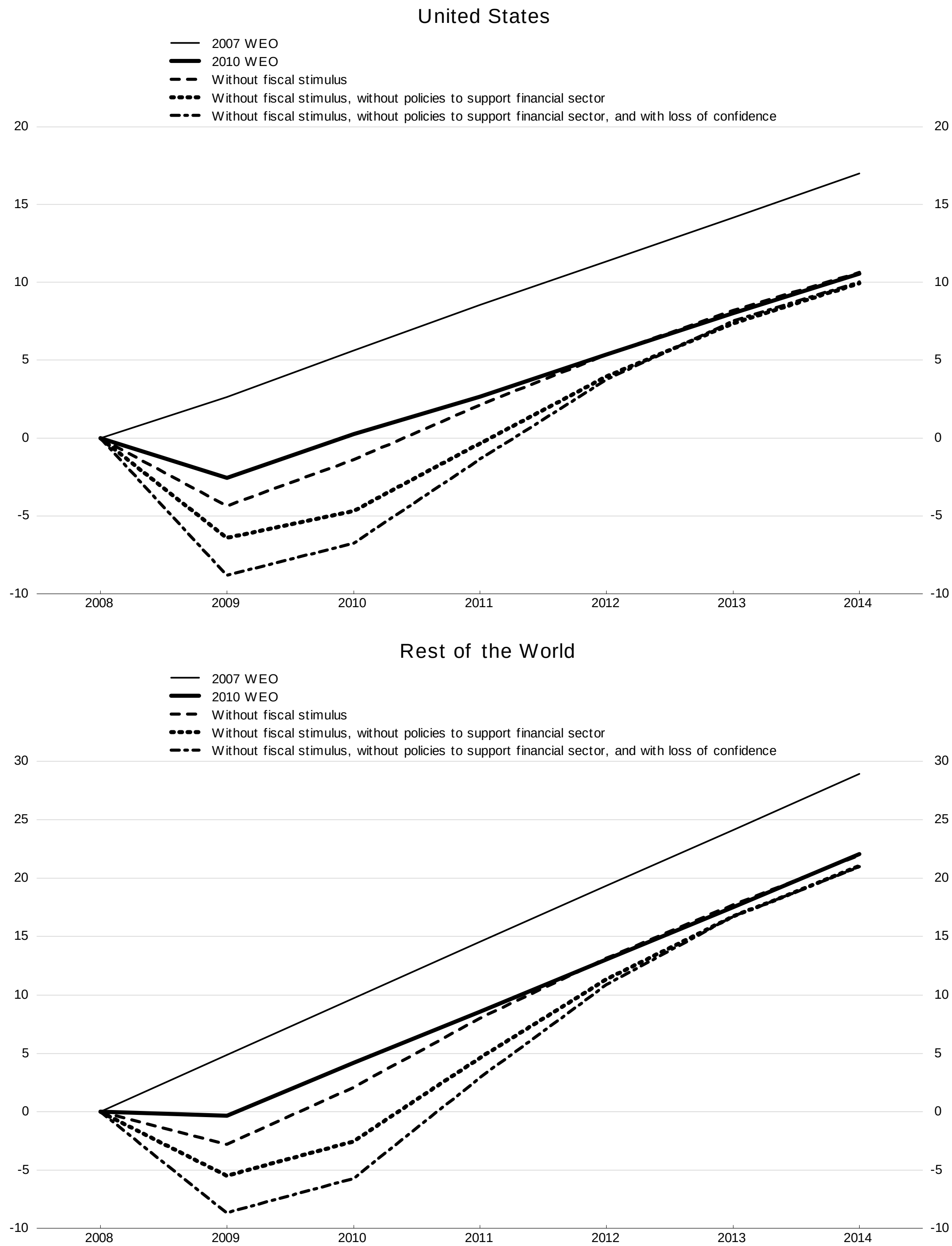

Figure 9. Nonlinearities in the Banking Model

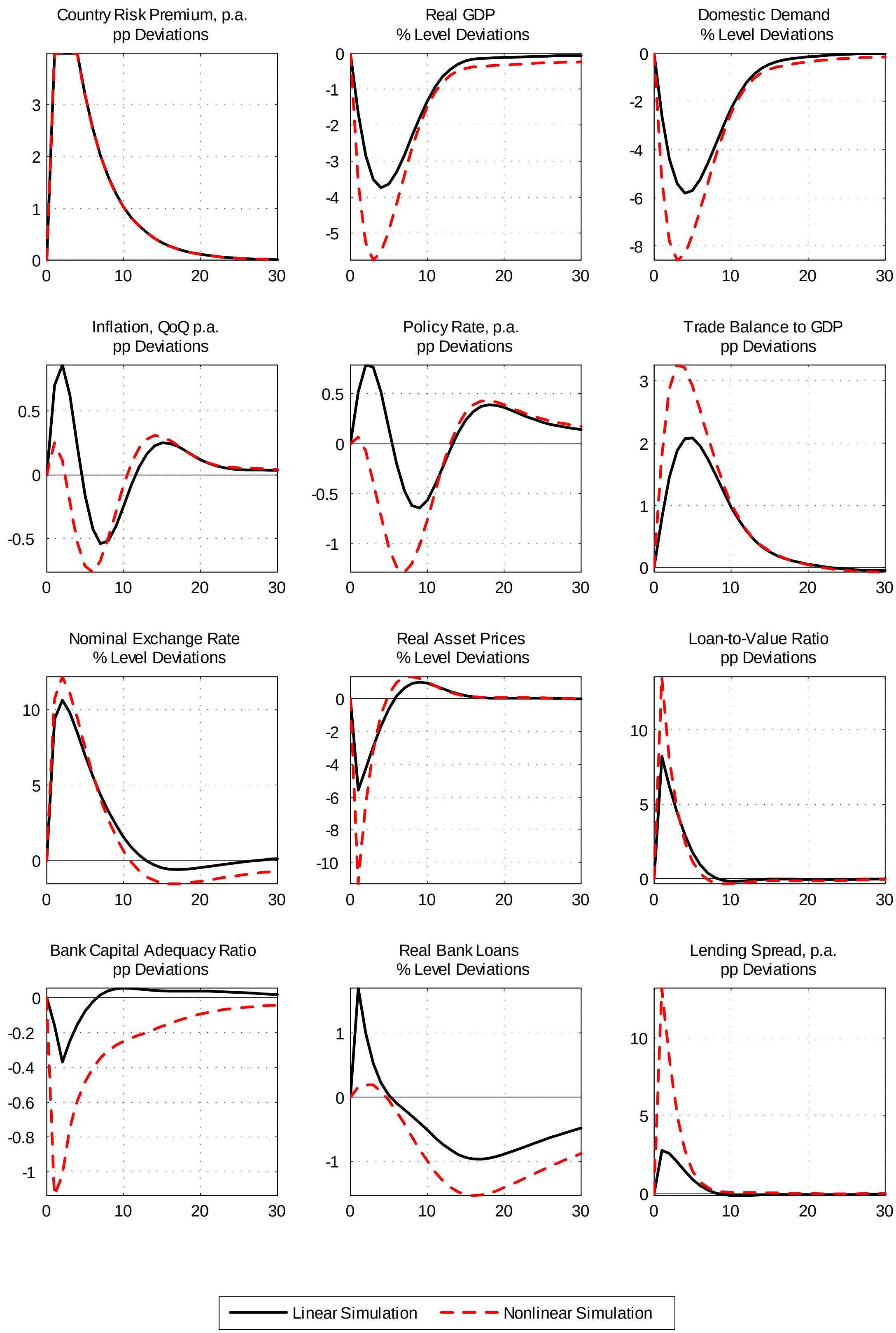

Figure 10. Good versus Bad Credit Expansions

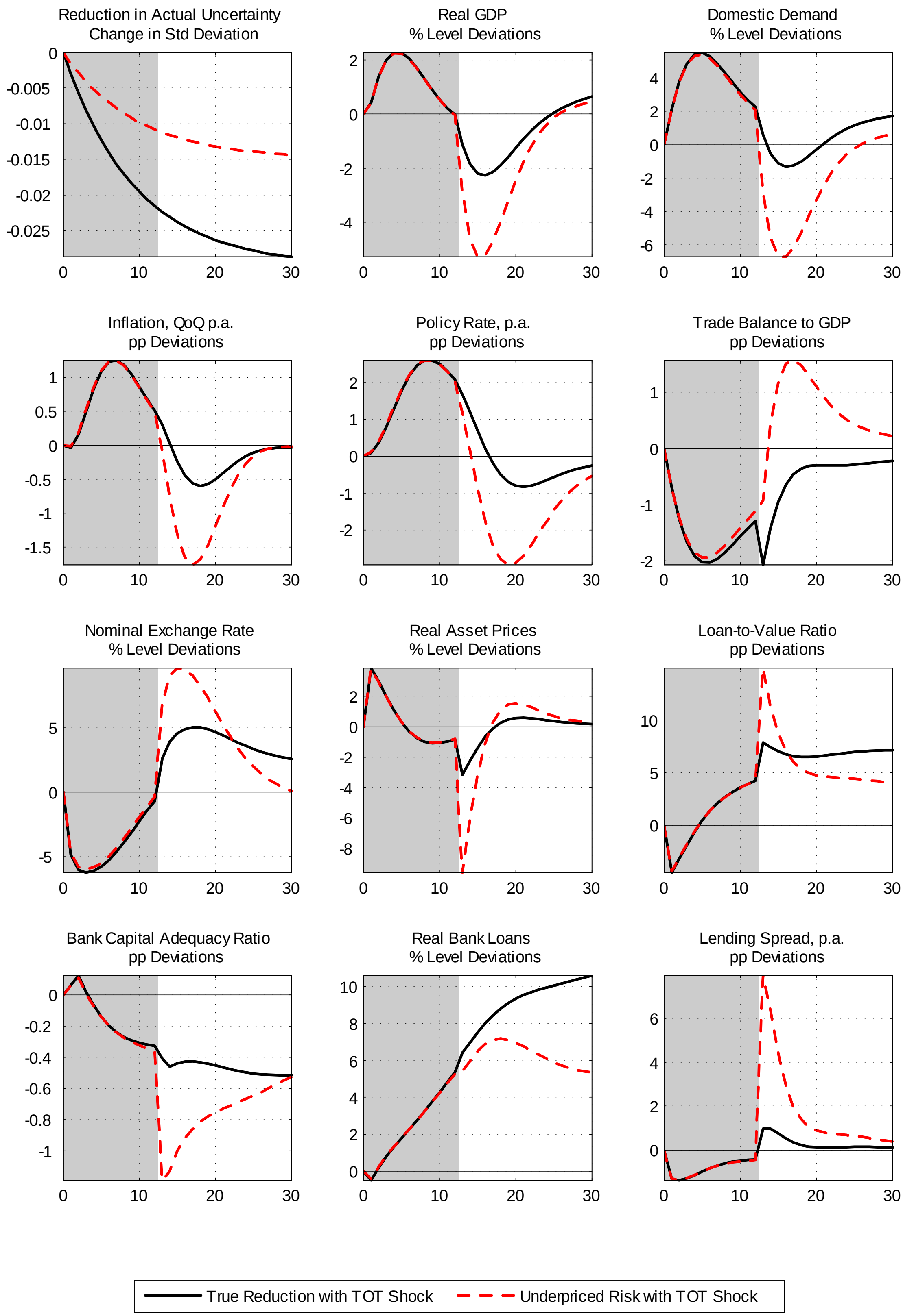

Figure 11. Steady State Effects of Higher MCAR

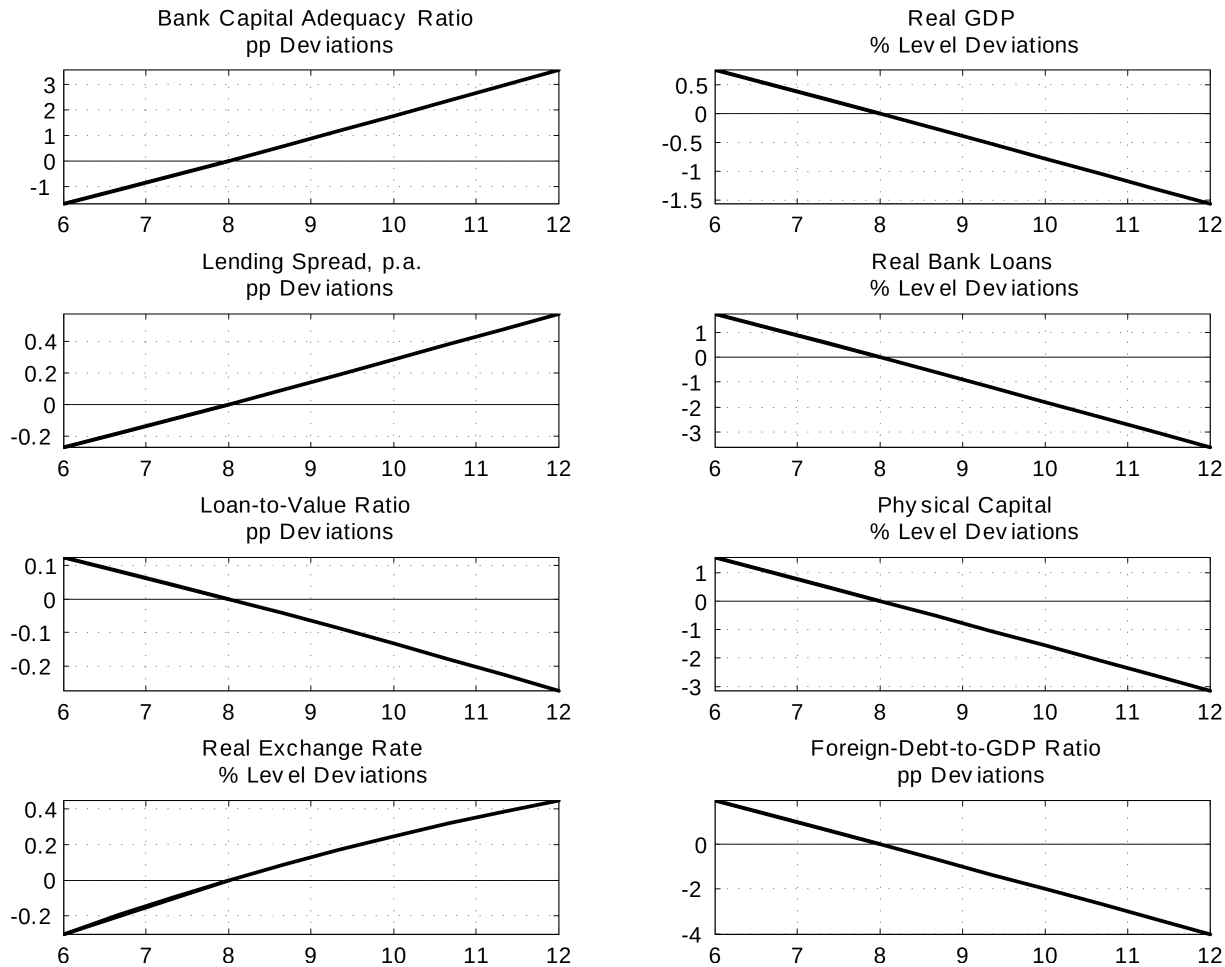

Figure 12. Dynamic Effects of Countercyclical MCAR