Monetary Exit Strategy and Fiscal Spillovers [1]

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Abstract

The aftermath of the global financial crisis has seen two types of concerns in regards to monetary policy outcomes. Some (eg Paul Krugman or Brad De Long) worry primarily about the short-term possibility of deflation caused by a prolonged slump. In contrast, others (eg Greg Mankiw or John Taylor) worry more about excessively high inflation in the longer-term caused by recent bailouts/quantitative easing and/or political pressure to monetize the intertemporal fiscal shortfall arising from aging populations. We model monetary-fiscal interactions jointly over both horizons, and in a sense endogenize Leeper's (1991) active/passive policy regimes. Our focus is on the *strategic* aspect of the policy interactions under incomplete information, which is not captured in standard macro models, but which the recent events including the U.S. debt-ceiling negotiations showed to be of crucial importance. In order to incorporate institutional features our game theoretic framework allows for stochastic revisions of the policy stance - generalizing the Stackelberg leadership concept from static to dynamic. Our analysis shows, perhaps surprisingly, that the probabilities of short-term deflation and of long-term high inflation are *positively* related. It is not one or the other, but instead it is either both of them, or neither of them - depending on the institutional design and preferences of the two policies. Our main policy implication is that a legislated long-term monetary commitment (eg a numerical target for average inflation) may play the role of a monetary 'credibility insurance' over all phases of the business cycle. Specifically, we show a mechanism through which an explicit commitment of the central bank can help avoid both deflation and excessive inflation by changing the incentives of governments, and reducing the likelihood of a costly tug-of-war between monetary and fiscal policy. We extend the analysis to a monetary union with various types of governments and show that monetary commitment is less effective since the common central bank has less leverage over potentially free-riding governments. The paper concludes by discussing empirical evidence for these findings.

Keywords: monetary-fiscal interactions, fiscal stress, deflation, active/passive policy, Game of Chicken, asynchronous moves, stochastic timing, equilibrium selection. **JEL Classification Numbers:** E52, C70.

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'By establishing an inflation objective at this juncture the Fed can guard against both of these problems. Providing a firm anchor for long-run inflation expectations would make the threat of deflation less likely. But a firm anchor would also give the Fed flexibility to respond to the weakness of the economy – because it would help ensure that any new moves to quantitative easing would not be misinterpreted as signalling a shift in the central bank's long-run inflation goal, making an upward surge in inflation expectations less likely too.' Mishkin (2010)

1. Introduction

The aftermath of the global financial crisis (GFC) has presented policymakers all over the globe with major challenges. High uncertainty about economic conditions has made it difficult to assess the danger that: (i) their economy may fall into a deflationary trap in the short-term; and that (ii) past fiscal and monetary actions combined with demographic trends may lead to high inflation in the long-term.[3]

This paper offers a way of modelling both the short-run and long-run aspects of a post-downturn situation, and the linkage between them. We postulate the monetary (M) vs fiscal (F) interaction as a game between the central bank and the government in the presence of an underlying intertemporal budgetary shortfall [the so-called 'fiscal gap', see Kotlikoff (2006)], as well as incomplete information about the economy's recovery prospects.

Each policy can engage in an '*active*' (A) or '*passive*' (P) *stance*. These are defined slightly differently from the seminal contribution of Leeper (1991) - focusing on his two polar cases. Our A policy stance provides no adjustment to balance the long-term budget constraint, whereas a P policy stance provides the full adjustment necessary - independently of the other policy (ie assuming the other policy plays A). Specifically, PF can balance the budget constraint via a F reform in which future taxes and government expenditures are aligned, whereas PM can do so by inflating them and/or the accumulated debt away similarly to Sargent and Wallace (1981).

As the A vs P policy regimes in Leeper (1991) and the subsequent literature are exogenous, our aim is to (in a sense) *endogenize* them. In doing so our main focus is on the *strategic* interactions between the M and F policymakers that are not captured in standard macroeconomic models.

The reader may wonder: What strategic considerations are there to examine in the era of independent central banks? The fact that M and F policy are inter-related through spillovers of economic outcomes and expectational channels is uncontroversial. Arguably, the developments of the past few years suggest that strategic considerations may be crucial in determining the outcomes of both M and F policies. For example, the July 2011 debt-ceiling negotiations in the United States showed how political (and divorced from good economics) policy interactions can be, with important implications

[3]The fiscal stimuli of 2008-2010 only form a small part of the observed fiscal stress facing advanced countries. For example, IMF (2009) estimate that in G20 countries the average contribution of the global financial crisis to the long-term fiscal imbalance is only 10.8% of the contribution of aging populations related factors. United Nations data show that between 1960 and 2040 the old-age dependency ratio in advanced economies is predicted to more than triple on average, with most of the rise yet to come. This implies dramatic increases in pensioner/worker and total dependency ratios: see Figure 1 in Section 3 below.

for M policy. As another example, the European Central Bank's initial resistance to quantitative easing, and its subsequent change of view suggest that strategic interactions between M and F policy need to be taken into account, and formally modeled. It is apparent that the importance of strategic considerations will grow over time as countries face increasing F stress from aging populations.

To focus on the policymakers' strategic behaviour under uncertainty we use game theoretic methods rather than a DSGE model. Specifically, to examine the role of various institutional factors that make policies more pre-committed to their past actions, we develop a game theoretic framework with general timing of moves, in which the ability to revise the previous stance may differ across the two policies.

In addition to this difference in timing, the presence of a F gap also leads to divergent objectives of the two policymakers: while the central bank is 'responsible' the government is 'ambitious'.[4] Therefore, we no longer have the M and F 'symbiosis' of Dixit and Lambertini (2003), but a potential coordination problem and/or outright conflict between the policies as each prefers a different policy regime. Our setting assumes that each policymaker prefers the *other* policy to deal with the underlying problem: the weak recovery in the short-term and the F gap in the long-term. Therefore, our analysis can roughly be interpreted as examining the following question: *'Which policy, if any, will (be forced to) deal with the short-term threat of a double-dip recession, and which with the long-term F imbalance?'*

Let us acknowledge that in focusing on a dynamic game with stochastic timing of moves our analysis abstracts from the dynamic adjustment to the equilibrium active/passive regime. Therefore, the analysis is unable to provide insights into the dynamics of debt, or how expectations are affected as the economy approaches its F limit. This implies that while our paper is consistent with Leeper's (2010) call for '*more attention to information and uncertainty, ... and more focus on institutional design*', his call for '*more dynamic modelling*' is only answered at the game theoretic level, not at the macroeconomic level.[5]

2. Sketch of the Game Theoretic Analysis and Findings

To incorporate uncertainty, our policymakers are unsure which game they are playing. They believe that with probability $(1 - p)$ economic conditions will keep improving, and the economy recovers at a good pace without any additional stimulatory measures. This is our '*Normal times*' scenario depicting the long-term perspective. In contrast,

[4] For the responsible/ambitious terminology see eg Faust and Svensson (2001). In addition to unaffordable welfare/health/pension schemes in the presence of an aging population, government's ambition may be due to high accummulated debt (eg Greece) or liabilities implied by public guarantees for financial institutions (eg Ireland). For completeness in Section 6 we will also consider the case of a monetary union in which some governments are responsible and therefore not in conflict with the common central bank.

[5] This is driven by our belief that the observed and predicted F imbalances dictate increased focus on the first moment (steady-state debt and inflation levels) as opposed to the second moment (debt and inflation variability) emphasized in most DSGE models. This parallels the past developments in the literature whereby the high inflation of the 1970s led to a focus on 'inflation bias', whereas once inflation fell to low levels the focus switched to the 'stabilization bias'. The dire F projections and their possible M implications ala unpleasant monetarist arithmetic suggest to us that switching back may be in order.

the policymakers believe that with probability p economic conditions are such that a double-dip recession and deflation are imminent without a policy stimulus. This is our '*Downturn*' scenario depicting the short-term perspective of stabilizing adverse cyclical deviations. While we assume for simplicity that the M and F policymakers have the same estimate of p, this value is not restricted in our analysis to reflect the fact that in the real world it varies over the business cycle. One of the aims of the paper is to identify 'business-cycle-proof' institutional characteristics that deliver socially optimal outcomes for all $p \in [0, 1]$.

Normal Times Scenario. Following much of the literature we represent the Normal times scenario by the Game of Chicken.[6] There are two pure strategy Nash equilibria: the socially optimal Ricardian regime (AM, PF) with (average) *low* inflation/nominal debt, and a socially sub-optimal (PM, AF) regime with (average) *high* inflation/nominal debt. The former is preferred by the responsible central bank since the F gap is dealt with by F policy alone, whereas the latter is preferred by the ambitious government since the central bank 'helps' it using M measures.

In addition to a policy conflict, the Game of Chicken also features a coordination problem since both policymakers would prefer either pure Nash equilibrium to the mixed strategy one in which they randomize between the regimes in an uncoordinated fashion. This is in line with Davig and Leeper's (2010) showing a number of active/passive regime switches in the United States over the past six decades. Importantly, their estimates indicate that the inferior regime (PM, AF) has prevailed since 2002, and in the absence of structural F reforms is set to prevail into the foreseeable future.[7] Our analysis derives circumstances under which F excesses spill over onto M policy in equilibrium, implying that the concerns of the unpleasant monetarist arithmetic and the Fiscal Theory of the Price Level (FTPL) literature may be justified.

Downturn Scenario. In contrast, the Downturn scenario (denoted by 'prime') is represented by the Battle of the Sexes. In this scenario the Ricardian regime (AM', PF') is no longer assumed optimal since a potent stimulus of either M or F policy is required to address the continued adverse shock. Instead, the pure Nash equilibria are (AM', AF') featuring (a non-Ricardian and hence more effective) F stimulus, and (PM', PF') featuring a M stimulus. Both stimuli can be of the 'unconventional' form designed to lower long-term yields. This scenario assumes that in the absence of a stimulus, deflation and liquidity trap may occur. On the other hand, a joint stimulus of both policies may be excessive and over-heat the economy possibly leading to imbalances further down the track.

Despite the differences from the Normal times scenario, the Downturn game still contains both a coordination problem (how to escape the mixed Nash) and a policy conflict (whose preferred pure Nash will be selected). Many M and F policy papers have these two features, and hence point to the two types of interactions we examine.[8]

[6] Appendix A shows how this game can be derived from an intertemporal budget constraint of the government under reasonable circumstances.

[7] This is consistent with Li, Li, and Yu (2011) whose estimates suggest that the Fed was not adhering to the Taylor Principle since the early 2000s.

[8] For example Adam and Billi (2008), Branch, et al. (2008), Benhabib and Eusepi (2005), Dixit and Lambertini (2003), Barnett (2001), Blake and Weale (1998), Nordhaus (1994), Sims (1994), Woodford (1994), Leeper (1991), Petit (1989), Alesina and Tabellini (1987), or Sargent and Wallace (1981). While

The assumption that both policymakers prefer the other policy to carry out the required stimulus, supported below by among other citing Bernanke (2011) and reporting data on the U.S. Treasury bond issues in 2010-11, is not essential for our results. Nevertheless, it links the Downturn scenario to the Normal times scenario by highlighting the fact that additional stimulatory measures in the short-term may jeopardize the policymakers pursuit of their preferred stance once the Downturn threat is over. In terms of the central bank, large scale quantitative easing (QE) makes it harder to perform a successful M exit, and increases the likelihood of higher inflation down the track. In terms of the government, large (conventional) F stimulus packages increase the size of debt, and hence make it difficult to later continue politically popular policies of low taxes and high spending, and avoid reforms towards F sustainability. Alternatively, using unconventional F measures and reducing the average maturity of public debt by issuing more short-term bonds increases the 'rollover risk' for the government.

Standard Timing of Moves. What is the solution of these games? Under simultaneous moves, neither standard nor evolutionary game theory provide a way to select between the pure Nash equilibria in the Game of Chicken and the Battle of the Sexes due to the symmetry. The Pareto-inferior mixed Nash in each game is therefore a possibility, and reason for concern.[9]

Therefore, a common solution has been to apply Stackelberg leadership. Most famously, Sargent and Wallace (1981) focus on the case of the government being the Stackelberg leader in the Normal Times situation, and the central bank the follower. This gives the government an upper hand in the policy interaction, and enables it to achieve its preferred long-term policy regime by forcing a M solution to the F gap. Unfortunately, F leadership seems more relevant today than ever before as the unsustainable F stance driven by aging populations is largely pre-committed by the existing legislation.

Generalized Timing of Moves. In order to be able to provide insights into equilibrium selection and identify institutional factors that can potentially avoid such inferior policy regimes, our main methodological innovation is to generalize the timing of the game. In particular, we allow the policymakers to revise their stance with some positive probability, but not necessarily with certainty, and possibly only with a delay. This is in contrast to the standard repeated game, in which moves are made simultaneously every period, alternating move games of Maskin and Tirole (1988) in which players alternate every other period, or the Stackelberg leadership in which the revision is immediate. Neither of these timing setups seems realistic in the M and F policy context.

Note that unlike the standard Stackelberg leadership concept which is static, our leadership concept is dynamic. In particular, in the standard framework the follower can revise his action immediately, ie there is no cost to the leader from mis-coordination or conflict. In contrast, our framework allows for such costs as the revision may arrive later in the game and payoffs accrue over time.

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these papers contain a wide range of modelling approaches and macroeconomic environments, our insights relate to their common conflict/coordination features, and are therefore applicable to all these papers.

[9]We show that uncertainties about the business cycle and/or the government's preferences greatly magnify the reasons for concern by making the inferior uncoordinated policy regimes more likely.

We assume that the timing of the revision opportunity is exogenous and common knowledge, but it can be made private information and/or endogenized. Our framework is general in being able to capture an arbitrary timing of the revision opportunity, both deterministic and stochastic [for a detailed exposition see Basov, Libich, and Stehlík (2011)]. Incorporating revisions leads to an asynchronous timing of moves, and allows us to postulate two institutional features: *long-term M commitment* and *F rigidity*. Both concepts relate to the respective policy's inability to alter its stance. The different labels come from our focus on the case of a responsible M policy facing an ambitious F policy.

What factors influence these institutional features in the real world? Arguably, they depend on whether the underlying determinants of the policies are legislated. The degree of F rigidity naturally increases in the size of the F gap implied by the existing legislation. The greater the shortfall between mandatory future government expenditures and taxes, the harder it may be for the government to implement reforms towards sustainability. Similarly, the degree of long-term M commitment increases when a numerical target for average inflation is legislated. This is because such a transparent objective cannot be easily reconsidered - due to political, institutional, and reputational constraints.[10]

Findings. Our aim is to examine how the degree of M commitment, F rigidity, policy preferences, as well as economic uncertainty affect the strategic policy interactions, and jointly determine the equilibrium policy regimes. We show that whether deflation occurs in the short-term, and whether F excesses spill over to M policy in the long-term (thwarting the success of the central bank's exit strategy) depends on the *relative* inability to change the previous policy stance, ie the following ratio:

$$\frac{F \text{ rigidity}}{\text{long-run } M \text{ commitment}}.$$

We identify three main cases: (i) *F-dominance* - F is the leader and this ratio is above a certain threshold T_M, (ii) *M-dominance* - M is the leader and this ratio is below a certain threshold T_F, and (iii) *non-dominance* - the ratio is in the intermediate interval.

In the F-dominance case, long-run spillovers will surely occur because F rigidity gives the government an upper hand in the policy tug-of-war. The M exit strategy will be unsuccessful as in Normal times we have the (PM, AF) equilibrium. In contrast, in the M-dominance case long-run F spillovers will surely be avoided as a strong commitment gives the central bank ammunition to counter-act excessive F stance - yielding the (AM, PF) equilibrium in Normal times. These results are in the spirit of Sargent and Wallace (1981) and the FTPL literature. Importantly, in both cases deflation is prevented in the short-term equilibrium. This is because the dominant policy can indirectly induce the dominated policy to respond and provide the required stimulus in the Downturn scenario.

The intermediate non-dominance case is of particular interest as it does not exist under static (Stackelberg) leadership, and therefore has not been discussed in the existing literature. In this case one policy is still the leader in the game (more committed/rigid than the other), but insufficiently so to fully dominate. Unlike in the static framework,

[10] The New Zealand Policy Target Agreement is a good example of such constraints. It implies that changes to the legislated inflation target can only be done infrequently (at pre-specified occasions), and that the Governor of the central bank is personally accountable for achieving the target.

dynamic M leadership is no longer sufficient to guarantee optimal M outcomes: the central bank's commitment must be *sufficiently* strong relative to F rigidity.

This is hardly a trivial task given the observed demographic trends depicted in Figure 1 below, and the resulting F gap facing advanced economies. For example, IMF (2009) estimates the net present value of the impact of aging-related spending on F deficits to be 409% of GDP as the average for G20 countries. Nevertheless, while F spillovers may occur under dynamic M leadership, their probability is reduced compared to the F-dominance case because the socially optimal outcomes are in the set of subgame perfect equilibria. Therefore, the chances of a successful M exit are increased.

Perhaps surprisingly, the fact that neither policy has sufficient leverage over the other in the non-dominance region may be a possible disadvantage in the short-term relative to the F-dominance case. Policies are more likely to engage in a tug-of-war that is costly for both policymakers and society. This conflict has the form of a 'waiting game', in which both policies delay required (conventional or unconventional) stimulatory measures hoping to induce the other policy to carry them out. This increases the likelihood of a double-dip recession accompanied by deflation - an outcome that never occurs under static leadership. Furthermore, as an important policy warning, the analysis shows that a higher estimated cost of deflation actually increases the probability of deflation, as it increases the range of parameters under which the waiting game can occur in equilibrium.

We derive the T_M and T_F thresholds that separate the F-dominance, M-dominance, and non-dominance regions of equilibria. They are, in addition to the timing of the policy revisions (ie the degrees of F rigidity and M commitment), functions of the probability of adverse conditions p and the policy payoffs. In particular, they depend on the cost of a potential policy conflict relative to coordinated actions. This 'conditionality' refines the intuition of the standard findings where the static Stackelberg leader (dominant policy) ensures his preferred outcomes under all circumstances with no strings attached. It can thus be argued that the results derived under static leadership may not be robust, and the picture they paint for M policy is overly optimistic.

Policy Implications. The main policy implication of our dynamic leadership framework is as follows. In order to minimize the probability of *both* deflation in the short-term, and of subsequent F-M spillovers (ie maximize the credibility of a M exit), the central bank should be as strongly committed as possible in the long-term. As the cost of policy conflict varies with economic conditions, a certain degree of M commitment that is sufficient for M credibility and stable prices in Normal times may be insufficient in the aftermath of a downturn such as the GFC. Formally, the increase in the threshold T_F due to higher p may mean that we move from the M-dominance to the non-dominance region. This means that the probabilities of short-term deflation and long-term excessive inflation both increase, implying they may be positively (rather than negatively) related. Therefore, a strong long-term M commitment that ensures optimal M outcomes for any value of p acts as a '*credibility insurance*' over the business cycle.

In practice, long-term M commitment has commonly been implemented as a legislated numerical target for average inflation. A recommendation to adopt such explicit commitment has been recently made by a number of economists, both for short-run and long-run reasons, eg Bernanke (2003), Goodfriend (2005), Hamilton (2008), Walsh

(2009), or Mishkin (2010). The above quote by the latter author summarizes these views - stressing desirable effects over both horizons in line with our findings.

Interestingly, our analysis implies that an explicit M commitment may improve not only short and long-term M outcomes, but also long-term F outcomes. By reducing the structural incentives of the government to spend excessively through a credible threat of a policy conflict, a more explicit long-term M commitment can discipline F policy and help gain political support for necessary F reforms.

We discuss below some empirical evidence for this 'disciplining effect' presented in Franta, Libich, and Stehlík (2011). Nevertheless, in our extension to the case of a M union we identify an important caveat. If a free-riding problem exists in the currency union, whereby some governments do not internalize the negative externality their F neglect imposes on other members, then an even infinitely strong M commitment of the common central bank may be ineffective in avoiding deflation in the short-term, and high inflation in the long-term. Such free-riding governments cannot be disciplined by the common M policy, and hence some form of direct enforceable F rules are necessary. As argued by many, such F commitment is beneficial in non-union countries as well, among other because it better anchors F expectations.

3. The Game Theoretic Setup

To be able to focus on the strategic aspects of the policy interaction and incomplete information we will present it as the following 2×2 games

(1)

		F	
		PF	AF
M	AM	a, w	b, x
	PM	c, y	d, z

Normal times: probability $1 - p$

		F	
		PF'	AF'
M	AM'	a', w'	b', x'
	PM'	c', y'	d', z'

Downturn: probability p

3.1. **Normal Times.** We make the following assumptions about the Normal times scenario (which is expected by both policymakers to occur with probability $1 - p$). First, there exists a sizeable F gap - government's unfunded liabilities mandated by existing legislation. This is uncontroversial given the observed demographic trends of longer life expectancy and lower birth rates in combination with pay-as-you-go systems. In fact, the above mentioned increases in old-age dependency ratios do not reveal the full extent of the problem. As Bongaarts (2004) reports, the actual pensioner per worker ratio in advanced economies is commonly 50-100% higher than the old-age dependency ratio. Figure 1 reports the *total* dependency ratios for selected countries.[11]

As an implication of these demographic trends, IMF (2009) reports the net present value of the impact of aging-related spending on F deficits in the order of hundreds of percent for virtually all advanced countries. Even in the United States, where these demographic factors are less unfavourable than the average of advanced economies (and in any other G7 country), Batini, Callegari, and Guerreiro (2011) estimate that: *'a full*

[11] As an aside, the fact that both advanced and emerging countries such as China and India face aging populations implies that the 'global saving glut' situation of the early 2000s is going to get dramatically reversed, with 'interesting' implications for capital markets.

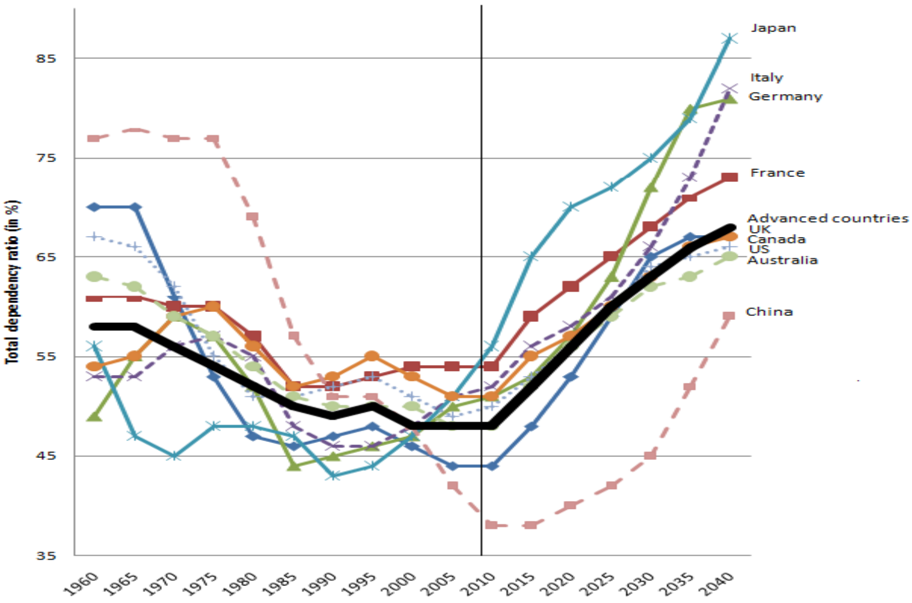

Figure 1. Total dependency ratio (population aged 0-14 or 65+ over population aged 15-64) in selected countries, and the man for advanced (developed) countries. United Nations data, 1960-2010 actual, 2011-2040 forecast.

elimination of the fiscal and generational imbalances would require all taxes to go up and all transfers to be cut immediately and permanently by 35 percent.'

Second, we assume that in the Normal times equilibrium the budget constraint has to be satisfied, ie at least one policy needs to be passive. This effectively rules out default on debt in the long-run as an ongoing long-term solution.

Third, to incorporate a policy conflict we assume that both policymakers prefer the *other* policy to balance the budget constraint. This is because the central bank dislikes deviations from price stability, and the government dislikes reneging on promises of high transfers and low taxes. But the existence of F gap means that at least one of the policies will have to give in.

To keep our focus on the game theoretic insights under general timing, we relegate the formalization of these assumptions to Appendix A. It first postulates the long-term budget constraint, and discusses the potential sources of F stress and its solutions. This is then used to give a formal definition of the $\{AM, PM, AF, PF\}$ policy stances, and to derive the steady-state debt outcomes in each policy regime. The following table summarizes them, and indicates which policy deals with the underlying F gap:

		F	
		PF	AF
M	AM	Stable real debt Fiscal Stable nominal debt	Rising real debt Neither Rising nominal debt
	PM	Falling real debt Both Stable nominal debt	Stable real debt Monetary Rising nominal debt

While in the (AM, PF) and (PM, AF) regimes the budget constraint is balanced by F and M policy respectively, in the (AM, AF) regime neither policy is adjusted, and hence debt is on an explosive path, both in nominal and real terms. Therefore, the latter cannot be an equilibrium in Normal times. Finally, in the (PM, PF) regime both policies contribute towards the budget constraint in an uncoordinated fashion and therefore real debt is actually falling.[12] The fact that it is disliked by both policymakers implies that this outcome also cannot be a long-term equilibrium.

Finally, Appendix A introduces utility functions for the policymakers. In line with Leeper's (1991) policy rules, the primary goal of the central bank is to achieve stable prices (low inflation). In contrast, the government attempts to stabilize the real value of debt, also suffering disutility from reneging on its promises of net transfers. This implies that in Normal times AM and PF can be interpreted as long-term *discipline*, and PM and AF as *neglect*. This is because, absent of the influence of the other policy, the policy's primary target is on average delivered by the policy in the former case, and over-shot in the latter.[13]

The utility functions are used to give an example of how the underlying macroeconomic structure can be mapped into the above 2×2 game theoretic representation. It is shown that our three assumptions imply the Game of Chicken in Normal times, ie the payoffs in (1) satisfy

$$a > d > \max\{b, c\} \quad \text{and} \quad z > w > \max\{x, y\}. \tag{2}$$

The following payoff matrix offers an example using specific values of the policy parameters (for details see Appendix A)

(3)

		F	
		PF	AF
M	AM	Ricardian (Nash) $\mathbf{0}, \mathbf{-3}$	tug-of-war $-4, -4$
	PM	tug-of-war $-4.05, -3.25$	monetization/FTPL (Nash) $\mathbf{-3.8}, \mathbf{0}$

Game of Chicken

The intuition of the Game of Chicken closely resembles the unpleasant monetarist arithmetic of Sargent and Wallace (1981). There are two pure strategy Nash equilibria, each

[12] In Leeper's (1991) setup the (PM, PF) outcome leads to indeterminacy. To avoid this we pin the PM stance down by the exact size of unfunded net transfers, see Definition 2 of Appendix A.

[13] Note that PF can also be interpreted as an intertemporarilly balanced budget (including factors such as the government's implicit guarantees for financial institutions). This is in line with Leeper and Walker (2011) who highlight *'the importance of building in the possibility of adopting a policy rule that incorporates a balanced budget.'*

preferred by a different player. The central bank wants to deliver stable prices, and an intertemporarilly balanced budget allows the bank to do so. Therefore, the bank prefers the socially optimal 'Ricardian' outcome (AM, PF): Leeper's (2010) 'M-regime'. In contrast, the ambitious government prefers to spend excessively and/or avoid necessary F reforms for political economy reasons, and would like the central bank to inflate some of the promises/debt away. Therefore, the government's preferred outcome is (PM, AF): Leeper's 'F-regime'.[14] If the policymakers do not coordinate their actions, for example if they play the mixed strategy Nash equilibrium, they engage in a tug-of-war generating inferior off-diagonal outcomes.

3.2. **Downturn.** We make the following five assumptions about the Downturn scenario (which is believed occur with probability p). First, as adverse economic conditions continue, the economy requires a potent expansionary response in order to fully recover. If neither policy responds, or we only have a Ricardian type response (AM', PF') in which future taxes are expected to rise to offset the current budget shortfall, the economy experiences a prolonged recession and possibly a deflationary/liquidity trap.

Second, we assume that the two policies are substitutes in providing the required stimulus. This can be interpreted both in terms of conventional M and F policies (lower interest rates and higher government spending respectively), and well as unconventional ones. In terms of the latter Barro (2010) argues: '*My conclusion is that QE2 may be a short-term expansionary force, thereby lessening concerns about deflation. However, the Treasury can produce identical effects by changing the maturity structure of its outstanding debts.*'

Third, unlike in Normal times the intertemporal budget constraint may not be satisfied in the short-run Downturn equilibrium. As a justification of this assumption see eg Davig and Leeper's (2010) estimates of U.S. policy regimes showing the occurrence of the (AM, AF) regime under Reagan/Volcker.

Fourth, to incorporate a coordination problem we assume that a joint expansionary response of both policies, (PM', AF'), may be excessive and over-heat the economy, potentially planting seeds for imbalances in the future. This assumption can be motivated by eg Taylor and Ryan (2010) who argue in regards to the Fed's response to the dot.com bust: '*The Fed's decision to hold interest rates too low for too long from 2002 to 2004 exacerbated the formation of the housing bubble.*'[15]

Fifth, as in Normal times there is a policy conflict since both policymakers prefer the other policy to stabilize the shock: the central bank prefers (AM', AF'), whereas the government prefers (PM', PF'). This is because the policymakers understand that their additional stimulatory measures jeopardize the pursuit of their preferred long-run (Normal times) regime once the Downturn threat is over. For example central banks may resist further QE on the grounds that it will make the subsequent exit strategy harder and less credible.

[14] This sort of government preferences can be derived from an overlapping generations model with an aging population. See Kuehnel (2011) for formal modelling of how this '*shifts political power from the young to the old*'.

[15] Similar concerns can be heard about the policy behaviour in the post-GFC period, see for example Rajan (2011).

As Barro (2010) argues: *'The downside of QE2 is that it intensifies the problems of an exit strategy aimed at avoiding the inflationary consequences of the Fed's vast monetary expansion.'* Similarly, additional conventional F measures deteriorate the long-run fiscal position, and make it difficult for the government to engage in politically popular spending programs in the future. The same is true for unconventional F measures that increase the rollover risk for the government. The following remarks from Fed Chairman Bernanke (2011) clearly express the M preference for (AM', AF'): *'I have advocated that the negotiations about the budget focus on the longer term ... in light of the weakness of the recovery, it would be best not to have sudden and sharp fiscal consolidation in the near term. That doesn't do so much for the long-run budget situation, it's a negative for growth.'*

The latter two assumptions provide a link between the short-term and long-term horizons by postulating that cyclical stabilization actions affect the outcomes of the policies, which in turn affect future options and choices. Importantly, the reverse is also true: the preferences over Normal times actions affect the policy responses to cyclical disturbances. It should however be emphasized that our main findings are largely independent of these assumptions. We discuss below the fact that they remain valid even if we assume that the policymakers prefer to stabilize the adverse shock themselves, for example because they want to be seen as 'doing something', or simply believe that their policy is more effective in addressing the economic weakness.[16]

These five assumptions of the Downturn scenario imply the Battle of the Sexes game in which

$$b' > c' > \max\{a', d'\} \quad \text{and} \quad y' > x' > \max\{w', z'\}. \tag{4}$$

We will formalize these assumptions in the simplest possible way by including two perceived costs (common across the policymakers): an *over-stimulating cost* C associated with the joint-stimulus outcome (AM', PF'), and a *deflation cost* D associated with the no-stimulus outcome (AM', PF'). Formally, we assume

$$a' = a - D, b' = b, c' = c, d' = d - C, w' = w - D, x' = x, y' = y, z' = z - C. \tag{5}$$

It is straightforward to see that we have the Battle of the Sexes game, (4) holds, if the two costs are sufficiently large

$$C > \min\{d - c, z - x\} \quad \text{and} \quad D > \min\{a - c, w - x\}. \tag{6}$$

The following payoff matrix offers a specific example using the same underlying parameter values as in the Normal times payoff matrix (3), and $C = 5, D = 9$:

(7)

		F	
		PF'	AF'
M	AM'	deflation $-9, -12$	recovery (Nash) $\mathbf{-4, -4}$
	PM'	recovery (Nash) $\mathbf{-4.05, -3.25}$	over-stimulating $-8.8, -5$

Battle of the Sexes

[16]This alternative assumption seems more relevant at the very start of an economic contraction rather than its aftermath we focus on.

Using the modelling short-cut through C and D rather than a fully articulated stochastic macro model has the advantage of a transparent link between the Normal times and Downturn scenarios. Even more importantly, it enables us to separate the effect of our stochastic timing from the effect of a stochastically evolving state as examined in 'stochastic games', see Shapley (1953).

While the Battle of the Sexes is a coordination game and the Game of Chicken an anti-coordination game, they are similar. Both have two Pareto-efficient pure strategy Nash equilibria, each preferred by a different player, and one mixed strategy Nash that is Pareto-inferior to both pure Nash for both players. Both scenarios therefore feature a coordination problem as well as a policy conflict. In a nutshell, these are implied by the divergent preferences of M and F policy, which are in turn implied by the existence of F gap.

A large body of literature (selected papers are cited in footnote 8) features both a coordination problem and a policy conflict, and hence points to these two classes of games. We can interpret their general payoffs as follows. From the central bank's point of view, $(b' - a')$ and $(a - b)$ denote the policy *conflict (or mis-coordination) cost* in Downturn and Normal times respectively. Analogously, $(y' - w')$ and $(z - x)$ are such costs from the government's point of view. In contrast, the policymakers' *victory gain* (relative to 'surrendering' and complying with the opponent's preferred pure Nash) is expressed by $(b' - c')$ and $(a - d)$ for the central bank, and $(y' - x')$ and $(z - w)$ for the government.

Note that since a' and w' are decreasing in the deflation cost (aversion) D, the policymakers' conflict cost in the Downturn scenario is increasing in D. In addition, Appendix A shows how the conflict costs and victory gains depend on the main policy preference parameters, namely the central bank's conservatism ϕ_M, and the government's aversion to reneging on promised net transfers relative to real debt variability aversion, δ_F.

4. Generalized Timing of Moves

Macroeconomic setups have commonly been studied using a one-shot game, or its repeated analog. In both of these settings players' moves are always simultaneous, which is arguably unrealistic in the macroeconomic policy context.[17] In order to relax such synchronicity assumption and allow us to incorporate institutional characteristics we will generalize the timing as follows:

(1) Expecting the Downturn and Normal times scenarios with probability p and $1-p$ respectively, the players move simultaneously at time $t = 0$.
(2) One of the players, called *reviser*, can move again in time $t \geq 0$ with some (ex-ante known) positive probability. The player does so using p and observing the initial play of the opponent, called the *leader*, who has to stick to his initial choice to the end of the dynamic stage game (normalized to $t = 1$).
(3) Payoffs accrue continuously over $t \in [0, 1]$.[18]

[17] It should be noted that most existing micro-founded macroeconomic models implicitly assume a simultaneous move since the M and F policy instruments (and hence the policies' stance) can be adjusted every period.

[18] In Basov, Libich, and Stehlík (2011) we allow *both* players to revise their initial actions on $t \in [0, 1]$. While the solution of the game is much more complex, the intuition is similar because what matters is

Our framework allows for an arbitrary timing of the revision opportunity. The top panels of Figure 2 offer three examples: normal, uniform, and binomial distributions, the latter in line with the popular Calvo (1983) scheme.[19]

If the F gap/rigidity is large and no numerical long-term M commitment is legislated then F is the likely leader in the game (the United States is a possible example). In such case the last column of Figure 2 featuring a binomial timing can be interpreted as the government being able to reconsider its F stance once a year in the proposed budget, whereas the central bank being able to reconsider its M stance more frequently: every six weeks at the FOMC meeting.[20]

Conversely, if F gap/rigidity is low and the central bank is committed by legislation to a numerical target for average inflation then M is the likely leader in the game (Australia is a possible example).[21] This is because explicit targets and policy settings are more difficult to alter than implicit ones - due to political, institutional, and reputational constraints.

The following definition describes several related concepts used in our analysis.

Definition 1. *(i) The cumulative distribution function (CDF) summarizes the probability that by time t the reviser has had a revision opportunity (see the bottom panels of Figure 2). We call it the* ***revision function****, and denote it by* $R_i(t)$*, where* $i \in \{M, F\}$ *is the reviser.*
(ii) Based on i's ***revision speed*** *we will distinguish three cases:*

$$\int_0^1 R_i(t)\mathrm{d}t \begin{cases} = 1 & \text{(standard) } \textbf{static leadership}, \\ \in (0,1) & \textbf{dynamic leadership}, \\ = 0 & \text{(standard) } \textbf{simultaneous move.} \end{cases} \tag{8}$$

(iii) The reciprocal of the complementary CDF,

$$\frac{1}{\int_0^1 (1 - R_i(t))\,\mathrm{d}t} \in [1, \infty],$$

expresses the degree of the leader's ***commitment*** *or* ***rigidity*** *- relative to reviser i.*[22]

---

the players' *relative* inability to revise actions. Let us also note that while the dynamic stage game can be repeated, we do not do so since our focus is on deriving circumstances under which the dynamic stage game itself has a unique and efficient subgame perfect equilibrium. In such case allowing for reputation building through repetition would not alter the outcomes. Nevertheless, allowing for repetition would have the standard effects of possibly improving coordination and reducing the probability of inferior outcomes, see Mailath and Samuelson (2006).

[19] As the dimension of the normal form of the game is now 4×16 we will not present it here, and below focus our attention on the actions appearing on the equilibrium path of the subgame perfect equilibria.

[20] Libich and Stehlík (2011) offer a detailed mathematical treatment of several specific distributions, including combinations of CDFs. They calibrate the standard Calvo case to the European monetary union data and show that the degree of F rigidity in the union was very high already prior to the GFC.

[21] For example, the above discussed Policy Target Agreement in New Zealand specifies that the inflation target can only be altered when a new government or central bank Governor take office, ie roughly every 3-4 years.

[22] Naturally, we have $\int_0^1 (1 - R_i(t))\,\mathrm{d}t = 1 - \int_0^1 R_i(t)\mathrm{d}t$.

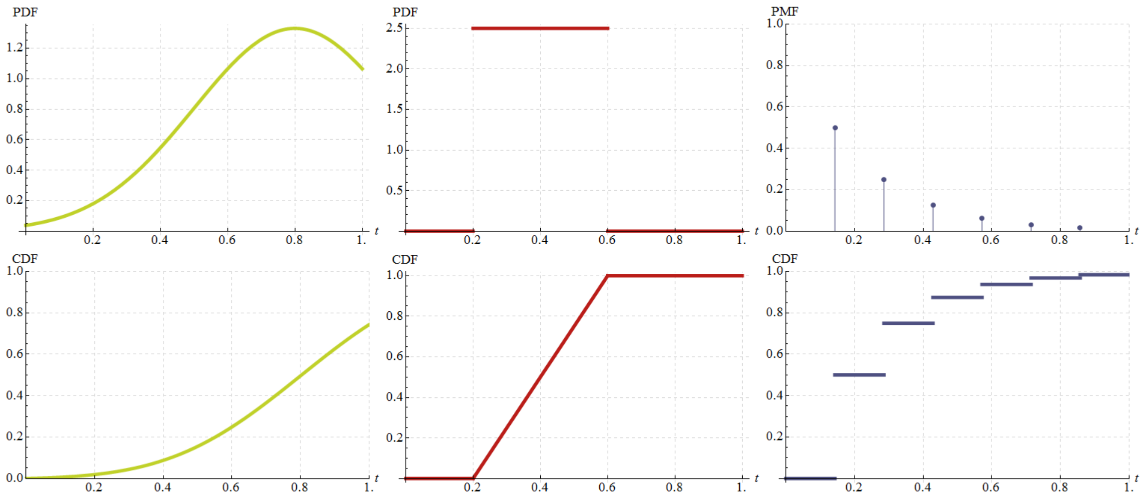

FIGURE 2. Three examples of timing: (truncated) normal, uniform, and binomial distributions, and the corresponding CDFs.

The setup makes clear that the standard frameworks are two extreme (and not necessarily the most plausible) cases, which calls in question the robustness of conventional results.

5. Results

In order to better highlight the effect of dynamic leadership and the two considered institutional factors (M commitment and F rigidity) under uncertainty, we contrast them with the standard simultaneous move game and the static (Stackelberg) leadership.

5.1. Simultaneous Moves: $\int_0^1 R_i(t)\mathrm{d}t = 0$**.** The players' payoff from each regime, denoted by double prime, is a weighted average of those in Downturn and Normal times with p as the weight. For example, $a'' = (1-p)\,a + pa'$. Using (5) yields the following

(9)

		F	
		PF	AF
M	AM	$a'' = a - pD, w'' = w - pD$	$b'' = b, x'' = x$
	PM	$c'' = c, y'' = y$	$d'' = d - pC, z'' = z - pC$

It is apparent that even if (2), (4) and (6) hold, ie the underlying games are known to be Chicken and the Battle of the Sexes, under incomplete information we may have any class of game in (9). The ranking of the regimes by each policymaker depends on the exact values of C, D, and p, and there exists values under which any of the possible ranking obtains. Hence there is a large number of possible (Bayesian Nash) equilibria.[23] We can therefore conclude that:

[23] For example, if $D > \frac{a-c}{p}$ then $a'' < c''$, whereas if $D \in \left(a-c, \frac{a-c}{p}\right)$ then $a'' > c''$, and similarly for all relevant pairs of payoffs. Such ambiguity is further exacerbated if each policymaker has a different estimate of C, D, and p, which is likely to be the case in the real world.

Remark 1. *Uncertainties about the business cycle and/or the potential deflation/overheating costs greatly compound the coordination problem between M and F policy. This highlights the importance of aligning the objectives of the respective policymakers, and of effective communication between them to minimize the occurrence of Pareto-inferior regimes.*

5.2. **Static Leadership: $\int_0^1 R_i(t)\mathrm{d}t = 1$.** Note that as defined, under static leadership the reviser makes two moves at $t = 0$, the first under perfect and the second under imperfect information. But since the first one is payoff irrelevant, our reviser in this special case is identical to the Stackelberg follower.

We are interested in deriving the circumstances under which one policy '*surely-wins*' the game. We define this as a situation in which the dynamic stage game has a *unique* subgame perfect equilibrium payoff: the one preferred by the leader. As implied by (2) and (4), these preferred payoffs are for M delivered by $(AM', AM; AF', AF', PF, PF)$, and for F by $(PM', PM', PM, PM; PF', AF)$.

Proposition 1. *(i)* ***(F-dominance)*** *Under static F leadership, long-term F spillovers onto M policy occur under* ***all*** *circumstances, ie for any p and any payoffs satisfying (2) and (4).*
(ii) ***(M-dominance)*** *Under static M leadership, long-term F spillovers onto M policy occur under* ***no*** *circumstances.*
(iii) Under static leadership, short-term deflation occurs under ***no*** *circumstances.*

The long-term part of the proposition is in line with Sargent and Wallace (1981) in which leadership is an advantage that allows to force the opponent into compliance. The intuition of the short-run game is analogous: the leader can induce the reviser to attend to the temporary economic weakness.

5.3. **Dynamic Leadership.** This session shows that while the intuition of Proposition 1 still applies the results are not robust. It will become apparent that the above standard timing assumptions may not only hide potentially important insights, but also provide possibly misleading predictions, eg they down-play the possibility of deflation arising from a policy mis-coordination.

Proposition 2. *(i)* ***(F-dominance)*** *Under dynamic F leadership, F spillovers onto M policy* ***surely occur*** *if and only if F rigidity is* ***sufficiently high*** *relative to long-term M commitment,*

$$\frac{1}{\int_0^1 (1 - R_M(t))\,\mathrm{d}t} > T_M = \frac{\overbrace{p\left(y' - w'\right) + (1-p)(z - x)}^{F\text{'s weighted conflict costs}}}{\underbrace{p\left(y' - x'\right) + (1-p)(z - w)}_{F\text{'s weighted victory gains}}} \in (1, \infty)\,. \tag{10}$$

(ii) ***(M-dominance)*** *Under dynamic M leadership, F spillovers onto M policy* ***surely do not occur*** *if and only if F rigidity is* ***sufficiently low*** *relative to long-term M*

commitment,

$$\text{(11)} \qquad \frac{1}{\int_0^1 (1 - R_F(t))\, \mathrm{d}t} > T_F = \frac{\overbrace{p\left(b' - a'\right) + (1 - p)\,(a - b)}^{M\text{'s weighted conflict costs}}}{\underbrace{p\left(b' - c'\right) + (1 - p)\,(a - d)}_{M\text{'s weighted victory gains}}} \in (1, \infty)\,.$$

(iii) ***(non-dominance)*** *If neither of the two conditions hold then F spillovers onto M policy* ***may or may not occur*** *in the long-run. Furthermore,* ***deflation may occur*** *in the short-run, unlike in cases (i)-(ii), and unlike under static leadership. Paradoxically, more deflation averse policymakers are more (rather than less) likely to experience deflation since T_M and T_F are increasing in D.*

Proof. Appendix B presents the full proof. To demonstrate the intuition of the solution here let us depict the special case $p = 1$, ie the policymakers are certain that economic conditions would not improve in the absence of additional expansionary measures, but prefer the other policy to deal with the problem.

Consider the case of F being the leader that is relevant to claim (i). Solving backwards, player F knows that through her own inaction she can force M policy to expand the economy when the bank's revision opportunity arrives. This rewards F for pursuing his preferred outcome $(PM', PM'; PF')$. Nevertheless, as the initial waiting game is costly - potentially leading to a deflation - the government's victory reward has to more than compensate this initial cost. Formally, for F to surely-win the game PF' must be the unique best response not only to the simultaneously played PM', but also to AM', ie the following incentive compatibility condition must hold

$$\underbrace{w' \int_0^1 (1 - R_M(t))\, \mathrm{d}t}_{(AM', PF')\text{: policy conflict}} + \underbrace{y' \int_0^1 R_M(t) \mathrm{d}t}_{(PM', PF')\text{: } F \text{ victory}} > \underbrace{x'}_{(AM', PF')\text{: } F \text{ surrender}}.$$

Rearranging this yields the following condition

$$\frac{1}{\int_0^1 (1 - R_M(t))\, \mathrm{d}t} > T_M = \frac{\overbrace{(y' - w')}^{F\text{'s conflict cost}}}{\underbrace{(y' - x')}_{F\text{'s victory gain}}},$$

which is the special case of (10) under $p = 1$. If satisfied, M will surrender from the start and there is in fact no conflict in equilibrium. The government's threat of inaction becomes credible, and forces the central bank into stimulatory action, which prevents deflation. Formally, the area below the CDF, $\int_0^1 R_M(t) \mathrm{d}t$, over which F's victory gain accrues is sufficiently large relative to the conflict cost area above the CDF, $\int_0^1 (1 - R_M(t))\, \mathrm{d}t$. Put differently, M policy is expected to be able to revise quickly which implies a small potential cost to the government from mis-coordination.

It should by now be apparent that if M is the leader, the case of claim (ii), the T_F threshold is just a mirror image of T_M. The intuition is simply reversed: it is now M who is willing to undergo a costly conflict with F, and induce her to expand the economy. □

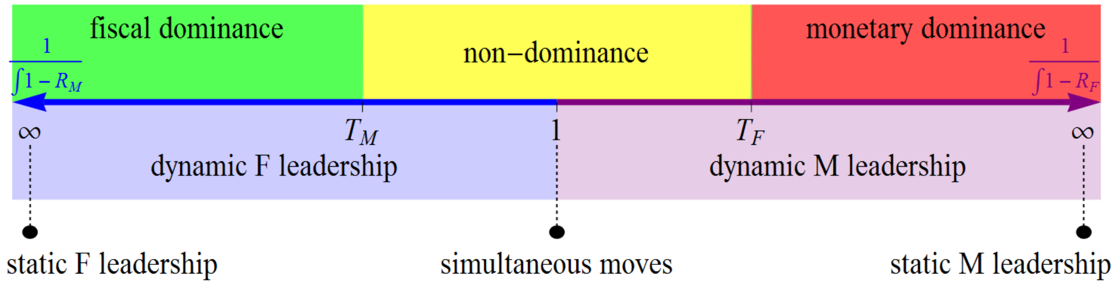

FIGURE 3. The top part shows the F rigidity vs M commitment space under dynamic leadership, featuring the thresholds and regions of equilibria. The bottom part shows the relationship to the standard timing: simultaneous moves and static leadership.

The results for dynamic leadership are graphically summarized in the upper part of Figure 3 showing the two thresholds T_M and T_F and the three equilibrium regions. Naturally, if the payoffs are symmetric then $T_F = T_M$, that is the two dominance regions are of equal size.[24]

In which of the three regions of equilibria is the economy most likely to end up? There is little doubt that the degree of F rigidity in countries advanced is high, taking into account existing debt and demographic factors leading to a large estimated F gap. Therefore, unless there exists a strong institutional commitment of M policy that anchors the long-run inflation level and provides strong incentives for the central bank to deliver on it, the F-dominance region seems a real possibility.

Observed outcomes support this conclusion. Economist (2011) reports that between mid-November 2010 and end-March 2011 '*America's Treasury has issued some \$589 billion in extra long-term debt, of which the Fed has bought \$514 billion*', with a similar picture for the United Kingdom. The Economist concludes: '*In effect, QE in both countries has been undermined by debt-management policy*', which implies (PM', AF') in our setting. In contrast, the increase in the cash rate by the Reserve Bank of Australia just seventeen days before the November 2007 Federal election (at a time when other central banks were already reducing their rates), and the focus of both major Australian parties on F discipline resulting in virtually zero debt can be considered a sign of long-term M-dominance, (AM, PF).[25] This interpretation would imply that, all else equal, both short-term deflation and long-term excessive inflation are more likely in the United States than in Australia.

It should be noted that the results refine and partly qualify those under the simultaneous move and static leadership indicated in the bottom part of Figure 3. First,

[24]Obviously, the reviser cannot surely-win the game: even $\int_0^1 (1 - R_i(t))\,\mathrm{d}t \to 1$ is an insufficient degree of commitment/rigidity for reviser i.

[25]Brash (2011), the former Governor of the Reserve Bank of New Zealand, makes similar arguments, eg *'I have not the slightest doubt that having legislation which requires government and central bank to formally agree, and disclose to the public, the inflation rate which the central bank must target has a most useful role in creating strong incentives for good fiscal policy.'* He offers several real world examples of how this has occured.

they show that the leader may not always surely-win the game: its commitment/rigidity may be insufficiently strong, in the interval $\frac{1}{\int_0^1 (1-R_i(t))\mathrm{d}t} \in (1, T_i)$. In fact, under some circumstances the non-dominance region may be much larger than the two dominance regions. Second, they identify several variables that determine the required degree of commitment/rigidity for a policy to fully dominate. In particular, the thresholds T_F and T_M in (10)-(11) are increasing functions of the leader's conflict costs relative to his victory gain - in Downturn and Normal times weighted by the probability p. Third, they show how uncertainty about the business cycle and the potential costs of deflation may play a role in the effectiveness of institutional design features such as an explicit inflation target. Specifically, if the cost/gain in Downturn exceeds that in Normal times then T_F and T_M are increasing in p. This reduces the range of parameters over which the socially optimal outcomes occur, and increases the range of parameters that may lead to deflation, giving a very different message from that under static leadership.

It is straightforward to see that under the alternative assumption of the dominant policymaker preferring to respond to the underlying adverse shock himself the intuition is unchanged. In such case, if (10)-(11) hold then the dominant policymaker has the power to force the dominated one *not* to respond to the shock, and thus ensure his preferred Downturn outcomes. The only difference is the form of the potential policy conflict. As both policies prefer to respond, the potential tug-of-war in the Downturn scenario would no longer be a waiting game with neither policy responding, but one with both policies responding aggressively.

6. Extension: Monetary Union with Three Types of Governments

Our benchmark setup focused on the frequently studied case of a responsible central bank facing an *ambitious* government, F^A. This section introduces two additional types of government: *responsible*, F^R, and *ultra-ambitious*, F^U. We do so in the context of a monetary union with a common central bank headed by a responsible governor as in our benchmark specification. But it will be apparent that the analysis can also be interpreted as a single country setting in which the central bank has incomplete information about the type of government $i \in \{A, R, U\}$ it is facing.[26]

To allow the latter interpretation, and make the analysis illustrative we will focus on the case in which the timing of F moves is the same across the three types of governments. This seems natural as the principal opportunity of countries to change their F stance happens in the annual budget.

Denote the proportion of the F^A, F^R and F^U types of government in the union by f^A, f^R and f^U respectively, where $f^A + f^R + f^U = 1$.[27] The overall payoff of the common central bank is a weighted average of the payoffs obtained from interactions with each

[26]The policy interaction thus features two layers of uncertainty: about economic conditions and the opponent's type. Both of them seem realistic in the post-GFC environment.

[27]These proportions can express the relative number of such countries, or can be weighted by their economic size - whichever is more relevant in the particular M union. In a single country interpretation, these proportions are the probabilities of the respective government's type as percieved by the central bank.

government type i, using the weights f^i. The payoff of each government type is directly determined by its own stance and that of the common central bank.[28]

A responsible government will be assumed to prefer the socially optimal outcomes, her payoff satisfying

$$w_R > y_R > z_R > x_R \text{ and } x'_R > z'_R > y'_R > w'_R.$$

Using the policy parameter values utilized in (3) and (7) with one change, we can achieve this by sufficiently increasing the government's aversion to reneging on promises in a Downturn, and by sufficiently decreasing it in Normal times.[29]

		F^R	
		PF	AF
M	AM	Ricardian (Nash) **0, 6**	tug-of-war $-4, -4$
	PM	tug-of-war $-4.05, 2.75$	monetization/FTPL $-3.8, 0$

Normal times (responsible F)

		F^R	
		PF'	AF'
M	AM'	deflation $-9, -15$	recovery (Nash) $\mathbf{-4, -4}$
	PM'	recovery $-4.05, -6.25$	over-stimulating $-8.8, -5$

Downturn (responsible F)

We have a symbiosis scenario in both the Downturn and Normal times. This is because both games have a unique Pareto-efficient Nash equilibrium, consisting of the preferred outcome for both players and coinciding with the socially optimal outcome $(AM', AF'; AM, PF)$. This means that if all governments in the union are responsible (or, under the single country interpretation, the probability of a responsible government is unity), this outcome will obtain under all parameter values and any timing of moves (leadership). Put differently, deflation, over-stimulating, and F spillovers never occur even if the degree of M commitment is low.

In contrast, we assume that ultra-ambitious governments are unwilling to coordinate with the central bank. This reflects a free-riding problem in a M union, present primarily in small member countries. Intuitively, the political benefits of excessive spending in an individual member country accrue predominantly to the indisciplined government itself, whereas the cost (negative externality) in terms of higher interest rates and risk is spread across all union members. Therefore, if a country only forms a small part of the union, and does not internalize this negative externality it imposes on fellow members, it may be unwilling to change its excessive F stance even if the common central bank is known to be pursuing AM.[30] Formally, the payoffs satisfy:

$$z_U > x_U > w_U > y_U \text{ and } y'_U > w'_U > x'_U > z'_U.$$

Conversely to the case of a responsible F, we can achieve this by sufficiently decreasing the government's aversion to reneging on promises in a Downturn, and by sufficiently

[28]Indirectly, the actions of other governments in a M union also have an impact since they determine the incentives of the common central bank, and hence the equilibrium outcomes.

[29]The following matrices alter $\delta_F = 3$ in (20) to $\delta_F = 6$ in the Downturn and $\delta_F = -6$ in Normal times.

[30]For a formal modelling of this free-riding in a M union see Libich, Savage and Stehlík (2010).

increasing it in Normal times.[31]

		F^U	
		PF	AF
M	AM	Ricardian $0, -6$	tug-of-war $-4, -4$
	PM	tug-of-war $-4.05, -6.25$	monetization/FTPL (Nash) $\mathbf{-3.8, 0}$

Normal times (ultra-ambitious F)

		F^U	
		PF'	AF'
M	AM'	deflation $-9, -3$	recovery $-4, -4$
	PM'	recovery (Nash) $\mathbf{-4.05, 5.75}$	over-stimulating $-8.8, -5$

Downturn (ultra-ambitious F)

Both games now have a unique Pareto-efficient Nash equilibrium: (PM', PF') and (PM, AF). Nevertheless, these equilibria do *not* coincide with the central banker's preferred and socially optimal outcomes. This means that if all governments in the union are ultra-ambitious, deflation and over-stimulating never occur in the short-term regardless of the degree of M commitment. This is because the common central bank is induced to provide the required stimulus. Nevertheless, F spillovers occur with certainty, and this is true even if the central bank is infinitely strongly committed relative to F rigidity, $\frac{1}{\int_0^1 (1 - R_F(t))\,\mathrm{d}t} \to \infty$.[32]

The above implies that the preferred subgame perfect equilibrium of F^R is the same as M's, whereas F^U shares his preferred equilibrium with F^A. We may therefore see the common central bank joining forces with the responsible governments to better 'battle' the 'coalition' of the (ultra) ambitious governments. The following proposition is a generalization of Proposition 2, indicating which coalition dominates, if any.

Proposition 3. *(i) **(ambition-dominance)** F spillovers onto M policy surely occur iff (10) holds, for which a necessary condition is that the proportion of responsible governments in the union (or probability of the responsible government type in a single country) is sufficiently low*

$$f^R < \underline{f^R} = \frac{p(c' - a') + (1 - p)(d - b)}{p(b' - d' + c' - a') + (1 - p)(a - c + d - b)}. \tag{12}$$

Then and only then deflation is surely avoided under all types of government.
*(ii) **(responsibility-dominance)** F spillovers onto M policy surely do not occur iff the proportion of responsible governments in the union is sufficiently high*

(13)
$$\frac{1}{\int_0^1 (1 - R_F(t))\,\mathrm{d}t} > T_F =$$
$$\frac{f^A\,[p(b' - a') + (1 - p)(a - b)]}{f^A[p(b' - c') + (1 - p)(a - d)] + f^R[p(b' - d') + (1 - p)(a - c)] - f^U[p(c' - a') + (1 - p)(d - b)]},$$

[31] The following matrices alter $\delta_F = 3$ in (20) to $\delta_F = -6$ in the Downturn and $\delta_F = 6$ in Normal times.

[32] Arguably, an ultra-ambitious government is more likely in a currency union than in a single country. This is not only because the common central bank cannot effectively punish mis-behaving governments, but also because financial markets tend to defer their punishment due to the possibility of bailout by fellow members.

for which a necessary condition is

$$f^R \geq \overline{f^R} = \frac{f^U[p(b'-a')+(1-p)(a-b)]-[p(b'-c')+(1-p)(a-d)]}{[p(c'-d')+(1-p)(d-c)]}. \tag{14}$$

While avoided in countries with responsible and ambitious governments, deflation surely occurs in the short-run in countries with ultra-ambitious governments.
(iii) ***(non-dominance)*** *If neither (12) nor (13) hold then F spillovers onto M policy may or may not occur in the long-run. Furthermore, deflation may occur in the short-run under all types of governments.*

Proof. See Appendix C. □

The intuition of our benchmark dynamic leadership results carries over. What determines the outcomes of the policy interaction is the degree of M commitment of the common central bank relative to the degrees of F rigidity of ambitious governments, as well as uncertainty and the policymakers' conflict costs and victory gains over the business cycle.

The additional contribution is to show how responsible governments potentially improve the outcomes, and ultra-ambitious governments (free-riding) make them worse. In particular, if countries with responsible governments make up a large enough part of the M union, then a strongly committed central bank is willing to undergo the conflict with the remaining ambitious and ultra-ambitious governments, with the support of the responsible government types. It knows that ambitious governments will comply in both the short-term and long-term, and hence the exit strategy will be successful. Nevertheless, the ultra-ambitious governments will not do so, which will in such countries lead to a double-dip recession/deflation in the short-term, and continued F excesses in the long-term. Obviously, this may mean a forced departure of such free-riding country from the M union the modelling of which is beyond the scope of this paper.

If the M union is composed primarily of the ultra-ambitious governments (or, in the single country interpretation, the central bank perceives the probability of the ultra-ambitious government type to be above a certain threshold), then even an infinitely strong M commitment may not ensure avoiding F spillovers. Formally, if $f^R < \overline{f^R}\left(f^U\right)$ then the T_F threshold in (13) does not exist, and hence even if all types of government can revise their stance instantly, $\int_0^1 R_F(t)\mathrm{d}t = 1$, the conflict with the F^U types would be too costly for M. This means that in Figure 3 there would only be two rather than three equilibrium regions: the M-dominance region disappears. It will be interesting to follow the developments in the European monetary union and see in which equilibrium regime the Eurozone ends up.

7. Summary and Conclusions

The post-GFC situation of continued economic weakness combined with dire long-term F projections poses unprecedented challenges for policymakers. The paper attempts to provide some insights into the possible macroeconomic outcomes, and offers some policy recommendations - both in a single country and a currency union setting.

To do so we postulate a game theoretic framework with generalized timing of moves. This allows us to examine the *strategic* aspect of monetary-fiscal policy interactions, unaccounted for in standard macroeconomic models. Our analysis provides a link between the short-run (stabilization) considerations and long-run (sustainability) considerations under incomplete information about the business cycle conditions.

Allowing for stochastic revisions and asynchronous timing of actions enables us to postulate the concepts of long-term M commitment and F rigidity relating to the policies' inability to alter its previous stance. We show that the outcomes of the policy interaction, both short-term and long-term, depend on these institutional features as well as uncertainty, structural factors, and the central bank's and government's preferences that all affect the magnitude of a potential policy conflict in various phases of the business cycle.

Importantly, in addition to the standard M-dominance and F-dominance cases of Sargent and Wallace (1981), we identify an intermediate non-dominance case where the intuition differs from conventional results. Most strikingly, deflation can occur in the aftermath of a Downturn, and in fact the more deflation averse policymakers are the more likely deflation is.

We derive thresholds T_F and T_M that separate these three cases. Given that the magnitudes of the variables affecting these thresholds differ across countries, our analysis offers an explanation for the observed differences in institutional design of both policies. For example, it may explain why some countries legislated a numerical target for average inflation in the early 1990s whereas others have not, and why F policy has improved in some countries since then but deteriorated in others.

While more research is required to provide definitive answers regarding the desirability of such M commitment for individual countries, the paper offers a general lesson: in uncertain times M policy may need to be committed more strongly/explicitly to cater for a likely increase in the magnitude of the conflict cost. In particular, our analysis implies that in the presence of a F gap and absence of a legislated commitment to an inflation target, M policy will be the reviser (follower) in the game as in Sargent and Wallace (1981). This will yield the undesirable F-dominance scenario in which F excesses spill over to M policy, and the M exit from the extraordinary GFC actions proves unsuccessful. Given that the probability p of adverse economic conditions varies over the course of the business cycle the implication is that an explicit commitment serves as a credibility insurance of M policy against F pressure and spillovers.

Interestingly, we show that such M commitment may not only improve the outcomes of M policy, but also discipline the government and lead to superior long-term F outcomes too. Franta, Libich, and Stehlík (2011) provide empirical evidence for such disciplining effect by comparing F outcomes of inflation targeters pre-adoption and post-adoption, and contrasting them with F outcomes of non-targeters.

In all early adopters of the regime (New Zealand, Canada, United Kingdom, Sweden, and Australia) F outcomes started improving 1-3 years after the adoption of the regime (in the case of the UK after the subsequent granting of central bank instrument independence). In contrast, F outcomes have not changed or worsened in major non-targeters (United States, Switzerland, and Japan) over this period. This is in line with the authors' evidence from a Structural Vector Autoregression model estimated with Bayesian techniques. Introduction of an explicit inflation target usually led to a change in the direction of the central bank's responses to government spending/debt shocks from accommodative to pro-active. In non-targeting countries the changes have been mainly in the opposite direction.

As an important caveat, it was shown that such disciplining by the central bank may be ineffective against some (ultra-ambitious) types of governments. These are more likely in a M union due to incentives for free-riding of (especially small) member countries. This may explain the fact that despite the European Central Bank's explicit inflation commitment F outcomes have generally been unsatisfactory. Therefore, in such countries politicians' incentives need to be altered directly by implementing enforceable F rules [for convincing arguments see eg Leeper (2010)]. These can be modelled in our setup by reducing the government's aversion to a F reform in Normal times (effectively making them responsible as per our M union extension - converting them to the F^R types); and at the same time allowing them to change the newly embarked upon PF stance only with a very low probability.[33]

The fact that only a handful of countries have implemented some sort of binding Fiscal Responsibility Act with explicit and accountable F targets suggests that the political reality of such an institutional reform may be difficult. The outcomes in Europe teach us that even if legislated, such arrangements may lack traction as they are hard to enforce - especially in a M union [for a discussion see Libich, Savage, and Stehlík (2010)].

Let us mention three issues regarding the robustness of our findings. First, considering other classes of games would not change our main insights that, under some but not all circumstances: (i) a stronger M commitment reduces the probability of deflation in the short-term and of F spillovers in the long-term; and that (ii) the effectiveness of this depends on economic conditions and the type of government. As the extension showed our results obtain weakly (only in some but not all classes of games).[34]

Second, Basov, Libich, and Stehlík (2011) allow both players to revise their initial actions on $t \in [0, 1]$, and imply that the nature of our results would be unchanged. This is because what matters in coordination and anti-coordination games are the *relative* (rather than absolute) degrees of the players' commitment/rigidity, ie the likelihood and speed of F policy changing its stance relative to M policy.

Third, our long-term M commitment concept is compatible with the timeless perspective pre-commitment of Woodford (1999) or quasi-commitment of Schaumburg and Tambalotti (2007). This is because it does not prescribe (a rule for) *how* actions need to be dynamically changed in response to disturbances, it only restricts the frequency with which the policy stance can be altered. This implies that an explicit numerical target for average inflation does not necessarily reduce the policy's flexibility to respond to shocks: for formal modelling of this see Libich (2011). As Brash (2011) reflects on his experience as central bank Governor: *'An inflation target is only a strait jacket if it is*

[33]This would be likely to alter the incentives and payoffs of the central bank in the Downturn scenario. As there is no long-term problem, the central bank would be more willing to stimulate the economy and play PM'.

[34]For example in the Prisoner's Dilemma game a player's commitment/rigidity does not help escape the inefficient equilibrium, but it does not 'hurt' the respective player either.

badly designed. All those with which I'm familiar allow for monetary policy to respond flexibly and predictably to exogenous shocks...'

8. References

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Appendix A. The Macroeconomic Intuition of the Normal Times Scenario

A.1. **Fiscal Stress.** Our exposition of intertemporal problems draws on Leeper and Walker (2011). In order to better highlight the key issues regarding F stress - that are of a long-term nature - we will suppress the dynamics and consider two periods only: period 0 represents the past, and period 1 represents the future[35]

$$R_1 B_1 - \lambda \frac{Z_1 - T_1}{P_1} = R_0 B_0, \tag{15}$$

where B is the stock of bonds, R is the applicable gross nominal interest rate, and P_1 is the future price level. $Z_1 - T_1$ is the level of *future net transfers* (transfers Z_1 minus taxes T_1) *promised* to the households by the existing legislation - in nominal terms

[35] In the current situation it is certainly important to understand the dynamics of debt, and how it is affected as the economy approaches its F limit. Nevertheless, from a long-term perspective represented by the Normal times scenario what really matters is the *average stance* of the policies.

('dollars'). In contrast, $\lambda(Z_1 - T_1)$ is the *actual* (delivered) level of future net transfers. This implies that $(1 - \lambda_t) \in [0, 1]$ can be interpreted as a *reneging* parameter, and that $\frac{\lambda(Z_1 - T_1)}{P_1}$ expresses the delivered net transfers in real terms ('goods').

Intuitively, existing debt including interest payments must be paid for by future primary surpluses or by issuing new bonds. Further, promised net transfers can be reneged upon by the government, or their real value inflated away by the central bank. We can discuss the two main *sources* of F stress using (15):

1. **Past fiscal excesses** or **bank bailouts** (eg Greece and Ireland respectively): high B_0, usually also associated with high R_0 due to a risk premium.
2. **Future demographic trends (aging population)**: $Z_1 > T_1$.

In order to streamline the analysis and focus on advanced economies we will follow Leeper and Walker (2011) and highlight the latter source of F stress. They do so by postulating the promised transfers variable Z_1 as an exogenous AR(1) process - possibly divorced from T_1 and hence from the sustainable path. Since our budget constraint (15) abstracts from the dynamics of debt we can simply incorporate a fiscal gap by imposing

$$Z_1 - T_1 > 0. \tag{16}$$

What are the possible *solutions* to this gap? They can be summarized as follows:

1. **Structural fiscal reform**: reducing Z_1 and/or increasing T_1 to ensure the required level of $Z_1 - T_1 \leq 0$.
2. **Reneging on promises**: $\lambda = 0$.
3. **Monetization/FTPL** [ala Sargent and Wallace (1981) and Leeper (1991) respectively]: increase in P_1.
4. (only temporary) **Borrowing**: growing debt $B_1 > B_0$.

We explicitly examine solution 2. in which F policy is passive and adjusts λ, and solution 3. in which M policy is passive and adjusts P_1. We consider the former solution to be socially optimal to highlight the fact that F settings should be balanced over the long term.[36] The above reduced-form setup implies that λ and P can be treated directly as instruments of F and M policy respectively.

A.2. **Active and Passive Policies.** Due to our focus on steady-state outcomes we define A vs P policies differently from Leeper (1991). In his analysis each policy follows a simple dynamic rule. Specifically, the central bank responds to deviations of the price level from its target, $P - P^T$, with a change in its interest rate instrument. The government responds to deviations of real debt from its target, $\frac{B}{P} - b^T$, by adjusting promised net transfers $Z_1 - T_1$ (or, equivalently in the above setup, the reneging parameter λ). If the policymakers respond sufficiently aggressively to the observed deviation to stabilize their targeted variable, the policies are called AM and PF. If they respond insufficiently strongly they are labelled PM and AF.

Intuitively, Leeper's (1991) A and P policies refer to *the degree of adjustment of the policy instrument for the purposes of balancing the budget constraint*, which we follow.[37]

[36]Obviously, sovereign default may be an optimal short-term solution for an individual country.

[37]As Davig and Leeper (2011) explain: *'an active authority is not constrained by current budgetary conditions'*, whereas a passive authority *'maintains the value of government debt'* and *'is constrained by consumer optimization and the active authority's actions'*.

His analysis however does not pin down the exact strength of policy responses, A and P are defined as a parameter *range* for each policy. To overcome this multiplicity, we depict the two most natural candidates (polar cases) for each regime.

Definition 2. *An* ***active policy stance,*** AM/AF*, is such that it provides no adjustment at all to balance the budget constraint (15). In contrast, a* ***passive policy stance,*** PM/PF*, is a level* P^* *and* λ^* *respectively that provides the full adjustment necessary to balance the budget constraint and keep stable real debt - independently of the other policy (ie assuming the other policy plays A). Formally:*
(i) active fiscal policy AF*: choosing* $\lambda = 1$*;*
(ii) active monetary policy AM*: choosing* $P_1 = P^T$*;*
(iii) passive fiscal policy PF*: choosing* $\lambda^* \left(P_1 = P^T, b^T, Z_1, T_1, R_0, B_0\right) < 1$*;*
(iv) passive monetary policy PM*: choosing* $P_1^* \left(\lambda = 1, b^T, Z_1, T_1, R_0, B_0\right) > P^T$*.*

To derive λ^* and P_1^* let us reduce the number of free parameters by normalizing: (a) $R_0 = R_1 = 1$ (which can be interpreted as the 'no discounting' case, and which we will maintain throughout for parsimony), (b) $B_0 = 1$ (which we will consider to be the socially optimal nominal debt level), (c) $P^T = 1$, which implies (d) the social optimal level of real debt, $b^T = 1$, and (e) $Z_1 - T_1 = 2$. Imposing these with $P_1 = P^T$ in (15) yields $B_1 = B_0$, which implies $\lambda^* = 0$. Similarly, the value P_1^* is obtained from (15) by imposing $\lambda = 1$ and $\frac{B_1}{P_1} = b^T = 1$, namely $P_1^* = 2$. Using these normalizations with (15)-(16) and Definition 2 the Normal times outcomes in the four policy regimes are as follows:

(17)

		F	
		PF $(\lambda^* = 0)$	AF $(\lambda = 1)$
M	AM	$\frac{B_1}{P_1} = \frac{1}{1} = b^T$	$\frac{B_1}{P_1} = \frac{3}{1} > b^T$
	PM	$\frac{B_1}{P_1} = \frac{1}{2} < b^T$	$\frac{B_1}{P_1} = \frac{2}{2} = b^T$

A.3. **Policy Preferences.** In order to map the budget constraint to the game theoretic representation (1), we will postulate the policymakers' utility functions - in a way consistent with the standard intuition of the dynamic policy rules of Leeper (1991). The preferences can be summarized as follows:

$$U_i = -\phi_i (P_1 - P^T)^2 - \left(\frac{B_1}{P_1} - b^T\right)^2 - \delta_i (1 - \lambda)^2, \tag{18}$$

where $i \in \{M, F\}, \phi_i \geq 0$ is the degree of the policymakers' inflation conservatism relative to debt conservatism, and $\delta_i \geq 0$ denotes their aversion to reneging on promised net transfers relative to debt variability.[38] To highlight the primary target of each policy these weights will satisfy:

$$\phi_M > 1 > \delta_M = 0 \quad \text{and} \quad \delta_F > \phi_F = 0. \tag{19}$$

We could now postulate the rest of the macroeconomic structure, and derive an optimal setting of the policies through constrained optimization. For our purposes it would

[38] Note that debt variability is closely positively related to output variability, which is a standard component of the central bank's reduced-form preferences.

however be both a distraction incurring some loss of generality (applicability to a large range of macroeconomic models), and a restriction in terms of the institutional features that can be considered. This is because one can only examine three possible timing scenarios: the simultaneous move, static M leadership, and static F leadership, see eg Dixit and Lambertini (2003). In contrast, our generalized timing of moves will capture dynamic M and F leadership, ie any relative degree of M commitment and F rigidity. To ensure insights are not lost we have selected the most natural candidates for the active/passive policy stance in Definition 2 [for the same mapping of a macro setup to a game theoretic representation see eg Cho and Matsui (2005)].

A.4. **Mapping to the Game Representation.** Combining (17) with (18)-(19) then implies the following payoffs matrix:

		F	
		PF	AF
M	AM	$0, -\delta_F$	$-4, -4$
	PM	$-\phi_M - \frac{1}{4}, -\delta_F - \frac{1}{4}$	$-\phi_M, 0$

Naturally, we need to impose that $\max\{\phi_M, \delta_F\} < 4$ to ensure that in Normal times the unsustainable regime with explosive debt (AM, AF) is inferior for both policymakers to the regimes (AM, PF) and (PM, AF) in which the budget constraint is balanced. This, with no further assumptions required, implies that we have the Game of Chicken in Normal times summarized by (2), and why most of the literature has used this class of game. To offer a specific example, set

$$\phi_M = 3.8 \quad \text{and} \quad \delta_F = 3, \tag{20}$$

used in the payoff matrices (3) and (7) in the main text.

Appendix B. Proof of Proposition 2

Proof. Focus on claim (i) whereby F is the leader. Solving by backwards induction, F knows that when M's revision opportunity comes up, M will play his static best response to F's initial play: both in Downturn and Normal times. Therefore, for F to surely-win the game and always play PF' and AF, it is required that F is willing to undergo a costly conflict with M: both in Downturn and Normal times. In other words, both PF' and AF have to be the unique best responses not only to PM' and PM respectively, but also to AM' and AM. This will be the case if the subsequent (post-revision) victory gain is sufficiently high to compensate F for the initial conflict cost. Formally, the following incentive compatibility condition needs to hold:

$$p\left(\overbrace{\underbrace{w'\int_0^1 (1-R_M(t))\,\mathrm{d}t}_{(AM',PF')\text{: conflict}} + \underbrace{y'\int_0^1 R_M(t)\mathrm{d}t}_{(PM',PF')\text{: victory}}}^{\text{Downturn}}\right) + (1-p)\left(\overbrace{\underbrace{x\int_0^1 (1-R_M(t))\,\mathrm{d}t}_{(AM,AF)\text{: conflict}} + \underbrace{z\int_0^1 R_M(t)\mathrm{d}t}_{(PM,AF)\text{: victory}}}^{\text{Normal times}}\right) >$$

$$\underbrace{px'}_{(AM',AF')\text{: surrender (Downturn)}} + \underbrace{(1-p)\,w}_{(AM,PF)\text{: surrender (Normal times)}}.$$

Rearranging yields condition (10) and proves claim (i). The proof of claim (ii), made under M being the leader, is analogous due to the symmetry. The proof also implies that unless both (10) and (11) hold there exist multiple types of subgame perfect equilibrium payoffs, so neither player surely-wins. This means that both short-term deflation and long-term F-M spillovers may occur in this intermediate non-dominance region. This completes the proof. □

Appendix C. Proof of Proposition 3

Proof. Focus on claim (i) in which M is the reviser, and solve backwards. When M's revision opportunity arrives his best response to the ambitious governments' (PF', AF) must uniquely be (PM', PM). Formally, we have the following necessary condition

$$\begin{aligned} p\left(f^A c' + f^R d' + f^U c'\right) + (1-p)\left(f^A d + f^R c + f^U d\right) > \\ p\left(f^A a' + f^R b' + f^U a'\right) + (1-p)\left(f^A b + f^R a + f^U b\right), \end{aligned} \tag{21}$$

which, after rearranging, yields (12). Intuitively, the proportion (probability) of the F^A and F^U types, relative to the F^R type, has to be sufficiently high to sway M to comply with them. If satisfied, the central bank would choose to go into conflict with the F^R government types rather than the F^A and F^U types to minimize its associated conflict cost. This is despite the bank being postulated as responsible.

Moving backwards, at time $t = 0$ both the F^A and F^U types of government have to play uniquely (PF', AF) in equilibrium, regardless of M's initial play. For F^U this is automatically satisfied (as she has a strictly dominant strategy in the underlying game), and for F^A this is - assuming (21) holds - ensured by (10) derived in the benchmark specification. Then we know that the exit strategy will surely be unsuccessful, as M will play (PM', PM) from $t = 0$.

In terms of claim (ii), M knows that while the actions of F^R and F^U type governments are independent of M's actions, the F^A type's revision will be the static best response to M's initial play. Using this information implies that for M to uniquely play (AM', AM) the following incentive compatibility has to hold

$$\begin{gathered} f^A\left\{p\left[a'\int_0^1(1-R_F(t))dt + b'\int_0^1 R_F(t)dt\right] + (1-p)\left[b\int_0^1(1-R_F(t))dt + a\int_0^1 R_F(t)dt\right]\right\} + \\ f^R[pb' + (1-p)a] + f^U[pa' + (1-p)b] > \\ f^A[pc' + (1-p)d] + f^R[pd' + (1-p)c] + f^U[pc' + (1-p)d]. \end{gathered}$$

This, after rearranging, yields (13), which is just a generalized version of (11) with three types of governments (and nests the benchmark case of $f^R = f^U = 0$). Equation (13) suggests that if its denominator is non-positive then the T_F threshold does not exist. This implies the necessary condition (14) and completes the proof. □