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# Financial stability: To Regulate or Not? A public choice inquiry

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## Abstract

The paper takes the stand that the central banks as financial regulators have their own interest in imposing more regulations. It models the institutional behaviour for the central bank and government using the Indirect Inference testing and estimation method as it finds a set of coefficients of the model that can generate the actual observed behaviour for the US. The paper establishes that good monetary policy can reduce instability. Regulation at worst destabilises the economy and at best contributes little to stabilise the economy. After the financial crisis, financial regulations were too severe and thus actually increased instability.

Keywords: DSGE, Regulations, Financial Stability, Monetary Policy

JEL classification: E10; E58; G28

Since the recent financial crisis central banks have been given more responsibilities as financial regulators for macro-prudential supervision. The idea is that since they conduct monetary policy, they are in the perfect position to observe macroeconomic developments and therefore anticipate threats to financial stability. Financial stability affects price stability and the monetary policy transmission process to the point that central banks recognise that they cannot ignore it (Blinder, 2010; Goodhart and Schoemaker, 1995). The justification for this financial stability agenda arises from the social effects of bank failures. First, banks are supposed to mitigate an asymmetric information problem between savers and borrowers. But if they fail, borrowers are left without credit which cannot be replaced from other sources. Second, a bank's failure can cause financial contagion, as the lenders doubt the health of the financial system and withdraw deposits. Lastly, the cost of default on small depositors is considered to be politically intolerable. Thus the aim of these financial stability regulations is to offset the market failures caused by the existence of monopoly power, externalities and information asymmetries, and thus enhance social welfare.

Traditionally, if we followed the public interest approach to regulations, we would believe that in their role as a financial regulator, central banks would wish to conduct their regulatory operations in the most efficient manner without political and personal bias. However, this ignores the possibility that concentrating more supervisory powers in the hands of central bankers could make them more prone to be manipulated by the banking industry itself or to pursue other objectives, such as political power or bureaucratic and other private rewards. The public choice approach based on private interest (Stigler, 1971) argues that regulators do not maximise social welfare but rather their own welfare. Buchanan (1980) argued that individuals who behave selfishly in markets can hardly behave wholly altruistically in political life. These researchers show that we cannot take for granted that regulators will act in the interests of society as a whole. It is a possibility that regulators abuse their power and force banks to divert the flow of credit to satisfy the private interests of regulators. The more power the regulator has, the less efficient the banking system and the more corruption in the lending process (Barth et al, 2004; Quintyn and Taylor, 2002). Barth et al. (2006) concluded that Stigler and Buchanan were correct: the structure of banking regulation and policy in most of the world ultimately benefits the private interests of government officials and bankers.

In this paper we explore this public choice approach to central banks and question the idea that they are benevolent pursuers of the public interest. We note that the financial crisis starting in 2007 was preceded by a credit boom that central banks could have avoided; that the Lehman crisis itself could have been prevented by concerted central bank action; and that the period of recovery from the crisis was hampered by a surge in bank regulation that prevented credit expansion. This triple failure of central banks sits poorly with the idea that they were devoted to the public-spirited aims of preventing and ameliorating the crisis.

We build a theoretical model of the regulative behaviour of the central bank; we estimate and test this model against the raw data. From the policy viewpoint we question the appropriateness of rigid and aggressive regulatory control of the financial system, and ask whether it is the only way to reduce future financial instability. The analysis that we make, based on the public choice approach, assumes that regulators have their own interests which they maximise. We model the choices made by the central bank and the government subject to their constraints: the ‘Institutional Model’. We combine this institutional behaviour with a macroeconomic model for the US to analyse whether the Institutional Model we propose here was likely to have generated the actual institutional behaviour that we observe in the data — using the Indirect Inference method to check this match between model simulated behaviour and data behaviour. As far as we are aware this is the first attempt to model regulatory behaviour and how regulation is formed as well as its impact on macroeconomic stability, and provide empirical support for such a model.

The paper is organised as follows. Section 1 presents the model for the choices made by the central bank and the government. Section 2 shows how, according to our model of the US, different policy choices in monetary policy and regulation affect overall economic stability. Section 3 constructs our Institutional Model to conform qualitatively with these relationships and estimates and tests the resulting model by Indirect Inference. Section 4 concludes.

## 1 Modelling regulation

### 1.1 How to model the private interest of central banks?

We follow the approach of Niskanen (1971). He assumed that regulators seek to maximise their private utilities. If they could, they would use the regulations and their power to increase their income, but due to the nature of their job as civil servants, they cannot exploit the market to raise income. Therefore, they resort to maximising utility from pursuing non-pecuniary goals such as prestige, reputation, an expansion of authority and power, feelings of control, their salary, and a greater budget to spend. Most of these factors are related to the size of the agency. We can generalise this argument to financial regulators and thus to central banks. We therefore model the central bank as aiming to maximise the size of the agency by imposing more financial regulations in order to obtain the biggest non-pecuniary benefits. This behaviour leads to an excessive number of regulative officials and an excessive volume of regulations. These in turn result in inefficiency. It is easy to think of a regulator as a monopolist. If the regulator is free to set the price for its service, it would set the level where the total revenue is maximised. However, it cannot choose the price because the price is the cost per unit of service delivered, so to increase the revenue it increases the size and thus decreases the efficiency. We have to note that the growth in regulators’ size is only possible because politicians have their own interest in allowing this to happen. That is, the size of a regulator is positively correlated with the extent of regulations, as motivated by the regulator’s private interests. Across developed countries, there is evidence that central banks as regulators either reduced or did not aggressively raise their size prior to the financial crisis, but since then they have almost all increased the numbers of their employees (Figure 1).

### 1.2 How to model the relationship between social welfare and regulation?

On the other hand, financial regulators need to care also about how their regulations impact on the macroeconomic and financial environment, since without a reasonable impact their role will be put at risk. Their ultimate goal for society needs to be to maintain stability in inflation and output which can be achieved partly through financial stability. Therefore, from the welfare-maximising point of view, a central bank also has to ensure financial stability. In the literature, it is common to find the assumption and also the conclusion that the more banking regulation there is, the better financial stability, and thus better welfare (Brunnermeier and Sannikov, 2016). This rationale can be understood with an example of the most widely-used form of macro-prudential regulation, capital adequacy requirements. Capital serves as a buffer against losses, and hence failure, and it is important when deposit insurance is in place. The idea is that due to asymmetric information in the financial market, depositors are faced with an adverse selection problem: they have a high incentive to withdraw funds all at once in the event of bad news which can result in a bank run. Deposit insurance acts like a safety net to stop this from happening, but it creates a moral hazard problem as banks

have an incentive to increase risk taking. Capital requirements ensure that banks maintain costly capital against risky assets to offset this moral hazard (Berger, Herring and Szego, 1995; Kaufman, 1991; Furlong and Keeley, 1989; Keeley and Furlong, 1990). Tayler and Zilberman (2016) advocated macroprudential policy in the form of Basel III that focused on forcing banks to increase the quality of their assets, to raise the capital/asset ratio and to hold countercyclical capital buffers. They argue this macroprudential approach is optimal and better than the use of Taylor Rules in a period of financial distress. It can deliver both financial and economic stability.

However, this view is disputed. For example, Kahane (1977), Koehn and Santomero (1980), Kim and Santomero (1988), Besanko and Katanas (1996) and Blum (1999) argue that capital requirements can lead to an increase in bank risk taking behaviour — to offset the cost of the extra capital imposed on normal banking activity, given that it is extraordinarily difficult for regulators to set capital standards that mimic those that would be demanded by well informed, undistorted private market agents. Thus, more regulations can create more risk and a wider credit spread, with negative effects on financial stability and ultimately on welfare.

For example, higher capital requirements can force capital deficient banks to raise significant amounts of capital, which might not be their optimal level. This means that their capital structure is now sub-optimal and their value falls. With higher capital holding they will have less ability to get deposit insurance subsidies. Altogether this leads to a higher cost of capital. Gorton and Pennacchi (1990) argue that bank equity is uniquely costly, and that this cost comes from the role of demand deposits as an efficient means of exchange: forcing banks to increase capital means that in general equilibrium, consumers must hold more bank equity — the less preferred medium of exchange — in aggregate and therefore demand a higher expected return on equity in compensation, so raising the cost of capital.

Another form of regulation is a tax levied on banks. Banks take deposits and pay an interest rate on them. These deposits are used to produce loans for which the bank charges a loan interest rate. The bank's profit margin on a loan is determined by the spread between the loan rate and the deposit rate (plus default and other costs). Therefore, any tax imposed on the bank will be borne not only by the bank (by accepting lower profits), but also the depositors (by paying a lower interest rate on deposits), and/or the borrowers (by charging them higher interest rates on loans). Either way, the market is distorted.

### 1.3 A way to look at these choices

We are dealing here with strategic choices made by the government and the central bank, to whom two main tasks are delegated: a monetary rule and the management of macro-prudential policy. The latter policy involves significant internal organisation by the central bank in a way that is simply unobservable to the outside world including government. We can only observe the results in the form of stability (the inverse of the economy's variability) and the total size of the central bank bureaucracy.

There is a model of the economy which all can consult: we will assume it is like the one we set out in Le et al. (2016) — the widely-used Smets and Wouters (2007) model with various extensions to deal with banks, the zero lower bound, the monetary base and Quantitative Easing (QE), which we found could fit the data behaviour well on our Indirect Inference test<sup>1</sup>. From this model of the economy we would like to construct a model of institutional behaviour, which we will call our Institutional Model — the main focus of this paper. Using this model, we can discover the effects of different monetary rules on Stability ( $S$ ), given the overall size of the Central Bank ( $P$ , for its Power); we do this from our simulations of the model for different monetary rules. We can also discover the effects of  $P$  on  $S$  by positing a macro-prudential Rule that focuses on the credit premium,  $pm$ . We can do this as follows.

In order to include regulation in our model of the economy to allow for the analysis of the effects of such policy on the economy, we review the credit premium equation. The  $pm$  function depends on model variables including the monetary base,  $m_t$ , and also an error term,  $\epsilon_t$ , plus a regulation error term,  $\eta_t$ :

$$pm_t = f(m_t) + \epsilon_t + \eta_t.$$

Now assume that  $\eta_t$  becomes an explicit macro-prudential instrument targeted on  $pm$  as:  $\eta_t = \kappa\mu_t$  where  $\kappa$  is the level of the importance and resources given by the government to the regulatory function and

<sup>1</sup>The model is relatively familiar and standard, therefore we do not set out in detail, but list the equations in the Appendix.

$\mu_t = \psi(pm_t) + \xi_t$  where  $\psi$ , which lies between zero and  $\frac{1}{\kappa}$ , is the response size of macro-prudential policy to the premium and  $\xi$  represents the associated error with a certain variance,  $\sigma_\xi^2$ . All together the premium is

$$pm_t = \frac{1}{1 - \kappa\psi} \{f(m_t) + \epsilon_t + \kappa\xi_t\}$$

the total error term is therefore  $\frac{1}{1 - \kappa\psi}(\epsilon_t + \kappa\xi_t)$ . So far we have assumed that regulations have direct effects on the credit premium. However, they should also have indirect effects because regulations might cause changes in the financial markets that in turn impact the credit premium. To model this, we assume that the change in regulations that is uncorrelated to the response in credit premium, would create some extra noise in the financial markets and eventually affect the credit premium. The idea is that at the minimum level of regulation ( $\kappa = 0$ ), there is no extra noise, but deviating from this minimum, there is more volatility. Therefore, the function is

$$\kappa\xi_t = g(\kappa)\epsilon_t$$

so that the credit premium function is

$$pm_t = \frac{1}{1 - \kappa\psi} \{f(m_t) + \epsilon_t + g(\kappa)\epsilon_t\}$$

with the total error equals  $\frac{1}{1 - \kappa\psi}[1 + g(\kappa)]\epsilon_t$ . This premium function says that scaling up regulations is associated with rising power ( $P$ ) and this results in rising the size of macro-prudential responses via  $\frac{1}{1 - \kappa\psi}$  and also the associated variance of its error  $\epsilon_t + g(\kappa)\epsilon_t$ . The functional form for the  $g$  function is chosen to yield the shape of our Policy Function for the Institutional Model. This Policy Function shows stability ( $S$ ) is a function of power ( $P$ ) and the monetary rule ( $M$ ). Its derivation is based of the following rationales.

We can simulate a rising power ( $P$ ) in our model by raising  $\kappa$  steadily: we should find that beyond a certain point stability declines as the error variance rises and dominates the stabilising effect of  $\psi$ . What we have here is a Laffer Curve in  $P$  and  $S$ . Two levels of  $P$  can deliver the same  $S$ ; the organisation can grow and take more macro-prudential action to create  $S$  but with increasing inefficiency. On the other hand, we can also measure our Monetary Rules ( $M$ ) in terms of effectiveness in increasing stability ( $S$ ): in Le et al. (2016) we found that there was a clear ranking of rules in terms of type and size of responses of monetary instruments. The Taylor rule was found to be the least stabilising, while price level targeting or nominal GDP targeting rules with or without monetary reforms delivered more stability. We arrange these in order of stability as a measure  $M$ . Together, our model of the economy gives us the following type of Policy Function:

$$S = a + bM + cP - dP^2 - \sigma_E^2$$

where  $M$  is a continuous schedule of possible monetary rules of increasing power to increase  $S$ , and  $\sigma_E^2$  is the error variance, representing the ambient noise in the economy. We can think of the latter term as from time to time shifting, as it did upwards in the financial crisis and downwards during the Great Moderation. When these shifts occur there is a shift in the institutional equilibrium.

So far we have modelled the effects of power ( $P$ ) and the monetary rule ( $M$ ) on stability ( $S$ ). We now set up an Institutional Model where we address the question of how these power and monetary setup are chosen in the first place. They must be the outcomes of some optimisation problems. To capture these choices, we now introduce the two sets of preferences, of society/government:  $U_S = f(S, P, M)$  where  $P$  enters negatively as a resource cost and  $M$  also enters negatively because increasing the stabilising effect requires a finite governmental effort to persuade the policy maker that the monetary rule must be changed to a more interventionist level: so that  $\frac{dU_S}{dS} > 0$ ,  $\frac{dU_S}{dP} < 0$ ,  $\frac{dU_S}{dM} < 0$ ; and of the central bank  $U_B = f(S, P)$  where now  $P$  enters positively because the central bank enjoys higher levels of power so that  $\frac{dU_B}{dS} > 0$ ,  $\frac{dU_B}{dP} > 0$ . In both cases we assume well-behaved second derivatives. These two deciding institutions maximise their utility subject to their constraints.

The maximisation proceeds in a sequence. First, the government chooses  $M$  and ‘target  $P$  and  $S$ ’ (i.e. what it thinks  $P$  and  $S$  should be according to the Policy Function) to maximise its utility w.r.t.  $S, P, M$  subject to the Policy Function for  $S$ . This situation is illustrated in Figure 2.

The government then can enforce the delivery of  $M$  by passing a law mandating this monetary rule, which it can monitor from observable policy actions and economy outcomes. Next, the government delegates the organisation of regulation to the central bank. Now it cannot monitor the technical operations or size of the central bank effectively because it does not know the central bank's 'production function' in which regulatory activity and size delivers stability. The central bank maximises its utility, taking  $M$  as given but subject again to the Policy Function. Because it enjoys power it now proceeds to choose a location where it delivers both stability and power. In effect it goes 'over the Laffer Curve maximum point' onto the other side to achieve stability and, for it, an acceptable amount of power. This is illustrated in Figure 3.

One may ask why the government permits this choice? The answer is that the government (of politicians) cannot carry out these functions without delegating them to a bureaucracy, here the central bank, as the relevant group of bureaucrats. It cannot gauge the efficiency of the central bank's operations. It can observe central bank size and stability, and it 'knows the model' as it did in order to optimise its choice of monetary rule. But the Policy Function is subject to an error variance, which can change; and it cannot prove in the public domain that the same stability can be achieved at lower size in practice, as implied by its (true) model. We appeal here to the politics of delegation and bureaucracy: that politicians have no instrument to force the bureaucracy to be efficient, because of asymmetric information<sup>2</sup>. In effect the government can, by choosing the best  $M$ , force the central bank to limit its use of  $P$  because the Laffer Curve maximum is shifted by a good  $M$  far over to the left. Plainly the more effective monetary policy is at stabilising the economy the less need there is for macro-prudential regulation and the less easy it is for the central bank to justify a large size for its bureaucracy.

Thus out of this model comes a choice of  $M$  by the government and a subsequent choice of  $P, S$  by the Bank, given  $M$ . These choices are dictated by the Policy Function whose parameters here are estimated from our model of the economy above. We can set up the Institutional Model formally as follows. The government's utility function is written as:

$$U_G = S^\delta - M^\beta - kP$$

where  $k > 0 < \delta < 1 < \beta$ .

It maximises this subject to the policy function for stability:

$$S = a + bM + cP - 0.5dP^2 - \sigma_E^2$$

where  $a, b, c, d$  are all positive.

Maximising the Lagrangian  $U_G - \lambda S$ , it finds the first order conditions as follows:

$$\begin{aligned} 0 &= \frac{dL}{dS} = \delta S^{\delta-1} - \lambda \\ 0 &= \frac{dL}{dM} = -\beta M^{\beta-1} + \lambda b \\ 0 &= \frac{dL}{dP} = -k + \lambda(c - dP) \end{aligned}$$

The solutions for  $M$  and  $P$  are:

$$\begin{aligned} M &= \left(\frac{\delta b}{\beta}\right)^{\frac{1}{\beta-1}} S^{-\frac{1-\delta}{\beta-1}} \\ P &= \frac{c}{d} - \frac{k}{\delta d} S^{1-\delta}. \end{aligned}$$

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<sup>2</sup>This is a point well understood by powerful Treasuries, such as HM Treasury. They can only achieve efficiency for a ministry by cutting its budget, and thereby forcing it to manage its resources effectively at the cost of failing in its tasks. Even then it risks losing the battle in the court of public opinion because the ministry will cut the most popular functions first to make its case against 'cuts'. Thus it is reported that Daniel Barenboim, director of the Berlin State Opera, some years back fended off a 10% cut on his huge budget from the bankrupt Berlin Region by saying '10%? Then there will be no opera: 90% of my budget is overheads and cannot be cut!'

It follows that as  $S$  falls,  $M$  and  $P$  both rise. The solution for the total differential evaluated at  $S = P = 1$  is:

$$dS = -[1 + b(\delta b/\beta)^{\frac{1}{\beta-1}} \frac{1-\delta}{\beta-1} + (c-d)(k/\delta d)(1-\delta)]^{-1} d\sigma_E^2$$

so that  $\frac{dM}{d\sigma_E^2} > 0$  and  $\frac{dP}{d\sigma_E^2} > 0$ .

We note that only  $M$  is determined by this choice.  $P$  is delegated to the central bank, which is forced to follow the chosen  $M$  but is free to choose its own optimal  $P$ . Its utility function is written as:

$$U_{CB} = S^\epsilon + \chi P$$

where  $\epsilon > 1$  and which it maximises subject to the same policy function. Maximising its Lagrangean  $L = U_{CB} - \lambda S$  it finds the first order conditions:

$$\begin{aligned} 0 &= \frac{dL}{dS} = \epsilon S^{\epsilon-1} - \lambda \\ 0 &= \frac{dL}{dP} = \chi + \lambda(c - dP) \end{aligned}$$

The solution for  $P$  is:

$$P = \frac{c}{d} + \frac{\chi}{\epsilon d} S^{-(\epsilon-1)}$$

so that  $\frac{dP}{dS} = \frac{\chi}{\epsilon d} (1-\epsilon) S^{-\epsilon} < 0$ , i.e. more instability is associated with more power. That is, power is assumed to be very attractive, so that the marginal utility of power is higher than the marginal utility of stability.

Now we note that the actual solution for  $P$  is given by the central bank's choices. When we substitute these into the policy function to find  $S$ , we obtain the new total differential, evaluated at  $S = P = 1$ , as:

$$dS = -[1 + b(\delta b/\beta)^{\frac{1}{\beta-1}} \frac{1-\delta}{\beta-1} + (c-d)(\chi/\epsilon d)(\epsilon-1)]^{-1} d\sigma_E^2$$

So, once both government and central bank have acted, we obtain the result that a rise in the volatility of the environment raises  $M$  and  $P$  but still causes a fall in stability,  $S$ .

We obtain the following observable outcomes for institutions as functions of the environmental volatility (with signs of the first derivatives):

$$\begin{aligned} M &= f(\sigma_E^2+) \\ P &= f(\sigma_E^2+) \\ S &= f(\sigma_E^2-) \end{aligned}$$

It is these functions we would like to check in the data. In terms of the Indirect Inference method we will be using for our empirical work these functions are the auxiliary model to be found in data regressions or in observed data moments.

However, first we must consider whether the key Policy Function for  $S$  that we have assumed in our Institutional Model can be generated by our Underlying Model of the economy. We now turn to this issue.

#### 1.4 Does the Underlying Model imply a Policy Function for $S$ of the type assumed in the Institutional Model?

With the Institutional Model in mind, which established how regulations affect the economy, we now use the underlying model of the economy to run experiments for different levels of regulation under each monetary regime. Our objective is to get a measure of the relationship between the monetary policy regime ( $M$ ), the amount of regulation ( $P$ ) and the degree of stability in the economy ( $S$ ) in different data episodes.

We identify various monetary regimes: the original (Taylor Rule), reformed (strong Quantitative Easing policy), nominal GDP targeting (NGDPT) with/without reform, and price level targeting (PLT) with/without reform. Also we have a model of the effects of the macro-prudential instrument for the credit premium:  $pm_t = \frac{1}{1-\kappa\psi} \{f(m_t) + \epsilon_t + \kappa\xi_t\}$ , with the total error term  $\frac{1}{1-\kappa\psi}(\epsilon_t + \kappa\xi_t) = \frac{1}{1-\kappa\psi}[1 + g(\kappa)]\epsilon_t$ . We choose  $1 + g(\kappa)$  to be  $\{1 + \kappa^2 - 4.5\kappa\}\epsilon_t$ . The idea is that before the crisis, regulation was at its minimum, but as regulation starts rising above this minimal level the noise rises as some function of  $\kappa$ .

We want to see how under this model of US regulation different monetary rules and different regulative intensity affect economic stability, which we measure by the frequency of crises, or their length and severity. We simulate the model many times and then calculate how many crises there are in these simulations. We define a crisis as a drop in GDP that takes at least 3 years to recover from. Table 1 reports how many crises occur every 1000 years as well as the average length and depth of the crises for the different monetary rules and level of regulation. We find that when there is no regulation ( $\kappa = 0$ ), the economy with just a monetary regime of Taylor Rule experiences the highest frequency of crisis. This can be mitigated if we adopt other alternative monetary regimes. While the reformed monetary regimes where QE is used intensively can improve economic stability, it works better in a combination with either NGDPT or PLT. In the latter 2 cases, there are almost no crises. This shows that stability depends vitally on the choice of monetary regime. If we adopt more and more regulation ( $\kappa$ ) in the hope of reducing instability we find that under the alternative monetary regimes, NGDPT with/without reform and PLT with/without reform, regulation initially hardly changes or improves stability. However, excessive regulation can even bring more instability. When the monetary regime is under the standard Taylor Rule or reformed, some additional financial regulation improves the economic situation, while a lot of regulation worsens the economic situation, bringing a higher frequency of crises, which are also longer and deeper.

Figure 4 shows the overall stability for each monetary regime, where we use  $\frac{1}{frequency + 0.5length + 2depth}$  as a measure of overall stability. Again we see that some regulation, in the form of  $\kappa = 0.2$ , is best for the original and reformed monetary regimes, but does not improve the more stabilising regimes. As  $\kappa$  rises further all regimes are destabilised.

These experiments show that it is important to choose a good monetary regime if one wants to minimise economic instability. In addition, adding some regulation does improve stability for poorly stabilising monetary policy rules. However, for highly stabilising rules, regulation (with  $\kappa > 0$ ) does not add stability. Under all monetary rules regulation, as it rises beyond some moderate level, progressively worsens stability.

What this suggests is that if governments prove able to undertake only moderately effective monetary reforms, as exemplified by our ‘reformed’ column, then they will, given their concern for stability, also choose some degree of regulation (such as  $\kappa = 0.2$ ). However central banks will implement much heavier regulation in practice, given that government has introduced this degree of regulation in principle. We have observed both these tendencies since the financial crisis, with the introduction of both QE (which we consider to be the ‘reformed’ policy) and heavy regulation. Of course we have not observed any of the more radical reforms that we find are much more effective, such as PLT and NGDPT where the price level and nominal GDP respectively are targeted by the interest rate rule.

What finally we find here is that there is indeed a Policy Function resembling the one we assume in the Institutional Model. It is quadratic in P with a peak of stability at a low level of regulation and it is shifted upwards systematically by rising M.

We now turn to testing and estimating the Institutional Model.

## 2 Testing and Estimation

### 2.1 Data Moments

We consider the data sample from 1984.02 to 2012.02 for the US. The series are the square of the output gap as a measure of volatility ( $S^{-1}$  i.e. the inverse of stability), the monetary regime ( $M$ ) and the total percentage change in the number of employees in the Federal Reserves over the sample ( $P$ ) as shown in Figure 5.  $M$  is a proxy for the stabilising property of monetary policy. We divide the data into four sub-samples/episodes, depending on the level of regulations and monetary regimes, as identified in our Underlying Model.

We identify different monetary regimes, based on Taylor’s speech at the panel on “Monetary Policy in the



Future” at an IMF event Rethinking Macro Policy (2015). His view was that during the Great Moderation period monetary policy adhered to the Taylor Rule, but during the early 2000s, monetary policy was looser than that prescribed by the Taylor Rule, and this caused the build up of debt and risk-taking. In response to the crisis, the Fed implemented its unconventional monetary policy — Quantitative Easing (QE). Taylor argued that this QE was a deviation from the Taylor Rule too. So if we treat the standard Taylor Rule as 1 ( $M = 1$ ), then it can be assigned to the periods of 1984.02-1990.04 and 1991.01-1999.04. The period of the pre-crisis boom 2000.01-2007.02 is thought as a poor Taylor Rule episode where monetary policy responded little to inflation and output gap and it is assigned with  $M = 0.5$ . The period from crisis 2007.03 onwards is where the Fed used both QE and Taylor Rule, and thus aggressively responded to the low level of liquidity and thus we assign  $M = 1.5$  to this episode.

We use detrended data for our analysis on the grounds that there are likely to be omitted trends — such as ideas about regulation and monetary policy, as well as world developments in trade and financial markets — driving all our three variables in the Institutional Model. The data is plotted in Figure 5.

From these episodes we construct a number of correlations between these series over the different sub-samples (reported in Figure 5). We are interested in whether this data behaviour can be generated by our Institutional Model. This leads us to the next section.

## 2.2 The Underlying Model and simulating it for each episode

Besides gathering the facts of each episode, we need also to simulate the Underlying Model to generate the facts about the potential variability of each episode, which we obtain by bootstrapping that Model in each episode to obtain the distribution of its variability.

To do this we need to create a corresponding version of the Model for each episode, with its own  $M$  and  $P$ .

For the regulative behaviour in each episode we create a correlate to  $P$  in  $\kappa$ . We rate the periods of 1984Q2-1990Q4 and 1991Q1-1999Q4 as having some but quite limited banking regulations, which we associate with  $\kappa = 0.2$ . These periods were ones where the number of employees was moderate. The later period of the noughties, from 2000Q1 until 2007Q2 when the financial crisis struck, is associated with very light regulation, and for this episode we set  $\kappa = 0$ ; here the number of employees fell to low levels. Finally in the period since the crisis, 2007Q3 until 2012Q2, where there has plainly been highly aggressive regulation and the number of employees rose sharply: here we set  $\kappa = 0.4$ .

For monetary policy we use the standard estimated Taylor Rule for the two periods of the 1980s and the 1990s. For the noughties period we use a Taylor Rule with the response to inflation and the output gap halved. Finally, for the post-crisis period we return to the estimated Taylor Rule supplemented by a QE rule, relating the credit rate to the level of  $M0$ .

## 2.3 Testing and Estimation of the Institutional Model

To answer whether the Institutional Model could be the data generating one, we need to simulate it to obtain the counterpart joint distribution for the correlations across different data sub-samples. The process is as follows.

First, we use our Underlying Model for the US economy to generate in each episode the distribution of  $S$ . We need this in order to ‘animate’ the Institutional Model as realistically as possible with an exogenous source of noise. Notice that  $\sigma_E^2$  is not directly observable since it is produced by all the shocks in the economy and these cannot be aggregated into a single measure of volatility. So in each episode we repeatedly resample the innovations (1000 times) and generate corresponding  $S$  values, which we measure as the inverse of the variance of the output gap. Once we inject the  $S$  into the Institutional Model it reads out an implied  $\sigma_E^2$  since the two are perfectly correlated in that model. So effectively we are applying an estimate of  $\sigma_E^2$  to the Institutional model.

Our reliance on the Underlying Model is limited to finding the distribution of  $S$  in each episode. One could imagine doing this in other ways using the observed variation in  $S$  during each sample episode and bootstrapping a time series process for  $S$ . However, this would produce much less than the full variation implied by the structural model in which the effect of all the economy’s shocks interact with the reaction of regulative and monetary policies. As our Underlying Model has already been tested for its fit to the US

macro facts over this sample as a whole, we regard it as given in this testing procedure, so that we are in effect only testing the accuracy of the Institutional Model. Of course the Underlying Model will not be completely accurate; however, its inaccuracy should not materially affect the test of the Institutional Model because it will only affect the precise distribution of  $S$ , to which the test is fairly insensitive.

From this process we obtain 1000 different values of  $S$  in each of the 4 episodes; we combine these randomly into 1000 sets of four  $S$  values. We can think of each of these sets as a potential history of the four episodes, so that we have 1000 sequences of these 4 episodes that could have randomly occurred.

We now carry the obtained  $S$  across to the parameterised Institutional Model, which solves for the following observable outcomes for institutions as functions of the environmental volatility (with signs of the first derivatives):

$$M = f(\sigma_E^2+); P = f(\sigma_E^2+); S = f(\sigma_E^2-).$$

From these equations we can see immediately that each  $S$  corresponds to a unique  $\sigma_E^2$ . We can now use this Institutional Model also to derive  $M$  and  $P$ . Thus we end up with 1000 sets of 4  $S, M, P$  and  $\sigma_E^2$ , one for each episode. Then we calculate the correlation between these variables. Since  $S$  and  $\sigma_E^2$  are perfectly correlated, we take out  $\sigma_E^2$  and consider only the other 3 variables. We end up with 1000 sets of 3 correlations. These moments correspond to those we constructed from the data.

Lastly, we compute the joint distribution of these correlations. The Wald test statistic then is computed for the data correlations, to determine where in this distribution they lie.

Estimation of the parameters of the Institutional Model is carried out by minimising this Wald statistic through a search algorithm across the parameter space. This estimation process found a set of model parameters (Table 2) that delivers a p-value of 0.230 which means that the model easily passes the test. In Table 3 we compare the correlations from the actual data with those from the simulations. As expected, we find the the actual correlations are within the upper and lower percentiles and very close to the mean.

Given the assumptions that regulations were less strict before the crisis, relaxed during crisis and aggressive after crisis, we do find that the estimation can find a model that fits the data and this estimated Institutional Model can therefore be considered the true model generating the observed data. This model suggests that regulation became more severe after the Great Recession; and that this increase in regulation is also increasing instability.

## 2.4 Robustness Checks

The first robustness check is concerned with the question of whether the estimated Institutional Model can generate the Laffer Curve behaviour of stability and power. Figure 6 shows that there is a strong Laffer curve effect from rising  $P$  to  $S$ : the more regulation the lower the stability in the area to the right of the Laffer Curve where the central bank chooses to operate. Hence we see from Figure 7 the effects of general volatility ( $\sigma^2$  on the x-axis) that as it rises the response of  $P$  is positive but quite muted; this is because although the central bank likes more regulation, the cost of adding more is expensive due to further instability. On the other hand we see that rising volatility causes the government to choose stronger monetary targeting policies ( $M$ ) because the gains from higher stability much outweigh the administrative costs of change that contribute a negative effect of  $M$  to the utility function (it also wants but cannot determine a strongly rising  $P$  because it is on the left hand side of the Laffer curve where a rise in  $P$  raises stability).

The second robustness check is concerned with our estimation. We need to check how accurate our parameter estimates are. In order to do this, we perform a Monte Carlo exercise to check the power of the Indirect Inference test. If we take the estimated Institutional Model as the true model of how the decisions on monetary policy and regulations are made we vary the estimated coefficients of the Institutional Model and see how often an increasingly false version of the model would be rejected at the 5% level. Table 4 shows the power of the test; to create it we have varied all the Institutional Model coefficients randomly by  $+x\%$  or  $-x\%$ , where the  $x$  is shown in the left hand column but obeying the parameter size restrictions of the model (including non-zero), so that the model is always correctly specified. It shows that the power rises slowly reaching over 70% once it gets to 80% false, where it stays until reaching the parameter bounds. The Institutional Model only defines the relationship between three variables and with only four episode data points; so the Indirect Inference test does have reasonable power given the limitations on our auxiliary model and data sample. In other words, we can be reasonably confident, given that this model passes the test, that

it yields policy conclusions that are qualitatively robust, in that we know that any model that gets close to the parameter bounds of the specification will be rejected almost all the time.

Perhaps an even more important check is on the power of the test in rejecting a model that is seriously mis-specified. Generally we find that the IIW test has an almost total intolerance in this respect, rejecting models with a different structure close to 100% of the time. The reason for this is that the auxiliary model is some (often crude) approximation to the reduced form of the true model and if the model is identified (usually these models are over-identified) then its reduced form will be totally distinguishable from that of different models with enough data and even with limited data should be easily distinct — see Le et al. (2017). We checked whether a model in which the central bank would maximise on the *correct* side of the Laffer Curve (i.e. was not dominated by power-seeking ambition but rather by the general interest) would be systematically rejected by the data from the true model: we made the parameter  $\chi$  negative instead of positive (i.e. the central bank now would dislike, instead of liking,  $P$ , the number of its employees, representing its Power). Regardless of the absolute size of this now-negative parameter the model is rejected by 100% of the true data samples.

All this suggests that the data support a model in which central banks aim to raise regulation beyond its optimal level: any model where this is not true will always be rejected: this is our public choice position about the behaviour of central banks.

### 3 Conclusions and policy implications

Many believe that more regulation would make banks safer. In his speech at the National Bureau of Economics Research Summer Institute 2014, Stanley Fischer praised the rigid regulations of the Dodd-Frank Act on the banking system. He said “...by raising the capital and liquidity ratio for SIFIs (systemically important financial institutions), and through the active use of the stress tests, regulators and supervisors have strengthened bank holding companies and thus reduced the probability of future bank failures...”. In a similar vein, Neel Kashkari, the president of the Federal Reserve Bank of Minneapolis, in his speech at the Brookings Institution in 2016 suggested a range of options to deal with an individual large bank failure: “...(1) Breaking up large banks into smaller, less connected, less important entities; (2) Turning large banks into public utilities by forcing them to hold so much capital that they virtually can’t fail...; (3) Taxing leverage throughout the financial system to reduce systematic risks wherever they lie...”. He emphasised the point in his blog on April 6th 2017, calling for a doubling of the banks’ capital/asset ratios in the belief that more banking regulation by making banks better capitalised would prevent any instability like that of the recent crisis. This view has been attacked in different contributions by Congdon, Goodhart and Hanke (all 2017); they have argued that official actions to increase banks’ capital/asset ratios since 2008 have had counter-productive results. Banks have reacted by reducing credit and so deposits and the money supply. This has worsened and prolonged the Great Recession, thus worsening instability. Furthermore ‘macro-prudential measures’ (alias credit controls) create market distortions and may be mistimed cyclically compared with monetary reaction via rules. Central banks failed to prevent a large credit boom before the crisis, failed to provide the necessary liquidity to stop the Lehman collapse and subsequently prevented the necessary growth in credit for the recovery by draconian regulation. We attribute these gross failures at least partially to central banks having concern with their own interests rather than the social interest.

In this paper we present an Institutional Model where, besides the choice of the government, the central bank as a financial regulator maximises its power through a strengthening of macro-prudential policy. This theoretical Institutional Model suggests that given a monetary regime, financial regulation helps to improve stability only up to a point, above which it creates more distortions. We performed two exercises given this model. First, we integrated the idea of a maximum level of regulation into a model of the US economy to see the effects of regulation on the wider macroeconomy. We found that in line with the argument of Congdon, Goodhart and Hanke above, good monetary policy can effectively reduce instability while regulation destabilises the economy in the presence of well-conducted monetary policy. Even when monetary policy is only weakly stabilising, regulation makes little contribution and risks being pushed to excessive levels by central banks to satisfy their own bureaucratic interests. Second, to validate the conclusion, we used Indirect Inference testing and estimation to see whether our Institutional Model could have generated the observed moments for the US economy. We found that the estimated Institutional Model can be the

true model generating the observed data. Its results suggest that regulations were rather too severe after the recent crisis period. Such severity can actually cause more instability. We also find that the data totally reject the idea that central banks could be benevolent pursuers of the public interest, confirming that they aim to raise regulation above its optimal level.

## References

- [1] Barth, J.R., Caprio G., Levine R. (2004), ‘Bank regulation and supervision: what works best?’, *Journal of Financial Intermediation*, 13(2), 205-248.
- [2] Barth, J.R., Caprio G., Levine R. (2006), *Rethinking Bank Regulation. Till Angels Govern*. Cambridge, Cambridge University Press.
- [3] Berger A. N., Herring R. J. and Szegö G. P. (1996), ‘The Role of Capital in Financial Institutions’, *Journal of Banking & Finance*, 19 (3–4), 393-430.
- [4] Besanko, D., and Katanas G. (1996), ‘Do Capital Adequacy Requirements Reduce Risk in Banking?’, *Journal of Financial Intermediation*, 5, 160-183.
- [5] Blinder, A. (2010), ‘It’s Broke, Let’s Fix it: Rethinking Financial Regulation’, *International Journal of Central Banking*, 6(4), 277-330.
- [6] Blum, J., (1999), ‘Do Capital Adequacy Requirements Reduce Risks in Banking?’, *Journal of Banking and Finance*, 23, 755-771.
- [7] Brunnermeier, M. and Sannikov Y. (2016), ‘The I Theory of Money’, NBER Working Paper No. 22533.
- [8] Buchanan, J. (1980), ‘Rent seeking and profit seeking’, in James M., Buchanan R.D. and Tullock, G., editors, *Toward a Theory of the Rent-Seeking Society*, 3-15. College Station: Texas A&M University Press.
- [9] Congdon, T. (2017), ‘What were the causes of the Great Recession? The mainstream approach vs. the monetary interpretation’, In: Congdon, Tim, (ed.) *Money in the Great Recession. Did a Crash in Money Growth Cause the Global Slump?*. Buckingham studies in money, banking and central banking. Edward Elgar Publishing, Cheltenham, UK, 155-164. ISBN 9781784717827; pp. 27-56.
- [10] Fischer, S. (2014), ‘Financial Sector Reform — How Far Are We?’, National Bureau of Economic Research, Summer Institute 2014.
- [11] Furlong, F. T. and Keeley, M.C. (1989), ‘Capital Regulation and Bank Risk-Taking: A Note’, *Journal of Banking and Finance*, 13, 883-891.
- [12] Goodhart, C. (2017), ‘Why has monetary policy not worked as expected? Some interactions between financial regulation, credit and money’ In: Congdon, Tim, (ed.) *Money in the Great Recession. Did a Crash in Money Growth Cause the Global Slump?*. Buckingham studies in money, banking and central banking. Edward Elgar Publishing, Cheltenham, UK, 155-164. ISBN 9781784717827; pp. 155-163.
- [13] Goodhart, C. and Schoemaker D. (1995), ‘Should the Functions of Monetary Policy and Banking Supervision Be Separated?’, *Oxford Economic Papers*, 47 (4), 539-60.
- [14] Gorton, G. and Pennacchi G. (1990), ‘Financial Intermediaries and Liquidity Creation’, *The Journal of Finance*, 45 (1), 49-71.
- [15] Hanke, S. (2017), ‘The Basel rules and the banking system: an American perspective’ In: Congdon, Tim, (ed.) *Money in the Great Recession. Did a Crash in Money Growth Cause the Global Slump?*. Buckingham studies in money, banking and central banking. Edward Elgar Publishing, Cheltenham, UK, 155-164. ISBN 9781784717827; pp. 164-177.

- [16] Kahane, Y. (1977), ‘Capital Adequacy and the Regulation of Financial Intermediaries’, *Journal of Banking and Finance*, 1(2): 207–18.
- [17] Kashkari, N. (2016), ‘Lessons from the Crisis: Ending Too Big to Fail’, Remarks at the Brookings Institute, Washington D.C.
- [18] Kashkari, N. (2017), ‘Jamie Dimon’s Shareholder (Advocacy) Letter’, [Blog] Available at: <https://medium.com/@neelkashkari/jamie-dimons-shareholder-advocacy-letter-c2d867f3cc1e>
- [19] Kaufman, O. (1991), ‘Lender of Last Resort: A Contemporary Perspective’, *Journal of Financial Services Research*, 5, 95-110.
- [20] Keeley, M. C., and Furlong F. T. (1990), ‘A Reexamination of MeanVariance Analysis of Bank Capital Regulation’, *Journal of Banking and Finance*, 14 (1): 69–84.
- [21] Kim, D., and Santomero. A. M. (1988), ‘Risk in Banking and Capital Regulation’, *Journal of Finance*, 43 (5), 1219–33.
- [22] Koehn, M., and Santomero. A. M. (1980) ‘Regulation of Bank Capital and Portfolio Risk’, *Journal of Finance*, 35 (5), 1235–44
- [23] Le, V. P. M., Meenagh, D. and Minford, P. (2016), ‘Monetarism rides again? US monetary policy in a world of quantitative easing’, *Journal of International Financial Markets, Institutions and Money*, 44, 85-102.
- [24] Le, V. P. M., Meenagh, D., Minford, P. and Wickens, M. (2017) A Monte Carlo procedure for checking identification in DSGE models, *Journal of Economic Dynamics and Control*, 2017, 76, (C), 202-210.
- [25] Niskanen, W. A. (1971), *Bureaucracy and Representative Government*, Aldine-Atherton, Chicago.
- [26] Quintyn, M. and Taylor, M. W. (2002), ‘Regulatory and Supervisory Independence and Financial Stability’, Working paper, International Monetary Fund.
- [27] Smets, F. and Wouters R. (2007), ‘Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach’, *American Economic Review*, 97(3), 586-606.
- [28] Stigler, G.J. (1971), ‘The Theory of Economic Regulation’, *The Bell Journal of Economics and Management Science*, 2(1), 3-21.
- [29] Tayler, W. J. and Zilberman R. (2016), ‘Macroprudential regulation, credit spreads and the role of monetary policy’, *Journal of Financial Stability*, 26(C), 144-158..
- [30] Taylor, J. (2015), Rethinking Macro Policy III: Session 3. Monetary Policy in the Future, International Monetary Fund.

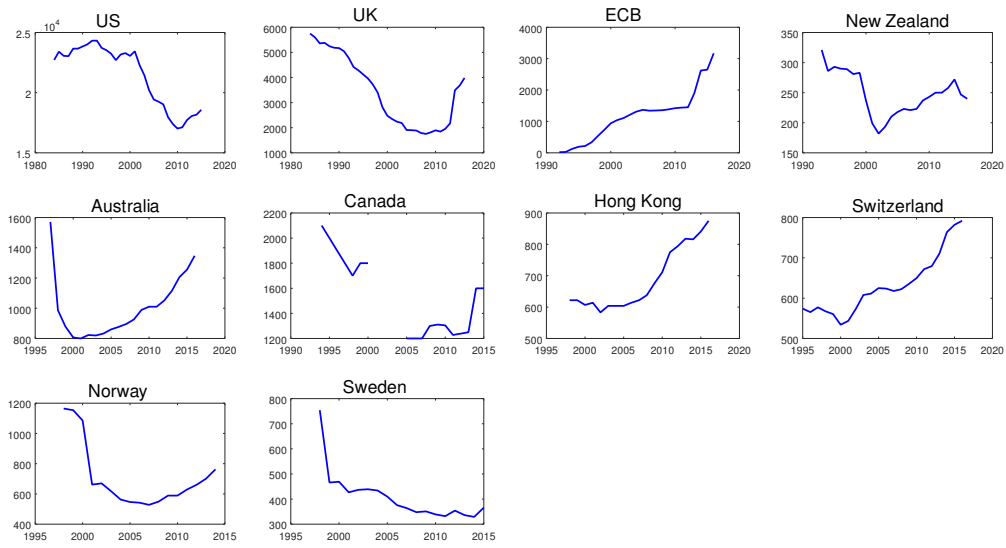


Figure 1: Number of employees in different central banks

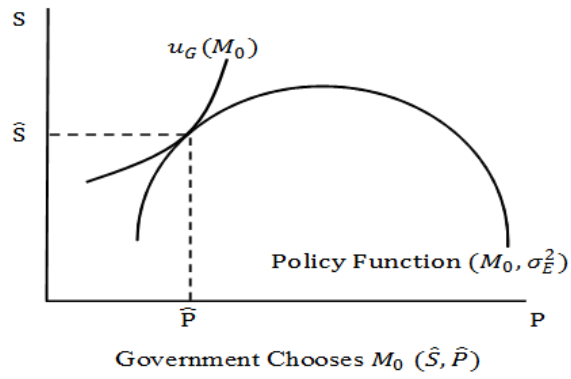


Figure 2: Government Preferences

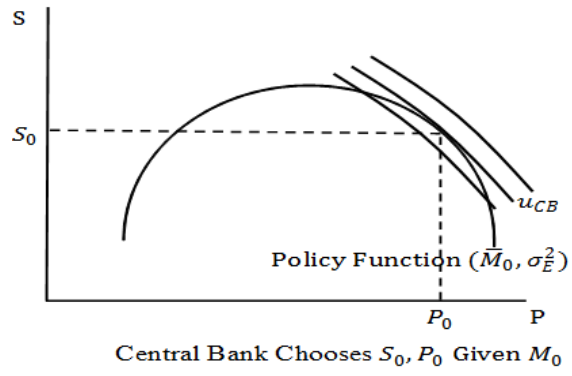


Figure 3: Central Bank Preferences

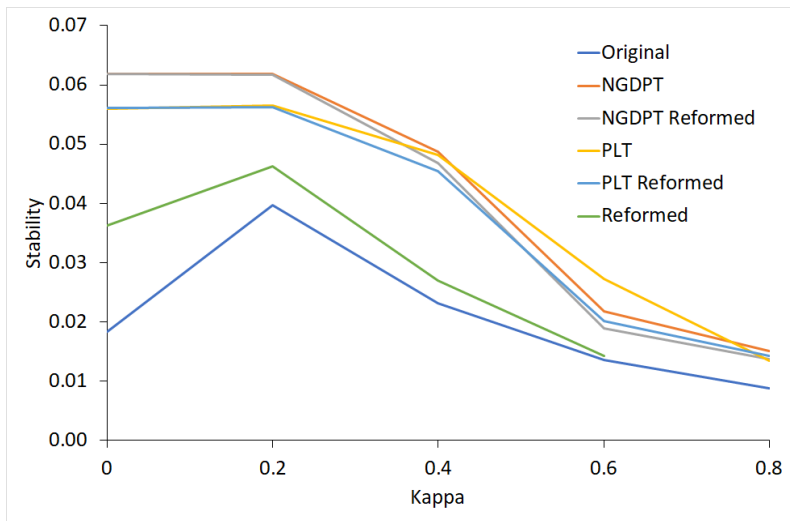


Figure 4: Stability of Monetary Regimes

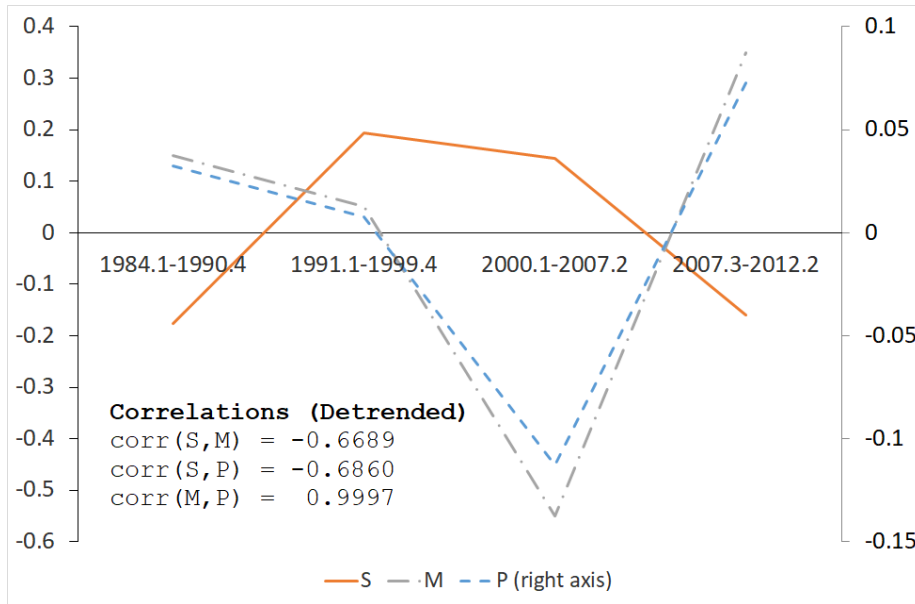


Figure 5: Data (detrended)

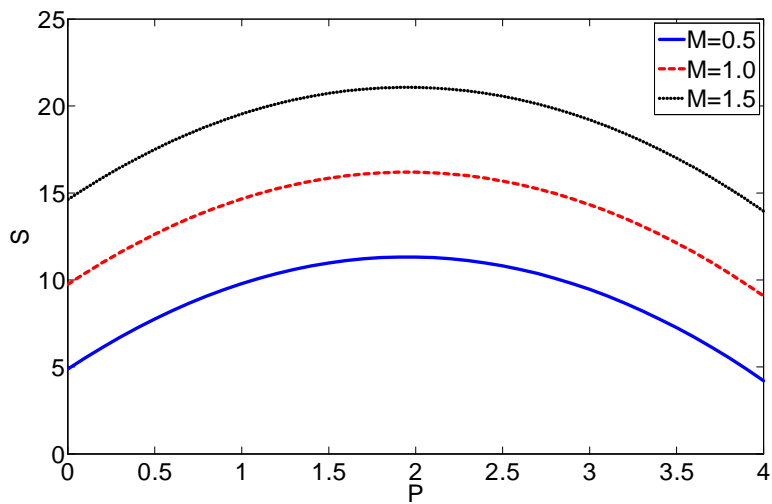


Figure 6: Policy Function



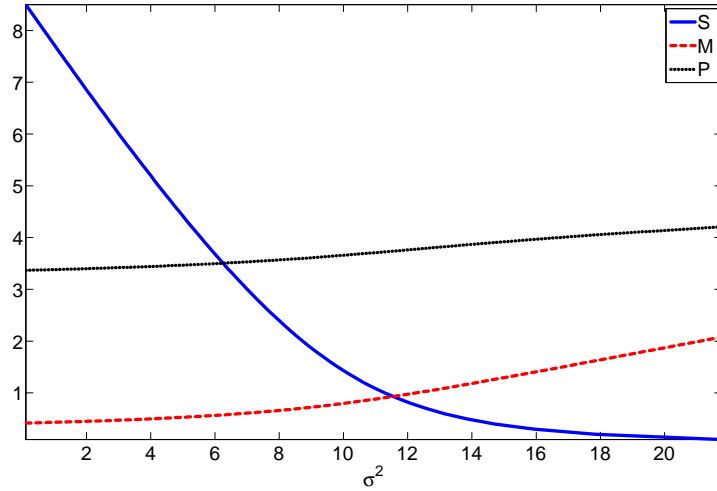


Figure 7: Response of Institutional Model to underlying stability

	$\kappa$ value	Original	Reformed	NGDPT	NGDPT and Reformed	PLT	PLT and Reformed
Frequency of crises every 1000 years	0.0	15.291	11.429	4.444	4.402	5.816	5.800
	0.2	10.304	8.056	4.444	4.453	5.682	5.783
	0.4	16.830	14.317	6.221	6.465	7.079	7.323
	0.6	16.903	16.669	9.207	9.608	10.034	10.368
	0.8	15.769	—	12.142	12.527	13.855	13.376
Length	0.0	32.511	19.443	15.432	15.467	15.776	15.787
	0.2	17.405	16.530	15.439	15.442	15.751	15.750
	0.4	25.458	21.714	17.763	17.974	17.241	18.007
	0.6	41.666	37.758	24.169	26.232	22.367	25.988
	0.8	50.459	—	22.808	23.704	23.892	24.058
Depth	0.0	11.409	3.189	2.011	2.015	2.071	2.072
	0.2	3.093	2.644	2.002	2.008	2.070	2.067
	0.4	6.828	5.927	2.699	2.946	2.534	2.851
	0.6	17.831	17.201	12.260	15.094	7.702	13.068
	0.8	36.457	—	21.334	24.148	24.275	22.383

"—" models do not converge

Table 1: Comparison of Stability

Coefficients	$\epsilon$	$\chi$	$\delta$	$\beta$	$b$	$c$	$d$
Initial	1.5	0.5	0.5	1.5	0.5	0.5	0.5
Estimated	1.105	6.641	0.336	4.701	9.754	6.607	3.387

Table 2: Estimated Coefficients

	corr(S,M)	corr(S,P)	corr(M,P)
Actual detrended	-0.6689	-0.6860	0.9997
Mean Simulations	-0.7720	-0.8376	0.9902
Lower 25th Percentile	-0.9997	-0.9997	0.9482
Upper 25th Percentile	-0.0789	-0.3082	1.0000

Table 3: Comparison of data correlations with simulated correlations

Falseness in %	Rejection Rate in %
5	6.6
9	7.9
10	9.3
30	21.1
50	29.5
80	72.9
100	73.9

Table 4: Power of the Test

## 4 Appendix: Le et al. (2016) Model Listing

Consumption Euler equation

$$c_t = \frac{\frac{\lambda}{\gamma}}{1 + \frac{\lambda}{\gamma}} c_{t-1} + \frac{1}{1 + \frac{\lambda}{\gamma}} E_t c_{t+1} + \frac{(\sigma_c - 1) \frac{W_* L_*}{C_*}}{\left(1 + \frac{\lambda}{\gamma}\right) \sigma_c} (l_t - E_t l_{t+1}) - \left( \frac{1 - \frac{\lambda}{\gamma}}{\left(1 + \frac{\lambda}{\gamma}\right) \sigma_c} \right) (r_t - E_t \pi_{t+1}) + e b_t \quad (1)$$

Investment Euler equation

$$inn_t = \frac{1}{1 + \beta \gamma^{(1-\sigma_c)}} inn_{t-1} + \frac{\beta \gamma^{(1-\sigma_c)}}{1 + \beta \gamma^{(1-\sigma_c)}} E_t inn_{t+1} + \frac{1}{(1 + \beta \gamma^{(1-\sigma_c)}) \gamma^2 \varphi} qq_t + e inn_t \quad (2)$$

Tobin Q equation

$$qq_t = \frac{1 - \delta}{1 - \delta + R_*^K} E_t qq_{t+1} + \frac{R_*^K}{1 - \delta + R_*^K} E_t r k_{t+1} - E_t c y_{t+1} \quad (3)$$

Capital Accumulation equation

$$k_t = \left( \frac{1 - \delta}{\gamma} \right) k_{t-1} + \left( 1 - \frac{1 - \delta}{\gamma} \right) inn_t + \left( 1 - \frac{1 - \delta}{\gamma} \right) \left( 1 + \beta \gamma^{(1-\sigma_c)} \right) \gamma^2 \varphi (e inn_t) \quad (4)$$

Price Setting equation

$$r k_t = \omega^r \left[ \begin{array}{l} \frac{1}{\alpha \left( \frac{1}{1 + \beta \gamma^{(1-\sigma_c)} \iota_P} \right) \left( \frac{(1 - \beta \gamma^{(1-\sigma_c)} \xi_p)(1 - \xi_p)}{\xi_p ((\phi_p - 1) \epsilon_p + 1)} \right)} \\ \left\{ \begin{array}{l} \pi_t - \frac{\beta \gamma^{(1-\sigma_c)} \iota_P}{1 + \beta \gamma^{(1-\sigma_c)} \iota_P} E_t \pi_{t+1} - \frac{\iota_P}{1 + \beta \gamma^{(1-\sigma_c)} \iota_P} \pi_{t-1} + \left( \frac{1}{1 + \beta \gamma^{(1-\sigma_c)} \iota_P} \right) \\ \left( \frac{(1 - \beta \gamma^{(1-\sigma_c)} \xi_p)(1 - \xi_p)}{\xi_p ((\phi_p - 1) \epsilon_p + 1)} \right) ((1 - \alpha) w_t - e a_t) - e p_t \end{array} \right\} \\ + (1 - \omega^r) \left[ \frac{e a_t}{\alpha} - \frac{1 - \alpha}{\alpha} w_t \right] \end{array} \right] \quad (5)$$

Wage Setting equation

$$w_t = \omega^w \left[ \begin{array}{l} \frac{\beta \gamma^{(1-\sigma_c)}}{1 + \beta \gamma^{(1-\sigma_c)}} E_t w_{t+1} + \frac{1}{1 + \beta \gamma^{(1-\sigma_c)}} w_{t-1} + \frac{\beta \gamma^{(1-\sigma_c)}}{1 + \beta \gamma^{(1-\sigma_c)}} E_t \pi_{t+1} - \frac{1 + \beta \gamma^{(1-\sigma_c)} \iota_w}{1 + \beta \gamma^{(1-\sigma_c)}} \pi_t \\ + \frac{\iota_w}{1 + \beta \gamma^{(1-\sigma_c)}} \pi_{t-1} - \frac{1}{1 + \beta \gamma^{(1-\sigma_c)}} \left( \frac{(1 - \beta \gamma^{(1-\sigma_c)} \xi_w)(1 - \xi_w)}{(1 + \epsilon_w (\phi_w - 1)) \xi_w} \right) \\ \left( w_t - \sigma_l l_t - \left( \frac{1}{1 - \frac{\lambda}{\gamma}} \right) \left( c_t - \frac{\lambda}{\gamma} c_{t-1} \right) \right) + e w_t \end{array} \right] + \\ (1 - \omega^w) \left[ \sigma_l l_t + \left( \frac{1}{1 - \frac{\lambda}{\gamma}} \right) \left( c_t - \frac{\lambda}{\gamma} c_{t-1} \right) - (\pi_t - E_{t-1} \pi_t) + e w_t^S \right] \quad (6)$$

Labour demand

$$l_t = -w_t + \left( 1 + \frac{1 - \psi}{\psi} \right) r k_t + k_{t-1} \quad (7)$$

Market Clearing condition in goods market

$$y_t = \frac{C}{Y} c_t + \frac{I}{Y} inn_t + R_*^K k_y \frac{1 - \psi}{\psi} r k_t + c_y^e c_t^e + e g_t \quad (8)$$

Aggregate Production equation

$$y_t = \phi \left[ \alpha \frac{1 - \psi}{\psi} r k_t + \alpha k_{t-1} + (1 - \alpha) l_t + e a_t \right] \quad (9)$$

Taylor Rule

$$r_t = \rho r_{t-1} + (1 - \rho)(r_p \pi_t + r_y y_t) + r_{\Delta y}(y_t - y_{t-1}) + er_t \text{ for } r_t > 0.0625 \quad (10)$$

Premium

$$E_t cy_{t+1} - (r_t - E_t \pi_{t+1}) = pm_t = \chi(qq_t + k_t - n_t) - \psi m_t + \xi_t + epr_t \quad (11)$$

Net worth

$$n_t = \frac{K}{N}(cy_t - E_{t-1} cy_t) + E_{t-1} cy_t + \theta n_{t-1} + enw_t \quad (12)$$

Entrepreneurial consumption

$$c_t^e = n_t \quad (13)$$

M0

$$\Delta m_t = \psi_1 \Delta M_t + errm_{2t} \text{ for } r_t > 0.0625 \text{ and } \Delta m_t = \psi_2 (s_t - c^*) + errm_{2t} \text{ for } r_t \leq 0.0625 \quad (14)$$

M2

$$M_t = (1 + \nu - \mu)k_t + \mu m_t - \nu n_t \quad (15)$$