

STRUCTURAL REFORMS AND CAPITAL
MARKET INTERVENTIONS DURING A
FINANCIAL CRISIS

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Structural Reforms and Capital Market Interventions during a Financial Crisis

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Abstract

I study how structural reforms in product and labor markets affect an economy that is going through a financial crisis. Of specific interest is the role of credit intermediation in a crisis and how it is influenced by reforms. I consider three key characteristics of the recent financial crisis that are potentially relevant for policy analysis: First, the crisis was triggered in the financial sector; second, there were spillovers from the financial to the real sector due to credit rationing; third, governments actively intervened in the credit market during the crisis. I construct two dynamic general equilibrium models with financial frictions to address these issues—a closed economy model and a monetary union model. I show that permanent structural reforms have positive effects on aggregate output in both the long and the short run. They affect the capital market positively and stimulate credit intermediation. Contrariwise, reforms that are either implemented temporarily or announced to be implemented in the future have negative consequences for output in the short run. Moreover, reforms that are implemented in one country of a currency union have positive short-run effects on both the reforming country and its foreign counterpart. My results also hold if the central bank is constrained by a lower interest rate bound. I also show that reforms have a qualitatively similar impact as a direct intervention in the credit market. Moreover, credit market interventions are complementary to structural reforms.

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1 Introduction and Motivation

Do structural labor and product market reforms in peripheral Europe depress output in the short run when a financial crisis hits the economy? This dissertation addresses the question by considering three essential characteristics of the recent crisis: First, the crisis was triggered in the financial markets; second, there were spillovers from the financial sector to the real economy; third, monetary policy measures were unconventional. My results favor permanent reforms. The wealth effect associated with reforms enhances credit intermediation and mitigates the contraction of economic activity.

When Lehman Brothers collapsed in 2008, the global financial system began to struggle. Interbank lending froze, resulting in a slow-down of the real economy worldwide. A sovereign debt crisis followed in the European Monetary Union. Politicians and economists alike have since been debating about the appropriate policies to adopt. One suggestion is to reduce macroeconomic imbalances within member states. Although differences in the ability to compete have been documented (see, e.g., Dieppe et al., 2012), there is dissent on the effectiveness of structural policies in a crisis scenario, particularly when interest rates are close to zero.

The main argument in favor of structural reforms is that they initiate a wealth effect. Shifts in the long-run aggregate supply are associated with increases in expected future income that immediately stimulate demand and lead to output growth (see, e.g., Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2014)). In the context of a monetary union, reforms in less competitive member states can lead to real devaluations relative to the rest of the union. In addition to wealth effects, there are changes in terms of trade, encouraging households to substitute in favor of the reforming countries (see, e.g., Farhi, Gopinath, and Itskhoki, 2014).

However, reforms might have negative implications for output growth in the short run. In a recent paper, Eggertsson, Ferrero, and Raffo (2014) show that if the nominal interest rate is at a lower bound, deflationary pressures resulting from reforms can cause the real interest rate to appreciate. The higher real interest rate induces households to reduce current consumption in favor of future consumption, leading to a further contraction of economic activity in the short run.

The recent literature on structural reforms has discovered that standard transmission channels of specific policy initiatives may be distorted in special situations. For this purpose, the crisis scenario itself was often considered in the analysis of reforms. However, the fact that the recent crisis was *financial* in its nature has generally been ignored. In the following, I address three issues that are potentially relevant for policy analysis.

First, the crisis originated in the financial sector of the economy. After a long period of growth, asset prices in the housing and mortgage market in the United States suddenly began to decline by the end of 2006. In turn, falling asset prices deteriorated the balance sheets of some major financial institutions, including Bear Stearns, Fannie Mae, Freddie Mac, and Lehman Brothers. Ultimately, an asymmetric information problem appeared in the interbank market: The fact that any borrower in the market was potentially linked to a struggling financial institution induced a vicious circle that drastically slowed down interbank lending. Many existing models used to study reforms omit these dynamics. Instead, they focus on the outcomes of the crisis, such as a contraction of output, deflation, and the fact that interest rates are close to the zero lower bound. For example, a standard procedure to initiate a crisis in a model is to induce a shock to the preference structure of households which leads to a reduction in consumption demand. It is, however, questionable if preference shocks are appropriate for modeling debt related crisis (see, e.g., Eggertsson and Krugman, 2012).

Second, there is a fundamental link between the financial and the real sector. The fact that interbank lending slows down is by itself not alarming. However, in the recent crisis, the distortions in the financial sector swapped over to the real economy. Financial intermediaries restricted lending to firms in the real sector drastically. The depletion of credit supply became apparent in substantially increasing credit spreads. The increased costs of borrowing in turn affected the profits of firms and thus their asset prices. Ultimately, the drop in real sector asset prices fed back to the financial sector, further eroding financial intermediaries' ability to carry out their main function. Such an amplification is known as financial acceleration. Although there is seminal research on the interaction between the financial and the real sector¹, showing that worsening conditions in the process of credit intermediation have substantial consequences for the real sector, much of the literature on structural reforms ignores the financial sector.

Third, governments intervened in the credit markets during the financial crisis. Large scale asset purchasing programs were initiated in the United States and Europe with the purpose of restoring the functioning of the financial markets. Thus, governments stepped in as *lenders of last resort* to relax the credit constraints which hampered the flow of funds from capital suppliers to goods producing firms. The previous literature on reforms rarely takes this behavior into account. Instead, monetary policy is assumed to rely on the nominal interest rate in order to react to crisis. Therefore, the constraint imposed on the monetary authority by the zero lower bound on nominal interest rates was of primary interest in many studies.

The main contribution of this dissertation consists in addressing these

¹See, e.g., Bernanke (1981, 1983), Bernanke and Gertler (1989), Bernanke, Gertler, and Gilchrist (1996), Kiyotaki and Moore (1997), Nolan and Thoenissen (2009), Gertler and Karadi (2011), Jermann and Quadrini (2012), and Brunnermeier and Sannikov (2014). I will review the literature in detail in Section 2.1.

issues when studying the effects of structural reforms in a crisis scenario. The model I construct builds on the standard monetary New-Keynesian dynamic equilibrium framework (see, e.g., Smets and Wouters, 2003, 2007; Christiano, Eichenbaum, and Evans, 2005). The core element of the model is the financial sector which channels capital from households to firms. Credit constraints arise endogenously from a moral hazard problem following Gertler and Karadi (2011). Financial intermediaries' leverage is therefore an important state variable in the model. Eventually, shocks are accelerated in the capital markets. The model incorporates asset prices and credit spreads. The dynamical behavior of these variables in response to structural reforms provides insights into how these policies influence credit intermediation. Prices and wages are sticky and hence money plays a role in the model. I consider different types of monetary policy rules. These include Taylor rules in which a constraint on the lower level of the nominal interest rate is imposed, as well as unconventional monetary policy rules as in Gertler and Karadi (2011). Specific characteristics of the European Monetary Union are modeled following Eggertsson, Ferrero, and Raffo (2014). Reforms are modeled as reductions in taxes on wages and retail prices, which increase competition in the labor and product markets, respectively.

I deviate from the previous literature in various aspects. In contrast to Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2014), Eggertsson, Ferrero, and Raffo (2014), and Cacciatore, Fiori, and Ghironi (2016), I consider investment in physical capital. In contrast to Eggertsson, Ferrero, and Raffo (2014), Gerali, Notarpietro, and Pisani (2015a,b), Vogel (2016), Gomes (2014), and Anderson, Hunt, and Snudden (2014), I do not model the crisis as originating from a shock to demand. Instead, the starting point of my analysis is a shock in the financial market that leads to a credit crunch as in Andrés, Arce, and Thomas (2014). The major distinction from Andrés, Arce, and Thomas (2014) is the modeling of leverage and credit market frictions. In contrast to Anderson, Hunt,

and Snudden (2014), who intend to capture unconventional monetary policy by relaxing the zero lower bound constraint, I explicitly account for direct interventions in the credit market while keeping the interest rate constraint.

My analysis reveals that the financial sector plays an important role in the way structural reforms affect the economy. The following scenario illustrates the main mechanisms: Financial intermediaries borrow funds at fixed interest from households. They invest these funds and their own equity in the capital stock. Hence, they hold a leveraged position. A moral hazard problem imposes a constraint on leverage. Assume that a financial market shock lets asset prices drop sharply. As a result, the net worth of financial intermediaries falls and balance sheets of banks deteriorate. Bankers' debt-to-equity ratios increase substantially, tightening the credit constraint and letting credit spreads increase accordingly. Households respond by reducing the amount of funds supplied to bankers. Consequently, the supply of credit to goods producing firms declines, and so does production. In sum, the initial disturbance is accelerated in the financial market and ultimately the real sector is driven into a recession.

My study shows that in this setting reforms aimed at reducing the cost of labor or the monopoly power of firms are effective in reducing the multiplicative effects in the credit intermediation process. Expectations of higher future income and production volume are immediately reflected in the financial market. Asset prices increase and credit spreads adjust. Balance sheets in the financial sector recover and debt-to-equity ratios decrease. The moral hazard constraint is relaxed. Households' capital supply increases, facilitating production and mitigating the recession. The wealth effect works, no matter whether the central bank is facing a lower bound on interest rates or not. Moreover, unconventional policy measures that stimulate credit intermediation are not in conflict with structural reforms. Thus, my model suggests that reforms are an appropriate measure to combat economic contraction in a financial crisis.

The structure of this dissertation is as follows. The next section reviews the literature related to the research question. First, I introduce the foundations, modeling, and implications of financial acceleration because it is the central element of the model which I will use to analyze reforms. Second, I describe why reforms are on the academic and political agenda. Reviewing evidence on the accumulation of current account imbalances within European countries, I explain why the present situation was deemed unsustainable and why optimum currency theory suggests that structural reforms may help restoring balance in Europe. Third, I present research on reforms in product and labor markets. I show how such reforms are typically modeled in theory and how reforms affect an economy in the short and long run. The final section of the literature review is devoted to research that studies reforms in crisis scenarios.

I then proceed to study structural reforms in a financial crisis. I begin by looking at a closed economy in sections 3 and 4. I introduce a New-Keynesian monetary dynamic stochastic general equilibrium model that is closely related to that of Gertler and Karadi (2011). The purpose of studying a closed economy first is to reduce complexity and to introduce the most relevant model features in a parsimonious way. I describe the crisis as arising from the financial sector and focus on the way reforms affect the economy in such scenario.

In sections 5 and 6, I assess structural reforms in the context of the European Monetary Union. Therefore, I extend the model to a two-area economy where both areas share the same currency. The monetary union model builds to a large extent on the setup of Eggertsson, Ferrero, and Raffo (2014). When modeling the capital markets, I again make use of the framework developed by Gertler and Karadi (2011). In the initial state, the model is characterized by asymmetries between the European areas. The regions differ with respect to the degree of competition in product and labor markets. I then go on to study how structural policies that reduce these imbalances affect the economies of the core and periphery

countries as well as the monetary union. Moreover, I study the impact of reforms when monetary policy is unconventional.

The final section summarizes and discusses the findings, and draws conclusions.

2 Literature Review

Structural reforms in product and labor markets are a controversial topic in the European Monetary Union, particularly in the aftermath of the financial crisis. The first subsection of this short review is devoted to the financial aspects of the crisis. I introduce credit frictions and financial acceleration because these are the key elements for both the motivation for my study and the theoretical models that I use for the analysis. I then describe why structural reforms are on the agenda and what is the reasoning behind the idea of implementing reforms, in normal as well as special situations. The second subsection outlines the main ideas of the optimum currency area theory and how they relate to the present discussion. Of special interest is the question if a lack of an appropriate shock adjustment mechanism in the European Monetary Union has led to the accumulation of imbalances. The third subsection focuses on the theoretical modeling of structural reforms. The final subsection deals with the adoption of structural reforms in a crisis scenario.

2.1 Credit Constraints and Financial Acceleration

Financial acceleration refers to a macroeconomic concept that emphasizes the relevance of financial frictions for the transmission of economic shocks. In fact, besides depressing real economic variables, an adverse shock may also deteriorate the functioning of the financial sector, which, in turn, amplifies the impact on real variables.

Although the simultaneous appearance of distressed financial markets and economic downturns, especially during the Great Depression in the 1930s, was well acknowledged, neither classical or Keynesian economists, nor monetarists devoted much attention to the link between the functioning of the financial system and real economic activity until the '80s. Instead, liquidity preference theory, fiscal multiplication mechanisms, business cycle theory, and the econometric evaluation of the relationship

between money and output were high on the agenda of macroeconomists.

One view was that the financial sector was merely a mirror of real economic activity and thus needed no special attention. Contrasting approaches considered the impact of a distorted financial system on the supply of money and emphasized adverse effects on real economic activity when money is non-neutral. That is, money as opposed to credit was considered the relevant financial aggregate (see, e.g., Gertler, 1988).

According to Bernanke (1983), however, financial sector distortions play a major role in the explanation of the Great Depression in the United States. He argues as follows. Bank defaults, which are for example caused by bank runs, reduce the efficiency of the financial sector and disturb the process of credit intermediation. Sectors that heavily rely on credit intermediation eventually find it difficult to get access to capital. Ultimately, their ability to operate their business erodes, and their capacity to repay debts decreases, which in turn diminishes their access to credit even further. Bernanke also supports his argument by showing empirically that financial variables are important determinants, relative to monetary aggregates, in explaining the Great Depression.

Overall, Bernanke (1983) highlights some important points. First, monetary aggregates fail to explain the magnitude of the variations of real variables, in particular output. Second, theories focusing on the non-neutrality of money are inappropriate when explaining persistent deviations of output. Finally, the author emphasizes the rationality assumption for research on the relationship between real and financial variables.

While taking into account that participants in the financial market behave rationally, microeconomic research explored in greater detail the frictions underlying the credit intermediation process. In particular, economists addressed that borrowers typically have more information about their own financial condition than lenders. Such an information asymmetry was shown to have substantial implications for the function-

ing of capital markets.

One prominent approach to studying the effects of asymmetric information on financial contracts is based on the so-called *lemons problem* (Akerlof, 1970). The main idea is as follows. It is assumed that lenders cannot, or at least not fully, observe some measure of quality of borrowers ex ante. The quality measure is usually related to the willingness or ability of the borrower to repay debt. Ultimately, the lender must evaluate the likelihood of default given limited information. For example, in Stiglitz and Weiss (1981) lenders cannot observe the riskiness of borrowers' projects, while in Jaffee and Russell (1976) lenders cannot observe the *honesty* of borrowers. Myers and Majluf (1984) consider information asymmetries between management or existing shareholders of a firm and potential new shareholders. In particular, if management has more information with respect to the firm value, it may be optimal for them to cheat external financiers in favor of existing shareholders. Consequently, lenders may treat the issuance of new shares as a negative signal (see, e.g., Greenwald, Stiglitz, and Weiss, 1984).

The literature on lemon problems provides several important insights. First, the optimal behavior of lenders when information is distributed asymmetrically can involve adverse selection. In other words, lenders treat all borrowers as average. As a consequence, low-quality borrowers benefit at the expense of high-quality borrowers. Second, there is some form of credit rationing. For example, lenders may reduce the amount of credit to borrowers to increase the ratio of collateral to debt. Alternatively, some borrowers may not be given credit at all. Third, borrowers prefer internal over external funding, because internal funding does not typically involve information asymmetries. Fourth, lending will be highly sensitive to changes in the interest rate if the interest rate feeds back to the quality of borrowers (see, e.g., Mankiw, 1986).

Other prominent approaches to information asymmetries are based on the *costly state verification* framework (see Townsend, 1979; Gale and

Hellwig, 1985; Williamson, 1987). One major advantage of this over the lemons approach is that the form of the financing contract is not imposed exogenously but emerges endogenously in the model.

The structure of the model is as follows. An entrepreneur aims at investing in a project with uncertain return and requires some financing in addition to its equity. Information is asymmetrically distributed because only the entrepreneur can observe the project's return ex post. The lender can, however, audit the borrower at a cost, thereby reducing the information asymmetry. The entrepreneur has limited liability. Hence, its payoff is at least zero. Given that the lender cannot observe the project return, there is an incentive for the entrepreneur to cheat the lender by misrepresenting the return in order to increase its own return. Moreover, if the entrepreneur's payoff is negative, he will maximize profits by declaring bankruptcy.

The optimal financing contract in this framework will have the following characteristics. First, it will encourage the entrepreneur not to understate project returns. The contract therefore involves that the borrower will audit in case of bankruptcy but will accept a fixed return in the no-default case. Second, the expected monitoring cost will be minimized.

This framework has several implications. First, there will be a premium on external finance to compensate the lender for the expected cost of bankruptcy. Such premium is often referred to as an *external finance premium* or a *lemons premium*. Second, asymmetric information increases the marginal cost of capital. Hence, firms will demand less financing and invest less if the problem is worse (see, e.g., Gale and Hellwig, 1985). Third, credit rationing can appear even in the absence of adverse selection or moral hazard (Williamson, 1987). Fourth, the premium on external finance is inversely related to the net worth of the borrower. Consequently, borrowers' balance sheets, and particularly the degree of leverage, become a relevant determinant for aggregate investment activity (see, e.g., Bernanke and Gertler, 1990). This also suggests

that there is a relation of financing cost, leverage, and investment activity over the business cycle. In fact, if balance sheets are assumed to be stronger in upturns, leverage and external finance premium will be lower, which in turn stimulates investment.² Overall, asymmetric information suggests that financial structure is relevant and that the Modigliani and Miller (1958) theorem does not hold.

The macroeconomic literature adopted the asymmetric information frameworks in order to study the qualitative and quantitative implications of financial frictions for the dynamic behavior of real variables. One of the dominant research questions was whether these frictions could help explain the intensity and persistence of the response of macroeconomic variables to shocks. Closely related is the question whether the new insights give rise to new transmission channels of monetary policy. The idea is that monetary policy does not only affect market interest rates, but also directly and indirectly affects borrowers' balance sheets (*balance sheet channel*) and the supply of loans by banks (*bank lending channel*). These channels are commonly referred to as the *credit channel* (see, e.g., Bernanke and Blinder, 1988; Gertler and Gilchrist, 1994; Bernanke and Gertler, 1995; Mishkin, 1996).

One of the first attempts to study how financial factors affect real variables over the business cycle in a dynamic setting was made by Bernanke and Gertler (1989). Their starting point is an overlapping generations model that, in the case of perfect markets, has similar features to the neoclassical real business cycle model. They incorporate asymmetric information between lenders and entrepreneurs into the model by means of a costly state verification framework. The key feature of the model is that entrepreneurs' balance sheets are relevant for the cost of external financing. Specifically, borrower net worth is inversely related to the

²These implications may be challenged on empirical grounds. During the upswing period preceding the financial crisis, for example, leverage increased. Models that try to capture this feature will be discussed further below.

agency cost of financing investments. The authors show that changes in borrower net worth have substantial implications for output fluctuations. A positive productivity shock, for example, increases the income of entrepreneurs, improves their balance sheets, thereby relaxing borrowing constraints and decreasing the cost of external capital. This encourages investment, which ultimately amplifies the boom. This mechanism is often referred to as an *income-accelerator* on investment.

Their model also shows that the accelerating effects are highly non-linear. If, for example, borrower net worth is high in upturns, external finance will be less relevant and changes in cash flows will have minor consequences for investment. To the contrary, fluctuations in cash flows have great significance when internal finance is low. Another implication is that, in case there is a safe asset, lenders will choose to increase the share of investments in safe assets if the costs of monitoring is high. Thus, the model suggests that there is *flight-to-quality* in recessions (Bernanke, Gertler, and Gilchrist, 1996).

One drawback of the Bernanke and Gertler (1989) model is that the overlapping generations framework restricts the duration of credit contracts to single periods. Carlstrom and Fuerst (1997) consider long-lived entrepreneurs instead. They incorporate the main mechanism of Bernanke and Gertler (1989) into a standard real business cycle model and evaluate the model quantitatively. The main advantage of their model is that it can replicate the hump-shaped response of output to a productivity shock. The result appears because an increase in productivity increases the return on internal capital and thus leads to a redistribution of wealth from households to entrepreneurs. The improvement in net worth is anticipated by households. Consequently, households expect the agency cost to diminish gradually when net worth increases and it is optimal to postpone investment. Overall, their results stress the importance of borrower's net worth as a state variable.

Kiyotaki and Moore (1997) construct an alternative model with credit

constraints to study the business cycle. Their key innovation is a mechanism that emphasizes asset prices, as opposed to cash flow, as the central variable in the accelerator process. The model distinguishes between constrained and unconstrained borrowers. Capital, which is thought of as land, has two functions. First, it is used as a production factor. Second, it is used as collateral for loans. Lenders can only force borrowers to repay loans that are secured so that eventually the price of land determines borrowers' credit limits. The constrained firms are assumed to be leveraged. If a productivity shock occurs, constrained firms will experience worsening net worth and will not be able to borrow more. Instead, they must reduce their demand for land in subsequent periods. However, land is in fixed supply. Unconstrained firms must therefore absorb the demand, which, in equilibrium, requires that the price of land drops. The decrease in asset prices further deteriorates net worth of constrained borrowers. Hence, there is acceleration.

Bernanke, Gertler, and Gilchrist (1999) construct what would become the workhorse model of the financial accelerator literature. According to the authors, it is *a synthesis of the leading approaches in the literature*. The key features are the following. First, it is a dynamic general equilibrium model. Second, the model incorporates monopolistic competition and price stickiness. Third, there is money. Hence, monetary policy plays a role in the model. Fourth, there are decision lags in investment that can generate the hump-shaped response of output as in Carlstrom and Fuerst (1997). Fifth, firms are heterogeneous with respect to their access to capital markets. Sixth, there are non-linear capital adjustment costs, leading to violations of Tobin's q^3 . In other words, the market value of a firm can differ from its reproduction value. Finally, there is a financial accelerator that combines elements of both Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). Specifically, the model incorporates the asset price channel.

³See Tobin (1969).

One of the main advantages of the model is that it allows for the analysis of the transmission of monetary policy in the presence of credit market frictions. The authors study, for example, how an unanticipated change in the interest rate affects real variables. They show that real variables, particularly investment and output, react stronger to the monetary policy shock when there are frictions in credit markets. Moreover, the response of real variables is more persistent. A decline in the interest rate increases the demand for capital, stimulates investment, and leads to rising asset prices. Thus, net worth of entrepreneurs increases, and the external finance premium declines. In turn, investment is further stimulated. Hence, there is a multiplication process at work.

Iacoviello (2005) constructs a New-Keynesian monetary model with credit constraints similar to Kiyotaki and Moore (1997), in which entrepreneurs and households face borrowing constraints. Firms can use real estate as collateral. A subset of impatient households is constrained in taking on nominal debt. The main implication of the model is that demand shocks are financially accelerated but supply shocks are decelerated. A positive demand shock increases housing prices, thereby relaxing entrepreneurs' borrowing constraints and encouraging investment. In addition, because consumer prices rise, the real value of debt decreases, encouraging impatient households to consume more. On the contrary, a positive supply shock increases asset prices but decreases consumer prices, and consequently the real value of debt increases. It follows from this asymmetry that a Taylor rule monetary policy that assigns a high weight to inflation can better offset supply shocks.

Goodfriend and McCallum (2007) study monetary policy in greater detail using a financial accelerator model. The structure of the banking sector is much richer than in Bernanke, Gertler, and Gilchrist (1999). In particular, the authors incorporate a production function for loans that depends on loan monitoring and collateral. Loan monitoring requires labor, while collateral can take the form of physical capital and

bonds, the latter being more efficient. Financial acceleration works in the conventional way. A positive monetary stimulus raises the demand for capital, increases asset prices, increases borrowers' net worth, and reduces the external finance premium. In addition, there is an effect that works in the opposite direction. Specifically, the same monetary stimulus increases the demand for bank deposits, which are required to facilitate transactions. This effect is referred to as *banking attenuator*.

A unique feature of the model is that it facilitates the derivation of five different interest rates: a collateralized and a uncollateralized loan rate, the government bond rate, the marginal product of capital, and an intertemporal shadow rate.⁴ Based on the model, the authors provide several insights. First, the steady-state premium on capital over the government bond is substantial. Hence, the structure of the banking sector can help explain the equity premium puzzle. Second, the external finance premium does not necessarily move counter-cyclically. Third, monetary policy may have unintended consequences if the central bank fails to appropriately account for the differences in interest rates. Specifically, the central bank may implement the *right strategy with the wrong instrument*.

Instead of studying the effects of standard shocks to the economy, such as productivity shocks or monetary policy shocks, a growing number of studies consider shocks that are specific to the financial sector. An example is Jermann and Quadrini (2012). Their model distinguishes between equity and debt financing. The constraints on debt are modeled in the usual fashion—that is, higher debt reduces the supply of funds from lenders while the value of collateral works in the opposite direction. With respect to equity, the authors assume that internal financing of firms is not limited to their profit. Instead, they can issue new equity shares at some cost. For example, a shock that induces a change in the capital

⁴The shadow rate serves as a benchmark and is derived from a fictitious default-free security that, in contrast to the government bond, cannot be used as collateral.

structure of the firm would, without the ability to issue shares, require the liquidation of assets, which would depress asset prices. If, however, the firm is able to adjust its capital structure by issuing shares, this effect would be dampened. Therefore, the model's structure highlights that the way financial shocks affect macroeconomic variables depends critically on the ability and speed at which firms can switch between equity and debt. The more rigid or costly the adjustment, the stronger the effects of financial shocks on the production of firms.

Christiano, Motto, and Rostagno (2014) include stochastic volatility of the effectiveness of capital into a financial accelerator model to study how a shock to uncertainty, i.e. a *risk shock*, affects the dynamical behavior of macroeconomic variables. In the model, each entrepreneur is subject to an idiosyncratic shock that determines how efficient capital can be used. This reflects that capital can potentially be more successful in one firm as opposed to another. The extent of dispersion across entrepreneurs is, however, non-constant and varies over time. The model implies that credit spreads increase in response to increasing risk. Based on their model, the authors show that risk shocks are important determinants of business cycles.

Bigio (2015) also considers heterogeneity in capital quality as a source business fluctuations. As per the model, entrepreneurs may default on wage payments to workers, in which case workers divert a fraction of output. The entrepreneur can ease the problem by making upfront wage payments. To do so, the entrepreneur needs liquidity, which requires the sale or collateralization of capital. Capital quality is heterogeneous and the quality of a unit of capital cannot be observed by the buyer. This information asymmetry makes liquidity costly. A shock to the dispersion of quality makes liquidity costlier, which, in turn, tightens the labor market constraints. Hence, financial frictions have real effects. The key insight is that liquidity can drop due to increasing capital quality dispersion, thereby causing a recession even though there is no change in the

productive capacity of the economy.

Many business cycle models that incorporate financial acceleration build on the assumption that non-financial firms face credit constraints. In contrast, Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) assume that financial intermediaries are not solely a veil to channel funds from households to firms. Instead, they consider that financial intermediaries are themselves constrained in their ability to obtain funds. The credit constraints arise from a moral hazard problem between households and banks that affects the flow of funds between the suppliers and lenders of capital. Shocks that affect bank balance sheets are eventually accelerated.⁵ The authors use the model to study unconventional policy measures by the central bank. Specifically, the central bank directly intervenes in the credit market when a crisis occurs, in order to relax the balance sheet constraints in the sector. The policy relies on the assumption that governments, as opposed to private banks, are not constrained by moral hazard and can therefore elastically issue risk-free debt. If the condition holds, government intervention can reduce the magnitude and persistence of a financial crisis substantially.

Gertler, Kiyotaki, and Queralto (2012) relax the assumption that financial intermediaries only rely on short-term debt to finance investments in the capital stock. Banks can issue outside equity, or alternatively subordinated debt, in addition to accepting deposits and therefore have a choice as to how vulnerable they are to macroeconomic shocks. The motivation for issuing equity is that it serves as a hedge against fluctuations in net worth. However, having more equity finance makes moral hazard more severe in their model. The optimal capital structure ultimately depends on the perceptions of fundamental risk in the economy. In particular, less fundamental risk justifies higher leverage. Moreover, the model implies that expectations of government interventions in a crisis scenario increase financial intermediaries' optimal leverage. Thus, a

⁵I will explain this model in greater detail in the following sections.

highly leveraged financial sector, as was for example observed before the financial crisis, potentially reflects financial intermediaries' expectations of government interventions in case a crisis occurs.

Gertler and Kiyotaki (2015) and Gertler, Kiyotaki, and Prestipino (2016) construct a model in which a financially accelerated recession opens up the possibility for bank runs. The main idea is that due to liquidity mismatch in the financial sector, a bank run is generally possible (see also Diamond and Dybvig, 1983; Cole and Kehoe, 2000). Bank liabilities can be withdrawn at any time, whereas bank assets have long maturities and are not perfectly liquid. Hence, if all depositors withdraw their funds at once, the bank will collapse, which is a reason for depositors to do so. In the model, households can choose to *run a bank* in each period. If they run and the banks are not able to repay deposits, the banking system will collapse. If this happens, households will have to invest directly into the capital stock, which is less efficient. Thus, households will not run as long as the liquidation value exceeds the value of deposits. An economic shock that accelerates in the financial market may not allow this condition to hold, implying the possibility of bank runs. If it is assumed that the probability of a bank run depends on the strength of the violation of this condition, an additional amplification mechanism for shocks appears. The anticipation of a bank run will therefore be harmful for an economy, even if it does not occur.

Traditional models of the financial accelerator have focused on modeling the amplification of shocks and the persistence of the crisis that arises subsequently. The economy is typically assumed to be in the steady state when the triggering shock occurs. A relatively new area of the literature explores whether an economy is more vulnerable to shocks in some states of the world than in others. The main idea is that although there are constraints in the financial market, they only occasionally bind, and consequently amplification effects are state dependent and highly non-linear.

Mendoza (2010) studies if credit frictions can explain *sudden stops*

in capital flows to emerging market countries. He constructs a dynamic stochastic general equilibrium of a small open economy with two special features of the credit market. First, firms require external finance to fund their working capital. Second, long-term debt as well as working capital loans cannot exceed a fraction of the market value of the physical capital that serves as collateral. From this setup emerges a ceiling on the leverage ratio of firms. As in other models of the financial accelerator, leverage amplifies the effect of shocks on macroeconomic variables in an asymmetric way. However, as net exports are countercyclical in the model, leverage grows in times when the emerging economy expands and may ultimately hit the ceiling. Once leverage is at its maximum, shocks lead to fire sales of assets which by itself enforces the constraint. Ultimately, investment and consumption decline and capital flows reverse. Therefore, the model can capture a sudden downturn after a period of sustained expansion.

Brunnermeier and Sannikov (2014) study financial frictions in a continuous time economy. In their model, there are experts and households that differ in their productivity in managing capital. For any given distribution of wealth, it would be optimal if experts would manage all the capital. Experts are, however, constrained in their ability to issue equity to households. Instead, they can only issue risk-free debt. It is assumed that households invest a fraction of their assets in a risk-free asset so that experts can be leveraged. Eventually, the determining variable in the model is the distribution of wealth between experts and less-productive households. Particularly, when experts' share of wealth increases, asset prices increase and leverage and risk premia decrease. One of the authors' main insights from this model is that amplification is highly non-linear. They show that near the steady state amplification is low or even zero; however, if the experts' share of capital is low, the acceleration mechanism becomes substantially stronger. Hence, an economy may occasionally switch to a crisis regime due to shocks. Once in that regime,

even small shocks can have large consequences. Moreover, the economy may be stuck in this regime for an extended period. Interestingly, this endogenous, state-dependent risk is rarely determined by fundamental risk. Rather, it is determined by the liquidity of capital, i.e. the frictions in the capital market. Moreover, amplification is asymmetric in the sense that amplification of positive shocks is small. Another interesting result is that financial innovations, although they reduce idiosyncratic risk, encourage higher leverage which increases systemic risk.

He and Krishnamurthy (2012, 2013) also consider a continuous time model in which specialists accept money from households and invest in a risky asset. Specialists can issue equity to households, but due to a moral hazard problem, the optimal equity contract implies a ceiling on the equity holdings of households. Specifically, the maximum equity holding is a fraction of specialists' wealth. Some characteristics of the model are similar to those of Brunnermeier and Sannikov (2014). In particular, the amplification of shocks is small in normal times but becomes large when the financial constraints are binding. In contrast to Brunnermeier and Sannikov (2014), however, recovery from the crisis regime is faster.

The recent financial crisis followed a boom period that involved substantial credit expansion. This evolution can be explained by occasional financial market runs as described by Boissay, Collard, and Smets (2016). The centerpiece of their model is a financial sector with heterogeneous banks which differ with respect to their intermediation efficiency. Banks receive deposits from households and can also borrow from other banks. There is asymmetric information in the sense that lenders cannot observe or verify the efficiencies of other banks. There is also moral hazard in the banking market. In precise terms, borrowing banks can at some cost divert funds, which cannot be recovered by lenders. There are four different return rates: An inefficient storage rate, the deposit rate, interbank rate, and the return on firm loans. The structure implies that inefficient banks will lend to efficient banks. If the interbank rate is high relative to

the loan rate, the cutoff efficiency to borrow will be high. Moral hazard imposes a limit on the borrowing capacity of the interbank market. In other words, the demand for funds is not strictly decreasing in the interbank rate because, at small rates, the market is more selective when choosing borrowers to prevent moral hazard. A market breakdown can appear in the model when the supply of funds exceeds the absorption capacity of the banking market. This can happen either due to the over-accumulation of assets by households, i.e. from the supply side, or due to an adverse productivity shock that reduces demand. The key point is, however, that a sequence of *positive* productivity shocks drives down interest rates, making the economy more vulnerable to shocks. In such a situation, small negative impulses to productivity can cause a collapse of the interbank market, resulting in severe recession. Thus, the model offers an explanation for the appearance of a sudden banking crisis in a credit-intensive boom.

The literature on credit frictions and financial acceleration is large and fast-growing. The key results of my short review are summarized as follows: The financial accelerator literature initially tried to explain why small shocks can have a large and persistent effect on macroeconomic variables. The explanation is based on frictions in the process of credit intermediation, which stem from asymmetric information or moral hazard between borrowers and lenders. One way to overcome incentive problems in financial contracts is monitoring which typically brings up the borrower's collateral, net worth, or leverage as a state variable. This implies that financial structure is relevant. Credit supply and capital returns thus depend on the borrowers' balance sheets, which themselves depend on asset prices. Hence, there is feedback from financial to real variables. A shock that changes, for example, asset prices is therefore accelerated in the credit market.

Eventually, the financial accelerator mechanism found its way into real business cycles models, dynamic New-Keynesian models, and mon-

etary models in order to explain several empirical observations including the size and persistence of macroeconomic variations in response to shocks, the flight-to-quality in recessions, and the hump-shaped response of output to productivity shocks.

The literature also gives insights into monetary policy. With credit frictions, the choice of inflation and output weights in a Taylor rule implicitly determines whether a central bank is better suited to react to supply or demand shocks. It is also relevant which particular interest rate the central bank targets. Different interest rates have different optimal rules. In a financial crisis, government intervention in the credit market can help to mitigate the crisis by encouraging credit flow. However, expected government intervention may also worsen moral hazard in the financial sector.

Financial shocks, risk shocks, and shocks to expected future market conditions are also important sources of business-cycle fluctuations. A change in the dispersion of a financial variable can induce a contraction of real economic variables, although there is no fundamental change in the productive capacity of an economy. Moreover, the anticipation of a bank run can harm an economy, even though a bank run never appears. Moreover, an economy's ability to quickly and inexpensively adjust the aggregate capital structure is a major determinant of its vulnerability to financial shocks.

According to recent research, financial acceleration is highly non-linear and thus economies may be prone to instability. Amplification of positive shocks is minor, but amplification of negative shocks is substantial. Economies occasionally switch to different regimes, resulting in sudden and substantial changes in real variables. A financial crisis can be preceded by a long period of expansion and be triggered by small shocks.

This review describes the emergence and development of the financial accelerator literature. Although it is far from complete, it attempts to cover the most relevant contributions in this fields. More comprehensive

reviews are, for example, provided by Gertler (1988) or, more recently, Brunnermeier, Eisenbach, and Sannikov (2012).

One of the main contributions of my study is that it takes credit frictions and financial acceleration into account in the evaluation of structural reforms. I will construct a scenario of a crisis which is driven by a financial shock and I will show how reforms affect asset prices and credit intermediation.

The following sections of this literature review explain the context of the recent discussion of reforms in the European Monetary Union and present how, from a theoretical perspective, reforms affect an economy in normal times and in a financial crisis.

2.2 Imbalances in the European Monetary Union

In a currency union, all member states agree to share one single currency as the official medium of exchange. A common currency reduces transaction costs and exchange rate uncertainty, thereby leading to greater competition due to reduced price distortions and increased transparency. Therefore, trade is expected to increase substantially among the member states of a currency union (see, e.g., Rose, 2000; Rose and van Wincoop, 2001; Glick and Rose, 2002; Frankel and Rose, 2002). Besides trade, there are other advantages of a fixed exchange rate, such as the disciplining of policymakers or the import of monetary policy credibility (see, e.g., Giavazzi and Pagano, 1988; Giavazzi, 1988; Herrendorf, 1997; Alesina and Barro, 2002).

Provided that capital can flow freely, all member states have to relinquish their independence with regard to monetary policy and devote monetary decision-making to a common authority. The discussion of the economic drawbacks of sharing a currency is built around the question, how an economy adapts to asymmetric shocks⁶ if exchange rates cannot

⁶Asymmetric shocks have different magnitudes in each country. Alternatively, a

adjust, and a single monetary authority has to cope with different or even inverse economic developments in different areas.⁷

Consider, for example, a positive shock to aggregate domestic demand in a simple two-country economy model with rigid prices, static expectations, free capital flow, and a flexible exchange rate (see Mundell, 1963; Fleming, 1962). The shock initially increases both the output and demand for domestic currency. Capital imports increase, leading to an appreciation of the domestic currency. The reduction in net exports lets output finally converge back to its natural level. The dynamics would be different if the exchange rate was fixed. In that case, upward pressure on the domestic currency would require central bank intervention to absorb the shock. Finally, if there is only one currency, an asymmetric shock may, from the perspective of both countries, require conflicting policy initiatives. If, for example, a share of goods is not tradable internationally, the degree of upward price pressure and the optimal monetary policy response will not necessarily be identical in both countries.

Optimal currency area theory addresses the question if a set of countries should abandon flexible exchange rates, taking into account the costs and benefits of doing so. The early literature on optimal currency areas proposed the following characteristics to help the currency union's member countries make smooth adjustments to asymmetric shocks. According to Mundell (1961), mobility of production factors, in particular labor, is an important characteristic. The idea is simple: Given a negative shock in one country, workers can move to a different country and avoid unemployment. McKinnon (1963) argues that mobility is important not only among regions, but also among industries. He highlights the openness of the economy, as measured by the ratio of tradables to non-tradables, as an indicator of how well a fixed exchange rate regime shock of equal size affects economies differently.

⁷Note the implicit assumption that monetary policy is at all effective in steering economic variables. This need not necessarily be the case as will be discussed below.

works. Kenen (1969) emphasizes product diversification. He argues that a large number of products make a national economy less vulnerable to idiosyncratic shocks. He also stresses that fiscal integration would improve the adjustment to asymmetric shocks. Given a common fiscal policy, the government could, for example, redirect spending from prosperous regions to those that suffer from a shock. Fleming (1971) emphasizes the similarity of inflation rates as an indicator of how well a currency union can adjust to asymmetric shocks.

Some major advancements in economic theory, particularly those of Lucas (1976), Kydland and Prescott (1977), Calvo (1978), and Barro and Gordon (1983) challenged the traditional view of the optimum currency area theory. Most of the theoretical models dealing with currency areas were built around a stable Phillips curve, suggesting that monetary policy is an effective tool in stabilizing an economy. If, however, individuals form their expectations rationally, the ability of the central bank in steering an economy might be severely limited. When this is the case, the cost of losing monetary control when joining a currency union is minor. Moreover, considering that entering a currency union is a substantial structural change, i.e. a regime shift, the characteristics described by the traditional theory are in fact endogenous (see, e.g., Frankel and Rose, 1998). Hence, the criteria need not necessarily be fulfilled *ex ante* but may instead be the result of entry to the currency union. The new approach of focusing on endogeneity is often termed the *new theory of optimum currency areas* (see, e.g., De Grauwe, 1992; Tavlas, 1993).

Frankel and Rose (1998), for example, argue based on empirical findings that business cycles are more correlated if countries are economically integrated. Therefore, the fulfillment of optimum currency area criteria is likely to emerge once a country has entered a currency union. In contrast, participation in a currency union may also cause the member states to diverge from each other. Krugman (1993) argues that countries may specialize over time once they have entered a currency union thus

becoming more vulnerable to asymmetric, that is region specific, shocks.⁸

Given that shock absorption is less than perfect, theory suggests that over time the economies of member states of a currency union diverge and imbalances accumulate. Numerous empirical studies focusing on the European Monetary Union confirm such accumulation.

Shortly after the introduction of the euro, Blanchard and Giavazzi (2002) document a trend of growing current account deficits of some European countries, particularly Greece and Portugal. They argue that standard economic theory can well explain this pattern. The idea is that goods and financial market integration lead to convergence among member states, especially with respect to productivity and competitiveness. This fosters expectations of higher growth in less-advanced countries relative to more-advanced countries. Thus, the improvement in wealth lets households save less in those countries with higher growth expectations, while these countries' higher expected rates of return encourage the more advanced countries to invest in the growing countries. This pattern is often referred to as capital *flowing downhill*.

In fact, productivity catch-up could be observed at that time (see, e.g., Gourinchas, 2002). Lane and Pels (2012), in an extension of the work of Blanchard and Giavazzi (2002), confirm that prosperous future expectations are related to the evolution of current accounts. Campa and Gavilan (2011) report that expectations about future growth increased in all southern European countries following the introduction of the euro. Moreover, the flow of capital from more-advanced European countries to less-advanced countries has been confirmed in the subsequent literature (see, e.g., Lane, 2010; Schmitz and von Hagen, 2011).

These *sustainable* imbalances are often referred to as *good* imbalances

⁸De Grauwe and Mongelli (2005) provide a comprehensive overview of the literature on endogeneity in the optimum currency area theory, where they cover the endogeneity of economic and financial integration, the endogeneity of symmetry of shocks, and the endogeneity of product and labor market flexibility.

(see Blanchard and Milesi-Ferretti, 2009). The more recent literature emphasizes, however, that these imbalances may in fact be *bad*, that is *unsustainable*.⁹

In a comprehensive study, Dieppe et al. (2012) analyze numerous indicators of competitiveness of the euro area countries and how they are related to external imbalances among these countries. They find that in Southern European countries the trade balance is related to indicators of competitiveness. Southern countries experienced higher increases in labor costs while simultaneously productivity growth was lower. In addition, they document that non-price factors such as regulations, technological innovation, labor force characteristics, and the general business environment contribute negatively to the trade balance.

Berger and Nitsch (2014) also document that convergence in terms of competitiveness did not occur in member states of the currency union. In contrast, they report a widening of trade imbalances after the introduction of the euro and argue that this may be a result of a lack of flexibility of product and labor markets in the periphery. Other papers that relate imbalances to the poor competitive position of the peripheral member states of the European Monetary Union are Arghyrou and Chortareas (2008) and Belke and Dreger (2013).

According to the idea of good imbalances, capital inflows in the periphery should be used in productive sectors, mostly the tradable goods sector. However, it seems that the non-tradable sector, especially residential construction, benefited most from the capital coming from the core (see, e.g., Giavazzi and Spaventa, 2011; Holinski, Kool, and Muysken, 2012). If capital is directed into inappropriate sectors, there might be some growth in the short run but eventually the economies will not catch-up in terms of productivity and competitiveness. Instead, the result of misguided capital utilization was that prices in the periphery increased

⁹Eichengreen (2010) points out the difficulty in identifying *good* and *bad* imbalances, even ex post.

substantially. Due to the common currency, inflation differentials between the core and the periphery could not be absorbed by currency depreciation. Moreover, as the European Central Bank sets the interest rate on a union-wide basis, real interest rates were lower in the periphery, which, in turn, encouraged spending and boosted demand. Therefore, some authors argue that imbalances are driven by demand, not supply. For example, Gaulier and Vicard (2012) point out that unit labor costs, one of the primary indicators of competitiveness, are only weakly correlated with exports. Instead, they argue that a boom in the non-tradable sector, especially construction, financed by core countries, led to rising prices in the periphery. Consequently, the demand for imports increased and at the same time labor costs rose. Therefore, the authors believe that decreasing competitiveness was the result, not the cause of external imbalances. Similar arguments are made by Wyplosz (2013), Sanchez and Varoudakis (2013), Comunale and Hessel (2014), Gabrisch and Staehr (2015), and Unger (2015).

Chen, Milesi-Ferretti, and Tressel (2013) identify trade shocks originating outside the euro area, in particular China and Eastern Europe, as an important driver of current account imbalances. They argue that the large demand of China was mainly served by Germany and other core countries, while at the same time countries in the periphery suffered from increased competition from China and Eastern European countries. The authors also document capital flows from the core to the periphery. They point out, however, that investors outside the euro area were primarily investing in securities originating from the core of Europe.¹⁰ The authors further argue that peripheral Europe, while in need of real exchange rate depreciation to be able to compete globally, experienced a real exchange rate appreciation that was driven by nominal exchange rate appreciation relative to other currencies and excessive intra-European financing.

Whether or not the member states of the European Monetary Union

¹⁰See also Hobza and Zeugner (2014).

were suitable candidates was—and continues to be—a subject of academic discussion.¹¹ Some of the criteria of the early literature were violated. However, the picture is less clear when endogeneity is considered. Krugman (2012) points out that the lack of labor mobility and fiscal integration played an important role in the accumulation of imbalances. De Grauwe (2013) argues that the lack of automatic stabilizers, in particular a fiscal transfer system on a currency union-wide level, is one of the major *design failures* of the Eurozone. Moreover, the authors stress that the role of the banking sector and the central bank’s role as the lender of the last resort, which have played an important role in the recent European crisis, have mostly been ignored in the early literature on optimal currency areas.

In summary, traditional optimum currency area theory has established various *ex ante* criteria to be met by candidates for entry into a fixed exchange rate regime. These include the mobility of production factors, flexible prices, openness, product diversification, fiscal integration, and the similarity of inflation rates. The fulfillment of these criteria is associated with more closely correlated business cycles and will thus make a currency union less vulnerable to asymmetric shocks. The new optimum currency area theory has challenged this view, arguing that these criteria are endogenous and may therefore be fulfilled *ex post*. There is no consensus on the question if members of the European Monetary Union are suitable candidates. By now, the literature has documented the accumulation of imbalances. Most studies suggest that these are unsustainable. There is evidence that current account imbalances stem from both supply and demand-driven forces.

How can balance be restored? This question has brought structural reforms on the political and academic agenda in Europe.

¹¹Mongelli (2008) provides a comprehensive review of the optimum currency area theory with a focus on the European Monetary Union.

2.3 Reforms in Product and Labor Markets

In a currency union, exchange rates cannot adjust in response to shocks. Moreover, monetary policy is designed on a unionwide level. Traditional optimum currency area theory suggests that prior to entry in a currency union, potential member states should initiate policies to improve the criteria as discussed in the last section. By doing so, the business cycles of the member economies are expected to converge. In other words, the correlation among countries of real variables and prices supposedly increases. Similarly, when member economies of a currency union have diverged and imbalances have accumulated, appropriate policies should result in a reduction in imbalances and let the economies converge.

The literature proposes a variety of reforms to achieve convergence. In this section, I will focus on structural reforms in product and labor markets.¹² Such reforms are in general designed to increase competition in the respective markets by reducing sources of inefficiencies. In the product market, a reform could, for example, include the reduction in entry barriers. Examples of labor market reforms are the reduction in hiring and firing costs, or reduced unemployment benefits.

Many of the modern approaches to model reforms in the product and labor markets built on the ideas of Blanchard and Giavazzi (2003). The authors construct a simple two-period general equilibrium model with monopolistic competition. Firms produce using only labor, and their number is fixed in the short run but endogenous in the long run. There are frictions in product and labor markets, which are thought of as regulation. Workers have bargaining power, and there are firm entry costs that determine the degree of competition between firms.

Deregulation consists of policies that reduce the monopolistic power of firms and workers. Product market deregulation decreases the total

¹²Other reforms include financial, trade, and capital account reforms, as discussed, for example, in Christiansen, Schindler, and Tressel (2013).

rents of firms and hence the rents available to workers. The level of labor market regulation determines how rents are distributed.

The long-run effects of product market deregulation are positive in their model. Although deregulation reduces the total rent available to workers, this loss is outweighed by workers' benefit from increased competition as consumers. Additionally, labor market deregulation is desirable in the long run as it leads to higher employment. However, reforms in the labor market lead to higher unemployment and lower real wages in the short run. As the number of firms is fixed, lower wages that result from a loss of bargaining power of workers do not lead to higher employment but instead increase the rent of firms. In the long run, a higher rent encourages firm entry and more competition so that workers ultimately gain.

The authors' results have received considerable attention as they have important implications for policy design. If a reform has negative short-term consequences for some groups or individuals of an economy, there might be opposition against these policies although the long-run benefits are positive. The specific degree of market deregulation, the way product and labor market reforms are combined, as well as the timing of policy measures can significantly influence their effectiveness.

The subsequent literature on product and labor market regulation has frequently build on the ideas of Blanchard and Giavazzi (2003). In particular, researchers have studied how reforms affect the economy in models that include more microeconomic details of either product or labor markets.

For example, Ebell and Haefke (2009) study product market regulation in a dynamic general equilibrium model with individual bargaining in multi-worker firms. They highlight two forces that are at work when competition is increased in the goods market. The first effect is standard. Output increases and so does employment. The second effect stems from individual bargaining and goes into the opposite direction.

The authors refer to it as *overhiring effect*. In response to higher output demand resulting from increased competition, firms hire more workers. The structure of individual bargaining in multi-worker firms implies that more hiring diminishes the bargaining power of workers. Thus, wages decrease. The lower income of workers ultimately lowers aggregate demand. The net effect of reforms on output and employment is nevertheless positive in their model.

In a similar model, extended to include heterogeneous firms as in Melitz (2003), Felbermayr and Prat (2011) describe a *selection effect* of product market reforms. In particular, they argue that reforms in the product market only have a positive effect on employment if the policy increases average firm productivity. In their model, a reform that raises market entry costs increases unemployment. Such a policy decreases average productivity because it protects the least productive firms and allows them to remain in the market. In contrast, a reform that increases recurring fixed costs of production pushes the least productive firms out of the market and thus affects employment positively. Thomas and Zanetti (2009) assess the impact of labor market reforms on price stability in a New-Keynesian model with search and match frictions in the labor market. They find that the effects of labor market policies on inflation volatility are quantitatively rather small.

Another strand of the literature focuses on the interaction between product and labor market reforms. Fiori, Nicoletti, Scarpetta, and Schiantarelli (2008), for example, present an extended version of the Blanchard and Giavazzi (2003) model where unions can lobby labor market regulations. They show that product market deregulation is more effective if workers experience high bargaining power. They argue that when bargaining power of workers is low, allocation in the labor market is more efficient, and thus employment is close to its optimal level. Consequently, the potential benefits of product market reforms are small.

Spector (2004) builds a similar model in which capital is used as

a production factor and labor is characterized by decreasing returns. He shows that product market deregulation can be inefficient, especially if workers' bargaining power is high. When competition increases in the product market, the total rents available for distribution decrease. Workers will use their bargaining power to increase their share of those smaller rents. However, due to increased competition it is difficult for firms to pass on these costs to consumers by raising prices. Instead they prefer to lower labor demand. Consequently, real wages may even fall, both in the short run and in the long. The author concludes that a high degree of labor market regulation favors product market regulation.

Bertinelli, Cardi, and Sen (2013) also study the effect of regulation in product markets on employment in a dynamic setting. They show that increasing competition in the goods market leads to higher employment in the long run and that this effect is much larger when labor force participation decision is endogenous, worker bargaining power is high, and unemployment benefits are low. They describe this as an *multiplicative employment effect*. In the short run, however, such policy results in unemployment.

In a real business cycle model with endogenous product creation and labor market frictions Cacciatore and Fiori (2016) analyze how deregulation in the product and labor market affect the business cycle in the short and in the long run. In particular, they consider lowering entry barriers, unemployment benefits, and firing costs such that one country, Europe, can catch up with another country, the United States. They find, first, that reforms can have negative short-term consequences for output and employment. The result arises from various channels. When firing costs are reduced, the immediate gain of instantaneous lay-offs outweighs the gains from lower future lay-off costs. Hence, unemployment increases in the short run. Reducing barriers to entry in the product market is also contractionary. One of the effects of the policy is that it reduces the demand for goods by new firms, which have to do an initial investment

to enter the market. Another effect is that increased competition resulting from product market reforms causes existing firms to immediately lay off workers. The authors' second finding is that deregulation in the product and labor markets is interdependent with respect to its effect on the volatility of the business cycle. When reforms are initiated simultaneously, they reduce volatility and are thus welfare enhancing. Negative consequences for welfare arise, for example, if firing costs are reduced in a situation where unemployment benefits and barriers to entry are high.

There is also growing interest in how reforms in one country affect the economies of other countries. Alessandria and Delacroix (2008) study labor market reforms in an international context. They show that removing firing restrictions internationally enhances welfare. However, if such policy is initiated unilaterally, the reforming country may not be the major beneficiary. Instead, a large part of the gain is captured by the foreign country.

Cacciatore, Fiori, and Ghironi (2015) construct a New-Keynesian model with heterogeneous firms, endogenous producer entry, and labor market frictions to explore how structural reforms in Europe affect the global economy, in particular Europe and the United States. Market reforms in Europe lead to firm entry in both regions and induce higher employment. The model implies reallocation across sectors in response to structural changes. The reforming country experiences a rise in productivity in the exporting sector and an improvement in the terms of trade. The foreign country experiences firm entry in the exporting sector. The result in the short run is a growing current account deficit in Europe.

Cacciatore, Duval, Fiori, and Ghironi (2016) study the implications of structural reforms for optimal monetary policy in a monetary union. They construct a dynamic stochastic general equilibrium model where labor market deregulation has the form of a reduction in unemployment benefits and employment protection and product market deregulation consists of a reduction in regulatory costs that pose barriers to product

creation. Their main finding is that the welfare maximizing monetary policy implies short- and long-run deviations from price stability when markets in the monetary union are highly regulated. In other words, long-run inflation absorbs to some extent the distortions implied by regulation. Deregulation is welfare enhancing in the long run and implies a lower optimal inflation target. In the short run, the initial optimal response to deregulation is expansionary (relative to a standard Taylor rule). Moreover, the authors show that a monetary union benefits from symmetric deregulation.

The main conclusions drawn from this section are as follows. Theoretical research frequently models product and labor market reforms as a reduction in some cost factor that supposedly enhances competition. The long-term benefits in terms of output or employment of such policies are positive. The short-run effects depend on the type and microeconomic modeling of the labor and product market, such as bargaining structure or firm entry, as well as timing and interaction of policies. Importantly, the effects can be negative. Policymakers can enhance the short-term benefits of reforms by considering the sequence of product and labor market deregulation and by coordinating internationally.

2.4 Reforms and the Financial Crisis

The advances made in the literature discussed so far stem mostly from a more detailed microeconomic modeling of market structures. Recent research suggests that the effectiveness of reforms does not only depend on the specific characteristics of the labor and product markets, but also on the state of the economy, monetary policy, and the financial market. This section discusses recent contributions in this field.

Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2014) argue that in a demand-driven crisis where the nominal interest rate is

zero, monetary and fiscal policy measures are unlikely to work.¹³ Therefore, the authors emphasize supply-side policies, such as increasing competition, as an appropriate tool to enhance recovery from a crisis. To study these policies, they construct a simple two-period model with money, monopolistic competition, and price rigidities. The model illustrates that when the interest rate is fixed because of the zero lower bound, competition enhancing supply-side policies are associated with a wealth effect. Increased competition leads to expectations of higher future output, income, and consumption. In the two-period setting, intertemporal optimization of households implies that higher future consumption, relative to current consumption, is accompanied by a rise of the interest rate. That is, if the interest rate was flexible, the wealth effect would be offset by a rise in the real interest rate. If, however, the interest rate is stuck at zero, current consumption must increase so that the optimality condition can hold. Therefore, the policy stimulates demand immediately in a crisis scenario.

To the contrary, Eggertsson, Ferrero, and Raffo (2014) argue that the real interest rate effect dominates if an economy is at the zero lower bound. They construct a New-Keynesian monetary dynamic stochastic general equilibrium model of the euroarea and study the effects of structural reforms that are initiated in the European periphery. The model consists of two countries that share a common monetary policy. There are a tradable and a non-tradable sector. Product and labor markets are monopolistically competitive. Prices and wages are sticky. Labor is the only factor of production and is immobile across countries and sectors. Reforms are modeled as reductions in the monopolistic power of workers and retail firms. The following scenario illustrates how the real interest rate channel works. First, there is a preference shock that reduces the

¹³By assumption, conventional monetary policy relies on lowering the interest rate to stimulate demand. Moreover, they assume that fiscal multipliers are close to zero in a crisis scenario.

demand for consumption goods. As a result, goods prices fall. The central bank reacts by reducing the interest rate to the zero lower bound to fight deflation. In this situation, reforms in the product and labor markets that increase competition cause further deflationary pressure. The central bank is, however, unable to react because the interest rate is already zero. The expectation of deflation in combination with zero interest implies a positive real interest rate. Consequently, households adjust their plans and postpone consumption to the future. Hence, current aggregate demand is further reduced. In summary, although reforms increase the long-run steady state output, their short-term consequences are negative.¹⁴

The two models presented so far illustrate that the effects of reforms critically depend on the assumption about which variables can adjust in which direction. In both models, demand is initially reduced and reforms imply an increase of future demand. In the first model, the increase of future demand is channeled through current demand because the interest rate is kept fixed. To the contrary, in the second model, the preference shock implies that current demand cannot go up. Instead, reforms drive up the real interest rate.

There is diverse research with respect to frictions that affect the transmission channels of reforms. For example, Cacciatore, Fiori, and Ghironi (2016) pose the question of how the reduction of market frictions affects firm entry in a crisis.¹⁵ The authors find that during a period of recession, the effects of reforms differ from those in normal times. Particularly, the negative short-run effects of a reduction in firing costs are larger and more persistent. In a recession, aggregate productivity is low and hence

¹⁴The same argument is made in Eggertsson (2012), though in a non-European context.

¹⁵Their model is similar to that in Cacciatore and Fiori (2016), which is discussed in section 2.3. Consequently, the effects of reforms in normal times are close to the ones described there.

job destruction increases when firing costs are reduced, which ultimately leads to further contraction of output. Reducing unemployment benefits has a positive effect in a crisis because the effect of lower wages on new job creation outweighs the impact of lower wages on income. In their model, product market reforms in times of recession have similar negative effects than in normal times.

One disadvantage of the above described models is that they do not incorporate capital and investment. However, structural reforms in the European context are particularly aimed at encouraging investment (see Fernández-Villaverde, 2014). Therefore, some authors have studied reforms in more comprehensive models. Vogel (2016) uses the Quarterly European Simulation Tool (QUEST) to study product and labor market improvements in the presence of a zero lower bound. QUEST is a New-Keynesian dynamic stochastic general equilibrium model used by the European Commission to perform policy analysis. The author shows that within this framework, short-term consequences of reforms can be negative. However, the real interest rate effect is much less important than in the model of Eggertsson, Ferrero, and Raffo (2014). Three features of the model turn out to be relevant for the transmission of reforms. The first is the presence of capital and investment, which makes the wealth effect relevant. Higher future income increases the demand for investment goods, thereby offsetting some of the negative effects of decreasing consumption demand. Second, the presence of imperfect capital markets poses limits on the real interest rate channel. In particular, the presence of liquidity constrained, non-Ricardian households makes consumption less sensitive to the real interest rate. Finally, there is a positive effect of increased competition due to trade with the rest of the world.

Gerali, Notarpietro, and Pisani (2015a,b) present similar results. They also incorporate physical capital in a New-Keynesian dynamic model. An aggregate demand shock drives the nominal interest rate to zero in their model. Reforms induce further deflationary pressure, resulting in an

increased real interest rate that reduces demand through intertemporal substitution. They show that reforms do not only affect consumption but also stimulate demand for investment goods. As capital accumulates, the productivity of labor increases, magnifying the wealth effect. Eventually, the wealth effect dominates.

Gomes, Jacquinet, Mohr, and Pisani (2013) study competition enhancing policies in the product and labor markets using the Euro Area and Global Economy Model (EAGLE, see Gomes, Jacquinet, and Pisani (2012)), a multi-country large-scale New-Keynesian model, and compare stand-alone deregulation in sectors and regions of Europe to coordinated measures. Their results are in favor of reforms, in the short as well as in the long-run, whether initiated unilaterally or not. Coordination across sectors and regions can, however, enhance the effectiveness of reforms by improving terms of trade vis-à-vis the rest of the world. Gomes (2014) uses a similar framework to study reforms when the economy is faced with a crisis and the interest rate is at the zero lower bound. She finds that structural reforms improve the recovery from a crisis and reduce the time in which the interest rate is zero. The effect of the zero lower bound in the short run is minor if the reforms are permanent. Reforms are followed by an improvement in investment and consumption, as agents adjust their plans in response to expectations of a better future. In contrast, transitory reforms have a considerable negative short-term impact on output.

Anderson, Hunt, and Snudden (2014) analyze how structural reforms can help mitigating the negative impact of fiscal consolidation in Europe. Their starting point is a situation where imbalances have accumulated. They assume that the European periphery must improve fiscal balances by means of spending cuts and tax increases. In their analysis, the authors use the Global Integrated Monetary and Fiscal Model (GIMF, see Kumhof, Laxton, Muir, and Mursula (2010)) of the International Monetary Fund, a comprehensive multi-country New-Keynesian monetary

model that has some special features: First, it includes overlapping generations of households and liquidity constraints resulting in large fiscal multipliers. Therefore, fiscal consolidations have a large negative impact on short-term output. Second, the model has incomplete asset markets and a financial sector. The model implies that economic changes are accelerated through the financial market. The main result of the paper is that structural reforms are an effective tool for smoothing out the contraction brought about by consolidation. Agents in the model gradually perceive the future prosperity that follows from reforms and adjust their plans accordingly. In other words, there is a wealth effect at work. The authors also consider the zero lower bound on interest rates, but only for the first two years after which the rate can fall below zero. This assumption captures easing of the monetary policy. Therefore, it should be kept in mind that the results shown in the paper do not solely reflect the outcomes of reforms, but also those of unconventional monetary measures.

The paper that is most closely related to the work in this dissertation is that of Andrés, Arce, and Thomas (2014). In contrast to the literature discussed so far, the authors consider some specific characteristics of financial markets and the role that debt played in the financial crisis. They build a dynamic equilibrium model of a small country within a monetary union. The model is supposed to capture slow and lengthy deleveraging of households and entrepreneurs. Thus, the model has the following features. First, impatient households and entrepreneurs borrow from patient households using long-term debt contracts that are amortized at a constant rate. Second, these debtors are constrained when assuming debt. Precisely, outstanding debt cannot exceed an exogenously given fraction of the collateral value. Third, the model includes real estate as collateral. The model setup implies two different regimes between which the economy switches endogenously. When the collateral value exceeds outstanding debt, constrained agents can receive new funds. If instead

the collateral value relative to the outstanding debt falls below a threshold, credit freezes and the economy enters a period of deleveraging. The authors then test if product and labor market reforms can enhance recovery from a deleveraging scenario. Their results are in favor of product market reforms. Increasing competition in the product market stimulates investment in both, the capital used in production and real estate. Consequently, real estate prices rise. As the value of the collateral increases, the loan-to-value ratio improves, and ultimately the economy switches to the normal regime. To the contrary, labor market reforms are not as effective in stimulating demand for real estate in the short run.

To sum up, the recent literature suggests that the effectiveness of reforms depends on the state of the economy. In particular, the presence of a lower bound on the nominal interest rate is relevant for the transmission of product and labor market policies. The above studies vary widely in how they assess the impact of reforms on the economy. But there seem to be some common channels through which reforms work. First, reforms that are associated with lower prices cause deflationary tendencies, and hence the real interest rate is affected. If it increases, individuals change their plans and consume less in the present, thus lowering aggregate demand. These short-term negative effects are typically large in models that do not incorporate physical capital. Second, reforms are associated with higher future output and therefore generate a wealth effect. In response to higher future income, individuals change their consumption plans so that consumption increases in all periods. The wealth effect typically dominates in the presence of physical capital. In these models, reforms that lead to a higher steady state output also imply higher steady state employment and a higher capital stock. Adjusting the capital stock to its new steady state level requires the production of investment goods. Therefore, if reforms lead to higher demand right after their implementation, they are beneficial both in the short term and in the long. Moreover, incomplete capital markets have been shown

to play a role in both—how the economy is driven into a situation where the central bank is constrained as well as the transmission of reforms.

The models I use in this dissertation to evaluate structural reforms deviate from the previous literature in various aspects. In contrast to Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2014), Eggertsson, Ferrero, and Raffo (2014), and Cacciatore, Fiori, and Ghironi (2016), they consider investment in physical capital. They also differ with respect to how the zero lower bound scenario arises. Eggertsson, Ferrero, and Raffo (2014), Gerali, Notarpietro, and Pisani (2015a,b), Vogel (2016), Gomes (2014), and Anderson, Hunt, and Snudden (2014) all assume that the crisis originates from a shock to demand. Such shock typically delivers a contraction of output in combination with deflation. However, as was discussed in the introduction, the financial sector has played a dominant role in the recent crisis. Therefore, the starting point of my analysis is a shock in the financial market that leads to a credit crunch as in Andrés, Arce, and Thomas (2014). The major distinction from Andrés, Arce, and Thomas (2014) is the modeling of leverage and credit market frictions. I use the framework of Gertler and Karadi (2011) where constraints with respect to leverage arise endogenously from moral hazard in the financial sector.

The incorporation of the Gertler–Karadi mechanism into a monetary union model allows me to study structural reforms while addressing the three key issues that I discussed in the introduction: First, the crisis was triggered in the capital markets. Second, the functioning of the financial sector is relevant for the real economic activity. Third, monetary policy reacted unconventionally during the crisis.

3 Model I - Closed Economy with Financial Market Frictions

Structural reforms are primarily discussed in the context of the European Monetary Union. However, before proceeding to a more elaborated model of a monetary union, I want to introduce the main ideas and model features in a parsimonious way. Hence, I present a closed economy model first. In particular, I describe the crisis as originating from the financial market and show how reforms affect financial variables.

In the model, households consume a composite of goods, save by purchasing bonds, and supply labor. Perfectly competitive firms that produce intermediate goods use labor and capital in their production. Monopolistically competitive retailers buy intermediate goods and sell them to consumers. The labor market is monopolistically competitive. Prices and wages are nominally rigid. There is a financial sector that borrows funds from households and lends to firms. The financial sector is balance sheet constrained, leading to financial acceleration when the capital market is disturbed. Structural reforms are modeled as permanent changes in the degree of competitiveness in product and labor markets.

The framework builds on the model of Gertler and Karadi (2011). More detailed descriptions including some derivations can be found in their paper.

3.1 Households

Households maximize their expected lifetime utility. They decide on consumption and saving and set wages on a staggered basis. The optimization problem of each individual (j) is given by

$$\max_{C_{j,t+s}, B_{j,t+s}, W_{j,t+s}} E_t \left[\sum_{s=0}^{\infty} \beta^s \left(\frac{(C_{j,t+s} - hC_{j,t+s-1})^{1-\sigma}}{1-\sigma} - \frac{L_{j,t+s}^{1+\nu}}{1+\nu} \right) \right], \quad (1)$$

subject to labor demand and the sequence of the budget constraints

$$C_{j,t} + B_{j,t} = (1 + r_{t-1})B_{j,t-1} + (1 - \tau_w) \frac{W_{j,t}}{P_t} L_{j,t} + T_{j,t}. \quad (2)$$

L_t denotes the amount of labor supplied, W_t denotes the nominal wage and C_t is a consumption bundle. β is the subjective time preference factor, h is a habit parameter, and ν is the inverse Frisch elasticity of labor supply. σ is the inverse of the elasticity of intertemporal substitution. P_t denotes the price level, T_t is a placeholder for all net transfers of firm profits and taxes to households, r_t is the real interest rate and B_t represents the total amount of real bonds. τ_w is a tax on wage income and is used by governments as a policy instrument. $E_t[\cdot]$ denotes the mathematical expectation of a variable conditional on information available at time t .

Optimization involves a consumption-saving plan. The household can, for example, choose to consume less in period t . Thus, her utility in this period will be lower. Specifically, the change in utility caused by a marginal change in consumption is given by

$$q_t = (C_t - hC_{t-1})^{-\sigma} - \beta h(C_{t+1} - hC_t)^{-\sigma}, \quad (3)$$

which is the partial derivative of the utility function with respect to consumption in period t . The reduction in current consumption allows the household to invest in a bond that earns some interest. Consequently, the household can increase consumption in the following period. When choosing optimally, the household will equate the foregone utility from a reduction in current consumption with the discounted expected future increase in utility. The standard Euler equation presents this behavior as follows:

$$1 = \beta(1 + r_t)E_t[\Lambda_{t,t+1}], \quad (4)$$

where the intertemporal marginal rate of substitution $\Lambda_{t,t+1}$ is given by

$$\Lambda_{t,t+1} = \frac{q_{t+1}}{q_t}. \quad (5)$$

Suppose that σ is equal to one, which implies logarithmic utility, and that the habit parameter is zero. Then the Euler-equation simplifies to

$$\frac{1}{C_t} = \beta(1 + r_t)E_t \left[\frac{1}{C_{t+1}} \right]. \quad (6)$$

The left-hand side shows the forgone utility of decreasing current consumption, whereas the right-hand side shows the expected benefit from saving in terms of utility, discounted by β , which reflects time preference.

The main idea of the habit preference structure is that households' utility does not solely depend on current consumption. Rather, households' utility from current consumption also depends on their previous consumption level. Habit persistence has originally been introduced to solve the equity premium puzzle (see Mehra and Prescott, 1985; Abel, 1990; Constantinides, 1990; Campbell and Cochrane, 1999) but has meanwhile found its way into the consensus New-Keynesian model because it helps to resolve the consumption puzzle (see Christiano, Eichenbaum, and Evans, 2005). In response to a monetary shock, consumption typically jumps in the standard constant risk aversion preferences framework. This pattern is inconsistent with empirical observations which show that consumption reacts gradually to shocks. Models with habit preferences can generate a hump-shaped response of consumption to shocks.

To assign a price or value to a stream of future payoffs it is useful to define a nominal stochastic discount factor, M :

$$M_{t,t+s} = \beta^s \Lambda_{t,t+s} \Pi_{t+s}^{-1}. \quad (7)$$

Π_t denotes gross inflation.

In addition to the consumption-saving decision, households decide on wages that they require in return for supplying differentiated labor. There are representative labor agencies which buy labor from households and combine these inputs to form aggregate labor supply. Labor agencies

are perfectly competitive and their technology is

$$L_t = \left(\int_0^1 L_{j,t}^{\frac{\epsilon_w - 1}{\epsilon_w}} dj \right)^{\frac{\epsilon_w}{\epsilon_w - 1}}, \quad (8)$$

where ϵ_w is the elasticity of substitution of labor with respect to wages. Labor agencies sell the labor aggregate to good producing firms at the aggregate wage level W_t . Their optimization problem consists of maximizing profits by choosing the amount of labor they hire from each household, that is

$$\max_{L_{j,t}} W_t L_t - \int_0^1 W_{j,t} L_{j,t} dj. \quad (9)$$

The first term represents revenue while the second term reflects costs. Agencies' profit maximization leads to labor demand functions

$$L_{j,t} = \left(\frac{W_{j,t}}{W_t} \right)^{-\epsilon_w} L_t \quad (10)$$

with corresponding wage index

$$W_t = \left(\int_0^1 W_{j,t}^{1-\epsilon_w} dj \right)^{\frac{1}{1-\epsilon_w}}. \quad (11)$$

Hence, the labor that the representative agency demands from a household depends on how this household's wage relates to the overall wage level. Moreover, the elasticity of substitution, ϵ_w , determines how labor demand reacts to changes in wages. Households are more powerful in setting wages if ϵ_w is low.

Before introducing wage stickiness and how households set wages optimally, it is useful to look at the optimality condition in the case of a perfectly competitive labor market with flexible wages. In this case, household would choose labor supply such that the following condition holds:

$$L_t^\nu = (1 - \tau_w) \frac{W_t}{P_t} \varrho_t. \quad (12)$$

The left-hand side shows the marginal loss in utility of working. The right-hand side shows the marginal gain: The real wage net of taxes

earned when working an additional hour allows the household to increase consumption, which, at the margin, generates utility ϱ_t . Optimality requires that the marginal loss in utility of working be offset by the additional gains from consumption.

Wage rigidity is modeled following Calvo (1983). This framework assumes that not every household is able to adjust its wage in every period. To implement the idea technically, it is assumed that households are not able to adjust wages with probability ξ in each period. The optimization problem of the household can be written as

$$\max_{\tilde{W}_{j,t}} E_t \left[\sum_{s=0}^{\infty} (\beta\xi)^s \left((1 - \tau_w) \frac{\tilde{W}_{j,t}}{P_{t+s}} L_{j,t+s} \varrho_{t+s} - \frac{L_{j,t+s}^{1+\nu}}{1+\nu} \right) \right], \quad (13)$$

where the choice variable $\tilde{W}_{j,t}$ is the reset wage. Optimization is subject to labor demand, given in Equation (10). The household can be viewed as an entrepreneur who maximizes profit. The cost covers the disutility of labor, which is determined in the utility function. The revenue comprises the net real wage, converted to utility while taking into account the level of consumption. Because the household cannot adjust the wage in the next period with probability ξ , it must consider how the reset wage affects its utility in the future. Moreover, the household takes the adjustment probability into account when discounting the future. Specifically, when the probability of not being able to reset the wage is high, discounting of future periods is smaller. Note that the optimization problem will simplify to a one-period problem if wages are flexible, i.e. if $\xi = 0$.

The optimality condition for this problem is:

$$\left(\frac{1 - \xi \Pi_{w,t}^{\epsilon_w - 1}}{1 - \xi} \right)^{\frac{1 + \epsilon_w \nu}{1 - \epsilon_w}} = \left(\frac{\epsilon_w}{\epsilon_w - 1} \right) \frac{X_{w,t}^A}{X_{w,t}^B}, \quad (14)$$

where

$$X_{w,t}^A = L_t^{1+\nu} + \xi \beta E_t [\Pi_{w,t+1}^{\epsilon_w} X_{w,t+1}^A] \quad (15)$$

and

$$X_{w,t}^B = (1 - \tau_w) \frac{W_t}{P_t} L_t \varrho_t + \xi \beta E_t [\Pi_{w,t+1}^{\epsilon_w - 1} X_{w,t+1}^B]. \quad (16)$$

$\Pi_{w,t}$ denotes gross wage inflation.

To grasp the intuition of the optimal wage setting decision it is useful to have a look at the implied steady state result. In this case, the time subscripts can be dropped and wage inflation is equal to one. Hence, the optimality condition simplifies to:

$$\frac{W}{P} = \frac{1}{1 - \tau_w} \frac{\epsilon_w}{\epsilon_w - 1} \frac{L^\nu}{\varrho}. \quad (17)$$

Hence, workers impose a markup on the marginal rate of substitution between labor and consumption. The markup depends on their monopoly power and the tax rate on wage income. The same result appears, if ξ is set to zero, that is if wages are perfectly flexible.

It is also useful to analyze the wage index, given in Equation (11) in the context of the price stickiness. The Calvo setting implies that in every period the fraction ξ of households cannot adjust wages. Moreover, all households that are able to adjust choose the same optimal reset wage \tilde{W}_t . The current wage index is thus a combination of the previous wage level and the reset wage, weighted by the probability of not being able to reset wages:

$$W_t = (\xi W_{t-1}^{1-\epsilon_w} + (1 - \xi) \tilde{W}_t^{1-\epsilon_w})^{\frac{1}{1-\epsilon_w}}. \quad (18)$$

Rearranging Equation (18) and substituting the result into Equation (14) yields an alternative expression of the wage setting condition:

$$\left(\frac{\tilde{W}_t}{W_t} \right)^{1+\epsilon_w \nu} = \left(\frac{\epsilon_w}{\epsilon_w - 1} \right) \frac{X_{w,t}^A}{X_{w,t}^B} \quad (19)$$

Hence, the variables $X_{w,t}^A$ and $X_{w,t}^B$ reflect how the reset wage is optimally chosen, relative to the wage index. If, for example, the marginal utility of consumption is high, $X_{w,t}^B$ will be lower, and consequently the reset wage will be lower too, relative to the index.

3.2 Intermediate Goods Firms

Intermediate good firms are perfectly competitive. They use capital, K_{t-1} , and labor as inputs. Capital is owned by the financial intermediaries. The production function is

$$\hat{Y}_t = (U_t Q_t K_{t-1})^\alpha L_t^{1-\alpha}, \quad (20)$$

where U_t denotes capital utilization and Q_t determines capital quality. The real price of replacing one unit of depreciated capital is one. Firms take prices as given and maximize profits by choosing the utilization rate and labor, considering the level of wages, the cost of depreciation, and the capital stock:

$$\max_{U_t, L_t} \frac{\hat{P}_t}{P_t} \hat{Y}_t - \delta(U_t) Q_t K_{t-1} - \frac{W_t}{P_t} L_t. \quad (21)$$

The depreciation function $\delta(\cdot)$ is

$$\delta(U_t) = \delta_A + \frac{\delta_B}{1 + \zeta} U_t^{1+\zeta}, \quad (22)$$

where ζ is the elasticity of marginal depreciation with respect to capital utilization and $\delta_A, \delta_B, \zeta > 0$. The parameters δ_A and δ_B will be calibrated so that, in the steady state, capital utilization is 100 percent and depreciation is 2.5 percent quarterly. If the entrepreneur chooses to increase capital utilization, it will imply a higher rate of depreciation. The optimality conditions are

$$\alpha \frac{\hat{P}_t}{P_t} \hat{Y}_t = \delta'(U_t) U_t Q_t K_{t-1} \quad (23)$$

and

$$(1 - \alpha) \hat{P}_t \hat{Y}_t = L_t W_t. \quad (24)$$

In the optimum, the marginal revenues of capital utilization must be equal to the marginal cost of depreciation. Similarly, the marginal revenues of employing more workers must be equal to the marginal cost of labor.

I assume that the logarithm of Q_t follows an autoregressive process of order one given by

$$\log(Q_t) = \phi \log(Q_{t-1}) + \varepsilon_t, \quad (25)$$

where ϕ determines autocorrelation and ε_t is an exogenous shock. A disturbance to capital quality does not imply the destruction of physical capital. Rather, it represents a disturbance to the efficiency of capital employment. The major implication of this shock is a change in asset prices. Thus it will be used to initiate the financial crisis scenario.

3.3 Retail Firms

The aggregate output of intermediate goods firms, \hat{Y}_t , is divided among a continuum of monopolistic competitive retailers:

$$\hat{Y}_t = \int_0^1 Y_{f,t} df, \quad (26)$$

where f denotes a retailer. Retailers buy intermediate goods at price \hat{P}_t , repackage the goods, and finally sell the finished goods to consumers at their individual price $P_{f,t}$. The final output amount is a constant elasticity of substitution aggregate. This can be viewed as a firm that combines individual repackaged goods according to the following technology:

$$Y_t = \left(\int_0^1 Y_{f,t}^{\frac{\epsilon-1}{\epsilon}} df \right)^{\frac{\epsilon}{1-\epsilon}}. \quad (27)$$

ϵ is the elasticity of substitution. The aggregate Y_t is sold at the aggregate price level, P_t . The optimization problem consists in maximizing profits by choosing the input from each retailer, that is

$$\max_{Y_{f,t}} P_t Y_t - \int_0^1 P_{f,t} Y_{f,t} dj. \quad (28)$$

The first term represents revenue while the second term reflects costs. Profit maximization leads to the following demand functions:

$$Y_{f,t} = \left(\frac{P_{f,t}}{P_t} \right)^{-\epsilon} Y_t. \quad (29)$$

The respective price index is

$$P_t = \left(\int_0^1 P_{f,t}^{1-\epsilon} df \right)^{\frac{1}{1-\epsilon}}. \quad (30)$$

Retailers set optimal individual prices $P_{f,t}$ subject to the prices \hat{P}_t they pay to intermediate goods firms. Nominal rigidities are introduced following Calvo (1983). In analogy to wage setting framework, it is assumed that retailers are not able to adjust their price with probability ξ in every period. A firm that can reset at time t will set a new price \tilde{P}_t to maximize profits subject to its individual demand, that is

$$\max_{\tilde{P}_{f,t}} E_t \left[\sum_{s=0}^{\infty} \xi^s M_{t,t+s} (1 - \tau_P) (\tilde{P}_{f,t} - \hat{P}_{t+s}) Y_{f,t+s} \right]. \quad (31)$$

A retailer's profit in any period depends on its margin over the price of intermediate goods firms, its individual demand, and the tax rate τ_P . This tax rate will subsequently represent the policy instrument with respect to the product market reform. Because the household cannot adjust the price in the next period with probability ξ , it must consider how the reset price affects its profits in future periods. Moreover, the retailer takes the adjustment probability into account when discounting the future. Specifically, when the probability of not being able to reset the price is high, discounting of future periods is lower. Note that the optimization problem will simplify to a one-period problem if price is flexible, that is if $\xi = 0$.

In equilibrium, all retailers that reset choose the same price. The resulting optimality condition is

$$\left(\frac{1 - \xi \Pi_t^{\epsilon-1}}{1 - \xi} \right)^{\frac{1}{1-\epsilon}} = \left(\frac{\epsilon}{\epsilon - 1} \right) \frac{X_{P,t}^A}{X_{P,t}^B}, \quad (32)$$

where

$$X_{P,t}^A = Y_t \hat{P}_t \varrho_t + \xi \beta E_t [\Pi_{t+1}^\epsilon X_{P,t+1}^A] \quad (33)$$

and

$$X_{P,t}^B = (1 - \tau_P)Y_t P_t \varrho_t + \xi \beta E_t [\Pi_{t+1}^{\epsilon-1} X_{P,t+1}^B]. \quad (34)$$

In the steady state, the above result simplifies to

$$P = \frac{1}{1 - \tau_p} \frac{\epsilon}{\epsilon - 1} \hat{P}. \quad (35)$$

Retailers impose a markup on the price they pay to intermediate goods firms. The markup depends on their monopoly power and the tax rate. The same result pops up if ξ is set to zero, i.e. if prices are perfectly flexible.

Analogous to the wage level, the current price level can be expressed as a combination of the previous price level and the current reset price:

$$P_t = (\xi P_{t-1}^{1-\epsilon} + (1 - \xi) \tilde{P}_t^{1-\epsilon})^{\frac{1}{1-\epsilon}}. \quad (36)$$

Moreover, the optimality condition can be rewritten as

$$\left(\frac{\tilde{P}_t}{P_t} \right) = \left(\frac{\epsilon}{\epsilon - 1} \right) \frac{X_{P,t}^A}{X_{P,t}^B}. \quad (37)$$

The variables $X_{P,t}^A$ and $X_{P,t}^B$ therefore reflect how the optimal reset price relates to the overall price level.

Finally, the output of intermediate goods firms must be equal to retailers' output multiplied by price dispersion.

$$Y_t D_t = \hat{Y}_t, \quad (38)$$

where the index of price dispersion is

$$D_t = \left(\int_0^1 \frac{P_{f,t}}{P_t} df \right)^{-\epsilon} = (1 - \xi) \left(\frac{1 - \xi \Pi_t^{\epsilon-1}}{1 - \xi} \right)^{\frac{\epsilon}{\epsilon-1}} + \xi \Pi_t^\epsilon D_{t-1}. \quad (39)$$

All retail profits are transferred to households.

3.4 Capital-producing Firms

In simple New-Keynesian frameworks, there is no distinction between the price of a consumption good and a capital or investment good. Thus, the market value of firm capital is always equal to the cost of replacing each unit of capital employed. In other words, Tobin's q , which is the ratio of the market value of capital to its replacement cost, is always equal to one.

In reality, the ratio of market-to-book values of stocks or stock indices, which is a standard measure of Tobin's q , is frequently not equal to one. For example, the average price-to-book ratio of the S&P500 between January 2000 and October 2016 is 2.75. More importantly, the book-to-market ratio is not constant over time, as was observed during the recent financial crisis where market prices of assets dropped substantially, although there was no fundamental shift in replacement costs. The price-to-book ratio of the S&P500, for example, dropped to a minimum value of 1.78 during the crisis.

One of the salient features of the Gertler and Karadi (2011) financial accelerator model is that it can capture deviations of asset prices from other goods prices. The standard way of driving a wedge between the market value of capital and its replacement cost is to introduce investment adjustment costs. The main idea is that it requires resources, i.e. it is costly for firms to adjust the growth rate of investment upward or downward. Adjustment costs constitute a constraint on investment, thereby affecting the price of the investment good. The additional costs that arise when the capital stock is increased must be balanced with the additional benefits. These benefits will be manifest in the price of capital. Specifically, the price of capital will reflect the value of relaxing the constraint.

To limit the degree of complexity at the level of the firms producing intermediate goods, it is useful to shift the investment decision to separate

entities: the capital-producing firms. Since all firms turn out to behave identically, they are not indexed subsequently. The theoretical structure is as follows.

After the production of intermediate goods is finalized, capital-producing firms buy all of the capital stock, rebuild depreciated capital, build new capital, and finally sell the capital back to firms producing intermediate goods. Investment adjustment costs only apply for building new capital, while, as noted earlier, the cost of one unit of depreciated capital is equal to one. The real cost of creating a new unit of capital stock is $P_{S,t}$, which is equal to the real price of a unit of capital in the market.

The optimization problem of capital-producing firms is to maximize the expected value of the sum of discounted future profits:

$$\max_{\hat{I}_{t+s}} E_t \left[\sum_{s=0}^{\infty} \beta^s \Lambda_{t,t+s} \left((P_{S,t+s} - 1) \hat{I}_{t+s} - f \left(\frac{\Delta_{I,t+s}}{\Delta_{I,t+s-1}} \right) (\Delta_{I,t+s}) \right) \right], \quad (40)$$

where net investment \hat{I} is given by

$$\hat{I}_t = I_t - \delta(U_t) Q_t K_{t-1}. \quad (41)$$

$\Delta_{I,t+s}$ is the sum of net and steady state investment:

$$\Delta_{I,t+s} = \hat{I}_{t+s} + \bar{I}. \quad (42)$$

The adjustment cost function is

$$f(\cdot) = \frac{\eta}{2} \left(\frac{\Delta_{I,t+s}}{\Delta_{I,t+s-1}} - 1 \right)^2. \quad (43)$$

Equation (40) shows that whenever the price of capital is larger than one, capital-producing firms' revenue will be positive if net investment is positive and vice versa. The adjustment costs are zero when there is no change in net investment, i.e. $f(1) = 0$. Investment adjustment costs are positive when the level of investment in one period differs from its previous value, which means the function has its minimum at one:

$f'(1) = 0$. Finally, the costs increase in the absolute deviation, i.e. $f''(\cdot) = \eta > 0$.

Optimality requires that the marginal benefit of producing one more unit of capital in period t is equal to the expected discounted marginal cost of producing that unit,

$$P_{S,t} - 1 = E_t \left[\sum_{s=0}^{\infty} \beta^s \Lambda_{t,t+s} \frac{\partial [f(\cdot) \Delta_{I,t+s}]}{\partial \hat{I}_t} \right], \quad (44)$$

which eventually yields an expression for the real stock price in period t :

$$P_{S,t} = 1 + f(\cdot) + \frac{\Delta_{I,t}}{\Delta_{I,t-1}} f'(\cdot) - E_t \left[\beta \Lambda_{t,t+1} \left(\frac{\Delta_{I,t+1}}{\Delta_{I,t}} \right)^2 f'(\cdot) \right]. \quad (45)$$

In the steady state, there is no change in investment, i.e. $\Delta_{I,t} = \Delta_{I,t-1}$. Equation (45) and the properties of the investment adjustment cost function imply that, in the steady state, the price of capital is equal to one. Consequently, capital-producing firms do not generate profits in the steady state. The profits or losses earned by such firms outside the steady state are transferred to households.

The distinction between goods and capital prices is especially relevant for the financial accelerator mechanism which will be described subsequently. Changes in asset prices will turn out to have far-reaching consequences for other variables of the model. Most importantly, they will affect the flow of funds from households to financial intermediaries and from there to the goods-producing sector.

3.5 Financial Intermediaries

The centerpiece of the model is the financial sector. As was discussed in the introduction, the model will capture the main characteristics of the recent financial crisis. Those include the impairment of balance sheets of financial intermediaries driven by a fall in asset price, the dysfunction of credit intermediation caused by an asymmetric information problem, and spill-overs to the real sector due to increasing capital costs.

Gertler and Karadi (2011) develop a model to capture these aspects in an elegant way. They introduce a financial friction by means of a moral hazard problem that affects the flow of funds between the borrowers and lenders of capital.

The framework builds on the idea that households do not directly interact with the goods-producing firms, but instead supply funds to intermediaries, which channel the funds to firms. In addition, the intermediaries have their own funds that they provide to firms. Therefore, bankers are leveraged. The moral hazard problem arises from the assumption that banks have the option to divert a share of the households' deposits. Households are rational and take this option into account. Specifically, they want their supply of funds to ensure that it is not paying off for the bank to divert funds. It will turn out that the capital supply of households depends on the leverage of the financial intermediaries. In summary, the moral hazard structure implies an endogenous capital constraint.

The assumptions underlying this model structure are not entirely in line with facts. In particular, households' fear of being betrayed by banks is not the core problem. Actually, traditional bank runs, in which non-institutional depositors withdraw huge amounts of funds, were rather rare during the crisis. Eventually, deposits were guaranteed by the state in many countries. Instead, the problem emerged predominantly among financial institutions. Owing to their interconnectedness, any market participant depends to some degree on all other participants' ability to repay debts. Therefore, the bankruptcy of a major institution is relevant for the entire system. However, it is difficult for anybody to evaluate which institution is affected and to what extent it is harmed. Moral hazard arises from asymmetric information. It is not the fear of funds being diverted. Rather, it is the fear that borrowers do not disclose their true financial condition.

Although the model assumptions are not entirely justified, the mecha-

nism nevertheless can capture the major aspects of financial acceleration during the crisis, including credit rationing, increasing credit spreads, and contraction of the real economy. In the following, I will introduce the rationales and conditions in the financial market, explaining how they finally lead to the desired characteristics.

A fraction of each household comprises bankers while the remaining fraction is made up of workers. Bankers manage financial intermediaries whose purpose is to borrow funds from households by issuing real one-period bonds $B_{j,t}$ and simultaneously provide capital to intermediate producers by buying the stock of capital at price $P_{S,t}$. To do so, the financial intermediary must, however, have an equity stake $N_{j,t}$ in the business. Each bank's balance sheet is thus

$$P_{S,t}S_{j,t} = B_{j,t} + N_{j,t}, \quad (46)$$

where $S_{j,t}$ denotes the share of total capital a banker owns. Relating the total assets that a banker controls to the value of its equity yields a measure of leverage:

$$\Phi_{j,t} = \frac{P_{S,t}S_{j,t}}{N_{j,t}} = \frac{P_{S,t}S_{j,t}}{P_{S,t}S_{j,t} - B_{j,t}}. \quad (47)$$

Equation (47) illustrates that a drop in asset prices increases, *ceteris paribus*, the bank's leverage ratio.

Financial intermediaries have to pay interest r_t on real bonds. Their investment in the capital stock yields the uncertain real return \hat{r}_{t+1} , which is given by

$$\hat{r}_{t+1} = \frac{\alpha \frac{\hat{P}_{t+1}}{P_{t+1}} \hat{Y}_{t+1} - \delta(U_{t+1})Q_{t+1}K_t}{P_{S,t}K_t} + \frac{P_{S,t+1}}{P_{S,t}} - 1. \quad (48)$$

The first term in Equation (48) consists of the difference of the revenue, which is attributable to capital and the cost of depreciation, relative to the investment amount. The second term reflects changes in the stock

price. Note that in the steady state in which $D = 1$, $Q = 1$, $P_S = 1$, and $\delta = \bar{\delta}$, Equation 48 simplifies to the standard real business cycle model result,

$$\hat{r}K = \alpha Y - \bar{\delta}K, \quad (49)$$

provided that there are no markups on prices ($\hat{P} = P$).

Bankers receive the return on capital and pay interest on deposits. Each banker's ex post profit, $p_{Bj,t+1}$, is

$$p_{Bj,t+1} = \hat{r}_{t+1}P_{S,t}S_{j,t} - r_t(P_{S,t}S_{j,t} - N_{j,t}), \quad (50)$$

where the first term is the return from the total investment in the firm and the second term is the fixed interest that the banker pays out to households. Consequently, a banker's net worth evolves as follows:

$$N_{j,t+1} = (\hat{r}_{t+1} - r_t)P_{S,t}S_{j,t} + (1 + r_t)N_{j,t}. \quad (51)$$

If the return on capital exceeds the risk-free return, a banker's net worth will grow. The gross growth rate of net worth is:

$$\frac{N_{j,t+1}}{N_{j,t}} = (\hat{r}_{t+1} - r_t)\Phi_{j,t} + (1 + r_t). \quad (52)$$

Hence, a high leverage ratio implies, *ceteris paribus*, a higher growth rate of bankers' net worth. To put a limit on capital accumulation, a finite horizon for bankers is introduced in the following manner. In each period, the probability that a banker stays a banker is θ . Otherwise, the banker becomes a worker. However, the ratio of bankers to workers is constant, which means that exiting bankers are randomly replaced by workers. Retiring bankers return their accumulated net worth to their households.

Bankers' objective is to maximize their expected terminal wealth, $V_{j,t}$:

$$V_{j,t} = E_t \left[\sum_{s=0}^{\infty} (1-\theta)\theta^s \beta^{s+1} \Lambda_{t,t+s+1} \left((\hat{r}_{t+s+1} - r_{t+s})P_{S,t+s}S_{j,t+s} + (1+r_{t+s})N_{j,t+s} \right) \right]. \quad (53)$$

The terminal wealth of bankers can also be written in an alternative way when $P_{S,t}S_{j,t}$ and $N_{j,t}$ are factored out. Specifically,

$$V_{j,t} = P_{S,t}S_{j,t}\Gamma_{j,t}^A + N_{j,t}\Gamma_{j,t}^B, \quad (54)$$

where $\Gamma_{j,t}^A$ and $\Gamma_{j,t}^B$ are written in recursive form:

$$\Gamma_{j,t}^A = E_t\left[\beta\Lambda_{t,t+1}\left[(1-\theta)(\hat{r}_{t+1} - r_t) + \theta\frac{P_{S,t+1}S_{j,t+1}}{P_{S,t}S_{j,t}}\Gamma_{j,t+1}^A\right]\right] \quad (55)$$

$$\Gamma_{j,t}^B = E_t\left[(1-\theta) + \theta\beta\Lambda_{t,t+1}\frac{N_{j,t+1}}{N_{j,t}}\Gamma_{j,t+1}^B\right]. \quad (56)$$

The growth rate of assets, which shows up in $\Gamma_{j,t}^A$, can be obtained from (47) and is given by

$$\frac{P_{S,t+1}S_{j,t+1}}{P_{S,t}S_{j,t}} = \frac{\Phi_{j,t+1}}{\Phi_{j,t}}\frac{N_{j,t+1}}{N_{j,t}}. \quad (57)$$

The growth rate of net worth, which shows up in $\Gamma_{j,t}^B$, is given in (52). Equation (54) thus reveals that, if the return on capital exceeds the risk-free rate, $\hat{r}_{t+1} > r_t$, the banker's optimal choice is to increase total assets. Specifically, increasing assets by one unit would increase expected terminal wealth by $\Gamma_{j,t}^A$ units.

Considering that all bankers act identically and that one share of stock corresponds to one unit of capital, it follows that

$$K_t = S_t. \quad (58)$$

It can be inferred from Equation (48) that, in the absence of financial frictions, bankers' optimal decisions to increase total assets would ultimately reduce the return on capital, so that finally $\hat{r}_{t+1} = r_t$. In other words, without financial frictions, there will be no credit spread. In this case there would be no benefit of modeling the financial sector at all.

The introduction of a constraint on financial intermediaries' asset accumulation will make the functioning of the financial market relevant

for real economic activity. Such a financial constraint is modeled by means of a moral hazard problem. In particular, it is assumed bankers can cheat by diverting some fraction λ of the funds provided to them and make a payment to their own household. These funds cannot be recovered by lenders. However, the banker will not be able to continue business after cheating. The result of this moral hazard problem is that households are only willing to provide funds to financial intermediaries as long as the banker's net worth is greater than or equal to the value of the fraction of assets that can be diverted. The incentive constraint is thus:

$$V_{j,t} \geq \lambda P_{S,t} S_{j,t}. \quad (59)$$

Equating this constraint with (54) yields

$$P_{S,t} S_t = \frac{\Gamma_t^A}{\lambda - \Gamma_t^B} N_t \quad (60)$$

and thus the financial sector leverage is

$$\Phi_t = \frac{\Gamma_t^A}{\lambda - \Gamma_t^B}. \quad (61)$$

The result is rather intuitive. First, a more severe moral hazard problem, i.e. a higher λ , implies that lenders will require that borrowers have a lower leverage ratio. Alternatively, the result can be interpreted in the context of the interbank market: If a financial institution lends to another financial institution, it will require a more solid balance sheet of the borrower, as measured by the ratio of equity to total assets, when the asymmetric information problem in the market is worse. Second, higher expected future profit opportunities of bankers, which are reflected in Γ_t^A and Γ_t^B , imply a higher tolerated leverage ratio.

The leverage ratio is not constant and plays an important role in the financial accelerator mechanism. Suppose, for example, that a shock lets asset prices drop. According to Equation (47), the leverage ratio would increase. However, if households do not tolerate a higher leverage ratio,

they would respond and reduce their supply of funds. Hence, there is credit rationing, which is one of the key features the model is supposed to capture. The lack of credit then affects the intermediate goods producers, which use capital as a production factor. In other words, there is a spillover from the financial sector to the real sector. The result is a lower level of production, which, in turn, feeds back to firms' profits, asset prices, and consequently the financial sector. In sum, the initial disturbance is amplified.

The final assumption with respect to the financial sector of the model refers to the equipment of newly established bankers. In particular, workers that randomly become new bankers receive a fraction $\chi/(1-\theta)$ of the assets managed by existing bankers as an initial endowment. The aggregate equity position of the financial sector is thus a weighted average of the equity of existing bankers who remain in business, which is provided in Equation (51), and the equity of new entrants in the banking sector. The weights are determined by the survival probability:

$$N_t = \theta((\hat{r}_t - r_{t-1})\Phi_{t-1} + (1 + r_{t-1}))N_{t-1} + \chi P_{S,t} S_{t-1}. \quad (62)$$

The derivation of the above conditions is based on that in Gertler and Karadi (2011).

3.6 Government and Resource Constraint

The central bank follows a zero-inflation target. To achieve zero inflation, the monetary authority sets the nominal interest rate according to

$$i_t = (1 + \bar{i})\Pi_t^\kappa - 1, \quad (63)$$

where \bar{i} is the steady state nominal interest rate, and $\kappa > 1$ determines the strength of reaction to deviations from the inflation target. Hence, monetary policy follows the Taylor (1993) principle: If inflation increases by one percent, interest rates should rise by more than one percent. Taylor rules are frequently used in the literature, although the rule is not

explicitly derived from an optimization problem. The main reason is that the Taylor principle can easily be rationalized within the New-Keynesian framework with rational agents, because it promotes stability and prevents the economy from being vulnerable to fluctuations and self-fulfilling expectations (Christiano, Trabandt, and Walentin, 2010).

In case there is a lower bound on the nominal interest rate, the rule changes to

$$i_t = \max[i_{lb}, (1 + \bar{i})\Pi_t^\kappa - 1], \quad (64)$$

where i_{lb} denotes the lower interest rate bound. The resource constraint in this economy is

$$Y_t = C_t + I_t + \frac{\eta}{2} \left(\frac{\Delta_{I,t}}{\Delta_{I,t-1}} - 1 \right)^2 (\Delta_{I,t}). \quad (65)$$

3.7 Calibration

The discount rate β is 0.995, implying an annual steady state real interest rate of 2 percent. The habit parameter is 0.65 as in Christiano, Eichenbaum, and Evans (2005). The inverse Frisch elasticity ν is 1.5, as suggested by Chetty, Guren, Manoli, and Weber (2011). The elasticities of substitution ϵ in the goods sector and the wage elasticity of substitution are both 5. The tax rates τ_P and τ_w are initially set to 10 percent. The steady state markups on goods and wages are therefore 38.8 percent before reforms are initiated. The probabilities ξ that prices and wages cannot be reset are 0.66.

The parameters of firms producing intermediate goods, capital-producing firms, and financial intermediaries are calibrated following Gertler and Karadi (2011).¹⁶ The capital share α is 0.33. Parameters of the depreciation function are chosen to match a steady state annual depreciation of 10 percent and a steady state utilization rate of capital of 100 percent

¹⁶Some of these values are based on estimates of Primiceri, Schaumburg, and Tambalotti (2006).

Table 1: Parameters - Closed Economy Model

<i>Households</i>		
Discount rate	β	0.995
Habit parameter	h	0.650
Inverse Frisch elasticity of labor supply	ν	1.500
Elasticity of intertemporal substitution	σ^{-1}	1.000
Probability of not being able to reset wages and prices	ξ	0.660
<i>Retailers</i>		
Elasticity of substitution in the goods sector	ϵ	5.000
<i>Labor agencies</i>		
Wage elasticity of substitution	ϵ_w	5.000
<i>Intermediate goods firms</i>		
Effective capital share	α	0.330
Steady state depreciation	$\bar{\delta}$	0.025
Elasticity of marginal depreciation w.r.t capital utilization	ζ	7.200
<i>Capital-producing firms</i>		
Elasticity of the price of capital w.r.t net investment	η	1.728
<i>Financial intermediaries</i>		
Fraction of capital that can be diverted	λ	0.4126
Proportional transfer of households to entering bankers	χ	0.0026
Survival rate of bankers	θ	0.975
<i>Government</i>		
Inflation coefficient of Taylor rule	κ	2.000
Lower bound on nominal interest rate	i_{lb}	0.000

($\delta_A = 0.021$ and $\delta_B = 0.033$). The elasticity of marginal depreciation with respect to capital utilization is 7.2. The elasticity of the price of capital with respect to net investment η is 1.728.

The survival rate of bankers θ is 0.975, implying an expected lifetime of a banker of 40 years. λ and χ are 0.4125 and 0.0026, respectively. These values imply a steady state private leverage ratio of 4 and an average annual credit spread of 100 basis points. The Taylor rule inflation coefficient κ is 2.

Table 1 summarizes all parameters.

3.8 Steady State and Policy Experiment

The following set of equilibrium conditions summarizes the model.

Euler Equation:

$$1 = \beta(1 + r_t)E_t[\Lambda_{t,t+1}] \quad (66)$$

$$\Lambda_{t,t+1} = \frac{\varrho_{t+1}}{\varrho_t} = \frac{(C_{t+1} - hC_t)^{-1} - \beta h(C_{t+2} - hC_{t+1})^{-1}}{(C_t - hC_{t-1})^{-1} - \beta h(C_{t+1} - hC_t)^{-1}} \quad (67)$$

Wage Setting:

$$\left(\frac{1 - \xi \Pi_{w,t}^{\epsilon_w - 1}}{1 - \xi} \right)^{\frac{1 + \epsilon_w \nu}{1 - \epsilon_w}} = \left(\frac{\epsilon_w}{\epsilon_w - 1} \right) \frac{X_{w,t}^A}{X_{w,t}^B} \quad (68)$$

$$X_{w,t}^A = L_t^{1+\nu} + \xi \beta E_t[\Pi_{w,t+1}^{\epsilon_w} X_{w,t+1}^A] \quad (69)$$

$$X_{w,t}^B = (1 - \tau_w) \frac{W_t}{P_t} L_t \varrho_t + \xi \beta E_t[\Pi_{w,t+1}^{\epsilon_w - 1} X_{w,t+1}^B] \quad (70)$$

Price Setting:

$$\left(\frac{1 - \xi \Pi_t^{\epsilon - 1}}{1 - \xi} \right)^{\frac{1}{1 - \epsilon}} = \left(\frac{\epsilon}{\epsilon - 1} \right) \frac{X_{P,t}^A}{X_{P,t}^B} \quad (71)$$

$$X_{P,t}^A = Y_t \hat{P}_t \varrho_t + \xi \beta E_t [\Pi_{t+1}^\epsilon X_{P,t+1}^A] \quad (72)$$

$$X_{P,t}^B = (1 - \tau_P) Y_t P_t \varrho_t + \xi \beta E_t [\Pi_{t+1}^{\epsilon-1} X_{P,t+1}^B] \quad (73)$$

Price Dispersion:

$$D_t = (1 - \xi) \left(\frac{1 - \xi \Pi_t^{\epsilon-1}}{1 - \xi} \right)^{\frac{\epsilon}{\epsilon-1}} + \xi \Pi_t^\epsilon D_{t-1} \quad (74)$$

Production Function:

$$Y_t D_t = (U_t Q_t K_{t-1})^\alpha L_t^{1-\alpha} \quad (75)$$

$$\log(Q_t) = \phi \log(Q_{t-1}) + \varepsilon_t \quad (76)$$

Optimal Capital Utilization:

$$\alpha \frac{\hat{P}_t}{P_t} Y_t D_t = \delta'(U_t) U_t Q_t K_{t-1} \quad (77)$$

$$\delta(U_t) = \delta_A + \frac{\delta_B}{1 + \zeta} U_t^{1+\zeta} \quad (78)$$

Optimal Labor:

$$(1 - \alpha) \hat{P}_t Y_t D_t = L_t W_t \quad (79)$$

Investment:

$$\hat{I}_t = I_t - \delta(U_t) Q_t K_{t-1} \quad (80)$$

$$\Delta_{I,t+s} = \hat{I}_{t+s} + \bar{I} \quad (81)$$

Asset Prices:

$$P_{S,t} = 1 + f(\cdot) + \frac{\Delta_{I,t}}{\Delta_{I,t-1}} f'(\cdot) - E_t \left[\beta \Lambda_{t,t+1} \left(\frac{\Delta_{I,t+1}}{\Delta_{I,t}} \right)^2 f'(\cdot) \right] \quad (82)$$

$$f(\cdot) = \frac{\eta}{2} \left(\frac{\Delta_{I,t+s}}{\Delta_{I,t+s-1}} - 1 \right)^2 \quad (83)$$

Capital Return:

$$\hat{r}_{t+1} = \frac{\alpha \frac{\hat{P}_{t+1}}{P_{t+1}} Y_{t+1} - \delta(U_{t+1}) Q_{t+1} K_t}{P_{S,t} K_t} + \frac{P_{S,t+1}}{P_{S,t}} - 1 \quad (84)$$

Financial Sector:

$$P_{S,t} S_t = \Phi_t N_t \quad (85)$$

$$\Phi_t = \frac{\Gamma_t^A}{\lambda - \Gamma_t^B} \quad (86)$$

$$\Gamma_t^A = E_t \left[\beta \Lambda_{t,t+1} \left[(1 - \theta)(\hat{r}_{t+1} - r_t) + \theta \frac{\Phi_{t+1}}{\Phi_t} ((\hat{r}_{t+1} - r_t) \Phi_t + (1 + r_t)) \Gamma_{t+1}^A \right] \right] \quad (87)$$

$$\Gamma_t^B = E_t \left[(1 - \theta) + \theta \beta \Lambda_{t,t+1} ((\hat{r}_{t+1} - r_t) \Phi_t + (1 + r_t)) \Gamma_{t+1}^B \right] \quad (88)$$

$$N_t = \theta((\hat{r}_t - r_{t-1}) \Phi_{t-1} + (1 + r_{t-1})) N_{t-1} + \chi P_{S,t} S_{t-1} \quad (89)$$

$$K_t = S_t \quad (90)$$

Fisher Equation:

$$1 + i_t = (1 + r_t) \Pi_{t+1} \quad (91)$$

Taylor Rule:

$$i_t = (1 + \bar{i})\Pi_t^\kappa - 1 \quad (92)$$

Resource Constraint:

$$Y_t = C_t + I_t + \frac{\eta}{2} \left(\frac{\Delta_{I,t}}{\Delta_{I,t-1}} - 1 \right)^2 (\Delta_{I,t}) \quad (93)$$

In the following, I drop all time subscripts and describe the steady state. Price and wage inflation are zero and therefore $\Pi = 1$ and $\Pi_w = 1$. Moreover, price dispersion, capital utilization, capital quality, the real stock price, and the marginal rate of substitution are equal to one: $D = 1$, $U = 1$, $Q = 1$, $P_S = 1$, and $\Lambda = 1$. The stochastic discount factor $M = \beta$. Consequently, the nominal and the real interest rate are $i = 1/\beta - 1$ and $r = 1/\beta - 1$, respectively.

The price and wage setting equations simplify to

$$P = \frac{1}{1 - \tau_p} \frac{\epsilon}{\epsilon - 1} \hat{P} \quad (94)$$

and

$$\frac{W}{P} = \frac{1}{1 - \tau_w} \frac{\epsilon_w}{\epsilon_w - 1} \frac{L^\nu}{\varrho}, \quad (95)$$

respectively. In the goods market, retailers impose a markup on marginal costs. Workers impose a markup on the marginal rate of substitution between labor and consumption. The size of the markup depends on the monopolistic power of the retailers and the workers, which is determined by the elasticities of substitution in the respective markets, as well as the tax rates. The policy experiments I make in the subsequent sections

will consider reductions in these tax rates. As will be shown later, higher markups lead to lower output.

To simplify calculations, I rewrite the markups as follows:

$$\mu_p = \frac{1}{1 - \tau_p} \frac{\epsilon}{\epsilon - 1} \quad (96)$$

$$\mu_w = \frac{1}{1 - \tau_w} \frac{\epsilon_w}{\epsilon_w - 1}. \quad (97)$$

Using the resource constraint and the investment equation, we can solve for consumption:

$$C = Y - \bar{\delta}K. \quad (98)$$

Rewriting the optimal capital utilization equation yields

$$K = Y \frac{\alpha \hat{P}}{\delta_B \bar{P}}. \quad (99)$$

The derivative of utility with respect to consumption is

$$\varrho = \frac{1 - \beta h}{(1 - h)C}. \quad (100)$$

Combining (94), (95), (98), (99), (100), and the optimal labor condition lets us write labor in terms of model parameters:

$$L = \left(\frac{(1 - \alpha)(1 - h\beta)\delta_B}{(1 - h)(\delta_B\mu_p - \alpha\bar{\delta})\mu_w} \right)^{\frac{1}{1+\nu}}. \quad (101)$$

With $0 < \alpha, \beta, h, \delta_B, \bar{\delta} < 1$, $\nu > 0$, and $\mu_p, \mu_w > 1$, rising markups decrease steady state labor. Plugging (101) and (99) into the production function and solving for Y yields

$$Y = \left(\frac{\alpha}{\delta_B\mu_p} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{(1 - \alpha)(1 - h\beta)\delta_B}{(1 - h)(\delta_B\mu_p - \alpha\bar{\delta})\mu_w} \right)^{\frac{1}{1+\nu}}. \quad (102)$$

Equation (102) shows that if we decrease markups in the product or labor markets, we end up with a higher output in the steady state. This reflects the central idea behind policies suggesting implementing structural

reforms in product and labor markets. Diminishing monopoly power reduces inefficiencies and is conducive to a larger production volume.

The steady state values of capital, investment, consumption, and real wages can easily be obtained. They are given by

$$K = \left(\frac{\alpha}{\delta_B \mu_p} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{(1-\alpha)(1-h\beta)\delta_B}{(1-h)(\delta_B \mu_p - \alpha \bar{\delta})\mu_w} \right)^{\frac{1}{1+\nu}} \frac{\alpha}{\delta_B \mu_p}, \quad (103)$$

$$I = \left(\frac{\alpha}{\delta_B \mu_p} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{(1-\alpha)(1-h\beta)\delta_B}{(1-h)(\delta_B \mu_p - \alpha \bar{\delta})\mu_w} \right)^{\frac{1}{1+\nu}} \frac{\bar{\delta}\alpha}{\delta_B \mu_p}, \quad (104)$$

$$C = \left(1 - \frac{\bar{\delta}\alpha}{\delta_B \mu_p} \right) \left(\frac{\alpha}{\delta_B \mu_p} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{(1-\alpha)(1-h\beta)\delta_B}{(1-h)(\delta_B \mu_p - \alpha \bar{\delta})\mu_w} \right)^{\frac{1}{1+\nu}}, \quad (105)$$

and

$$\frac{W}{P} = \frac{1-\alpha}{\mu_p} \left(\frac{\alpha}{\delta_B \mu_p} \right)^{\frac{\alpha}{1-\alpha}}. \quad (106)$$

Combining the financial sector optimality conditions lets us solve for the steady state leverage and return on capital:

$$\Phi = \frac{\beta\theta\chi - \theta\lambda + \beta\theta\lambda - \beta\chi + \sqrt{(\theta\lambda - \beta\theta\lambda + \beta\chi - \beta\theta\chi)^2 - 4\beta\theta\lambda\chi(\beta\theta - \beta)}}{2\beta\theta\lambda\chi} \quad (107)$$

$$\hat{r} = \frac{\beta - \theta + \theta\Phi - \beta\Phi\chi}{\beta\theta\Phi} - 1. \quad (108)$$

Of particular interest is the parameter λ , which is the fraction of funds that can be diverted by bankers, and thus represents the strength of the moral hazard problem in the financial sector. If λ increases, the steady state leverage ratio decreases. In other words, households require bankers to be less leveraged if the moral hazard risk is more severe. Besides, the required return on capital and consequently the spread between the risky and the risk-free asset are greater when λ is higher. Finally, N can be obtained by dividing K by Φ .

4 Model I - Analysis

I run several deterministic simulations to study how the model responds to exogenous shocks and structural policies over time.¹⁷ First, I show how reforms affect the economy in normal times. Second, I introduce a financial market shock and compare the behavior of the model with that of a model with frictionless capital markets. Third, I study the effectiveness of reforms in the presence of the zero lower bound on interest rates. Finally, I discuss how the reversal of reforms and the announcement of future reforms affect the short-term behavior of the economy.

4.1 Product and Labor Market Reforms

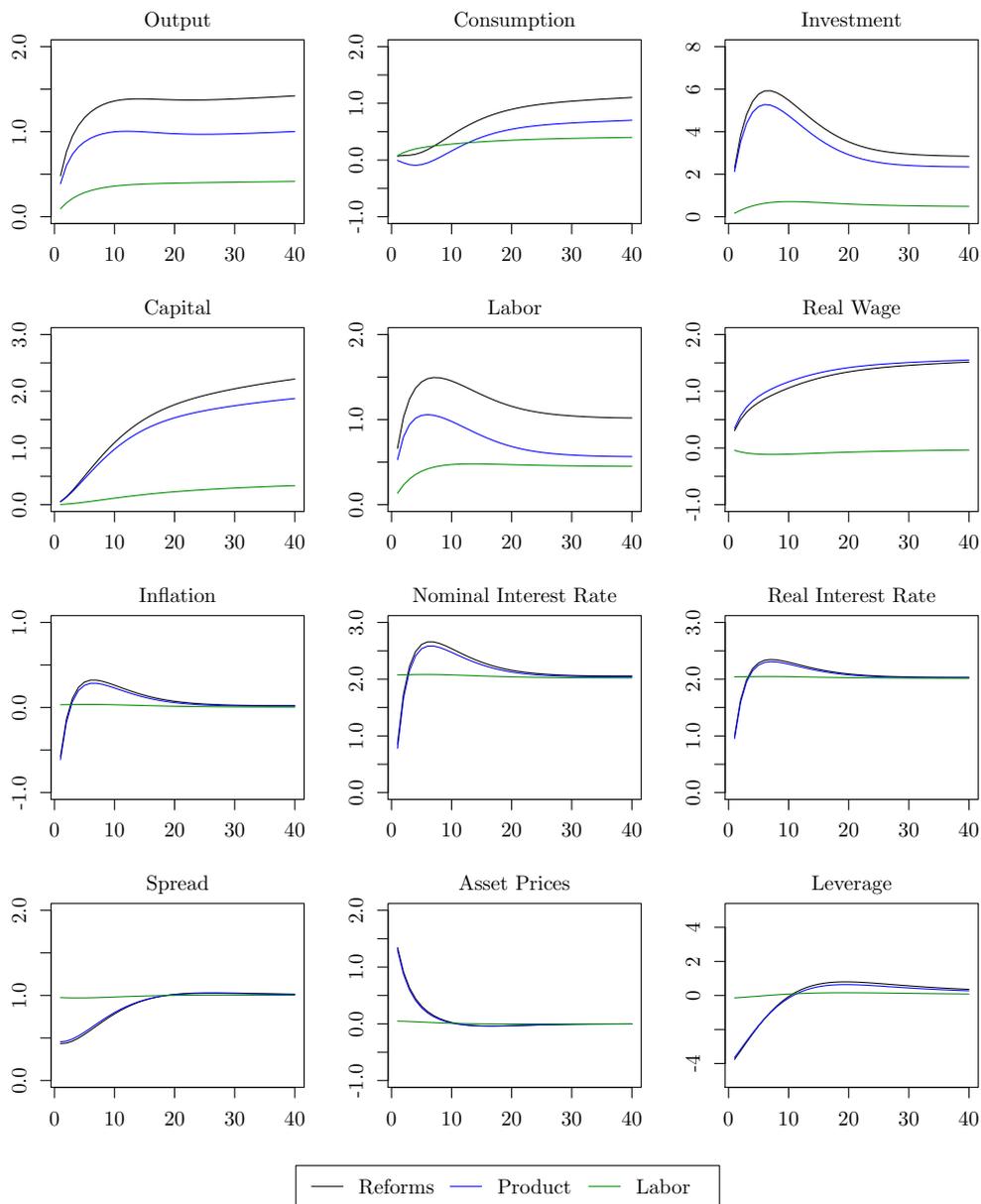
In the first scenario, I assume that structural reforms are initiated in the labor and product markets. Specifically, the policy instruments, namely τ_P and τ_w , are each permanently reduced by one percentage point. Figure 1 plots the responses to such reforms for selected variables. The blue, green, and black lines show, respectively, the responses to product, labor, and combined reforms.

As expected, prices fall when markups are reduced in the product market. Inflation drops, and in response, the central bank decreases the nominal interest rate. In the capital market, we observe an increase in asset prices, reduced leverage in the banking sector, and a reduction in credit spreads. Investment increases substantially to adjust the capital stock to the new steady state. Overall, the reform increases steady state output by about one percent. In the short run, output slightly overshoots.

The labor market reform increases long-run output by about 0.4 percent. The short-run impact, however, differs from that of the product market reform. The reduction in markups, which supposedly decreases labor costs, is almost completely offset by higher labor demand. Wages

¹⁷I use Dynare (see Adjemian et al., 2011) to run all the simulations. Appendix C contains the code.

Figure 1: Product and Labor Market Reforms



Note: Responses to a permanent reduction in policy rates in the labor market (green line), the product market (blue line), and both markets (black line) by one percentage point. Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

and product prices remain almost constant. Consequently, there are only minor changes in interest rates.

The effect of combined product and labor market reforms is approximately additive. That is, there are neither benefits nor drawbacks of combination in this setup.

4.2 Financial Accelerator

To demonstrate financial acceleration, I compare the dynamical behavior of a model with frictionless capital markets with the dynamical behavior of a model in which financial frictions arise endogenously from moral hazard.¹⁸ In particular, I consider a two percent shock to capital quality Q_t with an autocorrelation coefficient ϕ of 0.66. The results are plotted in Figure 2.

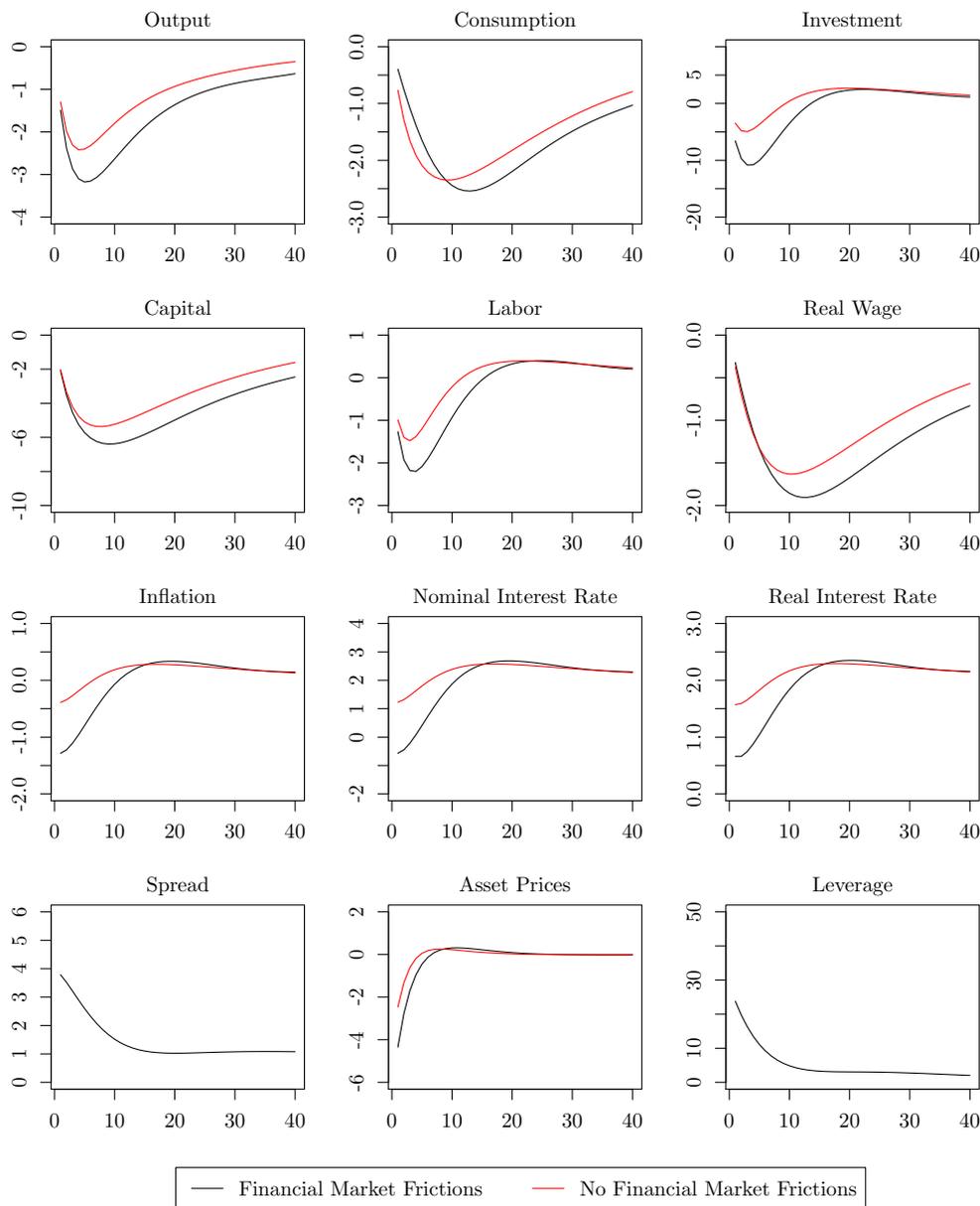
Not surprisingly, the impulse responses qualitatively appear identical to the ones reported in Gertler and Karadi (2011), as I have only slightly deviated from the authors' model.

The initial shock causes a recession. Without financial frictions, the maximum deviation of output from its steady state is approximately 2.4 percent. With financial frictions, the deviation is 33 percent stronger with a peak deviation of roughly 3.2 percent. The difference is primarily driven by investment as opposed to consumption. The maximum deviation of investment from its steady state value is more than twice as high when the capital market is not perfect.

The way financial acceleration works in the model is reflected in the financial sector variables. The recession implies a drop in asset prices of 2.5 percent upon impact in the unconstrained case, but 4.3 percent in the constrained case. The expected excess return (spread) increases to 4 percent in the model with capital market frictions. The drop in asset prices decreases the equity value of financial intermediaries. As a result,

¹⁸In the frictionless model $E[r_k] - r = 0$.

Figure 2: Financial Market Frictions



Note: Responses to a capital quality shock of two percentage points in the model with (black line) and without (red line) financial market frictions. Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

the debt-to-equity ratio (leverage) increases substantially. A highly leveraged banking sector lets households limit the funds they supply. The lack of credit, in turn, limits the amount of funds that banks can provide to the goods-producing sector. This channel connects the financial sector with the real economy.

Although the shock originates from the supply side, the recession is accompanied by deflation because of reduced consumption and investment demand. An important characteristic with regard to subsequent sections is that the response of inflation to the shock is much more severe if the disturbance is accelerated in the financial market. Inflation drops to -1.3 and -0.4 percent, respectively, in the model with and without financial frictions. The central bank rule requires a reduction in the nominal interest rate in order to combat deflation. In the model with the financial accelerator, deflation is so high that the interest rate drops to -0.6 percent. Hence there is a violation of the zero lower bound.

4.3 Structural Reforms at the Zero Lower Bound

I now consider scenarios where the central bank is limited in its ability to control the nominal interest rate. As discussed previously, the presence of cash effectively imposes a lower bound of zero on the nominal interest rate. Therefore, in what follows the central bank rule is

$$i_t = \max[0, (1 + \bar{i})\Pi_t^\kappa - 1]. \quad (109)$$

The black line in Figure 3 shows how the model with capital market frictions responds to a two percent capital quality shock with an autocorrelation coefficient of 0.66 as in the previous section. The presence of the zero lower bound makes the recession worse. Maximum output deviation from steady state drops to -3.6 percent, 0.4 percentage points more than in the case where the central bank is unconstrained. Consumption, investment, and labor also deviate more from their steady

state values. Deflation is more than 2 percent upon impact of the shock, and the central bank keeps the nominal interest rate at its minimum for five quarters. The real interest rate decreases slightly. Financial sector variables are also impacted by the zero lower bound. Asset prices react more sharply so that both leverage and spread increase relative to the case without central bank constraints.

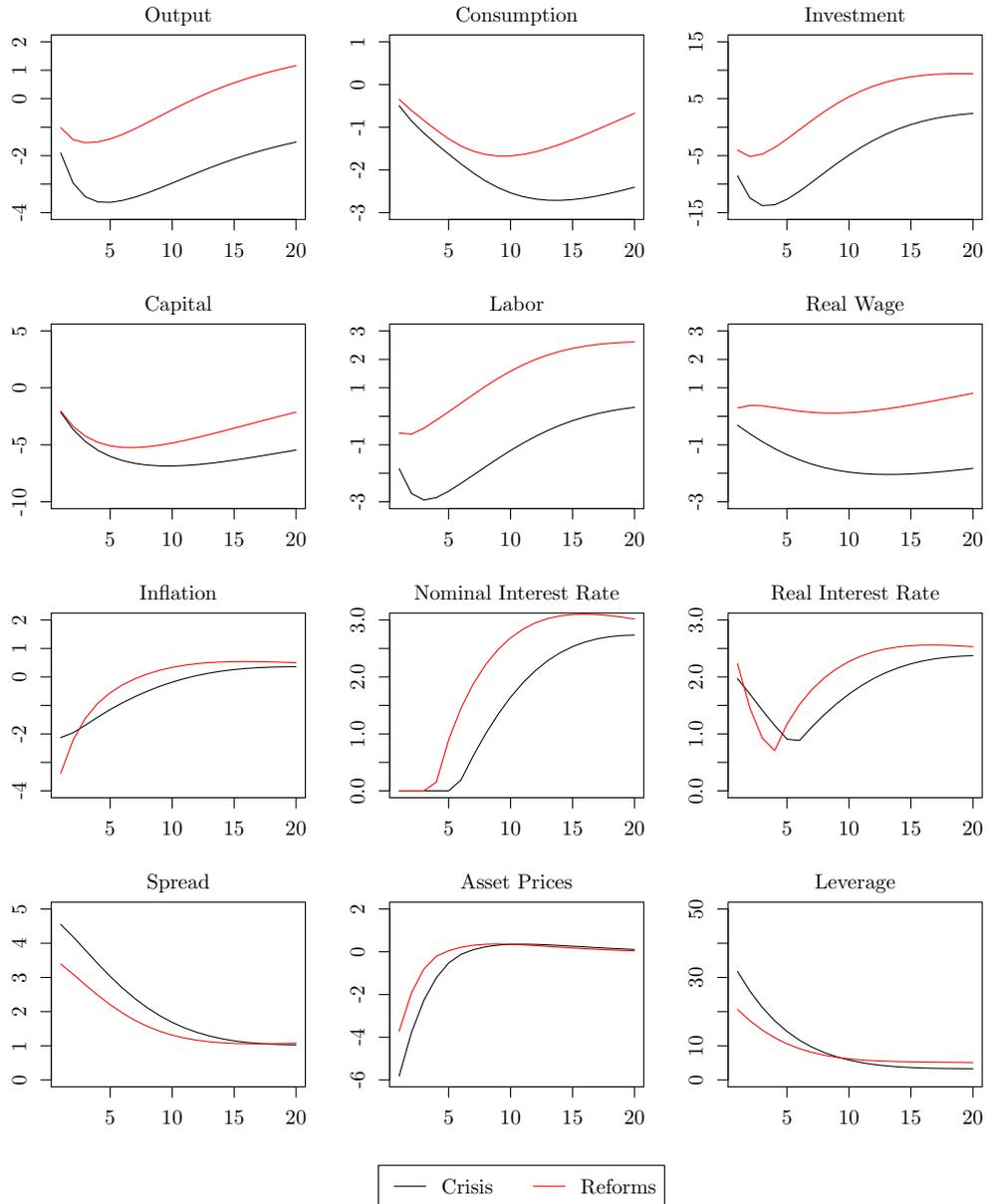
Next, I assume that reforms are initiated when a capital market shock occurs. In particular, the policy parameters τ_P and τ_w are each permanently reduced by two percentage points. This policy corresponds to a reduction in markups of 3 percentage points. The red line in Figure 3 shows the responses to the reforms in a crisis scenario.

The reforms put additional pressure on prices, causing inflation to fall to -3.4 percent. The nominal interest rate is set to zero by the central bank, and the real interest rate rises by about 0.2 percentage points to 2.2 percent. In Eggertsson, Ferrero, and Raffo (2014) an increasing real interest rate is the reason why output contracts in the short term when reforms are initiated because a high real interest rate represents an incentive for households to decrease spending. Their model does, however, not incorporate physical capital. As can be seen in Figure 3, there are no adverse effect on real variables in response to the reforms.

In the present model, the wealth effect dominates the real interest rate effect. The product and labor market reforms increase steady state output by 3 percent. Individuals consider their higher future income and adjust their plans accordingly. Consumption increases immediately relative to the case without reforms. The capital market variables also reveal a positive future outlook. In response to the reforms, asset prices jump by about 2.1 percentage points. The banking sector leverage decreases. The expected excess return decreases by about one percent. In sum, reforms lead to improving conditions in the financial markets, thereby enhancing the flow of funds from households to firms.

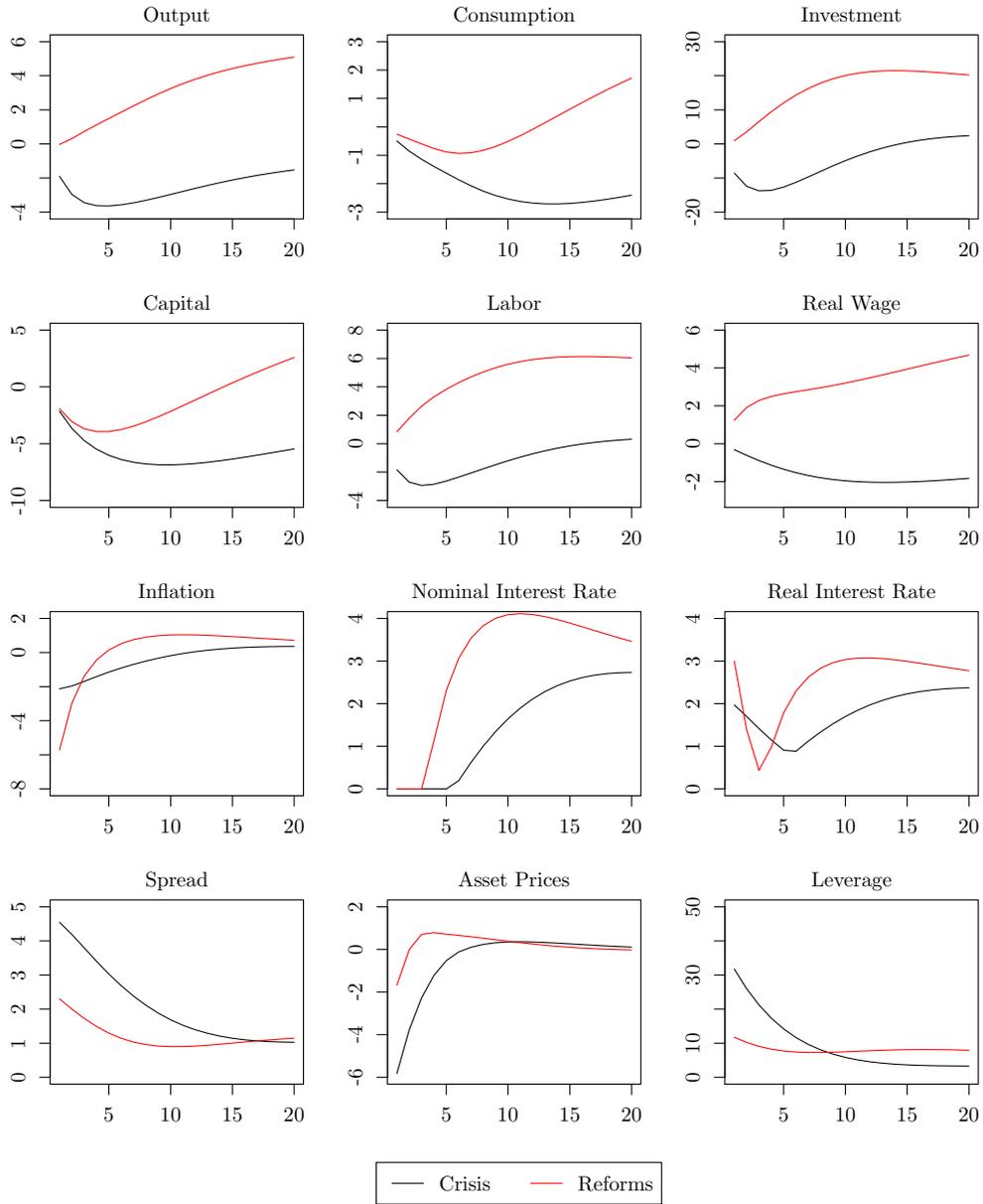
The next scenario increases the magnitude of structural changes. The

Figure 3: Structural Reforms at the Zero Lower Bound (1)



Note: Responses to a capital quality shock of two percentage points (black line) and a capital quality shock of two percentage points followed by a permanent reduction in policy rates in the product and labor markets of two percentage points (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

Figure 4: Structural Reforms at the Zero Lower Bound (2)



Note: Responses to a capital quality shock of two percentage points (black line) and a capital quality shock of two percentage points followed by a permanent reduction in policy rates in the product and labor markets of five percentage points (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

purpose is to check if the real interest rate effect is more influential when the deflationary pressure is stronger. Figure 4 plots the responses of the model economy to a permanent reduction in τ_P and τ_w of five percentage points.

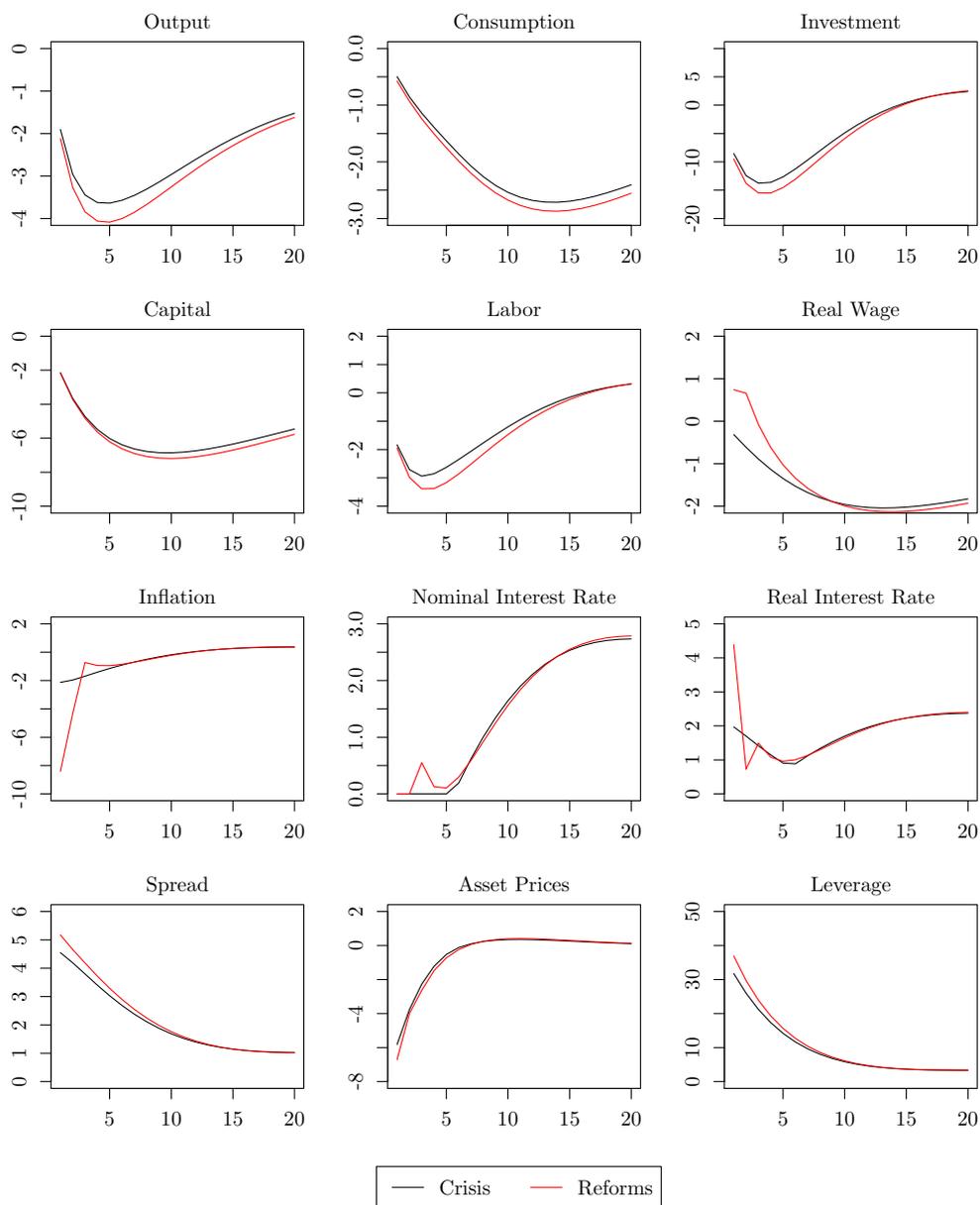
As expected, deflation is more severe when reforms are stronger. Upon impact, deflation is about 5.7 percent annually. The real interest rate jumps to approximately 3 percent. However, the impulse responses reveal that the wealth effect is still dominant. In fact, the increase in wealth is so strong that the initial shock to capital quality is more than offset by the reforms. Output and investment increase immediately. There is also a substantial increase in asset prices and a corresponding reduction in spread and leverage. Interestingly, although there is no output contraction at all, the overall response of asset prices is negative. The reason is that output expansion is initially mainly driven by labor as opposed to capital. While capital decreases in the short run, labor demand immediately increases. Workers benefit from rising real wages.

4.4 Temporary Reforms

In practice, there are various reasons why reforms are often withdrawn sometime after their implementation. As pointed out by Blanchard and Giavazzi (2003), negative short-term consequences of deregulation may antagonize some individuals or groups. Although there were no undesirable short-run implications of reforms in the previous analyses, I proceed and follow Eggertsson, Ferrero, and Raffo (2014) by considering a scenario where reforms are implemented temporarily. Specifically, I assume that τ_P and τ_w are each reduced by five percentage points for two consecutive quarters.¹⁹ Figure 5 plots the impulse responses.

¹⁹Individuals anticipate that the reforms are withdrawn from the third quarter onward.

Figure 5: Temporary Reforms



Note: Responses to a capital quality shock of two percentage points (black line) and a capital quality shock of two percentage points followed by a temporary reduction in policy rates in the product and labor markets of two percentage points for two quarters (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

Temporary reforms cause short-term pressure on prices. Deflation upon impact is about 8.4 percent, 2.7 percentage points more than in the case of permanent reforms. The nominal interest rate is temporarily reduced to zero and the real interest rate rises to 4.4 percent. The reform does not increase the steady state output. Hence, individuals do not expect higher future income. Households, therefore, do not respond to wealth, but rather adjust their expenditure plans to the real interest rate and reduce consumption. In the capital market, we observe a further drop in asset prices and rising spreads and leverage. This response shows that the initial reduction in demand is accelerated in the financial sector.

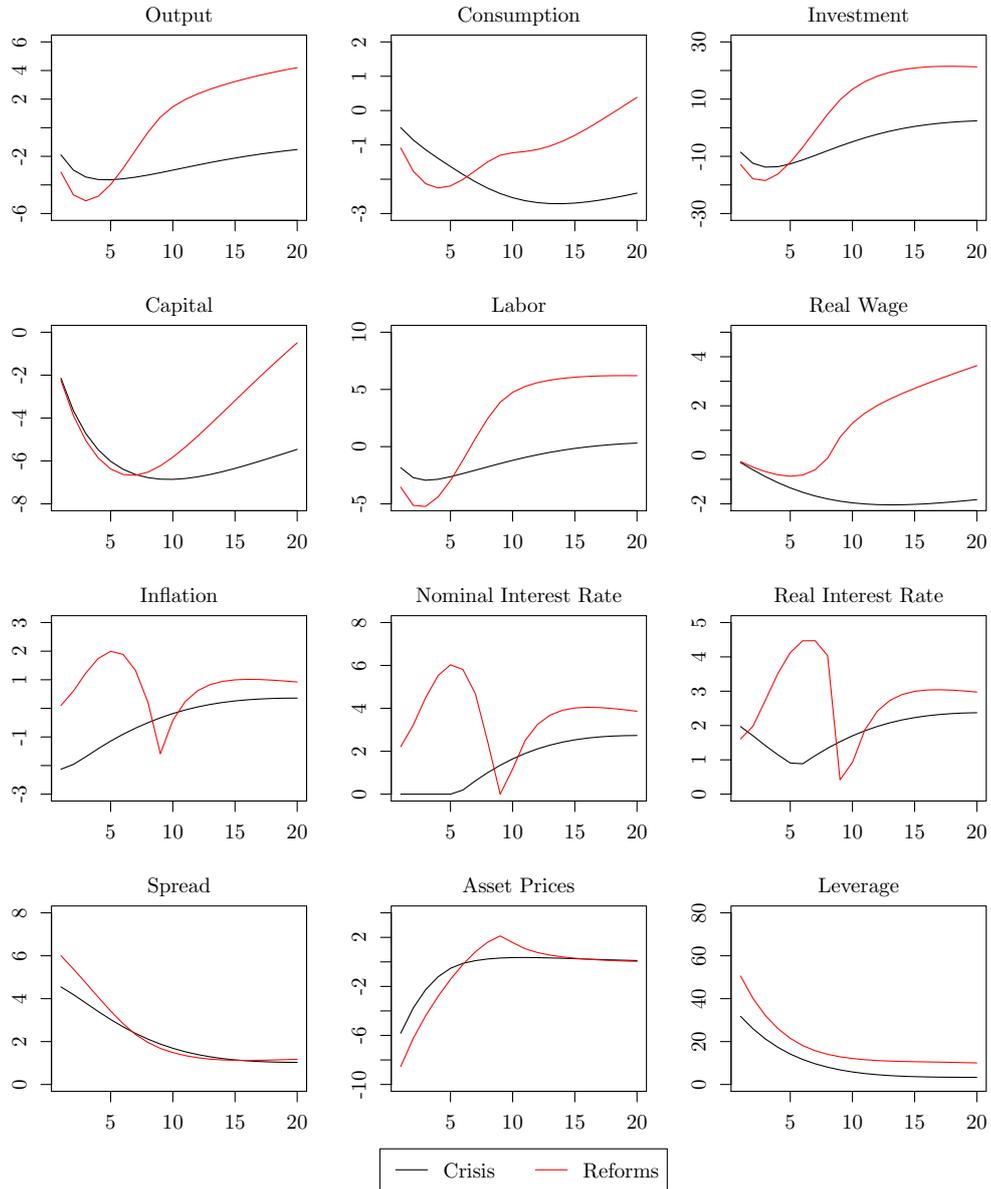
The temporary reform initially decreases output by 0.2 percentage points relative to the crisis scenario. The deviation reaches its maximum in quarter five with 0.4 percentage points. Overall, the economy has not recovered from the temporary reform after 20 quarters showing that the cumulative loss of this policy measure is material.

4.5 Announcement of Future Reforms

The previous experiment has shown that in the absence of higher future income, deflationary reforms result in a rising real interest rate and have negative short-term consequences for economic output. Naturally, the question arises how the economy behaves if there is a large increase in wealth combined with lower short-run deflation. Therefore, I consider a case where the government credibly announces structural reforms to be implemented at some future date. In particular, the policy is to keep the rates τ_P and τ_w at their original levels for eight quarters and permanently reduce them by 5 percentage points from the ninth quarter onward. The impulse responses of such deregulation policy are plotted in Figure 6.

Implementing the policy in the future greatly increases the steady state output. Therefore, individuals are subject to higher future income and wealth. Nevertheless, the short-term implications are negative. The

Figure 6: Announcement of Future Reforms



Note: Responses to a capital quality shock of two percentage points (black line) and a capital quality shock of two percentage points followed by a credible announcement to permanently reduce the policy rates in the product and labor markets by two percentage points in quarter eight (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters. 82

maximum deviation of output from its steady state value is 5.1 percent, which is about 1.7 percentage points higher than in the crisis scenario.

The announcement of policy changes also affects inflation. Individuals expect prices to decline in the future. Implicitly, current prices rise relative to future prices. As the implementation date of reforms gets closer, it becomes more and more attractive to postpone consumption to the post-reform era. The impulse responses of inflation and the nominal and real interest rate illustrate this pattern. The real interest rate is high for an extended period. Thus, consumption is reduced relative to the crisis scenario in the first few quarters, and the real interest rate effect dominates. The financial market also reflects the short-term contraction. Leverage and spread increase whereas asset prices drop relative to the scenario without reforms.

5 Model II - Monetary Union with Financial Market Frictions

Reforms are particularly discussed in a European context. Politicians and researchers frequently suggest that countries of peripheral Europe, for example Greece or Portugal, should reform their product and labor markets and support competition. The following analysis aims at shedding more light on this topic.

I construct a model with two countries that share a common currency managed by a central bank. Households consume tradable and non-tradable goods, save by purchasing bonds, and supply labor. Perfectly competitive firms producing intermediate goods in the non-tradable sector use labor as input, whereas the tradable sector uses labor and capital in its production. Labor is mobile across sectors but immobile across countries. Monopolistically competitive retailers buy intermediate goods and sell them to consumers. Prices and wages are nominally rigid. In each country, there is a financial sector that borrows funds from domestic households and lends to domestic firms. The financial sector is balance sheet constrained leading to financial acceleration when the capital market is disturbed. Countries differ with respect to their international competitive position due to taxes, which represent an inefficiency in the product and labor markets. Structural reforms are modeled as permanent changes in these taxes.

The structure of the model overlaps to a large extent with the model I have presented in section 3. Because the monetary union model includes two countries as well as tradable and non-tradable goods, I will do some minor modifications. In particular, many equations will be determined in terms of nominal instead of real returns. This is more convenient for handling prices and inflation rates for various products. I keep the model description to a minimum while preserving completeness. The framework builds on the work of Eggertsson, Ferrero, and Raffo (2014) who study

structural reforms in a monetary union without financial sector. The capital market framework is that of Gertler and Karadi (2011).

Most of the model equations refer to the home country, which is considered the periphery of the monetary union. Unless stated otherwise, similar equations hold for the core of the union, and variables as well as parameters are identical to those of the closed economy model. A * denotes a foreign variable. Appendix A lists the full set of model equations.

5.1 Households

Households decide on consumption and saving, and set wages on a staggered basis. The optimization problem of each individual (j) is given by

$$\max_{C_{j,t+s}, B_{j,t+s}, W_{j,t+s}} E_t \left[\sum_{s=0}^{\infty} \beta^s \left(\frac{(C_{j,t+s} - hC_{j,t+s-1})^{1-\sigma}}{1-\sigma} - \frac{L_{j,t+s}^{1+\nu}}{1+\nu} \right) \right], \quad (110)$$

subject to labor demand and the sequence of the budget constraints

$$P_t C_{j,t} + \frac{B_{j,t}}{\psi_{Bt}} = (1 + i_{t-1})B_{j,t-1} + (1 - \tau_w)W_{j,t}L_{j,t} + T_{j,t}. \quad (111)$$

Here, B_t represents the total amount of the nominal bonds. ψ_{Bt} is a time varying intermediation cost, which is introduced to ensure stationarity of the net foreign asset position. It decreases in the nominal debt-to-output ratio:

$$\psi_{Bt} = \exp \left[-\psi_B \frac{B_t}{P_t Y_t} \right], \quad (112)$$

with $\psi_B > 0$. Thus, if domestic households have a large amount of debt relative to output, the intermediation cost will be large, and consequently households will have less incentive to assume more debt. If domestic households are net lenders to the foreign country, they will earn a slightly lower return on bond holdings. Thus, there is neither

an incentive to increase lending nor to increase borrowing to the foreign country indefinitely.²⁰

In contrast to the closed economy model, $C_{j,t}$ here represents a consumption bundle that consists of tradable (T) and non-tradables (N) goods:

$$C_{j,t} = \left(\gamma_H^{\frac{1}{\varphi}} C_{Tj,t}^{\frac{\varphi-1}{\varphi}} + (1 - \gamma_H)^{\frac{1}{\varphi}} C_{Nj,t}^{\frac{\varphi-1}{\varphi}} \right)^{\frac{\varphi}{\varphi-1}}. \quad (113)$$

The parameter γ_H reflects households' preferred share of tradable goods in total consumption, and φ is the elasticity of substitution between tradable and non-tradable goods. A standard assumption is that $0 < \varphi < 1$, which implies that tradable and non-tradable goods are complements. Households minimize their consumption expenditures:

$$\min_{C_{Tj,t}, C_{Nj,t}} P_{T,t} C_{Tj,t} + P_{N,t} C_{Nj,t}, \quad (114)$$

where P_T and P_N and are the price indices of tradable and non-tradable composites, respectively. Optimality implies the following demand functions:

$$C_{Tj,t} = \gamma_H \left(\frac{P_{T,t}}{P_t} \right)^{-\varphi} C_{j,t}, \quad (115)$$

$$C_{Nj,t} = (1 - \gamma_H) \left(\frac{P_{N,t}}{P_t} \right)^{-\varphi} C_{j,t}. \quad (116)$$

Thus, consumption of tradable and non-tradable goods depends on the preference for tradables, the degree of substitutability between the goods, and how the respective prices relate to the overall price level. The price index is given by

$$P_t = \left(\gamma_H P_{T,t}^{1-\varphi} + (1 - \gamma_H) P_{N,t}^{1-\varphi} \right)^{\frac{1}{1-\varphi}}. \quad (117)$$

The consumption bundle of tradable goods comprises goods produced at home (H) and in the foreign (F) country. The consumption composites

²⁰The transaction cost will be small so that its effects on the model dynamics are negligible. The cost is only paid by home households, while foreign households receive the corresponding fee.

are, respectively

$$C_{Tj,t} = \left(\omega_H^\rho C_{Hj,t}^{\frac{\rho-1}{\rho}} + (1 - \omega_H)^{\frac{1}{\rho}} C_{Fj,t}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}} \quad (118)$$

and

$$C_{Tj,t}^* = \left(\omega_F^\rho C_{Fj,t}^{\frac{\rho-1}{\rho}} + (1 - \omega_F)^{\frac{1}{\rho}} C_{Hj,t}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \quad (119)$$

where ω_H and ω_F are the shares of domestically produced tradable goods, and ρ is the elasticity of substitution between tradable goods produced at home and in the foreign country. If $\rho > 1$, domestic and foreign tradable products will be substitutes. The law of one price holds for tradable goods. Hence, the price of a tradable that is both produced and consumed at home (P_H) is equal to the price of that same good consumed in the foreign country (P_H^*). The domestic households optimize their consumption expenditures as follows:

$$\min_{C_{Hj,t}, C_{Fj,t}} P_{H,t} C_{Hj,t} + P_{F,t} C_{Fj,t}. \quad (120)$$

The home country's demand for tradable goods produced domestically and in the foreign country are, respectively,

$$C_{H,t} = \omega_H \left(\frac{P_{H,t}}{P_{T,t}} \right)^{-\rho} C_{T,t} \quad (121)$$

and

$$C_{F,t} = (1 - \omega_H) \left(\frac{P_{F,t}}{P_{T,t}} \right)^{-\rho} C_{T,t}. \quad (122)$$

The price index of tradable goods is

$$P_{T,t} = \left(\omega_H P_{H,t}^{1-\rho} + (1 - \omega_H) P_{F,t}^{1-\rho} \right)^{\frac{1}{1-\rho}}. \quad (123)$$

Thus, consumption of domestic and foreign tradable goods depends on the preference for home tradables, the degree of substitutability between the goods, and how the respective prices relate to the price level of tradable goods.

The optimal consumption-saving condition for the domestic household is:

$$1 = \beta \psi_{Bt} (1 + i_t) E_t [\Lambda_{t,t+1} \Pi_{t+1}]. \quad (124)$$

Households' wage setting conditions and labor agencies' optimal demand conditions are identical to those in section 3.

5.2 Intermediate Goods Firms

Intermediate good firms are perfectly competitive. The non-tradable sector uses labor as the sole input. The aggregate production function is

$$\hat{Y}_{N,t} = L_{N,t}^{1-\alpha}. \quad (125)$$

In contrast, the tradable goods sector uses capital and labor as inputs. The production function is

$$\hat{Y}_{T,t} = (U_t Q_t K_{t-1})^\alpha L_{T,t}^{1-\alpha}. \quad (126)$$

The price of replacing one unit of depreciated capital is $P_{H,t}$. The optimality conditions are

$$\alpha \hat{P}_{T,t} Y_{T,t} D_{T,t} = P_{H,t} \delta' (U_t) U_t Q_t K_{t-1} \quad (127)$$

and

$$(1 - \alpha) \hat{P}_{q,t} Y_{q,t} D_{q,t} = L_{q,t} W_t, \quad (128)$$

where $q \in (T, N)$. The logarithm of Q_t follows an autoregressive process of order one:

$$\log(Q_t) = \phi \log(Q_{t-1}) + \varepsilon_t. \quad (129)$$

I assume that capital quality is identical in both countries and that financial shocks appear simultaneously:

$$Q_t = Q_t^*, \quad (130)$$

$$\varepsilon_t = \varepsilon_t^*. \quad (131)$$

The impact of a financial shock on production will, however, depend on each country's capital intensity.

5.3 Retail Firms

The structure of the retail firms is in general similar to that of the closed economy model in section 3. The only difference is that here tradable and non-tradeable goods are distributed by distinct retailers. Therefore, all equations have to be indexed by $q \in (T, N)$. The resulting optimality conditions are:

$$\left(\frac{1 - \xi \Pi_{q,t}^{\epsilon_q - 1}}{1 - \xi} \right)^{\frac{1}{1 - \epsilon_q}} = \left(\frac{\epsilon_q}{\epsilon_q - 1} \right) \frac{X_{q,t}^A}{X_{q,t}^B}, \quad (132)$$

where

$$X_{q,t}^A = Y_{q,t} \hat{P}_{q,t} \varrho_t + \xi \beta E_t [\Pi_{q,t+1}^{\epsilon_q} X_{q,t+1}^A] \quad (133)$$

and

$$X_{q,t}^B = (1 - \tau_q) Y_{q,t} P_{q,t} \varrho_t + \xi \beta E_t [\Pi_{q,t+1}^{\epsilon_q - 1} X_{q,t+1}^B]. \quad (134)$$

The indices of price dispersion are

$$D_{q,t} = (1 - \xi) \left(\frac{1 - \xi \Pi_{q,t}^{\epsilon_q - 1}}{1 - \xi} \right)^{\frac{\epsilon_q}{\epsilon_q - 1}} + \xi \Pi_{q,t}^{\epsilon_q} D_{q,t-1}. \quad (135)$$

5.4 Capital-producing Firms

Capital-producing firms behave similarly to those in the closed economy model. The main difference is that the cost of replacing a unit of depreciated capital is linked to the price of tradable goods ($P_{H,t}$) instead of the overall price index. Thus, depreciated capital is rebuilt from domestic tradable goods. The cost of creating a new unit of capital stock is $P_{S,t}$, which is equal to the price of a unit of capital in the market. The optimization problem of capital-producing firms is to maximize discounted profits:

$$\max_{\hat{I}_{t+s}} E_t \left[\sum_{s=0}^{\infty} M_{t,t+s} \left((P_{S,t+s} - P_{H,t+s}) \hat{I}_{t+s} - f \left(\frac{\Delta_{I,t+s}}{\Delta_{I,t+s-1}} \right) (\Delta_{I,t+s}) \right) \right]. \quad (136)$$

Therefore, the nominal stock price $P_{S,t}$ relates to net investment as follows:

$$P_{S,t} = P_{H,t} + f(\cdot) + \frac{\Delta_{I,t}}{\Delta_{I,t-1}} f'(\cdot) - E_t \left[M_{t,t+1} \left(\frac{\Delta_{I,t+1}}{\Delta_{I,t}} \right)^2 f'(\cdot) \right]. \quad (137)$$

The profits earned by capital-producing firms outside the steady state are transferred to households.

5.5 Financial Intermediaries

In contrast to the closed economy model, financial intermediaries here issue nominal one-period bonds $B_{j,t}^B$ instead of real bonds. Each bank's balance sheet in nominal terms is thus

$$P_{S,t} S_{j,t} = B_{j,t}^B + N_{j,t}. \quad (138)$$

Financial intermediaries have to pay nominal interest i_t on deposits. Their investment in the capital stock yields the uncertain nominal return \hat{i}_{t+1} that is given by

$$\hat{i}_{t+1} = \frac{\alpha \hat{P}_{T,t+1} Y_{T,t+1} - \delta(U_{t+1}) Q_{t+1} K_t}{P_{S,t} K_t} + \frac{P_{S,t+1}}{P_{S,t}} - 1. \quad (139)$$

Bankers' objective is to maximize their net worth $V_{j,t}$, that is

$$\max_{S_{j,t}} E_t \left[\sum_{s=0}^{\infty} (1-\theta) \theta^s M_{t,t+s+1} \left((\hat{i}_{t+s+1} - i_{t+s}) P_{S,t+s} S_{j,t+s} + (1+i_{t+s}) N_{j,t+s} \right) \right], \quad (140)$$

subject to

$$V_{j,t} \geq \lambda P_{S,t} S_{j,t}. \quad (141)$$

The ratio of intermediated assets to bankers' equity is

$$\Phi_t = \frac{\Gamma_t^A}{\lambda - \Gamma_t^B} \quad (142)$$

with

$$\Gamma_t^A = E_t[M_{t,t+1}[(1 - \theta)(\hat{i}_{t+1} - i_t) + \theta \frac{\Phi_{t+1}}{\Phi_t}((\hat{i}_{t+1} - i_t)\Phi_t + (1 + i_t))\Gamma_{t+1}^A]] \quad (143)$$

and

$$\Gamma_t^B = E_t[(1 - \theta) + \theta M_{t,t+1}((\hat{i}_{t+1} - i_t)\Phi_t + (1 + i_t))\Gamma_{t+1}^B]. \quad (144)$$

The evolution of aggregate financial sector net worth is given by

$$N_t = \theta((\hat{i}_t - i_{t-1})\Phi_{t-1} + (1 + i_{t-1}))N_{t-1} + \chi P_{S,t}S_{t-1}. \quad (145)$$

5.6 Government

The central bank follows a zero-inflation target for the monetary union. Union-wide price index and inflation are

$$P_{MU,t} = \sqrt{P_t} \sqrt{P_t^*} \quad (146)$$

and

$$\Pi_{MU,t} = \sqrt{\Pi_t} \sqrt{\Pi_t^*}, \quad (147)$$

respectively. This implies that the periphery and core of the monetary union are of equal size. To achieve zero inflation, the monetary authority sets the nominal interest rate according to

$$i_t = (1 + \bar{i})\Pi_{MU,t}^\kappa - 1, \quad (148)$$

where \bar{i} is the steady state nominal interest rate and κ determines the strength of reaction to deviations from the inflation target. In case there is a lower bound on the nominal interest rate, the rule changes to

$$i_t = \max[i_{lb}, (1 + \bar{i})\Pi_{MU,t}^\kappa - 1], \quad (149)$$

where i_{lb} denotes the lower interest rate bound.

5.7 Aggregation

The resource constraints in this economy are

$$Y_{T,t} = C_{H,t} + C_{H,t}^* + I_t + \frac{\eta}{2} \left(\frac{\Delta_{I,t}}{\Delta_{I,t-1}} - 1 \right)^2 (\Delta_{I,t}), \quad (150)$$

$$Y_{T,t}^* = C_{F,t}^* + C_{F,t} + I_t^* + \frac{\eta}{2} \left(\frac{\Delta_{I,t}^*}{\Delta_{I,t-1}^*} - 1 \right)^2 (\Delta_{I,t}^*), \quad (151)$$

$$Y_{N,t} = C_{N,t}, \quad (152)$$

and

$$Y_{N,t}^* = C_{N,t}^*. \quad (153)$$

Bond market clearing conditions are

$$\frac{B_t^X}{\psi_{B,t}} = (1 + i_{t-1})B_{t-1}^X + P_{H,t}C_{H,t}^* - P_{F,t}C_{F,t} \quad (154)$$

and

$$B_t^X + B_t^{X^*} = 0, \quad (155)$$

where B^X denotes a bond that finances net trade. The total bond amount is

$$B_t = B_t^X + B_t^B. \quad (156)$$

Total labor in each country is the sum of tradable and non-tradable labor:

$$L_t = L_{T,t} + L_{N,t}. \quad (157)$$

Each unit of capital corresponds to one share issued by firms producing intermediate goods:

$$K_t = S_t. \quad (158)$$

5.8 Calibration

The discount rate β is 0.995, implying an annual steady state real interest rate of 2 percent. The habit parameter is 0.65 as in Christiano,

Eichenbaum, and Evans (2005). The inverse Frisch elasticity ν is 1.5, as suggested by Chetty, Guren, Manoli, and Weber (2011). The intertemporal elasticity of substitution is 0.492, as suggested by Havranek, Horvath, Irsova, and Rusnak (2015). The elasticities of substitution in the tradable and non-tradable sectors, ϵ_T and ϵ_N , are 7.7 and 4, respectively. Eggertsson, Ferrero, and Raffo (2014) calibrate these values as they imply steady state price markups of 15 percent in the core countries' tradable sector and 33 percent in the non-tradable sector consistent with the estimates of Høj, Jimenez, Maher, Nicoletti, and Wise (2007). The wage elasticity of substitution ϵ_w equals that of the tradable sector. The tax rates τ_N and τ_w in the periphery are initially 10 percent, leading to markups of 48 percent in the non-tradable sector and 28 percent in periphery wages.²¹ Tax rates are zero in the core. The probabilities ξ that prices and wages cannot be reset are 0.66. The elasticity of substitution between home and foreign tradable goods ρ is 1.5, and the elasticity of substitution between tradable and non-tradable goods φ is 0.5. That is, foreign and domestic tradable goods are substitutes, whereas tradable and non-tradable goods are complements. The intermediation cost ψ is 0.001 as in Erceg, Guerrieri, and Gust (2006).

The parameters of firms producing intermediate goods, capital-producing firms, and financial intermediaries are calibrated following Gertler and Karadi (2011).²² The capital share α is 0.33. Parameters of the depreciation function are chosen to match a steady state annual depreciation of 10 percent and a steady state utilization rate of capital of 100 percent ($\delta_A = 0.021$ and $\delta_B = 0.033$). The elasticity of marginal depreciation with respect to capital utilization is 7.2. The elasticity of the price of

²¹Markups have been shown to be higher in periphery countries (see, e.g., Dieppe et al. (2012)). However, there is substantial variation in wage markups across industries (Jean and Nicoletti, 2015).

²²Some of these values are based on estimates of Primiceri, Schaumburg, and Tambalotti (2006).

capital with respect to net investment η is 1.728.

The survival rate of bankers θ is 0.975, implying an expected lifetime of a banker of 40 years. λ and χ are 0.4125 and 0.0026, respectively. These values imply a steady state private leverage ratio of 4 and an average annual credit spread of 100 basis points. The Taylor rule inflation coefficient κ is 2.

I set the remaining parameters to match consumption demand shares in the steady state of 67 percent in the core and 48 percent in the periphery, as documented by Lombardo and Ravenna (2012).²³ Home bias ω is 0.7 in both regions. The preference shares of tradable goods in the core γ_F and in the periphery γ_H are 0.57 and 0.31, respectively. These parameters imply a union-wide steady state import share of 15 percent, with 9 percent in the core and 21 percent in the periphery. Table 2 summarizes all parameters.

The calibrated model is also reasonable with respect to some other relative quantities. Real wages are 43 percent higher in the core. Total labor is about 4 percent lower in the periphery due to higher wage markups. The shares of labor in the tradable sector are 74 and 49 percent in the core and periphery, respectively. The capital intensity in the core is twice as high as in the periphery.

²³Average values of Austria, Belgium, France, Germany, and the Netherlands for the core and of Greece, Italy, Portugal, and Spain for the periphery.

Table 2: Parameters - Monetary Union Model

<i>Households</i>		
Discount rate	β	0.995
Habit parameter	h	0.650
Inverse Frisch elasticity of labor supply	ν	1.500
Elasticity of intertemporal substitution	σ^{-1}	0.492
Preference share of tradable goods in core countries	γ_H	0.570
Preference share of tradable goods in periphery countries	γ_F	0.310
Home bias in core countries	ω_H	0.700
Home bias in periphery countries	ω_F	0.700
Elasticity of substitution between tradable and non-tradable goods	φ	0.500
Elasticity of substitution between home and foreign tradable goods	ρ	1.500
Probability of not being able to reset wages and prices	ξ	0.660
<i>Retailers</i>		
Elasticity of substitution in the tradable goods sector	ϵ_T	7.700
Elasticity of substitution in the non-tradable goods sector	ϵ_N	4.000
<i>Labor agencies</i>		
Wage elasticity of substitution	ϵ_w	7.700
<i>Intermediate goods firms</i>		
Effective capital share	α	0.330
Steady state depreciation	$\bar{\delta}$	0.025
Elasticity of marginal depreciation w.r.t capital utilization	ζ	7.200
<i>Capital-producing firms</i>		
Elasticity of the price of capital w.r.t net investment	η	1.728
<i>Financial intermediaries</i>		
Fraction of capital that can be diverted	λ	0.4126
Proportional transfer of households to entering bankers	χ	0.0026
Survival rate of bankers	θ	0.975
<i>Government</i>		
Inflation coefficient of Taylor rule	κ	2.000
Lower bound on nominal interest rate	i_{lb}	0.0025

6 Model II - Analysis

I run several deterministic simulations to study how the model responds to exogenous shocks and structural policies over time.²⁴ Special emphasis is placed on the impact of the zero lower bound, the similarities between structural reforms and credit market interventions, and how peripheral reforms affect the monetary union as a whole.

6.1 Crisis Scenario

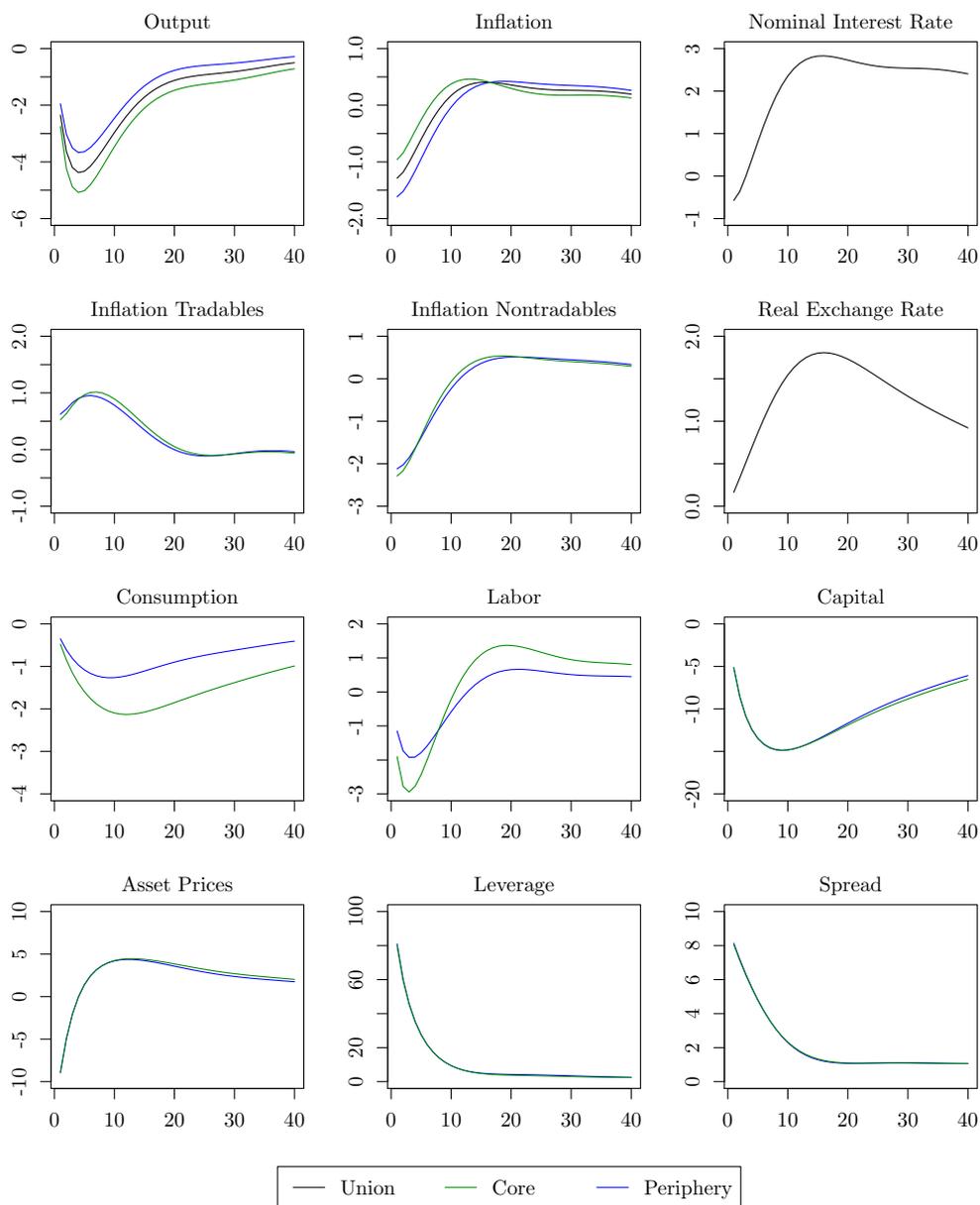
To demonstrate the behavior of the model in a crisis scenario, the impulse responses to a financial shock that hits both countries are plotted in Figure 7. I consider a 5 percent shock to capital quality Q_t with an autocorrelation coefficient ϕ of 0.66 .

The dynamics are similar to those shown in Gertler and Karadi (2011). There is an immediate drop in asset prices and required returns increase accordingly. Balance sheets of financial intermediaries deteriorate and leverage ratios significantly increase. There is a lack of credit and the economy enters a period of recession, which is characterized by unemployment and a decline in investment and consumption. The recession is long-lasting. The economy has not fully recovered after 10 years. Output contraction is accompanied by deflation, which is mainly driven by the periphery and, in particular, by the non-tradable sector. Union-wide inflation drops to -1.3 percent when the shock occurs. The central bank cuts the nominal interest rate substantially to combat deflation. The price level in the core increases relative to that of the periphery, which is reflected in the real exchange rate.

The shock depresses union-wide output by about 4.4 percent after one year. Output contraction in the core is more severe than in the periphery because production in the core is much more capital intensive.

²⁴I use Dynare (see Adjemian et al., 2011) to run all the simulations. Appendix D contains the code.

Figure 7: Crisis Scenario



Note: Responses to a capital quality shock of five percentage points in the monetary union (black line), the core (green line), and the periphery (blue line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

This pattern seems to be at odds with reality as countries in the periphery have been hit at least as hard as countries in the core. Although it is straightforward to recalibrate the shocks to get closer to the data, I choose not to do so for the following reasons: First, it does not alter the main point with respect to structural reforms I want to make here. Second, having a symmetric shock makes regional comparison easier. Third, this scenario does not yet reflect a lower bound on the nominal interest rate. The presence of a lower bound makes the recession worse, particularly in the periphery. Finally, this scenario does not consider unconventional monetary measures of the central bank. There is reason to believe that some of the excessive output contractions in the core relative to the periphery were smoothed out by the European Central Bank, as will be shown subsequently.

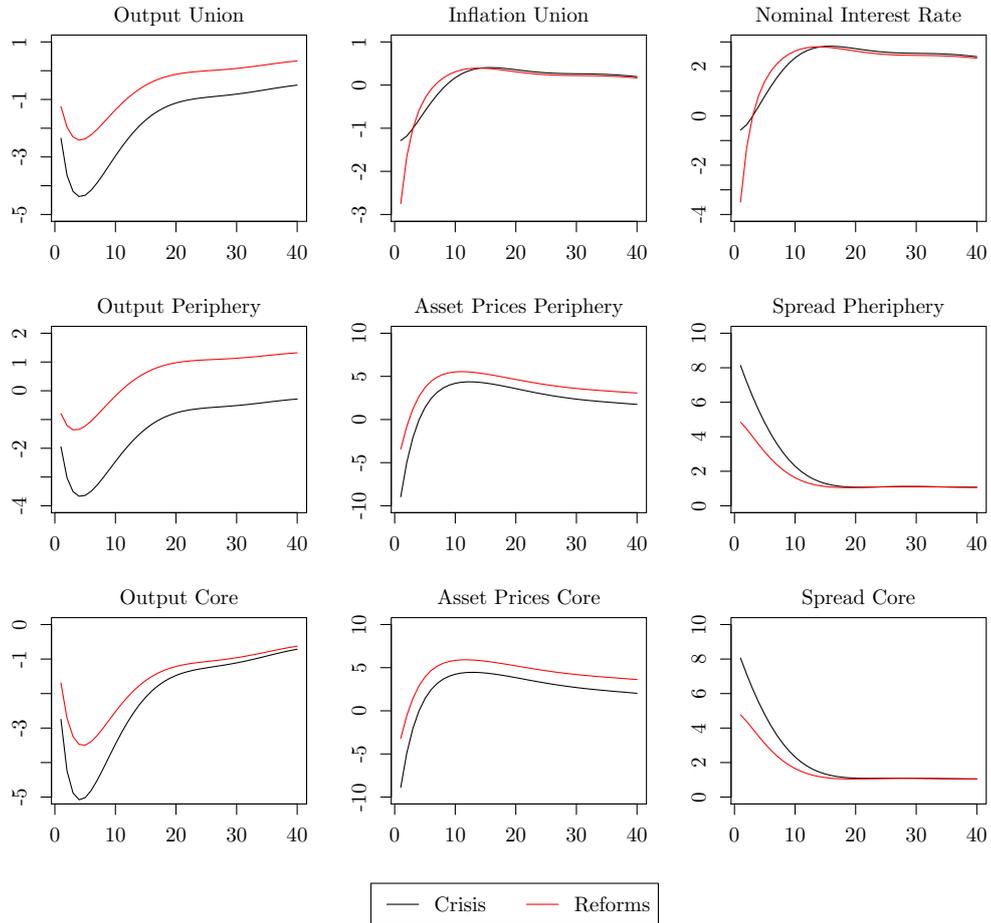
6.2 Structural Reforms in a Financial Crisis

Next, I assume that structural reforms are initiated in the periphery's labor and product markets. The policy instruments τ_N and τ_w are each permanently reduced by 5 percentage points. Figure 8 plots the responses to such reforms for selected variables.

The policy's intention is to reduce markups on wages and non-tradable goods. Consequently, prices fall and deflation worsens by about 1.5 percentage points annually. In response, the central bank decreases the nominal interest rate to less than -3 percent annually, which is far below the zero lower bound.

The contraction of output in the monetary union is considerably lower when reforms are initiated, with a peak deviation of only 2.4 percent compared to 4.4 percent without reforms. Although reforms are only initiated in the periphery, both regions benefit in the short run. This is because the steady state output in the periphery increases by about 1.6 percent. Hence, there is a wealth effect associated with such measures.

Figure 8: Structural Reforms in a Crisis



Note: Responses to a capital quality shock of five percentage points (black line) and a capital quality shock of five percentage points, followed by a permanent reduction in policy rates in the product and labor markets of five percentage points (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

The present value of future income goes up and consumption is adjusted accordingly. In contrast, saving is not attractive due to negative interest rates. The capital market also mirrors positive future outlooks. Asset prices rise by about 5.7 and 5.5 percentage points relative to the crisis

scenario in the core and periphery, respectively, whereas credit spreads decrease by 3.3 percentage points. Higher asset prices imply lower bank leverage and improved liquidity. The flow of credit finally encourages investment and production.

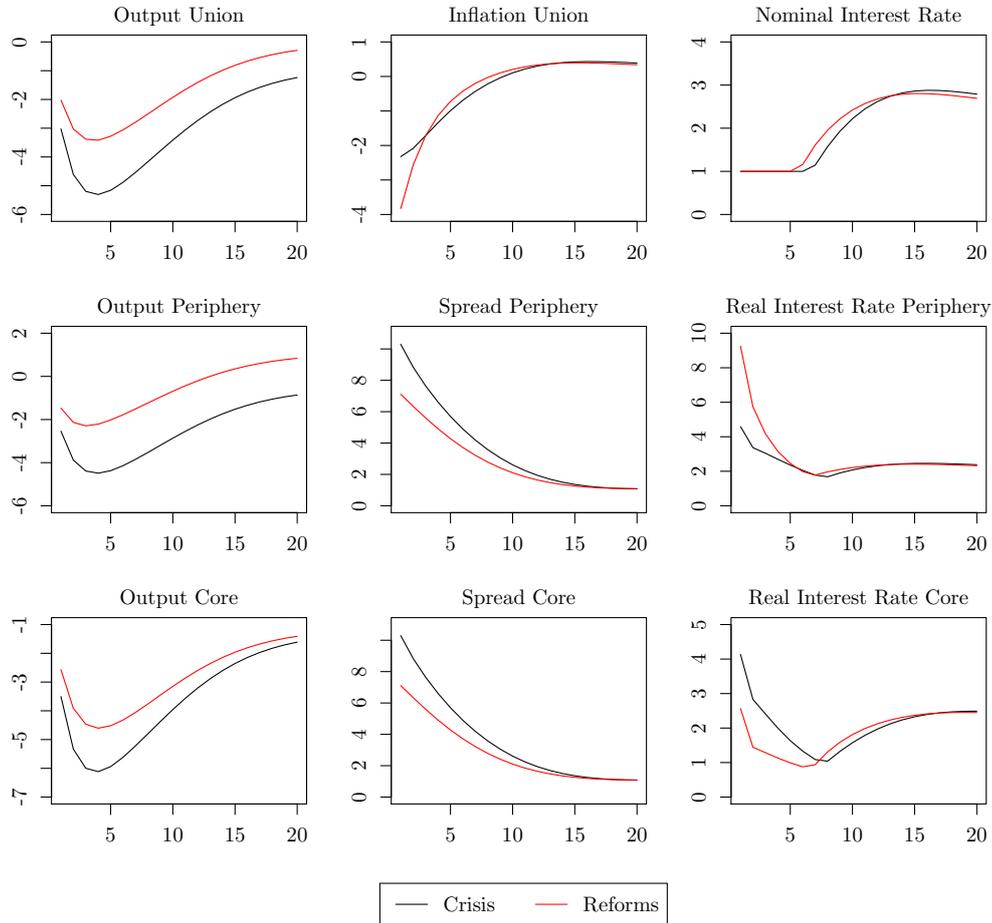
6.3 Effect of Lower Interest Rate Bounds

The presence of a lower interest rate bound can seriously limit the central bank's ability to combat deflation with standard measures. To study the effects of a lower bound, I run a simulation where the annual interest rate cannot fall below 1 percent. Figure 9 summarizes the results.

The response functions reveal that the lower bound has the following implications for the dynamics of the model. First, output contraction in both regions is more severe. For example, in the scenario without reforms the maximum deviation from the steady state is 4.5 percent in the periphery and 6.1 percent in the core, compared to 3.7 and 5.1 percent in a scenario without a lower bound. The relative impact of the bound is slightly higher in the periphery than in the core. Second, reforms are an adequate measure to stimulate the economy, even if the nominal interest rate is bounded. The impact of reforms on output is *qualitatively* identical to that in the scenario without lower bound. In other words, short-run output recovery is superior in both regions when reforms are initiated. However, the *quantitative* short-run effects are smaller when the central bank is constrained. For example, the average improvement in union-wide output in the first four quarters due to reforms is 1.7 percentage points in the case without bound and 1.6 percent in the case with bound.

This result is in contrast to Eggertsson, Ferrero, and Raffo (2014), who study structural reforms in a similar model without capital and financial intermediation. In their model, output contracts further in the short run when permanent reforms are initiated. The reason is that

Figure 9: Structural Reforms at the Zero Lower Bound (3)



Note: Responses to a capital quality shock of five percentage points (black line) and a capital quality shock of five percentage points, followed by a permanent reduction in policy rates in the product and labor markets of five percentage points (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

expected deflation increases the real interest rate drastically when the nominal interest rate hits the lower bound. As a result, households have an incentive to save and postpone consumption to the future. Since their model does not include capital, this real interest rate effect cannot be

offset by investment. In the model I have presented, the real interest rate is not dominating. The initial shock raises real interest rates by 2.6 percentage points in the periphery and 2.1 percentage points in the core. The reform causes a sizable deflation in the periphery that raises the real rate by an additional 4.7 percentage points to 9.3 percent. Hence, although the real interest rate in the periphery increases to more than four times its steady state value, there is still a substantial improvement in output following a reform.

The quantitatively small effect of the reform, compared to the case without a lower bound, on the nominal interest rate is attributable to the impact the bound has on credit spreads. In response to the reforms, these decrease by 3.2 percentage points in both the core and the periphery, which is slightly less than in the case with no lower bound. Nevertheless, there is always a reduction in spreads when reforms are initiated.

6.4 Credit Policy and Structural Reforms

In the aftermath of the financial crisis, the European Central Bank and other central banks implemented large-scale asset purchasing programs in order to encourage credit intermediation and stimulate the economy. In this section I compare structural reforms to credit intervention policies.

Gertler and Karadi (2011) study the implications of such unconventional monetary policy measures in a dynamic equilibrium framework. The main idea is that, on the one hand, the government is less efficient than private financial intermediaries in intermediating credit, but on the other hand, it has an advantage because it is not balance sheet constrained. Therefore, the government can choose to intervene in any of the following ways. It can issue government debt directly to households and use these funds to supply credit to firms producing goods. Alternatively, it could issue securities to banks, which, in turn, finance their security purchases by issuing bonds to households. Either way, the im-

plications are identical. The fact that there is an unconstrained debtor stimulates credit flow.

Formally, the government intends to lower credit spreads by varying the amount of credit it supplies to the economy. Its feedback rule is

$$\Psi_{c,t} = vE_t[(\hat{i}_{t+1} - i_t) - (\bar{\hat{i}} - \bar{i})], \quad (159)$$

where $\Psi_{c,t}$ is the share of publicly intermediated assets, $\bar{\hat{i}} - \bar{i}$ is the steady state credit spread, and $v \geq 0$ determines the strength of reaction to credit spreads. Thus, if the credit spread increases and credit constraints tighten in response to a financial shock, the government increases the share of publicly intermediated assets in order to relax the constraints and strengthen credit intermediation. Gertler and Karadi (2011) show that the private leverage ratio Φ_t is related to the overall leverage ratio $\Phi_{c,t}$ as follows:

$$\Phi_t = \Phi_{c,t}(1 - \Psi_{c,t}). \quad (160)$$

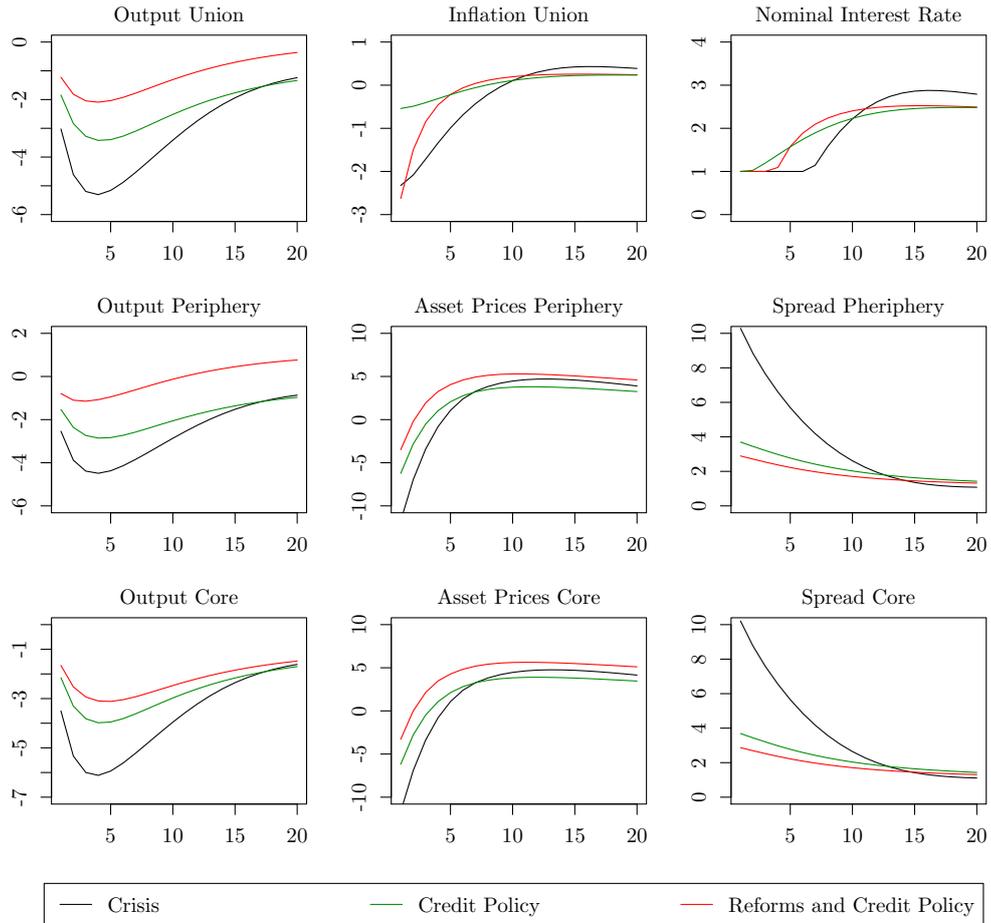
Hence, if the share of publicly intermediated assets increases, the leverage ratio of private financial intermediaries decreases.

Figure 10 shows the responses to a financial shock if the government follows a credit policy rule as defined above.²⁵ When the financial shock hits the economy, the government intervenes to reduce credit spreads. The issuance of debt leads to improving balance sheets in the financial sector because government-backed securities are considered safe. As leverage decreases, investment picks up and the recession is considerably mitigated.

In contrast to structural reforms, credit policy does not change the steady state output. Nevertheless, the effectiveness of both policies relies on the same mechanism: the resolution of deficiencies in the process of credit intermediation. While credit policy approaches the financial

²⁵I follow the baseline calibration of Gertler and Karadi (2011) in which v is 10. This parametrization illustrates a moderate intervention strategy.

Figure 10: Credit Policy



Note: Responses to a capital quality shock of five percentage points (black line), a capital quality shock of five percentage points followed by credit policy (green line), and a capital quality shock of five percentage points followed by credit policy and a permanent reduction in policy rates in the product and labor markets of five percentage points (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

market directly, structural reform policies indirectly facilitate lending through positive wealth effects. Hence, structural reforms have similar qualitative implications for the process of financial intermediation as a direct intervention in the credit market. Both policies lead to a reduction in credit spreads, rising asset prices, and lower leverage ratios.

Moreover, the two policies are not in conflict with each other. If structural reforms are implemented in addition to a government intervention, there will be an additional reduction in credit spreads. With respect to inflation, the policies have opposite effects. While reforms make deflation worse in a financial crisis, credit policy leads to rising prices. Hence, credit policy offsets some of the negative effects that reforms have on prices and reduces the time that the central bank is constrained by the lower interest rate bound. The reform experiments with and without credit policy (Figures 9 and 10, respectively) reveal that credit policy reduces deflation by more than one percentage point. Moreover, the time when interest rate is at the lower bound is shortened from five to three quarters.

The structure of the credit policy experiment implies that there are government interventions in both countries of the monetary union. Here, I have assumed that the interventions in both countries follow the same rule. The quantitative implications, however, are not identical in both countries due to different magnitudes of capital intensity. Specifically, the core country, which is more capital intensive, would issue more debt because the effects of a financial shock are more severe. In a monetary union, it may therefore be relevant whether the government intervention strategy is executed by the government independently or by the common central bank. If each government acts independently, the liabilities associated with the intervention policy accrue in each government's balance sheet and are consequently only borne by national households. If the same credit policy were initiated by the central bank, the liabilities would accrue in a common balance sheet. However, the assets and lia-

bilities of a monetary union's central bank are typically not distributed among the member states based on capital intensity. In the European Monetary Union, the shares are distributed according to population and output. Thus, the distribution of liabilities when the central bank intervenes does not necessarily match the distribution liabilities in case of independent government interventions.

7 Concluding Remarks

In the present dissertation, I study how structural reforms in the product and labor markets affect an economy that is going through a deflationary recession where a lower bound on the interest rate limits the central bank's ability to react. The topic is extensively discussed in academic research. I contribute to that literature by addressing three issues. First, I deviate from much of the previous literature in the way I characterize the crisis scenario. Many researchers initiate a crisis scenario by an exogenous shift in individuals' preferences, whereas I argue that the recent crisis resulted from the financial market. I thus model a capital markets shock that brings about a deflationary recession. Second, I consider financial acceleration and spillovers to the real sector in my analysis to show how reforms are reflected in financial market variables. Third, I consider that monetary policy acted unconventionally in the aftermath of the financial crisis. Therefore, in addition to standard Taylor rules, I consider interventions in the financial markets by the government that intend to relax credit constraints and stimulate financial intermediation.

My results are based on deterministic simulations of two dynamic stochastic general equilibrium models and are summarized as follows: First, reforms that increase competition in product and labor markets permanently have positive effects on aggregate output, both in the short and in the long run. The short-run effects of labor market reforms are smaller compared to those of product market reforms because the reduction in wage markups due to reforms is partly offset by higher labor demand. Besides, labor and product market reforms have approximately additive effects.

Second, a capital market shock will have a much stronger effect on output and inflation if financial markets are imperfect in the sense that households face a moral hazard vis-à-vis financial intermediaries. In fact, individuals will reduce lending if the banking sector leverage increases

due to falling asset prices. The credit crunch ultimately affects the goods producing sector and output contracts. Moreover, the fall in goods prices necessitates stronger central bank reaction to fight deflation.

Third, if the central bank is constrained by the zero lower bound, output and inflation will react more strongly to a capital market shock as compared to the unconstrained case. Consequently, the magnitude of the shock required to cause the interest rate to reach its lower bound is smaller. Permanent product and labor market reforms increase deflationary pressures. When the interest rate is already at its lower bound, the central cannot respond to these pressures. Thus, the real interest rate increases. However, in this framework, a rising real interest rate does not imply a reduction in current consumption and output. To the contrary, consumption and output increase immediately in response to permanent reforms. The reason is that such policy measures are associated with a higher steady state output, capital stock, and consumption. The adjustment of the capital stock to its new steady state level requires the production of new goods. Hence, demand for investment goods increases. Moreover, households adjust their consumption plans in anticipation of higher future income. Financial sector variables also reflect expectations of a higher future output. In response to permanent reforms asset prices increase and leverage in the banking sector and credit spreads decrease. This implies that lending from households to financial intermediaries and from there to firms increases so that production is facilitated.

Fourth, if reforms are implemented temporarily, the short-term consequences for output will be negative. Such a policy increases short-run deflation and lets the real interest rate rise. In contrast to permanent reforms, temporary reforms do not increase steady state output and wealth. Consequently, households reduce consumption in the short run in response to the higher real interest rate.

Fifth, structural reforms that are credibly announced for some future date are associated with higher output and income in the long run while

simultaneously deflationary expectations are reduced. Nevertheless, the short-term consequences are negative. Such a policy increases current prices relative to future prices. If the central bank follows a strict inflation target, it will respond by increasing the nominal interest rate. Eventually, the real interest rate increases and households postpone consumption until reforms are implemented. Investment does not outweigh this effect because the capital stock needs not be increased before the implementation of the reforms.

Sixth, permanent structural reforms could also improve recovery from a financial crisis if they are implemented in a currency union. By increasing competition in the product and labor markets, the reforming country increases output in the long run, and the positive wealth effect associated with reforms lets the economy recover faster from the financial crisis. Although the non-reforming country does not experience higher steady-state output, it nevertheless benefits in the short run from increased demand for tradable goods from the reforming country. The financial sector variables also reflect this result, as asset prices increase in all countries when reforms are implemented permanently. Hence, reforms will be beneficial on a union-wide level even if they are only implemented in one region.

Seventh, structural reforms have qualitatively similar effects on the financial variables to unconventional monetary policy measures that stimulate credit flow. Both policies induce a reduction in credit spreads, rising asset prices, and an improvement of the financial condition of financial intermediaries. Hence, both policies improve the financial sector's ability to carry out its main function, i.e. the channeling of funds from lenders to borrowers. While credit intervention policies approach the financial constraints directly, structural reform policies indirectly facilitate lending through positive wealth effects. The policies again do not conflict with each other. The combination of credit intervention and structural reforms improves the recovery from the financial crisis as compared to

stand-alone measures. Finally, credit policies could affect the members of a currency union asymmetrically if they are initiated by a common central bank. Especially if member countries differ with respect to capital intensity, the distribution of funds flowing to each country may not match the distribution of central bank liabilities.

Overall, my results reveal that taking the financial sector into account in the evaluation of structural reforms leads to policy implications that stand in contrast to the findings of some previous studies. I show that permanent reforms are appropriate to mitigate a financial crisis. They work in the short as well as in the long run, in the presence of a lower bound on interest rates, and in the case that government implements unconventional monetary policy. Permanent reforms generate wealth. Asset prices and required returns adjust accordingly. The credit market becomes more liquid. Credit intermediation enhances, and eventually the real sector benefits. The model suggests that structural reforms that increase competition in product and labor markets are an appropriate tool to combat economic contraction in a financial crisis.

The results are based on a model that obviously relies on assumptions and thus does not capture every aspect of the economic environment. The final paragraphs review the results considering some alternative model specifications that are frequently used in the literature. Moreover, some limitations of the model are discussed and directions of future research are proposed.

The model that I presented omits a standard feature of many recent dynamic general equilibrium models—the working capital channel. The main idea is that firms require short-term funding in order to finance working capital. This channel has important implications for the model's dynamics when monetary policy is assumed to follow the Taylor principle. In particular, interest rate changes affect the marginal cost of production in addition to influencing aggregate spending behavior. Hence, if the central bank reacts to inflation by increasing the interest

rate, marginal costs will increase, and thus there will be more upward pressure on prices. If this channel is too dominant, Taylor rules will have destabilizing effects on the economy (see Christiano, Eichenbaum, and Evans, 2005; Christiano, Trabandt, and Walentin, 2010). Including working capital in the model that I have presented would have some quantitative effects. Specifically, there would be additional downward price pressure during the crisis because the central bank's reaction to the financial shock involves a reduction in the nominal interest rate that would reduce the cost of working capital. The presence of a zero lower bound on the nominal interest rate would have two implications. On the one hand, the real interest rate would rise further which would worsen the crisis. On the other hand, the zero lower bound would impose a limit on the effects of this channel. The effects of reforms in the crisis scenario, however, would not change qualitatively. There would still be a wealth effect associated with reforms.

Another simplifying assumption I make is that the monetary union consists of two equally sized regions. This assumption is also made by Eggertsson, Ferrero, and Raffo (2014) because the periphery countries together make up a substantial share of total output. It is straight forward to extend the model to incorporate a size parameter. The results would, however, only change quantitatively, not qualitatively. For instance, if the periphery were smaller, the core country would benefit relatively less from reforms in the periphery. This is because the increase in the demand for tradeable goods would be relatively smaller.

One of the distinguishing features of my study is that the financial crisis is initiated by a supply-side shock. Other authors, for example Eggertsson, Ferrero, and Raffo (2014), model the crisis as arising from the demand side of the economy. A standard procedure to do this is to exogenously disturb households' optimization by means of a preference shock such that consumption demand decreases. In the Appendix B I construct a similar scenario and show that structural reforms also work in

a demand-driven crisis scenario. Moreover, I show that a preference shock would have some counter-factual implications in my model. A preference shock that decreases consumption demand implies that spreads decrease in the recession. This pattern was not observed during the financial crisis. Instead, spreads increased.

A shortage of the monetary union model is that the financial sectors are separated. That is, households save domestically and each country's financial sector invests in the domestic capital stock only. Thus, banks' investments are not diversified across countries. Nevertheless, two features of the model implicitly link the financial sectors closely to each other. First, the price of a unit of capital stock in each country is connected to the price of the tradable good. By assumption, domestic and foreign tradable goods are close substitutes and hence their prices behave similarly. Second, I have assumed that capital quality follows the same stochastic process in both regions. Thus, financial shocks appear simultaneously in the monetary union. Owing to these two model features, asset prices and credit spreads behave almost identically in both the regions (see, e.g., figures 7, 9, and 10). I therefore argue that the separation is not critical with respect to the results. Minor differences in domestic and foreign asset prices could also be interpreted as resulting from a home bias in investment, analogous to the bias in consumption of tradable goods.

The model does also not incorporate trade with the rest of the world. Although I leave the quantitative evaluation of reforms in an extended model to future research, I suspect that reforms would affect the core and the periphery of the monetary union asymmetrically. Reforms in the periphery imply a reduction in the price level of the periphery and, to a smaller extent, a reduction in the price level of the monetary union. Given deflation in the monetary union, the common currency would likely appreciate vis-a-vis the foreign currency in the short run. This would make tradable goods produced in the monetary union expensive relative

to the outside countries. Assuming that the core countries have a larger share of tradable goods production, then it follows that they would be affected more by changes in the exchange rate. Whether or not the core countries would benefit in the short run from reforms in the periphery depends on the distribution of trade. A higher share of trade with periphery countries would increase the benefits from an increased demand in those countries.

The main element of the model is the financial sector. Endogenous credit constraints arise due to a moral hazard problem between households and banks. As mentioned already in the model description, this characteristic may be challenged because credit rationing emerged predominantly among financial institutions themselves during the crisis. Nevertheless, the mechanism can generate some major features of the recent crisis including credit rationing, increasing credit spreads, and sharp and persistent contraction of the real economy. However, a drawback of the model is that leverage behaves countercyclically. That is, a favorable supply shock is accompanied by decreasing leverage. The boom period preceding the financial crisis was, to the contrary, characterized by increasing leverage.

Another interesting extension could therefore be to study structural reforms in a framework in which banking crisis results from a boom. For example, in the model of Boissay, Collard, and Smets (2016) a banking crisis and a subsequent recession can emerge from a sequence of favorable non-permanent supply shocks that lead to an expansion of credit and lower interest rates. Consequently, counter-party risk in the interbank market increases and, if the interest rate falls below a threshold, the market freezes. Structural reforms, especially if they were reversed or expected to be reversed in the future, could in the short run have effects similar to non-permanent supply shocks, lead to credit expansion, and make a financial crisis more likely. Thus, future research may consider the design of structural reforms not solely for responding to a crisis but

also as a potential source.

Some critical implications of the financial sector framework are also pointed out by Cole (2011). One questionable feature is that firms are prevented from self-financing their investments which would correspond to financing at the interest rate. Instead, the model imposes that firms refinance themselves every period, thereby effectively paying the return to capital which is higher than the interest rate in the steady state. Another issue is that banks in the model do not hedge their risk across states of the world. Moreover, the size of the banking sector is limited because bankers have a limited lifetime and new entering bankers receive relatively small initial endowments. Relaxing these assumptions would reduce the vulnerability of the economy to financial acceleration.

A critical assumption is also made with respect to credit intermediation by the government. Particularly, there is no moral hazard involved if the government acts as a financial intermediary. Moreover, it is implicitly assumed, that there is no limit for the government to issue bonds. Whether or not these assumptions are justified is subject to debate. On the one hand, central banks increased their balance sheet substantially during the crisis, which indicates that the assumption is, at least to some degree, justified. On the other hand, there are limits to borrowing as seen, for example, in some countries of the European periphery. The results of my study, which primarily concern structural reforms, do, however, not rely on these assumptions. Another relevant aspect is how expectations of government interventions affect the optimal behavior of economic agents. Gertler, Kiyotaki, and Queralto (2012), for example, show that expectations of government interventions in a crisis scenario increase financial intermediaries' optimal leverage, and thus the economy becomes more vulnerable to shocks. Again, the degree of leverage does not qualitatively affect the functioning of the wealth effect associated to reforms.

In this study, I consider the interaction of structural reform policies

and monetary policy in a financial crisis. A more comprehensive model could also consider the trade-offs or complementarities with other related policies. Besides reforms, government spending and fiscal consolidation are among the most intensively discussed suggestions to reduce imbalances in the European Monetary Union. According to the academic literature, these policies may affect an economy differently in a crisis than in normal times (see Corsetti, Kuester, Meier, and Müller, 2010; Christiano, Eichenbaum, and Rebelo, 2011; Erceg and Linde, 2012). Specifically, the government spending multiplier can be high during a recession when the interest rate is at its lower bound. Government spending imposes upward pressure on prices, which in normal times induces the monetary authority to increase the interest rate which, in turn, offsets the positive effects of government spending on output. When the interest rate is bound at zero, these offsetting effects are limited and thus spending multipliers are large. Anderson, Hunt, and Snudden (2014) consider a scenario where fiscal consolidation is contractionary due to high multipliers. They show that structural reforms are beneficial in such a scenario because they offset some of the negative effects by initiating wealth effects. The model that I construct does not take fiscal consolidation into account. That is, tax cuts do not affect government spending. Instead, taxes are transferred lump sum to households. If tax cuts would reduce government spending, some of the positive effects would be offset. However, although the policy instrument shows up as a tax rate in my model, the main idea is that reforms involve a reduction in an inefficiency. Thus, reforms can also be thought of as initiatives which not affect the government budget extensively, such as reductions of barriers to market entry or deregulation. Reforms therefore do not necessarily imply a reduction in government spending. Although the positive wealth effects of reforms suggest that they are beneficial regardless of whether government spending is increased or decreased, there is reason to believe that increasing spending is more complementary to structural reforms. The main reason

is that government spending increases upward pressure on prices. Thus, it cancels out the downward pressure on prices and the rise of the real interest rate which are implied by structural reforms when the interest rate is at the zero lower bound.

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Appendix

A Equilibrium Conditions - Monetary Union Model

Euler Equations:

$$1 = \beta\psi_{Bt}(1 + i_t)E_t[\Lambda_{t,t+1}\Pi_{t+1}] \quad (\text{A.1})$$

$$1 = \beta(1 + i_t)E_t[\Lambda_{t,t+1}^*\Pi_{t+1}^*] \quad (\text{A.2})$$

$$\Lambda_{t,t+1} = \frac{\varrho_{t+1}}{\varrho_t} = \frac{(C_{t+1} - hC_t)^{-\sigma} - \beta h(C_{t+2} - hC_{t+1})^{-\sigma}}{(C_t - hC_{t-1})^{-\sigma} - \beta h(C_{t+1} - hC_t)^{-\sigma}} \quad (\text{A.3})$$

$$\Lambda_{t,t+1}^* = \frac{\varrho_{t+1}^*}{\varrho_t^*} = \frac{(C_{t+1}^* - hC_t^*)^{-\sigma} - \beta h(C_{t+2}^* - hC_{t+1}^*)^{-\sigma}}{(C_t^* - hC_{t-1}^*)^{-\sigma} - \beta h(C_{t+1}^* - hC_t^*)^{-\sigma}} \quad (\text{A.4})$$

$$\psi_{Bt} = \exp\left[-\psi_B \frac{B_t}{P_t Y_t}\right] \quad (\text{A.5})$$

Price Indices:

$$P_t = (\gamma_H P_{T,t}^{1-\varphi} + (1 - \gamma_H) P_{N,t}^{1-\varphi})^{\frac{1}{1-\varphi}} \quad (\text{A.6})$$

$$P_t^* = (\gamma_F P_{T,t}^{*1-\varphi} + (1 - \gamma_F) P_{N,t}^{*1-\varphi})^{\frac{1}{1-\varphi}} \quad (\text{A.7})$$

$$P_{T,t} = (\omega_H P_{H,t}^{1-\rho} + (1 - \omega_H) P_{F,t}^{1-\rho})^{\frac{1}{1-\rho}} \quad (\text{A.8})$$

$$P_{T,t}^* = (\omega_F P_{F,t}^{1-\rho} + (1 - \omega_F) P_{H,t}^{1-\rho})^{\frac{1}{1-\rho}} \quad (\text{A.9})$$

Consumption Demand:

$$C_{T,t} = \gamma_H \left(\frac{P_{T,t}}{P_t} \right)^{-\varphi} C_t \quad (\text{A.10})$$

$$C_{T,t}^* = \gamma_F \left(\frac{P_{T,t}^*}{P_t^*} \right)^{-\varphi} C_t^* \quad (\text{A.11})$$

$$C_{N,t} = (1 - \gamma_H) \left(\frac{P_{N,t}}{P_t} \right)^{-\varphi} C_t \quad (\text{A.12})$$

$$C_{N,t}^* = (1 - \gamma_F) \left(\frac{P_{N,t}^*}{P_t^*} \right)^{-\varphi} C_t^* \quad (\text{A.13})$$

$$C_{H,t} = \omega_H \left(\frac{P_{H,t}}{P_{T,t}} \right)^{-\rho} C_{T,t} \quad (\text{A.14})$$

$$C_{F,t} = (1 - \omega_H) \left(\frac{P_{F,t}}{P_{T,t}} \right)^{-\rho} C_{T,t} \quad (\text{A.15})$$

$$C_{F,t}^* = \omega_F \left(\frac{P_{F,t}}{P_{T,t}^*} \right)^{-\rho} C_{T,t}^* \quad (\text{A.16})$$

$$C_{H,t}^* = (1 - \omega_F) \left(\frac{P_{H,t}}{P_{T,t}^*} \right)^{-\rho} C_{T,t}^* \quad (\text{A.17})$$

Wage Setting:

$$\left(\frac{1 - \xi \Pi_{w,t}^{\epsilon_w - 1}}{1 - \xi} \right)^{\frac{1 + \epsilon_w \nu}{1 - \epsilon_w}} = \left(\frac{\epsilon_w}{\epsilon_w - 1} \right) \frac{X_{w,t}^A}{X_{w,t}^B} \quad (\text{A.18})$$

$$\left(\frac{1 - \xi \Pi_{w,t}^{*\epsilon_w - 1}}{1 - \xi} \right)^{\frac{1 + \epsilon_w \nu}{1 - \epsilon_w}} = \left(\frac{\epsilon_w}{\epsilon_w - 1} \right) \frac{X_{w,t}^{A*}}{X_{w,t}^{B*}} \quad (\text{A.19})$$

$$X_{w,t}^A = L_t^{1+\nu} + \xi \beta E_t [\Pi_{w,t+1}^{\epsilon_w} X_{w,t+1}^A] \quad (\text{A.20})$$

$$X_{w,t}^B = (1 - \tau_w) \frac{W_t}{P_t} L_t \varrho_t + \xi \beta E_t [\Pi_{w,t+1}^{\epsilon_w - 1} X_{w,t+1}^B] \quad (\text{A.21})$$

$$X_{w,t}^{A*} = L_t^{*1+\nu} + \xi \beta E_t [\Pi_{w,t+1}^{*\epsilon_w} X_{w,t+1}^{A*}] \quad (\text{A.22})$$

$$X_{w,t}^{B*} = \frac{W_t^*}{P_t^*} L_t^* \varrho_t^* + \xi \beta E_t [\Pi_{w,t+1}^{*\epsilon_w - 1} X_{w,t+1}^{B*}] \quad (\text{A.23})$$

Price Setting:

$$\left(\frac{1 - \xi \Pi_{T,t}^{\epsilon_T - 1}}{1 - \xi}\right)^{\frac{1}{1 - \epsilon_T}} = \left(\frac{\epsilon_T}{\epsilon_T - 1}\right) \frac{X_{T,t}^A}{X_{T,t}^B} \quad (\text{A.24})$$

$$\left(\frac{1 - \xi \Pi_{N,t}^{\epsilon_N - 1}}{1 - \xi}\right)^{\frac{1}{1 - \epsilon_N}} = \left(\frac{\epsilon_N}{\epsilon_N - 1}\right) \frac{X_{N,t}^A}{X_{N,t}^B} \quad (\text{A.25})$$

$$\left(\frac{1 - \xi \Pi_{T,t}^{*\epsilon_T - 1}}{1 - \xi}\right)^{\frac{1}{1 - \epsilon_T}} = \left(\frac{\epsilon_T}{\epsilon_T - 1}\right) \frac{X_{T,t}^{A*}}{X_{T,t}^{B*}} \quad (\text{A.26})$$

$$\left(\frac{1 - \xi \Pi_{N,t}^{*\epsilon_N - 1}}{1 - \xi}\right)^{\frac{1}{1 - \epsilon_N}} = \left(\frac{\epsilon_N}{\epsilon_N - 1}\right) \frac{X_{N,t}^{A*}}{X_{N,t}^{B*}} \quad (\text{A.27})$$

$$X_{T,t}^A = Y_{T,t} \hat{P}_{T,t} \varrho_t + \xi \beta E_t [\Pi_{T,t+1}^{\epsilon_T} X_{T,t+1}^A] \quad (\text{A.28})$$

$$X_{T,t}^B = (1 - \tau_T) Y_{T,t} P_{T,t} \varrho_t + \xi \beta E_t [\Pi_{T,t+1}^{\epsilon_T - 1} X_{T,t+1}^B] \quad (\text{A.29})$$

$$X_{N,t}^A = Y_{N,t} \hat{P}_{N,t} \varrho_t + \xi \beta E_t [\Pi_{N,t+1}^{\epsilon_N} X_{N,t+1}^A] \quad (\text{A.30})$$

$$X_{N,t}^B = (1 - \tau_N) Y_{N,t} P_{N,t} \varrho_t + \xi \beta E_t [\Pi_{N,t+1}^{\epsilon_N - 1} X_{N,t+1}^B] \quad (\text{A.31})$$

$$X_{T,t}^{A*} = Y_{T,t}^* \hat{P}_{T,t}^* \varrho_t^* + \xi \beta E_t [\Pi_{T,t+1}^{*\epsilon_T} X_{T,t+1}^{A*}] \quad (\text{A.32})$$

$$X_{T,t}^{B*} = Y_{T,t}^* P_{T,t}^* \varrho_t^* + \xi \beta E_t [\Pi_{T,t+1}^{*\epsilon_T - 1} X_{T,t+1}^{B*}] \quad (\text{A.33})$$

$$X_{N,t}^{A*} = Y_{N,t}^* \hat{P}_{N,t}^* \varrho_t^* + \xi \beta E_t [\Pi_{N,t+1}^{*\epsilon_N} X_{N,t+1}^{A*}] \quad (\text{A.34})$$

$$X_{N,t}^{B*} = Y_{N,t}^* P_{N,t}^* \varrho_t^* + \xi \beta E_t [\Pi_{N,t+1}^{*\epsilon_N - 1} X_{N,t+1}^{B*}] \quad (\text{A.35})$$

Price Dispersion:

$$D_{T,t} = (1 - \xi) \left(\frac{1 - \xi \Pi_{T,t}^{\epsilon_T - 1}}{1 - \xi} \right)^{\frac{\epsilon_T}{\epsilon_T - 1}} + \xi \Pi_{T,t}^{\epsilon_T} D_{T,t-1} \quad (\text{A.36})$$

$$D_{N,t} = (1 - \xi) \left(\frac{1 - \xi \Pi_{N,t}^{\epsilon_N - 1}}{1 - \xi} \right)^{\frac{\epsilon_N}{\epsilon_N - 1}} + \xi \Pi_{N,t}^{\epsilon_N} D_{N,t-1} \quad (\text{A.37})$$

$$D_{T,t}^* = (1 - \xi) \left(\frac{1 - \xi \Pi_{T,t}^{*\epsilon_T - 1}}{1 - \xi} \right)^{\frac{\epsilon_T}{\epsilon_T - 1}} + \xi \Pi_{T,t}^{*\epsilon_T} D_{T,t-1}^* \quad (\text{A.38})$$

$$D_{N,t}^* = (1 - \xi) \left(\frac{1 - \xi \Pi_{N,t}^{*\epsilon_N - 1}}{1 - \xi} \right)^{\frac{\epsilon_N}{\epsilon_N - 1}} + \xi \Pi_{N,t}^{*\epsilon_N} D_{N,t-1}^* \quad (\text{A.39})$$

Production Functions:

$$Y_{N,t} D_{N,t} = L_{N,t}^{1-\alpha} \quad (\text{A.40})$$

$$Y_{N,t}^* D_{N,t}^* = L_{N,t}^{*1-\alpha} \quad (\text{A.41})$$

$$Y_{T,t} D_{T,t} = (U_t Q_t K_{t-1})^\alpha L_{T,t}^{1-\alpha} \quad (\text{A.42})$$

$$Y_{T,t}^* D_{T,t}^* = (U_t^* Q_t K_{t-1}^*)^\alpha L_{T,t}^{*1-\alpha} \quad (\text{A.43})$$

$$\log(Q_t) = \phi \log(Q_{t-1}) + \varepsilon_t, \quad (\text{A.44})$$

Optimal Capital Utilization:

$$\alpha \hat{P}_{T,t} Y_{T,t} D_{T,t} = P_{H,t} \delta'(U_t) U_t Q_t K_{t-1} \quad (\text{A.45})$$

$$\alpha \hat{P}_{T,t}^* Y_{T,t}^* D_{T,t}^* = P_{F,t}^* \delta'(U_t^*) U_t^* Q_t K_{t-1}^* \quad (\text{A.46})$$

$$\delta(U_t) = \delta_A + \frac{\delta_B}{1 + \zeta} U_t^{1+\zeta} \quad (\text{A.47})$$

$$\delta(U_t^*) = \delta_A + \frac{\delta_B}{1 + \zeta} U_t^{*1+\zeta} \quad (\text{A.48})$$

Optimal Labor:

$$(1 - \alpha)\hat{P}_{T,t}Y_{T,t}D_{T,t} = L_{T,t}W_t \quad (\text{A.49})$$

$$(1 - \alpha)\hat{P}_{T,t}^*Y_{T,t}^*D_{T,t}^* = L_{T,t}^*W_t^* \quad (\text{A.50})$$

$$(1 - \alpha)\hat{P}_{N,t}Y_{N,t}D_{N,t} = L_{N,t}W_t \quad (\text{A.51})$$

$$(1 - \alpha)\hat{P}_{N,t}^*Y_{N,t}^*D_{N,t}^* = L_{N,t}^*W_t^* \quad (\text{A.52})$$

$$L_t = L_{T,t} + L_{N,t} \quad (\text{A.53})$$

$$L_t^* = L_{T,t}^* + L_{N,t}^* \quad (\text{A.54})$$

Investment:

$$\hat{I}_t = I_t - \delta(U_t)Q_tK_{t-1} \quad (\text{A.55})$$

$$\hat{I}_t^* = I_t^* - \delta(U_t^*)Q_tK_{t-1}^* \quad (\text{A.56})$$

$$\Delta_{I,t+s} = \hat{I}_{t+s} + \bar{I} \quad (\text{A.57})$$

$$\Delta_{I,t+s}^* = \hat{I}_{t+s}^* + \bar{I}^* \quad (\text{A.58})$$

Asset Prices:

$$P_{S,t} = P_{H,t} + f(\cdot) + \frac{\Delta_{I,t}}{\Delta_{I,t-1}}f'(\cdot) - E_t \left[M_{t,t+1} \left(\frac{\Delta_{I,t+1}}{\Delta_{I,t}} \right)^2 f'(\cdot) \right] \quad (\text{A.59})$$

$$P_{S,t}^* = P_{H,t}^* + f(\cdot) + \frac{\Delta_{I,t}^*}{\Delta_{I,t-1}^*}f'(\cdot) - E_t \left[M_{t,t+1}^* \left(\frac{\Delta_{I,t+1}^*}{\Delta_{I,t}^*} \right)^2 f'(\cdot) \right] \quad (\text{A.60})$$

$$f(\cdot) = \frac{\eta}{2} \left(\frac{\Delta_{I,t+s}}{\Delta_{I,t+s-1}} - 1 \right)^2 \quad (\text{A.61})$$

$$f(\cdot)^* = \frac{\eta}{2} \left(\frac{\Delta_{I,t+s}^*}{\Delta_{I,t+s-1}^*} - 1 \right)^2 \quad (\text{A.62})$$

Capital Returns:

$$\hat{i}_t = \frac{\alpha \hat{P}_{T,t} Y_{T,t} - \delta(U_t) Q_t K_{t-1}}{P_{S,t-1} K_{t-1}} + \frac{P_{S,t}}{P_{S,t-1}} - 1 \quad (\text{A.63})$$

$$\hat{i}_t^* = \frac{\alpha \hat{P}_{T,t}^* Y_{T,t}^* - \delta(U_t^*) Q_t K_{t-1}^*}{P_{S,t-1}^* K_{t-1}^*} + \frac{P_{S,t}^*}{P_{S,t-1}^*} - 1 \quad (\text{A.64})$$

Financial Sector:

$$P_{S,t} S_t = \Phi_t N_t \quad (\text{A.65})$$

$$P_{S,t}^* S_t^* = \Phi_t^* N_t^*, \quad (\text{A.66})$$

$$\Phi_t = \frac{\Gamma_t^A}{\lambda - \Gamma_t^B} \quad (\text{A.67})$$

$$\Phi_t^* = \frac{\Gamma_t^{A*}}{\lambda - \Gamma_t^{B*}} \quad (\text{A.68})$$

$$\Gamma_t^A = E_t [M_{t,t+1} [(1 - \theta)(\hat{i}_{t+1} - i_t) + \theta \frac{\Phi_{t+1}}{\Phi_t} ((\hat{i}_{t+1} - i_t)\Phi_t + (1 + i_t))\Gamma_{t+1}^A]] \quad (\text{A.69})$$

$$\Gamma_t^{A*} = E_t [M_{t,t+1}^* [(1 - \theta)(\hat{i}_{t+1}^* - i_t) + \theta \frac{\Phi_{t+1}^*}{\Phi_t^*} ((\hat{i}_{t+1}^* - i_t)\Phi_t^* + (1 + i_t))\Gamma_{t+1}^{A*}]] \quad (\text{A.70})$$

$$\Gamma_t^B = E_t [(1 - \theta) + \theta M_{t,t+1} ((\hat{i}_{t+1} - i_t)\Phi_t + (1 + i_t))\Gamma_{t+1}^B] \quad (\text{A.71})$$

$$\Gamma_t^{B*} = E_t [(1 - \theta) + \theta M_{t,t+1}^* ((\hat{i}_{t+1}^* - i_t)\Phi_t^* + (1 + i_t))\Gamma_{t+1}^{B*}] \quad (\text{A.72})$$

$$N_t = \theta((\hat{i}_t - i_{t-1})\Phi_{t-1} + (1 + i_{t-1}))N_{t-1} + \chi P_{S,t} S_{t-1} \quad (\text{A.73})$$

$$N_t^* = \theta((\hat{i}_t^* - i_{t-1})\Phi_{t-1}^* + (1 + i_{t-1}))N_{t-1}^* + \chi P_{S,t}^* S_{t-1}^* \quad (\text{A.74})$$

$$K_t = S_t \quad (\text{A.75})$$

$$K_t^* = S_t^* \quad (\text{A.76})$$

Taylor Rule:

$$i_t = (1 + \bar{i})\Pi_{MU,t}^\kappa - 1 \quad (\text{A.77})$$

$$\Pi_{MU,t} = \sqrt{\Pi_t} \sqrt{\Pi_t^*} \quad (\text{A.78})$$

Resource Constraints:

$$Y_{T,t} = C_{H,t} + C_{H,t}^* + I_t + \frac{\eta}{2} \left(\frac{\Delta_{I,t}}{\Delta_{I,t-1}} - 1 \right)^2 (\Delta_{I,t}) \quad (\text{A.79})$$

$$Y_{T,t}^* = C_{F,t}^* + C_{F,t} + I_t^* + \frac{\eta}{2} \left(\frac{\Delta_{I,t}^*}{\Delta_{I,t-1}^*} - 1 \right)^2 (\Delta_{I,t}^*) \quad (\text{A.80})$$

$$Y_{N,t} = C_{N,t} \quad (\text{A.81})$$

$$Y_{N,t}^* = C_{N,t}^* \quad (\text{A.82})$$

Bond Market:

$$\frac{B_t^X}{\psi_{B,t}} = (1 + i_{t-1})B_{t-1}^X + P_{H,t}C_{H,t}^* - P_{F,t}C_{F,t} \quad (\text{A.83})$$

$$B_t^X + B_t^{X^*} = 0 \quad (\text{A.84})$$

$$B_t = B_t^X + B_t^B \quad (\text{A.85})$$

$$B_t^* = B_t^{X^*} + B_t^{B^*} \quad (\text{A.86})$$

B Demand-Driven Crisis

This experiment shall illustrate that structural reforms are also beneficial in a scenario in which the crisis is demand-driven.

To examine this question I consider a preference shock as typical in the literature. That is, the discount factor is exogenously disturbed so that households' desire to save increases. Formally, a preference variable, Υ_t , is introduced in the household optimization problem,

$$\max E_t \left[\sum_{s=0}^{\infty} \Upsilon_{t+s} \beta^s U_t(C_t) \right], \quad (\text{B.1})$$

which in the case of log-utility leads to the following simple Euler equation:

$$1 = \beta(1 + i_t) E_t \left[\frac{\Upsilon_{t+1}}{\Upsilon_t} \frac{C_t}{C_{t+1}} \frac{1}{\Pi_{t+1}^{-1}} \right]. \quad (\text{B.2})$$

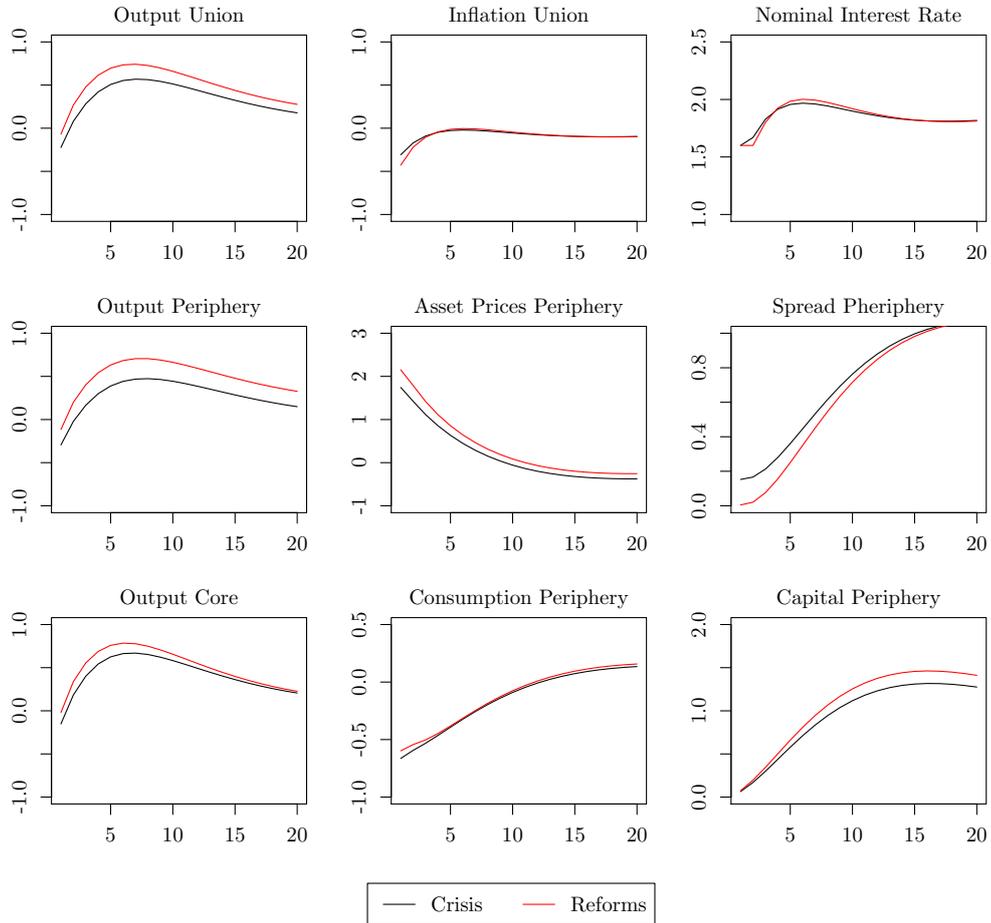
A positive shock to Υ_t implies that households suddenly attribute more weight to future consumption when optimizing expected utility. Consequently, current consumption drops. Therefore, a positive preference shock represents a negative demand shock.

However, in the baseline calibration of the monetary union model, a positive shock to preferences raises output immediately. Although consumption drops, investment demand is so high that it ultimately outweighs consumption. The reason is that shocks to preferences let spreads drop and even become negative.

In order to construct a scenario in which output contracts and spreads remain positive I set the habit parameter to zero and initiate a 25 basis points preference shock with an autocorrelation coefficient of 0.95. In addition, I consider a reduction in the tax rates of 50 basis points. I also increase the lower bound on the interest rate because the drop of the interest rate is not sufficiently large. Figure 11 plots the impulse responses.

The combination of shock and reform pushes the credit spread temporarily to zero. Consumption demand drops and is not outweighed by

Figure 11: Demand-driven Crisis



Note: Responses to a preference shock of 25 basis points (black line) and a preference shock of 25 basis points followed by a permanent reduction in policy rates in the product and labor markets of 50 basis points (red line). Inflation rates, interest rates and spreads are annualized percentages. All other numbers are percentage deviations from the steady state. Time in quarters.

investment. Therefore, output contracts upon impact. Prices in the goods market fall and the central bank lowers the nominal interest rate to combat deflation. In the financial market, the immediate reaction is an increase in the demand for assets or, alternatively, the supply of

funds. Consequently, asset prices rise and required excess returns fall. As capital is cheap, the demand for investment goods rises which reduces the strength of economic contraction.

The experiment reveals that structural reforms also work in this scenario. The channel is similar to that in a supply-driven crisis. Growth expectations associated with reforms lead to rising asset prices. Spreads tighten and the supply of credit increases. Capital is cheap and production expands. However, the scenario is not in line with the empirical observation that spreads increased during the financial crisis.

C Dynare Code - Closed Economy Model

```
-----  
% 1. Defining endogenous variables  
-----  
  
var  
  
C          //Consumption  
I          //Investment  
I_net     //Net demand for investment goods  
I_SS      //Steady state demand for investment goods  
Y         //Output  
YD        //Output  
L         //Total labor  
K         //Capital  
U         //Utilization of capital  
Rk        //Return on capital (gross)  
R         //Real interest rate (gross)  
R_nom     //Nominal interest rate (gross)  
dU_dC    //Derivative of utility wrt consumption  
MRS       //Marginal rate of substitution (real)  
NMRS      //Marginal rate of substitution (nominal)  
  
//Prices  
W         //Wage (real)  
MC_C     //Marginal cost consumption goods (real)  
Disp     //Price dispersion  
Infl     //Inflation  
RHO_A  
RHO_B  
WInfl    //Wage inflation  
RHO_WA  
RHO_WB  
  
//Financial intermediaries  
PHI      //Private leverage ratio  
N        //Net worth of bankers  
RHO_C  
RHO_D  
Ex_Ret   //Spread, Expected excess return  
Q        //Price (real) of capital  
  
//Processes  
Qual     //Quality of capital  
;
```

```

%-----
% 2. Defining exogenous variables
%-----

varexo

e_Qual      //Capital quality shock
tau_P       //Policy instrument product market
tau_W       //Policy instrument labor market
;

%-----
% 3. Defining parameters
%-----

parameters

beta        //Subjective discount rate
h           //Habit parameter
sigma       //Relative risk aversion
nu          //Inverse Frisch elasticity of labor supply
alpha       //Capital share
eps_C       //Elasticity of substitution goods sector
eps_W       //Elasticity of substitution wages
xi          //Probability of keeping prices fixed
psi_infl    //Taylor rule parameter
lambda      //Fraction of capital that can be diverted by bankers
chi         //Proportional transfer to entering bankers
theta       //Survival rate of bankers
PHI_SS      //Steady state leverage
Rk_SS       //Steady state return on capital
etta        //Elasticity of the price of capital wrt capital utilization
zeta        //Elasticity of marginal depreciation wrt net investment
delta       //Steady state depreciation
delta_a     //Parameter to fix steady state utilization
delta_b     //Parameter to fix steady state utilization
rho_Qual    //Autoregression parameter (capital quality process)
;

```

```

%-----
% 4. Calibration of parameters
%-----

betta      = 0.995;
h          = 0.65;
sigma      = 1;
nu         = 1.5;
alpha      = 0.33;
eps_C      = 5;
eps_W      = 5;
xi         = 0.66;
psi_infl   = 2;
chi        = 0.0026;
lambda     = 0.4126;
theta      = 0.975;
etta       = 1.728;
zeta       = 7.200;
PHI_SS     = (((-theta)*lambda + betta*theta*lambda - betta*chi + betta*theta*chi +
sqrt((-4)*betta*theta*((-betta) + betta*theta))*lambda*chi
+ ((theta*lambda - betta*theta*lambda
+ betta*chi - betta*theta*chi)^2))/(2*betta*theta*lambda*chi));
Rk_SS      = (betta-theta+theta*PHI_SS-betta*PHI_SS*chi)/(betta*theta*PHI_SS);
delta      = 0.025;
delta_b    = (Rk_SS-1+delta) ;
delta_a    = delta - delta_b/(1+zeta);
rho_Qual   = 0.66;

%-----
% 5. Model
%-----

model;

//PRICE SETTING

((1-xi*Infl^(eps_C-1))/(1-xi))^(1/(1-eps_C)) = eps_C/(eps_C-1) * RHO_A/RHO_B;
RHO_A = Y * dU_dC * MC_C + betta*xi* (Infl(+1))^(eps_C)*RHO_A(+1);
RHO_B = Y * (1-tau_P)*dU_dC + betta*xi* (Infl(+1))^(eps_C-1)*RHO_B(+1);

Disp = xi*Infl^eps_C*Disp(-1)+(1-xi)*(((1-xi*Infl^(eps_C-1))/(1-xi))^(eps_C/(eps_C-1)));

```

```

//WAGE SETTING

((1-xi*WInfl^(eps_W-1))/(1-xi))^(1+eps_W*nu)/(1-eps_W) = eps_W/(eps_W-1)*RHO_WA/RHO_WB;
RHO_WA = (L)^(1+nu) + betta*xi* (WInfl(+1))^(eps_W *(1+nu))*RHO_WA(+1);
RHO_WB = (1-tau_W)*dU_dC * W * L + betta*xi* (WInfl(+1))^(eps_W -1)*RHO_WB(+1);

WInfl = W/W(-1) * Infl;

//HOUSEHOLDS

//First-order condition
dU_dC = ((C-h*C(-1))^(-sigma) - betta*h*(C(+1)-h*C)^(-sigma));
MRS = (dU_dC / dU_dC(-1));
NMRS = MRS /Infl;
1 = betta* R * (MRS(+1)) ;

//INTERMEDIATE GOODS FIRMS

//Production function
YD = (U*Qual*K(-1))^(alpha)*L^(1-alpha);
YD = Y*Disp;

//Optimal labor
W = MC_C*(1-alpha)*YD/L;

//Optimal utilization
YD*MC_C = ((delta_b*U^zeta) *U *Qual*K(-1))/alpha;

//Evolution of capital
K = Qual*K(-1) + I_net;
I_net = I - (delta_a + delta_b/(1+zeta)*U^(1+zeta))*Qual*K(-1);

//Return on capital
Rk = ((MC_C*alpha*YD/(Qual*K(-1))
+Q-(delta_a+delta_b/(1+zeta)*U^(1+zeta))*Qual)/Q(-1);
Ex_Ret = (Rk(+1) - R);

//CAPITAL PRODUCING FIRMS

//First order condition
Q = 1+ etta/2*((I_net+I_SS)/(I_net(-1)+I_SS) -1)^2
+ (I_net+I_SS)/(I_net(-1)+I_SS)* etta*((I_net+I_SS)/(I_net(-1)+I_SS) -1)
- betta*((MRS(+1)))* ((I_net(+1)+I_SS)/(I_net+I_SS))^2

```

```

* etta*((I_net(+1)+I_SS)/(I_net+I_SS)-1);
I_SS      =      steady_state(I);

//FINANCIAL INTERMEDIARIES

//First-order condition: financial intermediaries
RHO_C     =      (1-theta)*beta*((MRS(+1)))*(Rk(+1)-R)
+ beta*((MRS(+1))*theta*(PHI(+1)/PHI * ((Rk(+1)-R)*PHI + R))*RHO_C(+1);
RHO_D     =      (1-theta) + beta*((MRS(+1))*theta* ((Rk(+1)-R)*PHI + R))*RHO_D(+1);
PHI       =      RHO_D/(lambda-RHO_C);

//Demand for assets
Q*K       =      PHI*N;

//Evolution of bankers net worth
N         =      theta*((Rk-R(-1))*PHI(-1)+R(-1))*N(-1) + chi*Q*K(-1);

//ECONOMY RESOURCE CONSTRAINT
Y         =      C + I + etta/2*((I_net+I_SS)/(I_net(-1)+I_SS) -1)^2*(I_net+I_SS) ;

//CENTRAL BANK RULE

//R_nom = 1/beta*Infl^psi_infl;           //Standard Scenario
R_nom     =      max(1.00, 1/beta*Infl^psi_infl); //ZLB Scenario

//FISHER EQUATION

R_nom     =      R*(Infl(+1));

//STOCHASTIC PROCESSES

//Quality of capital
log(Qual) =      rho_Qual*log(Qual(-1)) - e_Qual;

end;

```

```

%-----
% 6. Initial values
%-----

initval;
C          = 1.5514;
I          = 0.3466;
I_net     = 0;
I_SS      = 0.3466;
Y          = 1.8981;
YD        = 1.8981;
L          = 0.7127;
K          = 13.8671;
U          = 1;
Rk         = 1.0075;
R          = 1.0050;
R_nom     = 1.0050;
dU_dC     = 0.6505;
MRS        = 1;
NMRS      = 1;
W          = 1.2846;
MC_C      = 0.72;
Disp      = 1;
Infl      = 1;
RHO_A     = 2.5897;
RHO_B     = 3.2372;
WInfl     = 1;
RHO_WA    = 1.2493;
RHO_WB    = 1.5616;
PHI       = 3.9922;
N         = 3.4735;
RHO_C     = 0.0040;
RHO_D     = 1.6310;
Ex_Ret    = 0.0024;
Q         = 1;
Qual      = 1;
e_Qual    = 0;
tau_P     = 0.1;
tau_W     = 0.1;

end;

```

```

%-----
% 7. Compute
%-----

steady(maxit=1000);
check;

%-----
% 8. End values
%-----

endval;
C           = 1.5514;
I           = 0.3466;
I_net      = 0;
I_SS       = 0.3466;
Y           = 1.8981;
YD         = 1.8981;
L           = 0.7127;
K           = 13.8671;
U           = 1;
Rk         = 1.0075;
R           = 1.0050;
R_nom      = 1.0050;
dU_dC     = 0.6505;
MRS        = 1;
NMRS       = 1;
W           = 1.2846;
MC_C       = 0.72;
Disp       = 1;
Infl       = 1;
RHO_A      = 2.5897;
RHO_B      = 3.2372;
WInfl     = 1;
RHO_WA     = 1.2493;
RHO_WB     = 1.5616;
PHI        = 3.9922;
N           = 3.4735;
RHO_C      = 0.0040;
RHO_D      = 1.6310;
Ex_Ret     = 0.0024;
Q           = 1;
Qual       = 1;

```

```

e_Qual          = 0;
tau_P           = 0.1;      //Policy instrument
tau_W           = 0.1;      //Policy instrument

end;

```

```

%-----
% 9. Compute
%-----

```

```

steady(maxit=1000);
check;

```

```

%-----
% 10. Simulate
%-----

```

```

shocks;

```

```

//Standard shock scenario:
var e_Qual; periods 1;
values 0.02;

```

```

//Short-term reforms:
//var tau_P; periods 1:2;
//values 0.05;
//var tau_W; periods 1:2;
//values 0.05;

```

```

//Future credible reforms after 8 Quarters:
//var tau_P; periods 1:8;
//values 0.1;
//var tau_W; periods 1:8;
//values 0.1;

```

```

end;

```

```

simul(periods=100, maxit=100);

```

D Dynare Code - Monetary Union Model

```
%-----  
% 1. Defining endogenous variables  
%-----  
  
var  
  
C_NHH      //Consumption of non-tradables...produced in home...consumed in home  
C_THH      //Consumption of tradables...produced in home...consumed in home  
C_THF      //Consumption of tradables...produced in home...consumed in foreign  
C_NFF      //Consumption of non-tradables...produced in foreign...consumed in foreign  
C_TFF      //Consumption of tradables...produced in foreign...consumed in foreign  
C_TFH      //Consumption of tradables...produced in foreign...consumed in home  
  
C_TH       //Consumption of tradables...consumed in home  
C_TF       //Consumption of tradables...consumed in foreign  
C_H        //Total home consumption  
C_F        //Total foreign consumption  
  
Y_TH       //Output of tradables produced in home  
Y_TF       //Output of tradables produced in foreign  
Y_NH       //Output of non-tradables produced in home  
Y_NF       //Output of non-tradables produced in foreign  
Y_H        //Total home output  
Y_F        //Total foreign output  
Y_MU       //Total output of Monetary Union  
  
YD_TH      //Output of tradables produced in home  
YD_TF      //Output of tradables produced in foreign  
YD_NH      //Output of non-tradables produced in home  
YD_NF      //Output of non-tradables produced in foreign  
  
L_TH       //Labor tradables produced in home  
L_TF       //Labor tradables produced in foreign  
L_NH       //Labor non-tradables produced in home  
L_NF       //Labor non-tradables produced in foreign  
L_H        //Total labor home  
L_F        //Total labor foreign  
  
//All prices and wages are relative to the monetary union price level  
  
W_H        //Real wage home  
W_F        //Real wage foreign
```

```

P_int_TH //Marginal cost of tradables home
P_int_NH //Marginal cost of non-tradables home
P_int_TF //Marginal cost of tradables foreign
P_int_NF //Marginal cost of non-tradables foreign

p_THH //Price of tradables...produced in home...consumed in home (=p_THF)
p_TFF //Price of tradables...produced in foreign...consumed in foreign (=p_TFH)
p_NH //Price of non-tradables...produced in home...consumed in home
p_NF //Price of non-tradables...produced in foreign...consumed in foreign

p_TH //Price index of tradables...consumed in home
p_TF //Price index of tradables...consumed in foreign
p_H //Home price index
p_F //foreign price index

Disp_TH //Price dispersion tradables home
Disp_NH //Price dispersion non-tradables home
Disp_TF //Price dispersion tradables foreign
Disp_NF //Price dispersion non-tradables foreign

Infl_TH //Inflation of tradables in home
RHO_A_TH
RHO_B_TH

Infl_NH //Inflation of non-tradables in home
RHO_A_NH
RHO_B_NH

Infl_TF //Inflation of tradables in foreign
RHO_A_TF
RHO_B_TF

Infl_NF //Inflation of non-tradables in foreign
RHO_A_NF
RHO_B_NF

Infl_MU //Inflation in Monetary Union
Infl_H //Inflation home
Infl_F //Inflation foreign

R_nom //Nominal interest rate (gross)
dU_dC_H //Derivative of utility wrt consumption home
dU_dC_F //Derivative of utility wrt consumption foreign

```

```

MRS_H      //Intertemporal marginal rate of substitution home (real)
MRS_F      //Intertemporal marginal rate of substitution (real)
NMRS_H     //Intertemporal marginal rate of substitution (nominal)
NMRS_F     //Intertemporal marginal rate of substitution (nominal)

WInfl_H    //Wage inflation of tradables in home
RHO_WA_H
RHO_WB_H

WInfl_F    //Wage inflation of tradables in foreign
RHO_WA_F
RHO_WB_F

PHI_H      //Leverage home
RHO_FA_H
RHO_FB_H

PHI_F      //Leverage foreign
RHO_FA_F
RHO_FB_F

Rk_nom_H   //Nominal gross return on capital home
Rk_nom_F   //Nominal gross return on capital foreign

Q_H        //Relative stock price home (relative to price p_THH)
Q_F        //Relative stock price foreign (relative to price p_TFF)

N_H        //Net worth of bankers home
N_F        //Net worth of bankers foreign

U_H        //Utilization of capital home
U_F        //Utilization of capital foreign

K_HH       //Capital employed in home
K_FF       //Capital employed in foreign

I_HH       //Investments made in home
I_FF       //Investments made in foreign

I_HH_net   //Net-investments made in home
I_FF_net   //Net-investments made in foreign

I_HH_SS    //Steady state investments made in home
I_FF_SS    //Steady state investments made in foreign

B_H        //Total holding of bonds in home
B_F        //Total holding of bonds in foreign

```

```

psi_Bond //Intermediation cost in bond market (ensures stationarity)

Qual_H //Qualtiy of capital, valuation of capital home
Qual_F //Qualtiy of capital, valuation of capital foreign
Pref //Qualtiy of capital, valuation of capital

```

```

PIA_H //Share of publicly intermediated assets home
PIA_F //Share of publicly intermediated assets foreign

```

```
;
```

```

%-----
% 2. Defining exogenous variables
%-----

```

```
varexo
```

```

tau_PNH //Policy instrument
tau_WNH //Policy instrument
e_Pref //Preference shock
e_Qual_F //Capital quality shock
e_Qual_H; //Capital quality shock

```

```

%-----
% 3. Defining parameters
%-----

```

```
parameters
```

```

beta //Subjective discount rate
alpha //Effective capital share
h //Habit parameter
sigma //Relative risk aversion
gammmaaaH //Consumption share of tradable goods
gammmaaaF //Consumption share of tradable goods
rho //Elasticity of substitution home and foreign tradables
varphi //Elasticity of substitution tradables-non-tradables
nu //Inverse Frisch elasticity of labor supply
eps_T //Elasticity of substitution in tradable sector
eps_N //Elasticity of substitution in non-tradable sector
eps_W //Elasticity of substitution wages
xi //Probability of keeping prices fixed

```

```

omega      //Share of home tradable consumption (home bias)
psi_infl   //Taylor rule parameter
psi_B      //Intermediation cost parameter in bond market (ensures stationarity)
R_nom_SS   //Steady state nominal interest rate (gross)
chi        //Proportional transfer to entering bankers
lambda     //Fraction of capital that can be diverted by bankers
theta      //Survival rate of bankers
zeta       //Elasticity of depreciation
etta       //Inverse elasticity of net investment to the price of capital
rho_Qual   //Autoregression parameter (capital quality process)
rho_Pref   //Autoregression parameter (Preference process)
tau_PIA    //Efficiency cost of public intermediation in credit market
vu_PIA     //Strength of feedback of credit policy wrt credit spreads

```

```
//Steady state parameters
```

```

delta      //Steady state depreciation
delta_a    //Parameter to fix steady state utilization
delta_b    //Parameter to fix steady state utilization
PHI_SS     //Steady state PHI
Rk_SS     //Steady state return on capital

```

```
;
```

```

%-----
% 4. Calibration of parameters
%-----

```

```

beta      = 0.995;
alpha     = 0.33;
h         = 0.65;
sigma     = 1/0.492;
gammaaaaH = 0.31;
gammaaaaF = 0.57;
omega     = 0.7;
rhoho     = 1.5;
varphi    = 0.5;
nu        = 1.5;
eps_T     = 7.7;
eps_N     = 4;
eps_W     = 7.7;
xi        = 0.66;
psi_B     = 0.001;
psi_infl  = 2;
chi       = 0.0026;
lambda    = 0.4126;
theta     = 0.975;

```

```

zeta      = 7.200;
etta      = 1.728;
rho_Qual  = 0.66;
rho_Pref  = 0.9;
rho_A     = 0.95;
A         = 1;
tau_PIA   = 0.001;
vu_PIA    = 0;

```

```
//Steady State parameters
```

```

R_nom_SS  = 1/betta;
PHI_SS    = (((-theta)*lambda + betta*theta*lambda - betta*chi + betta*theta*chi
+ sqrt((-4)*betta*theta*((-betta) + betta*theta))*lambda*chi
+ ((theta*lambda - betta*theta*lambda + betta*chi - betta*theta*chi))^2))
/(2*betta*theta*lambda*chi));
Rk_SS     = (betta-theta+theta*PHI_SS-betta*PHI_SS*chi)/(betta*theta*PHI_SS);
delta     = 0.025;
delta_b   = (Rk_SS-1+delta) ;
delta_a   = delta - delta_b/(1+zeta);

```

```

%-----
% 5. Model
%-----

```

```
model;
```

```
//CONSUMPTION DEMAND
```

```
//Tradables
```

```

C_THH    = omegga*      (p_THH/p_TH)^(-rhho) * C_TH;
C_TFH    = (1-omegga)* (p_TFF/p_TH)^(-rhho) * C_TH;
C_TFF    = omegga*      (p_TFF/p_TF)^(-rhho) * C_TF;
C_THF    = (1-omegga)* (p_THH/p_TF)^(-rhho) * C_TF;

C_TH     = gammmaaaH*   (p_TH/p_H)^(-varphi) * C_H;
C_TF     = gammmaaaF*   (p_TF/p_F)^(-varphi) * C_F;

```

```
//Non-tradable
```

```

C_NHH    = (1-gammmaaaH)* (p_NH/p_H)^(-varphi) * C_H;
C_NFF    = (1-gammmaaaF)* (p_NF/p_F)^(-varphi) * C_F;

```

```

//PRICE SETTING

//Home tradables
((1-xi*Infl_TH^(eps_T-1))/(1-xi))^(1/(1-eps_T)) = eps_T/(eps_T-1) * RHO_A_TH/RHO_B_TH;
RHO_A_TH      = Y_TH * Pref * dU_dC_H * P_int_TH/p_H
+ betta*xi* (Infl_TH(+1))^(eps_T)      *RHO_A_TH(+1);
RHO_B_TH      = Y_TH * Pref * dU_dC_H * p_THH/p_H
+ betta*xi* (Infl_TH(+1))^(eps_T-1)    *RHO_B_TH(+1);

//Home non-tradables
((1-xi*Infl_NH^(eps_N-1))/(1-xi))^(1/(1-eps_N)) = eps_N/(eps_N-1) * RHO_A_NH/RHO_B_NH;
RHO_A_NH      = Y_NH * Pref * dU_dC_H * P_int_NH/p_H
+ betta*xi* (Infl_NH(+1))^(eps_N)      *RHO_A_NH(+1);
RHO_B_NH      = Y_NH * Pref * (1-tau_PNH)* dU_dC_H * p_NH/p_H
+ betta*xi* (Infl_NH(+1))^(eps_N-1)    *RHO_B_NH(+1);

//Foreign tradables
((1-xi*Infl_TF^(eps_T-1))/(1-xi))^(1/(1-eps_T)) = eps_T/(eps_T-1) * RHO_A_TF/RHO_B_TF;
RHO_A_TF      = Y_TF * Pref * dU_dC_F * P_int_TF/p_F
+ betta*xi* (Infl_TF(+1))^(eps_T)      *RHO_A_TF(+1);
RHO_B_TF      = Y_TF * Pref * dU_dC_F * p_TFF/p_F
+ betta*xi* (Infl_TF(+1))^(eps_T-1)    *RHO_B_TF(+1);

//Foreign non-tradables
((1-xi*Infl_NF^(eps_N-1))/(1-xi))^(1/(1-eps_N)) = eps_N/(eps_N-1) * RHO_A_NF/RHO_B_NF;
RHO_A_NF      = Y_NF * Pref * dU_dC_F * P_int_NF/p_F
+ betta*xi* (Infl_NF(+1))^(eps_N)      *RHO_A_NF(+1);
RHO_B_NF      = Y_NF * Pref * dU_dC_F * p_NF/p_F
+ betta*xi* (Infl_NF(+1))^(eps_N-1)    *RHO_B_NF(+1);

//WAGE SETTING

//Home
((1-xi*WInfl_H^(eps_W-1))/(1-xi))^((1+eps_W*nu)/(1-eps_W)) =
eps_W/(eps_W-1)*RHO_WA_H/RHO_WB_H;
RHO_WA_H      = (L_H)^(1+nu)* Pref
+ betta*xi* (WInfl_H(+1))^(eps_W *(1+nu))      *RHO_WA_H(+1);
RHO_WB_H      = (1-tau_WNH)* dU_dC_H * Pref * W_H/p_H * (L_H)
+ betta*xi* (WInfl_H(+1))^(eps_W -1)      *RHO_WB_H(+1);

//Foreign
((1-xi*WInfl_F^(eps_W-1))/(1-xi))^((1+eps_W*nu)/(1-eps_W)) =
eps_W/(eps_W-1)*RHO_WA_F/RHO_WB_F;
RHO_WA_F      = (L_F)^(1+nu)* Pref
+ betta*xi* (WInfl_F(+1))^(eps_W *(1+nu))      *RHO_WA_F(+1);
RHO_WB_F      = dU_dC_F * W_F/p_F * (L_F) * Pref
+ betta*xi* (WInfl_F(+1))^(eps_W -1)      *RHO_WB_F(+1);

```

//PRICE DISPERSION

```
Disp_TH      =   xi*Infl_TH^eps_T*Disp_TH(-1)
+ (1-xi)*((1-xi*Infl_TH^(eps_T-1))/(1-xi))^(eps_T/(eps_T-1));
Disp_NH      =   xi*Infl_NH^eps_N*Disp_NH(-1)
+ (1-xi)*((1-xi*Infl_NH^(eps_N-1))/(1-xi))^(eps_N/(eps_N-1));
Disp_TF      =   xi*Infl_TF^eps_T*Disp_TF(-1)
+ (1-xi)*((1-xi*Infl_TF^(eps_T-1))/(1-xi))^(eps_T/(eps_T-1));
Disp_NF      =   xi*Infl_NF^eps_N*Disp_NF(-1)
+ (1-xi)*((1-xi*Infl_NF^(eps_N-1))/(1-xi))^(eps_N/(eps_N-1));
```

//INFLATION

```
Infl_TH      =   p_THH/p_THH(-1) *Infl_MU;
Infl_NH      =   p_NH/p_NH(-1)  *Infl_MU;
Infl_TF      =   p_TFF/p_TFF(-1) *Infl_MU;
Infl_NF      =   p_NF/p_NF(-1)  *Infl_MU;
```

```
WInfl_H      =   W_H/W_H(-1)*Infl_MU;
WInfl_F      =   W_F/W_F(-1)*Infl_MU;
```

```
Infl_H       =   p_H/p_H(-1) * Infl_MU;
Infl_F       =   p_F/p_F(-1) * Infl_MU;
```

//OVERALL PRICE INDEX

//Tradables

```
p_TH         = (omegga*p_THH^(1-rhho)      + (1-omegga)*p_TFF^(1-rhho) )^(1/(1-rhho));
p_TF         = (omegga*p_TFF^(1-rhho)     + (1-omegga)*p_THH^(1-rhho) )^(1/(1-rhho));
```

//Consumer price index

```
p_H         = (gammmaaaaH*p_TH^(1-varphi)  + (1-gammmaaaaH)*p_NH^(1-varphi) )^(1/(1-varphi));
p_F         = (gammmaaaaF*p_TF^(1-varphi)  + (1-gammmaaaaF)*p_NF^(1-varphi) )^(1/(1-varphi));
```

//Monetary Union

```
p_H^(1/2)   = 1/p_F^(1/2);
```

//OVERALL OUTPUT / GDP

```
Y_MU        =   Y_H^(1/2)*Y_F^(1/2);
Y_H         =   Y_TH + Y_NH;
Y_F         =   Y_TF + Y_NF;
```

```

//HOUSEHOLDS

//First-order condition: Home
dU_dC_H      = ((C_H-h*C_H(-1))(-sigma) - beta*h*(C_H(+1)-h*C_H)(-sigma));
MRS_H        = Pref*(dU_dC_H / dU_dC_H(-1));
NMRS_H       = MRS_H / ( p_H/p_H(-1) * Infl_MU);
1            = psi_Bond* beta* R_nom * (NMRS_H(+1)) ;

//First-order condition: Foreign
dU_dC_F      = ((C_F-h*C_F(-1))(-sigma) - beta*h*(C_F(+1)-h*C_F)(-sigma));
MRS_F        = Pref*(dU_dC_F / dU_dC_F(-1));
NMRS_F       = MRS_F / ( p_F/p_F(-1) * Infl_MU);
1            = beta* R_nom * (NMRS_F(+1)) ;

//FINANCIAL INTERMEDIARIES

//First-order condition: home
RHO_FA_H     = (1-theta)*beta*((NMRS_H(+1)))*(Rk_nom_H(+1)-R_nom)
+ beta*((NMRS_H(+1))*theta*(PHI_H(+1)/PHI_H
* ((Rk_nom_H(+1)-R_nom)*PHI_H + R_nom))*RHO_FA_H(+1);
RHO_FB_H     = (1-theta) + beta*((NMRS_H(+1))*theta
* ((Rk_nom_H(+1)-R_nom)*PHI_H + R_nom))*RHO_FB_H(+1);
PHI_H        = RHO_FB_H/(lambda-RHO_FA_H);

//First-order condition: foreign
RHO_FA_F     = (1-theta)*beta*((NMRS_F(+1)))*(Rk_nom_F(+1)-R_nom)
+ beta*((NMRS_F(+1))*theta*(PHI_F(+1)/PHI_F
* ((Rk_nom_F(+1)-R_nom)*PHI_F + R_nom))*RHO_FA_F(+1);
RHO_FB_F     = (1-theta) + beta*((NMRS_F(+1))*theta
* ((Rk_nom_F(+1)-R_nom)*PHI_F + R_nom))*RHO_FB_F(+1);
PHI_F        = RHO_FB_F/(lambda-RHO_FA_F);

//Demand for assets
PHI_H/(1-PIA_H)*N_H = Q_H*K_HH ;
PHI_F/(1-PIA_F)*N_F = Q_F*K_FF ;

//Evolution of bankers net worth
N_H          = theta*((Rk_nom_H-R_nom(-1))*PHI_H(-1)+R_nom(-1))*N_H(-1)
+ chi * (Q_H*K_HH(-1)) ;
N_F          = theta*((Rk_nom_F-R_nom(-1))*PHI_F(-1)+R_nom(-1))*N_F(-1)
+ chi * (Q_F*K_FF(-1)) ;

```

```

//INTERMEDIATE GOODS FIRMS

YD_TH      =   Y_TH*Disp_TH   ;
YD_NH      =   Y_NH*Disp_NH   ;
YD_TF      =   Y_TF*Disp_TF   ;
YD_NF      =   Y_NF*Disp_NF   ;

//Production Functions: Home and foreign, tradables and non-tradables
YD_TH      =   (U_H*Qual_H*K_HH(-1))^(alpha) * L_TH^(1-alpha);
YD_NH      =   L_NH^(1-alpha);
YD_TF      =   (U_F*Qual_F*K_FF(-1))^(alpha) * L_TF^(1-alpha);
YD_NF      =   L_NF^(1-alpha);

//Optimal labor
W_H         =   P_int_TH * (1-alpha)*YD_TH/L_TH ;
W_H         =   P_int_NH * (1-alpha)*YD_NH/L_NH ;
W_F         =   P_int_TF * (1-alpha)*YD_TF/L_TF ;
W_F         =   P_int_NF * (1-alpha)*YD_NF/L_NF ;

L_H         =   L_NH + L_TH;
L_F         =   L_NF + L_TF;

//Optimal capital utilization
YD_TH*P_int_TH = p_THH*( (delta_b      *U_H^zeta) *U_H  *Qual_H*(K_HH(-1)) )/alpha;
YD_TF*P_int_TF = p_TFF*( (delta_b      *U_F^zeta) *U_F  *Qual_F*(K_FF(-1)) )/alpha;

//CAPITAL PRODUCING FIRMS

//First order condition: Capital producing firm
Q_H         =   p_THH+ p_THH *etta/2*((I_HH_net+I_HH_SS)/(I_HH_net(-1)+I_HH_SS) -1)^2
+ p_THH*(I_HH_net+I_HH_SS)/(I_HH_net(-1)+I_HH_SS)
* etta*((I_HH_net+I_HH_SS)/(I_HH_net(-1)+I_HH_SS) -1)
- betta*((NMRS_H(+1))* p_THH(+1)*((I_HH_net(+1)+I_HH_SS)/(I_HH_net+I_HH_SS))^2
* etta*((I_HH_net(+1)+I_HH_SS)/(I_HH_net+I_HH_SS) -1);
Q_F         =   p_TFF+ p_TFF *etta/2*((I_FF_net+I_FF_SS)/(I_FF_net(-1)+I_FF_SS) -1)^2
+ p_TFF*(I_FF_net+I_FF_SS)/(I_FF_net(-1)+I_FF_SS)
* etta*((I_FF_net+I_FF_SS)/(I_FF_net(-1)+I_FF_SS) -1)
- betta*((NMRS_F(+1))* p_TFF(+1)*((I_FF_net(+1)+I_FF_SS)/(I_FF_net+I_FF_SS))^2
* etta*((I_FF_net(+1)+I_FF_SS)/(I_FF_net+I_FF_SS) -1);

//CAPITAL

//Evolution of capital
K_HH       =   Qual_H*K_HH(-1) + I_HH_net;
K_FF       =   Qual_F*K_FF(-1) + I_FF_net;

```

```

//Investment
I_HH_net      =  I_HH - (delta_a + delta_b/(1+zeta)*U_H^(1+zeta))*Qual_H*K_HH(-1);
I_FF_net      =  I_FF - (delta_a + delta_b/(1+zeta)*U_F^(1+zeta))*Qual_F*K_FF(-1);
I_HH_SS       =  steady_state(I_HH);
I_FF_SS       =  steady_state(I_FF);

//Nominal return on capital
Rk_nom_H      =  ((P_int_TH * alpha*YD_TH/(Qual_H*(K_HH(-1))))
+ Q_H - (delta_a + delta_b/(1+zeta)*U_H^(1+zeta))*p_THH ) *Qual_H) /Q_H(-1) ;
Rk_nom_F      =  ((P_int_TF * alpha*YD_TF/(Qual_F*(K_FF(-1))))
+ Q_F - (delta_a + delta_b/(1+zeta)*U_F^(1+zeta))*p_TFF ) *Qual_F) /Q_F(-1) ;

//RESOURCE CONSTRAINTS

Y_TH          =  C_THH + C_THF + I_HH
+ etta/2*((I_HH_net+I_HH_SS)/(I_HH_net(-1)+I_HH_SS) -1)^2*(I_HH_net+I_HH_SS)
+ tau_PIA*PIA_H*Q_H*K_HH;
Y_TF          =  C_TFH + C_TFF + I_FF
+ etta/2*((I_FF_net+I_FF_SS)/(I_FF_net(-1)+I_FF_SS) -1)^2*(I_FF_net+I_FF_SS)
+ tau_PIA*PIA_F*Q_F*K_FF;
Y_NH          =  C_NHH ;
Y_NF          =  C_NFF;

//EVOLUTION OF FOREIGN ASSETS

B_H/psi_Bond  =  R_nom(-1)/Infl_MU * B_H(-1) + p_THH*C_THF - p_TFF*C_TFH;
B_H + B_F     =  0;
psi_Bond      =  exp(-psi_B*B_H/(p_H*(C_THH+C_THF+C_NHH))) ;

//CENTRAL BANK RULES

//Taylor rule
//R_nom       =  R_nom_SS*Infl_MU^psi_infl;
R_nom         =  max(1.0025, R_nom_SS*Infl_MU^psi_infl);

//Credit policy
PIA_H         =  vu_PIA * ( (Rk_nom_H(+1) - R_nom) - (Rk_SS - R_nom_SS) );
PIA_F         =  vu_PIA * ( (Rk_nom_F(+1) - R_nom) - (Rk_SS - R_nom_SS) );

```

```

//STOCHASTIC PROCESSES

//Quality of capital
log(Qual_H) = rho_Qual*log(Qual_H(-1)) - e_Qual_H;
log(Qual_F) = rho_Qual*log(Qual_F(-1)) - e_Qual_F;

//Preferences
log(Pref) = rho_Pref*log(Pref(-1)) + e_Pref;

end;

```

```

%-----
% 6. Initial values
%-----

```

```

initval;

C_NHH = 0.7796;
C_THH = 0.3868;
C_THF = 0.2076;
C_NFF = 0.5657;
C_TFF = 0.9518;
C_TFH = 0.3257;
C_TH = 0.6879;
C_TF = 1.1277;
C_H = 1.3327;
C_F = 1.6261;
Y_TH = 0.7629;
Y_TF = 1.6394;
Y_NH = 0.7796;
Y_NF = 0.5657;
Y_H = 1.5426;
Y_F = 2.2051;
Y_MU = 1.8443;
YD_TH = 0.7629;
YD_TF = 1.6394;
YD_NH = 0.7796;
YD_NF = 0.5657;
L_TH = 0.2609;
L_TF = 0.5607;
L_NH = 0.6897;
L_NF = 0.4273;
L_H = 0.9506;
L_F = 0.9881;

```

W_H	=	1.0648;
W_F	=	0.6788;
P_int_TH	=	0.5436;
P_int_NH	=	1.4059;
P_int_TF	=	0.3465;
P_int_NF	=	0.7653;
p_THH	=	0.6247;
p_TFF	=	0.3983;
p_NH	=	2.0828;
p_NF	=	1.0204;
p_TH	=	0.5399;
p_TF	=	0.4512;
p_H	=	1.4971;
p_F	=	0.6679;
Disp_TH	=	1;
Disp_NH	=	1;
Disp_TF	=	1;
Disp_NF	=	1;
Infl_TH	=	1;
RHO_A_TH	=	1.3429;
RHO_B_TH	=	1.5434;
Infl_NH	=	1;
RHO_A_NH	=	3.5492;
RHO_B_NH	=	4.7323;
Infl_TF	=	1;
RHO_A_TF	=	2.7521;
RHO_B_TF	=	3.1628;
Infl_NF	=	1;
RHO_A_NF	=	2.0971;
RHO_B_NF	=	2.7961;
Infl_MU	=	1;
R_nom	=	1.0050;
dU_dC_H	=	1.6642;
dU_dC_F	=	1.1106;
MRS_H	=	1;
MRS_F	=	1;
NMRS_H	=	1;
NMRS_F	=	1;
WInfl_H	=	1;
RHO_WA_H	=	2.5669;
RHO_WB_H	=	2.9500;
WInfl_F	=	1;
RHO_WA_F	=	2.8270;
RHO_WB_F	=	3.2489;
PHI_H	=	3.9922;
RHO_FA_H	=	0.0040;
RHO_FB_H	=	1.6310;

```

PHI_F      =          3.9922;
RHO_FA_F  =          0.0040;
RHO_FB_F  =          1.6310;
Rk_nom_H  =          1.0075;
Rk_nom_F  =          1.0075;
Q_H       =          0.6247;
Q_F       =          0.3983;
N_H       =          1.0541;
N_F       =          1.4441;
U_H       =           1;
U_F       =           1;
K_HH      =          6.7361;
K_FF      =          14.474;
I_HH      =          0.1684;
I_FF      =          0.3618;
I_HH_net  =           0;
I_FF_net  =           0;
I_HH_SS   =          0.1684;
I_FF_SS   =          0.3618;
B_H       =           0;
B_F       =           0;
psi_Bond  =           1;
Qual_H    =           1;
Qual_F    =           1;
Pref      =           1;
PIA_H     =           0;
PIA_F     =           0;
Infl_H    =           1;
Infl_F    =           1;
e_Qual_H  =           0;
e_Qual_F  =           0;
e_Pref    =           0;
tau_PNH   =          0.1;
tau_WNH   =          0.1;
end;

```

```

%-----
% 7. Compute
%-----

```

```

steady(maxit=10000, solve_algo = 2 );
check;

```

%-----
% 8. End Values
%-----

```
endval;  
  
C_NHH      =      0.7796;  
C_THH      =      0.3868;  
C_THF      =      0.2076;  
C_NFF      =      0.5657;  
C_TFF      =      0.9518;  
C_TFH      =      0.3257;  
C_TH       =      0.6879;  
C_TF       =      1.1277;  
C_H        =      1.3327;  
C_F        =      1.6261;  
Y_TH       =      0.7629;  
Y_TF       =      1.6394;  
Y_NH       =      0.7796;  
Y_NF       =      0.5657;  
Y_H        =      1.5426;  
Y_F        =      2.2051;  
Y_MU       =      1.8443;  
YD_TH      =      0.7629;  
YD_TF      =      1.6394;  
YD_NH      =      0.7796;  
YD_NF      =      0.5657;  
L_TH       =      0.2609;  
L_TF       =      0.5607;  
L_NH       =      0.6897;  
L_NF       =      0.4273;  
L_H        =      0.9506;  
L_F        =      0.9881;  
W_H        =      1.0648;  
W_F        =      0.6788;  
P_int_TH   =      0.5436;  
P_int_NH   =      1.4059;  
P_int_TF   =      0.3465;  
P_int_NF   =      0.7653;  
p_THH      =      0.6247;  
p_TFF      =      0.3983;  
p_NH       =      2.0828;  
p_NF       =      1.0204;  
p_TH       =      0.5399;  
p_TF       =      0.4512;  
p_H        =      1.4971;  
p_F        =      0.6679;
```

```

Disp_TH = 1;
Disp_NH = 1;
Disp_TF = 1;
Disp_NF = 1;
Infl_TH = 1;
RHO_A_TH = 1.3429;
RHO_B_TH = 1.5434;
Infl_NH = 1;
RHO_A_NH = 3.5492;
RHO_B_NH = 4.7323;
Infl_TF = 1;
RHO_A_TF = 2.7521;
RHO_B_TF = 3.1628;
Infl_NF = 1;
RHO_A_NF = 2.0971;
RHO_B_NF = 2.7961;
Infl_MU = 1;
R_nom = 1.0050;
dU_dC_H = 1.6642;
dU_dC_F = 1.1106;
MRS_H = 1;
MRS_F = 1;
NMRS_H = 1;
NMRS_F = 1;
WInfl_H = 1;
RHO_WA_H = 2.5669;
RHO_WB_H = 2.9500;
WInfl_F = 1;
RHO_WA_F = 2.8270;
RHO_WB_F = 3.2489;
PHI_H = 3.9922;
RHO_FA_H = 0.0040;
RHO_FB_H = 1.6310;
PHI_F = 3.9922;
RHO_FA_F = 0.0040;
RHO_FB_F = 1.6310;
Rk_nom_H = 1.0075;
Rk_nom_F = 1.0075;
Q_H = 0.6247;
Q_F = 0.3983;
N_H = 1.0541;
N_F = 1.4441;
U_H = 1;
U_F = 1;
K_HH = 6.7361;
K_FF = 14.474;
I_HH = 0.1684;

```

```

I_FF      =          0.3618;
I_HH_net =          0;
I_FF_net =          0;
I_HH_SS  =          0.1684;
I_FF_SS  =          0.3618;
B_H      =          0;
B_F      =          0;
psi_Bond =          1;
Qual_H   =          1;
Qual_F   =          1;
Pref     =          1;
PIA_H    =          0;
PIA_F    =          0;
Infl_H   =          1;
Infl_F   =          1;
e_Qual_H =          0;
e_Qual_F =          0;
e_Pref   =          0;
tau_PNH  =          0.1;
tau_WNH  =          0.1;

```

```
end;
```

```

%-----
% 9. Compute
%-----

```

```

steady(maxit=10000, solve_algo = 2 );
check;

```

```

%-----
% 10. Simulate
%-----

```

```
shocks;
```

```

var e_Qual_H; periods 1;
values 0.05;
var e_Qual_F; periods 1;
values 0.05;
//var e_Pref; periods 1;
//values 0.0025;

```

```
end;
```

```
simul(periods=100, maxit=100);
```