Debt Overhang and Monetary Policy in Czech Republic[*]

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Abstract

We investigate the consequences of excessive international debt overhang as they relate to both debtor and creditor countries. In particular, we assess the impact of monetary policy on financial stability and how it can be used to smooth borrowers, as well as creditors, consumption over the business cycle. Based on [Goodhart, Peiris and Tsomocos, 2018], we establish that an independent countercyclical monetary policy, that contracts liquidity whenever debt grows whereas it expands it when default rises, reduces volatility of consumption. In effect, monetary policy provides an extra degree of freedom to the policymaker. We implement our approach to the Czech and Eurozone area economies during the 1990s.

In our model, we introduce *endogenous* default *ά la* [Shubik and Wilson, 1977], whereby debtors incur a welfare cost in renegotiating their contractual debt obligations that is commensurate to the level of default. However, this cost depends explicitly on the business cycle and it should be countercyclical. Hence, contractionary monetary policy reduces the volume of trade and efficiency, thus increasing default. This occurs as the default cost increases the associated *default accelerator* channel engenders higher default rates. On the other hand, lower interest rates increase trade efficiency and, consequently, reduce the amplitude of the business cycle and benefit financial stability.

In sum, the appropriate design of monetary policy complements financial stability policy. The modelling of *endogenous* default allows us to study the interaction of monetary and macroprudential policy.

Keywords: debt, default, monetary policy, renegotiation, business cycles, open economy
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1. Introduction

This paper considers a counterfactual environment where an independent Czech monetary policy is used to stabilise credit conditions in the Czech Republic. Such policies are shown to perform a similar role to debt-forgiveness policies highlighted in [Goodhart et al., 2016], and have similar results: both lender and borrower consumption paths are stabilised over the business cycle.

The possibility of monetary policy being used as, additionally, a tool for financial stability has been debated since the financial crisis of 2007. The use of unconventional policies and large expansions of central bank balance sheets post-crisis could potentially have been avoided if the credit and financial booms could have been managed. Clearly such a role for monetary policy implies a trade-off for inflation-output stabilisation objectives.[1] We abstract from these, but also limit ourselves by not allowing inflation to play a redistributive role, either through direct wealth effects, or through affecting the real value of debt. In fact, we focus only on the liquidity aspect of monetary policy and the channel through which it affects real trade.

In this paper we examine the interaction between a set of debtors, whom we characterize as Czechs, and a set of creditors, whom we term Europeans. We outline the circumstances that may make the Czech debtors choose to renege, to default, on their unsecured debt, dependent on the various costs which such default entails. The costs and benefits of default are quite complex, and we have modelled these carefully. In our model, creditors (Europeans) can be more or less tough, (forgiving being the inverse of tough), in imposing penalties on the defaulting Czechs. We model this as a 'recovery' rate, whereby the European creditors can grab, and use for themselves (i.e. recover), a larger share (a higher recovery rate), of the underlying defaulted assets.

Most of the debate on the costs/benefits of default and renegotiation have primarily focused on the effects and trade-offs for the debtors', while the effects on creditors have largely been ignored, or assumed to be negative.[2]. The language of the discussion has been couched within the framework of a "zero-sum" game, and in other words the assumption that any debt relief to debtors must entail a (net present value) transfer of resources from creditors.

We show that, if policies of debt renegotiation or forgiveness such as those discussed in [Goodhart et al., 2016] are not available, then an independent monetary policy that varies appropriately over the business cycle can achieve similar results. Specifically, the volatility of both debtors and creditors consumption will fall.

From the early 1990s, the transition of the Czech economy from a planned to a market one resulted in significant foreign direct investment. The largest part of this investment was contributed to the banking and financial sectors, with up to 97% of banking assets being owned by foreign investors.[3] At the same time, the Czech National Bank statistics indicate that one fourth of total liabilities are owed to non-residents, which accounts nearly 95% of GDP [4], a number increasing rapidly in recent years. While the Czech Republic ran a positive net export of 4.6% of

[1] For an extensive discussion on these issues see [Borio, 2014], [*Monetary Policy and Financial Stability*, 2015], [Adrian and Liang, 2016], [Smets, 2014], [Woodford, 2012] among others.
[2] [Zettelmeyer et al., 2013], [Ardagna and Gaselli, 2014] and [Broner et al., 2014] for analysis of Greek restructuring episodes since 2010.
[3] See [Weill, 2003].
[4] Average number for 2013-2017.

GDP for 2006-2015, it ran a negative overall current account of -1.5% of GDP for the same period.[5] These large gross external liabilities indicate the fragility of the Czech economy, and its susceptibility to changes in the external funding environment even if Czech banks satisfy the capital requirement buffer of 10.5% with excess[6], a small negative shock could trigger a huge economic downturn with currency crisis and default crisis, which are positively correlated.

In our model we assume that the Czech capital stock, in addition to internal financing, is externally financed by inflation-indexed unsecured debt. Failure to honour the debt would invoke bankruptcy proceedings in which case the lender has a limited claim on the existing wealth of the borrower and cannot invoke bankruptcy proceedings. Thus a key feature of the paper is that the possibility of default in equilibrium exists on unsecured debt. We assume that Czech households can only issue inflation-indexed non-state-contingent bonds. Debtors may choose to renege on some of their debt obligations, but then suffer a renegotiation cost. In order to be able to borrow again, they must pay this cost and, in this sense, the decision to default is strategic. In our model, the possibility of default is micro-founded on the moral hazard relationship problem between debtors and creditors. If debtors default, they incur a welfare cost in renegotiations proportional to the scale of default. This cost effectively creates a borrowing constraint and stems from [Shubik and Wilson, 1977] and [Dubey et al., 2005] and applied in [Tsomocos, 2003], [Goodhart et al., 2005] and [Goodhart et al., 2006]. In the RBC literature, our model shares similar features to [De Walque et al., 2010]. Our closest methodological precursors are [Peiris and Tsomocos, 2015] (which studies a two period large open international economy with incomplete markets and default); [Goodhart et al., 2013], which explores the effect of international capital flow taxation on default and welfare in a deterministic two period large open economy; and [Walsh, 2015a] and [Walsh, 2015b], which consider default in a small open dynamic incomplete markets economy. In these latter two papers, the marginal cost of default depends on the level of wealth, so the propensity to default depends on business cycle fluctuations. We follow this notion here by introducing a macrovariable that governs the marginal cost of renegotiating debt (default), termed 'credit conditions'. We argue that credit-conditions can be adequately captured by an appropriate state variable in order to describe the relationship between loan delinquencies and capital stock. We hasten to add that the debtor country takes the credit-conditions variable as given since creditors are capable of imposing institutional arrangements that are non-negotiable.[7] Our economy displays the minimum features necessary to highlight the role that an aggregate credit-conditions variable plays in amplifying and propagating financial shocks. There is a representative Czech household which owns and operates a means of production and a large external lender, described as European Union households. Default generates an effective return differential between borrowers and lenders. Lenders receive repayment net of default. On the other hand, borrowers repay their obligations net of default but also incur the private cost of defaulting, the sum of which amounts to the gross of default interest rate. As borrowers require financing for investment in capital, the higher cost of debt caused by default results in a higher required rate of return on capital and hence a lower long-run capital stock. European Union creditors in our model can seize a proportion of defaulted debt. Thus, borrowers effectively incur two additive costs of

[5] Eurostat data.
[6] Basel III. Minimum buffer for Total Capital (8%) plus Conservation buffer (2.5%).
[7] Indeed, that was exactly the misconception that contributed to the unsatisfactory attempt to renegotiate the terms of the agreement during the summer of 2015.

defaulting: the non-pecuniary cost of renegotiation and a pecuniary punishment via having wealth confiscated. The pecuniary punishment for default is similar to the cost incurred by borrowers who obtain debt against durable collateral.[8] The difference in our specification is two-fold. Firstly, there is a general claim on wealth rather than on a specific asset. Secondly, that the seizure of wealth does not occur due to the change in some relative price, as in the literature on collateral, but because of the inability of the borrower to honour a debt obligation.

1. The Model

The economy consists of 2 countries, Czech Republic (the borrower) and the European Union (the lender), each inhabited by a continuum of identical infinitely lived agents. European households receive income from a portfolio of Czech and non-Czech assets. We simplify the nature of income generated from non-Czech assets, so European household decisions we model should be viewed as the marginal decisions affected by interactions with Czech financial assets, with income and expenditure decisions from non-Czech financial and economic interactions taken as given. As we assume a single homogenous good in the world economy, all trade balance effects are subsumed in the capital account. There is one fundamental source of uncertainty in our economy: shocks to Czech Total Factor Productivity (A). Fluctuations in TFP also determine various policy rules we consider for the recovery rate on outstanding debt: the recovery rate (κ). We study the impact of TFP shocks only, because we believe that after the initial crisis episode in 2009, the economy continued to maintain the same fundamental characteristics. In particular, we believe the economy was subject to regular TFP shocks. Certainly it experienced many other shocks including to the political environment (domestic and foreign, such as the refugee crisis) and the global economic environment. We believe that studying them and their implications for creditor debt policies would be additional to studying the more fundamental TFP shocks the country experienced. Finally, any shocks that reduce the capital stock and/or national income directly that do not depend on the business cycle can be summarised within the TFP shock we model.

1.1. The European Union

European households are assumed to have an outside source of income which does not depend on the loan portfolio extended to Czech Republic, and reflects their total net foreign assets (NFA). In addition, they purchase one-period inflation-indexed unsecured bonds issued by Czechs. Unsecured bonds are risky and there is an expected repayment rate associated with each bond.

Preferences include a CRRA utility function for consumption

[8] See [Geanakopolos and Zame, 2014] for an excellent overview of this literature where default occurs in equilibrium

$$\max \sum_{s=0}^{\infty} \beta^s E_t \left\{ \frac{\left[c_{t+s}^{EU} \right]^{1-\sigma} - 1}{1-\sigma} \right\}. \tag{1}$$

Each period European Union households earn income, from their (ex Czech Republic) net foreign assets and net Czech assets, and allocate it between consumption (c_t^{EU}) and new assets. Specifically [9],

$$\begin{aligned} c_t^{EU} + b_{u,t}^{EU} + \frac{adj_u^{EU}}{2}\left(b_{u,t}^{EU} - b_u^{EU}\right)^2 + NFA_t^{EU} \\ = \left(R_{t-1}^u\right)\left(1 - def_t^{CZ}\right) b_{u,t-1}^{EU} + \kappa_t \left(R_{t-1}^u\right)\left(def_t^{CZ}\right) b_{u,t-1}^{EU} + NFA_{t-1}^{EU}\left(R_t^{NFA}\right). \end{aligned} \tag{2}$$

The ex-Czech Net Foreign Asset position of European households is calibrated and assumed to evolve exogenously (a constant). The return on the NFA portfolio is also assumed to be exogenous and constant.[10] Recall that κ is the recovery rate on unsecured debt defaulted upon. It is exogenous to the model, but is interpreted as the outcome of a negotiation between creditors and debtors.

The maximisation programme yields

$$\psi_t^{EU} = \left[c_t^{EU} \right]^{-\sigma}. \tag{3}$$

$$\begin{aligned} \psi_t^{EU} \left\{ 1 + adj_u^{EU} \left(b_{u,t}^{EU} - b_u^{EU} \right) \right\} \\ = \beta^{EU} E_t \left\{ \psi_t^{EU} REP_{t+1} R_t^u \right\} \end{aligned} \tag{4}$$

where ψ_t^{EU} is the marginal utility of consumption of European households and

$REP_{t+1} = 1 - \left(1 - \kappa_{t+1}\right)\left(def_{t+1}^{CZ}\right)$ is the net delivery rate including the announced rate of default and the recovery rate. Note that European households care about the rate of return net-of-default and recovery. In the steady state, the net-of-default rate of return on loans is simply the rate of time preference.

Note that in the deterministic steady state $\frac{1}{\beta^{GER}} = \overline{REP}\,\overline{R}^u$.

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[9] This quadratic adjustment term (adj_s^{EU}) is used to guarantee that secured debt holdings converge back to steady state values.

[10] One may think of this as the fruit of a non-stochastic Lucas tree. It is taken as a constant in order to isolate the marginal effect on European consumption of their Czech portfolio, independent of unrelated fluctuations in total European income. More importantly, we do not allow European lenders to have alternative opportunities to invest savings. However, the supply of loans is not elastic as Europeans still have a legitimate consumption-savings decision, but the trade-off itself is limited to investments in Czech Republic. Nevertheless, alternative investment opportunities would provide a richer framework to study the supply of loans to Czech Republic.

2.2 Czech Republic

The Czech economy is represented by Czech households who wholly own firms in a competitive industry that identically has access to a production technology which uses capital (cap_t^{CZ}) and labour (lab_t^{CZ}) as inputs. The production function is Cobb-Douglas and has constant returns to scale, with an income share of α and $1-\alpha$ to capital and labour, respectively

$$F\left(cap_{t-1}^{CZ}, lab_t^{CZ}\right) = A_t\left(cap_{t-1}^{CZ}\right)^{\alpha}\left(lab_t^{CZ}\right)^{1-\alpha}. \tag{5}$$

Capital depreciates at a rate of δ % each period and labour is paid a competitive wage w_t^N. $A_t = Ae^{\varepsilon_t^A}$ is the total factor productivity and $\varepsilon_t^A = \rho\varepsilon_{t-1}^A + u_t^A$ is an autoregressive process with shock u_t^A. As there is a representative firm, National Production or GDP, is defined as $Y_t = F\left(cap_{t-1}^{CZ}, lab_t^{CZ}\right)$. Profits of Czech firms are

$$p_t\pi_t^{CZ} = p_tF\left(cap_{t-1}^{CZ}, lab_t^{CZ}\right) + p_t\left(1-\delta\right)cap_{t-1}^{CZ} - w_t^N lab_t^{CZ} - R_t^k cap_{t-1}^{CZ}. \tag{6}$$

Firms maximise profits each period which results in factor prices being determined at their marginal product values

$$p_tw_t^N = p_t\frac{\partial F\left(cap_{t-1}^{CZ}, lab_t^{CZ}\right)}{\partial lab_t^{CZ}}, \tag{7}$$

$$p_tR_t^k = p_t\frac{\partial F\left(cap_{t-1}^{CZ}, lab_t^{CZ}\right)}{\partial cap_{t-1}^{CZ}} + p_t\left(1-\delta\right). \tag{8}$$

Czech households access the international debt market and issue unsecured (b_u^{CZ}) claims at competitive interest rate (R^u are the gross rates) in order to finance consumption and investment decisions. Crucially, they decide how much of their debt obligation to repay.

If they do not honour their unsecured debt completely, they incur a non-pecuniary punishment, or utility cost, proportional to the amount they default upon, which reflects the costs involved in renegotiating the outstanding amount. Furthermore, lenders are able to seize a fraction (κ) of the outstanding debt from the new capital stock. We will conduct our normative policy analysis on four different descriptions of the path of the recovery rate, κ.

There is a liquidity requirement for Czech households which specifies that purchases of consumption and capital goods must be financed by domestic currency. In addition, net trades in the bond market (repayment of existing debt less new debt borrowed) must also be backed by cash. Cash is obtained from borrowing from the domestic money market (intraperiod loan market) at nominal interest rate i. All debt is indexed and so net trades are unaffected by domestic price level fluctuations.

The budget constraint of the Czech household requires the allocation of income from profits and labour plus new borrowings to consumption, investment, and repayment of existing debt. The cash-in-advance requirement results in several effective transaction moments.

Households first obtain money from the money market, promising to repay b_t^{CZ} at the end of the period. At the same time, households receive a nominal, but indexed, transfer from the domestic monetary-fiscal authority of $p_t \tau_t$.[11]

$$m_t^{CZ} = \frac{b_t^{CZ}}{1+i_t} + p_t \tau_t . \tag{9}$$

$$m_t^{CZ} \geq 0 . \tag{10}$$

$$\begin{aligned} p_t c_t^{CZ} + p_t cap_t^{CZ} + \left(R_{t-1}^u\right)\left(1 - def_t^{CZ}\right) p_t b_{u,t-1}^{CZ} \\ = p_t b_{u,t-1}^{CZ} - \kappa_t \left(R_{t-1}^u\right)\left(def_t^{CZ}\right) p_t b_{u,t-1}^{CZ} + m_t^{CZ} . \end{aligned} \tag{11}$$

$$b_t^{CZ} = p_t \pi_t^{CZ} + p_t R_t^k cap_{t-1}^{CZ} + p_t w_t^N lab_t^{CZ} . \tag{12}$$

The budget constraints can be combined, and the price level factored out, to obtain

$$\begin{aligned} c_t^{CZ} + cap_t^{CZ} + \left(R_{t-1}^u\right)\left(1 - def_t^{CZ}\right) b_{u,t-1}^{CZ} \\ = b_{u,t-1}^{CZ} - \kappa_t \left(R_{t-1}^u\right)\left(def_t^{CZ}\right) b_{u,t-1}^{CZ} + \frac{\pi_t^{CZ} + R_t^k cap_{t-1}^{CZ} + w_t^N lab_t^{CZ}}{1+i_t} + \tau_t , \end{aligned} \tag{13}$$

where c_t^{CZ} is consumption, unsecured and secured debt issued is b_u^{CZ} and b_s^{CZ}, respectively, at a gross interest rate of (R^u) and (R^s), respectively, and the proportion of unsecured outstanding debt repaid is ($1 - def^{CZ}$). $\kappa_t \left(R_{t-1}^u\right)\left(def_t^{CZ}\right) b_{u,t-1}^{CZ}$ is the amount lenders seize from the new capital stock, and $\frac{adj_u^{CZ}}{2}\left(b_{u,t}^{CZ} - b_u^{CZ}\right)^2$ is the cost of adjusting unsecured debt away from steady state levels and can be interpreted as the cost of renegotiating a different level of unsecured debt. We allow the capital stock to be substitutable with income, and as a consequence there is no non-negativity constraint on re-investment. The preferences include a CRRA utility function for consumption and disutilities from supplying labour and from renegotiating defaulted upon debt,

$$U_t^{CZ} = \frac{\left(c_t^{CZ}\right)^{1-\sigma} - 1}{1-\sigma} - \frac{\eta}{2}\left(lab_t^{CZ}\right)^2 - \frac{1}{2}\left\{def_t^{CZ}\left(R_{t-1}^u\right) b_{u,t-1}^{CZ}\right\}^2 \Omega_t^{CZ} . \tag{14}$$

[11] This is a Ricardian Fiscal policy and leaves the price level each period indeterminate. Importantly however, fluctuations in inflation have no wealth effects and the non-neutrality of monetary policy is derived solely from the cost of liquidity that money provides.

and permits the usual recursive representation. The recursive representation of preferences is

$$W_t^{CZ} = U_t^{CZ} + \sum_{s=1}^{\infty} \beta^s E_t W_{t+s}^{CZ} . \tag{15}$$

The decision variables are c_t^{CZ} , lab_t^{CZ} , $b_{u,t}^{CZ}$, $b_{s,t}^{CZ}$, def_t , cap_t. The renegotiation cost enforced on firms that choose to default on def_t^{CZ} % of their unsecured debt is

$$\frac{1}{2}\left\{\zeta + def_{t+s}^{CZ}\left(R_{t+s-1}^{u}\right)b_{u,t+s-1}^{CZ}\right\}^2 \Omega_{t+s}^{CZ} , \tag{16}$$

where Ω_t^{CZ} is a pro-cyclical macro-variable which governs the severity of the punishment enforced and $\zeta \to 0$ is an infinitesimally small positive number.[12] Ω_t^{CZ} is given by

$$\Omega_t^{CZ} \equiv \phi^{CZ} \left\{ \frac{\left(1-\bar{\kappa}\right)\overline{\psi}^{CZ}\left(1-\overline{def}^{CZ}\right)\left(\overline{def}^{CZ}\right)^{\gamma-1}}{\overline{CAP}^{CZ}} \right\} \frac{CAP_{t-1}^{CZ}}{B_{u,t-1}^{CZ}\left(1+r_{t-1}^{u}\right)\left(def_t^{CZ}\right)^{\gamma}} . \tag{17}$$

Ω_t^{CZ} is the shadow cost of renegotiation, or the stochastic discount factor for the cost of renegotiating debt in arrears. $\overline{\psi}^{CZ}$ is the steady state shadow value of consumption for the Czech household. ϕ^{CZ} is what we call the *default wedge* and determines the steady state rate of default. γ is the default accelerator as it governs the amplification of default through the credit condition variable. For $\gamma < 1$, a negative shock to income raises the shadow value of income ψ_t^{CZ} , which then increases the individual propensity to default def_t^{CZ} , which then is reflected in the aggregate interest rate , and so in turn again increases the individual propensity to default. As a consequence, γ allows us to calibrate the volatility of default rates independently of the equilibrium average default rate, which is determined by ϕ^{CZ} . The aggregate default rate also appears in the denominator as it allows us to consider the marginal effect of the decision of an individual firm on the aggregate cost of default to the whole economy. The inverse of the leverage ratio in the previous period also enters as the ratio of the aggregate capital stock to the aggregate debt due. As a consequence, Ω_t^{CZ} turns out to be procyclical, i.e. with a high cost (high value) in good times and a low cost (low value) in depressions. To see this, note that when the capital stock is growing, the leverage ratio is high, with the capital to debt ratio becoming low, and the shadow

[12] This parameter allows two steady-state equilibria to be supported; one where there is no default and one where default occurs in equilibrium. For the remainder of this section we consider the limit of $\zeta = 0$

cost of default to the borrower Ω_t^{CZ} is low. When the shadow cost of default is low, the firms default rate is likely to be higher (all else being equal).[13]

Ω_t^{CZ} dynamically governs the cost of default. In [Dubey et al., 2005] this is a constant, but the marginal cost of default is only proportional to this and hence constant. Here, even if Ω_t^{CZ} was constant, the marginal cost of default, here renegotiation, is proportional to the quantity in arrears. This alone would allow us to obtain a stationary solution. In contrast, [Walsh, 2015a] and [Walsh, 2015b] have Ω_t^{CZ} as a function of household wealth. As this is dynamic, so is Ω_t^{CZ}. However, there, this is necessary in order to obtain a stationary solution as the marginal cost of default is still linear in Ω_t^{CZ}. This is not so in our case. We obtain stationarity by having the marginal cost proportional to the quantity of default, however this alone would mean that the propensity to default *decreases* as the quantity of debt outstanding increases. The specification we have chosen for Ω_t^{CZ} negates this, as it falls when default rates and the stock of debt grows, hence increasing the propensity to default when the stock of debt grows, addressing the empirical findings in the literature.[14]

The optimisation yields the following first order conditions, with ψ_t^{CZ} defined as the shadow value of income:

$$\eta lab_t^{CZ} = \psi_t^{CZ} \frac{w_t}{1+i_t}, \tag{18}$$

$$\psi_t^{CZ} = E_t \beta \left\{ \psi_{t+1}^{CZ} \frac{R_{t+1}^k}{1+i_{t+1}} \right\}, \tag{19}$$

$$\frac{\psi_t^{CZ}}{R_t^u} = E_t \beta \left\{ \left(1-\left(1-\kappa_{t+1}\right) def_{t+1}^{CZ}\right) \psi_{t+1}^{CZ} + \left(def_{t+1}^{CZ}\right)^2 \left(R_t^u\right) b_{u,t}^{CZ} \Omega_{t+1}^{CZ} \right\}, \tag{20}$$

$$\psi_t^{CZ} b_{u,t-1}^{CZ} \left(R_{t-1}^u\right) = def_t^{CZ} \left(R_{t-1}^u\right)^2 \left(b_{u,t-1}^{CZ}\right)^2 \Omega_t^{CZ} + \kappa_t \left(R_{t-1}^u\right) b_{u,t-1}^{CZ} \psi_t^{CZ}, \tag{21}$$

Equation 18 is the first order condition with respect to labour supplied, while 19 is the first order condition with respect to capital and states that the shadow value of capital equals the marginal effect of capital on profits plus the increase in future capital stock. 20 is the FOC with respect to unsecured debt and states that the marginal benefit of debt in increasing the shadow value of capital is equated to the marginal cost of reducing profits by the repayment rate and the renegotiation cost of increasing the quantity of debt subject to default. Equation 21 is the FOC with respect to the repayment rate on loans and equalises the marginal cost on profits of repaying

[13] In richer models, where there are heterogeneous productive sectors, default in one sector will cause default in others: the chain reaction of default can exacerbate the financial difficulties of a relatively small sector of the economy into an economy-wide contagion. Our macroeconomic variable, Ω captures this notion that industries are linked and default is amplified as it spreads. An analogy is that if one room of a house floods, the entire house is likely to be flooded.

[14] As in [Benjamin and Wright, 2013]

an additional percent of debt to the marginal benefit of reducing the renegotiation cost of defaulting.

Equations 20 and 21 can be combined to give

$$\psi_t^{CZ} = R_t^u E_t \beta \left\{ \psi_{t+1}^{CZ} \right\}, \tag{22}$$

$$E_t \beta \left\{ \psi_{t+1}^{CZ} \frac{R_{t+1}^k}{1+i_{t+1}} \right\} =, \tag{23}$$

2. Monetary Fiscal Authority

The counterfactual Czech monetary fiscal authority sets a period-by-period short-term interest rate i_t, exchanges money for bonds and runs a period-by-period non-Ricardian seigniorage policy (fiscal policy). Formally, they select *a priori* the nominal value of seigniorage transferred to households each period at $T_t = \tau_t$. The flow budget constraints are

$$M_t^{CZ} = \frac{B_t}{1+i_t} + p_t T_t, \tag{24}$$

$$B_t = M_t^{CZ}. \tag{25}$$

As a consequence

$$M_t^{CZ} \frac{i_t}{1+i_t} = p_t T_t. \tag{26}$$

3. Market Clearing

$$Y_t^{CZ} = c_t^{CZ} + cap_t^{CZ} + \left(1 - def_t^{CZ}\right)\left(R_{t-1}^u\right) b_{u,t-1}^{CZ} + \kappa_t def_t^{CZ} \left(R_{t-1}^u\right) b_{u,t-1}^{CZ} - b_{u,t}^{CZ} \tag{27}$$

$$b_{u,t}^{CZ} = b_{u,t}^{GER} \tag{28}$$

4. Monetary Policy Rule

In our simulations, we consider nominal Czech interest rate governed by Taylor rule, where the Monetary Authority pays attention to interest rate and output gap:

$$\frac{1+i_t}{1+i_{ss}} = \left(\frac{1+i_{t-1}}{1+i_{ss}}\right)^{r_I} \left(\frac{y_t}{y_{ss}}\right)^{r_Y}. \qquad (26)$$

In our analysis we contrast this policy rule with a static regime where $i_t = i_{ss}$. Moreover, in order to compare quantitive aspects, we consider two different regimes of Taylor rule: low sensitive to output gap and high sensitive one.

5. Calibration

Our calibration follows closely that of [Goodhart et al., 2016]. The unsecured rate 1.17% annum, which implies about 0.30% per quarter. This compares with the average Czech 10 year bond yield from January 2013 to December 2017.[15] The recovery rate on Czech debt securities was taken from [Altman et al., 1999] who estimated that the recovery rate on securities with AA rating is 0.60 (Average Price) and 0.76 (Weighted Average Price) - we have taken the weighted average point of 0.76. The default rates was defined as the share of non-performing loans from total loans and was taken from the Czech National Bank, which gave the mean and standard deviation as 5.52% and 0.74% annum, respectively. Since we consider a quarterly simulation, the mean and standard deviation default rates is 1.3% and 0.7364% per quarter in the acyclical case while for unsecured debt repayment rates, the mean and standard deviations in our economy are 99.7% and 0.1767% per quarter in the acyclical regime, given the repayment rate includes a recovery rate of 76%. The present value of the debt forgiven is around 17.5%, using the model unsecured interest rate. These were set by choosing the default wedge, ϕ, to be 1/.987 and the default accelerator, γ, to be .93 to obtain higher volatility in default decisions and obtain counter-cyclical effects of default. The standard deviation of the shock (u_A) is 1%, and the coefficient of relative risk aversion, σ, is 2, following [Aliyev et al., 2014]. In the same paper, the private depreciation rate of capital was 1.00% per quater. It implies around 4% annum. [Aliyev et al., 2014] have a labour share of income of .50, so we choose α to be .50. The labour supply is set to .3544.

[15] Taken from St Louis FRED database “Long-Term Government Bond Yields: 10-year: Main (Including Benchmark)”.

The Europeans in our numerical excise are defined as countries with the largest cumulative FDI inflows into Czech Republic in 1993-2014. They are Netherlands (23.9%), Austria (13.2%), Germany (12.6%) and France (6.1%).[16] World Bank figures for the Net Foreign Asset (NFA) positions of Netherlands, Austria, Germany, and France and Czech unsecured liabilities (liabilities to Non-residents) give a ratio of Ex-Czech European NFA-to-Liabilities to Non-residents almost 106 in 2013 and 32 in 2017, which we use to obtain the ex-Czech NFA for Europeans of 40 times .

Table 1 lists values and sources.

Parameter	Description	Value	Source	Reference
u_A	Standard Deviation of TFP Shock	1%	1.44%	[Herber and Nemec, 2009]
ρ_A	Persistence of TFP shock	0.81	0.81	[Aliyev et al., 2014]
σ	Coefficient of relative risk aversion	2	2	[Aliyev et al., 2014]
δ	Depreciation rate	1%	1%	[Aliyev et al., 2014]
α	Share of Capital Income in Czech Republic	0.5	0.5	[Aliyev et al., 2014]
lab	Steady-state labour supply	0.353	0.353	
b_u / Y^{CZ}	Liabilities to Non-residents-to-GDP	100%	95%	Czech National Bank, average for 2013-2017
NFA/b_u	Ex-Czech European NFA-to-Liabilities to Non-residents	40	32 to 106 (2013 and 2017)	World Bank
$E\left(R_t^u - 1\right)$	Mean Annual Unsecured interest rate	0.51%	0.3%	St.Louis/FRED
$E\left(def\right)$	Mean default rates	1.30%	5.56% (annum)	Czech National Bank
$StD\left(def\right)$	StDev of default rates	0.7364%	0.74% (annum)	Czech National Bank
κ	Recovery rate on unsecured debt	0.76	0.76	[Altman et al., 1999]

Table 1: List of Calibrated Values

[16] source: czechinvest "Investment Climate in the Czech Republic" 2017 report and CNB.

Table 2 below shows the parameterisation of the economy.

Parameter	Description	Value
β^{EU}	European rate of time preference, quarterly	0.998
β^{CZ}	Czech rate of time preference, quarterly	0.995
ϕ^{CZ}	default wedge	0.987
γ	default accelerator	0.93
A_t	total factor productivity	1.005
η	household preference for labour	1.8056
r_I	sensitivity to interest rate	0.3
r_Y	sensitivity to output gap, low (high)	0.15(0.40)

Table 2: List of Parameters

6. Business Cycle Properties

In this section[17], we simulate the 2nd order approximate version of the economy and study the business cycle properties of our economy. We then examine the impulse responses of our policy regimes.

6.1. *Simulated Economy*

Table 3 shows the moments of key variables in our economy. The mean values change little across the policy regimes. However the standard deviation of all the variables is changed with the Taylor rule under consideration. That the standard deviation of unsecured rates rise is simply because of the additional volatility induced by nominal interest rates on the real interest rate.

All variables become less correlated with Czech production, apart from European consumption. This is because their income depends on the correlation of the repayment rate with Czech output, which falls.

[17] Numerical calculations were performed in Dynare. We consider deviations from the level.

	Mean			Standard Deviation		
	Acyc	Monetary with low sensitivity	Monetary with high sensitivity	Acyc	Monetary with low sensitivity	Monetary with high sensitivity
$R^u - 1$	0.005133	0.005136	0.005152	0.000987	0.002077	0.005019
REP	0.996469	0.996831	0.996391	0.001767	0.000667	0.001982
$R^k - 1$	0.055391	0.055400	0.055381	0.001336	0.001543	0.002081
cap^{CZ}	20.868255	20.871841	20.887235	0.446250	0.199295	0.525724
$wage^{CZ}$	3.863871	3.863113	3.865176	0.078799	0.047342	0.049944
lab^{CZ}	0.353103	0.353267	0.353066	0.003038	0.002499	0.003395
Y^{CZ}	2.729003	2.729610	2.729279	0.073283	0.050319	0.040854
c^{EU}	3.279128	3.280131	3.279005	0.005004	0.005525	0.012625
c^{CZ}	2.402310	2.401582	2.403021	0.019340	0.007491	0.021077
b_u	2.724825	2.728486	2.724160	0.016205	0.015176	0.030778
	Correlation with Production			**First Order Auto-correlation**		
	Acyc	Monetary with low sensitivity	Monetary with high sensitivity	Acyc	Monetary with low sensitivity	Monetary with high sensitivity
$R^u - 1$	0.4955	-0.9754	-0.9554	0.7934	0.7735	0.6466
REP	0.6732	-0.1042	-0.1727	0.9940	0.9532	0.9614
$R^k - 1$	0.6212	0.9256	0.6333	0.7800	0.8687	0.9326
cap^{CZ}	0.7397	-0.4983	-0.4244	0.9940	0.9858	0.9718
$wage^{CZ}$	0.9703	0.9735	0.7712	0.9345	0.7446	0.6845
lab^{CZ}	0.8195	0.9183	0.5198	0.7871	0.8621	0.9548
Y^{CZ}	1.0000	1.0000	1.0000	0.8842	0.7725	0.6539
c^{EU}	0.6037	-0.3077	-0.1355	0.9493	0.8705	0.8049
c^{CZ}	0.7913	0.2954	-0.1383	0.9902	0.8493	0.9571
b_u	0.7852	-0.6906	-0.5769	0.9862	0.9609	0.9302

Table 3: Business Cycle Properties of Simulated Economy

6.2. *Welfare Analysis*

Our conditional welfare analysis shows that welfare improves for both European and Czech households when the monetary-fiscal authority employs the active monetary policy regime. Below we report the percentage deviation from steady state values following a negative TFP shock under the acyclical monetary policy regime and the active ones with low and high sensitivity to output gap. The higher value corresponds to a higher value of undertaking the policy action. Both active policies improve welfare of Europeans and Czechs, while the active monetary policy with higher sensitivity to the output gap has the highest welfare properties due to its better smoothing of the business cycle.

	Acyc	Monetary with low sensitivity	Monetary with high sensitivity
$E_0\left(W^{CZ}\right)$	-0.0231	0.0116	0.0264
$E_0\left(W^{EU}\right)$	-0.76e-3	0.41e-3	0.59e-3

Table 4: Welfare Properties of Simulated Economy

6.3. *Impulse Responses*

[Goodhart et al., 2016] has shown that the possibility of debt forgiveness can help to manage business cycles. As shown there, more “lenient” debt forgiveness by creditor can decrease the business cycle fluctuations for lenders as well as for borrowers. The role of this subsection is to demonstrate how independent monetary policy can decrease fluctuations of key variables. Figures 1 to 3 give the impulse responses following a negative TFP shock under passive (black line) and active monetary policy regimes (red starred and blue dashed lines). When it occurs, the reduction in income (before an adjustment in labour supply) increases the marginal cost of honouring debt and default rates rise for all regimes. As default rates rise the credit conditions variable worsens and through the *default accelerator* we see an immediate large increase in default rates. There is also a contraction in investment (seen in lower capital stock, debt and higher European consumption or less European saving), which through the worsening expected credit conditions and default accelerator, raises future default rates. The higher default premium then raises the cost of debt, and the required return on capital, causing a further cycle of capital stock contraction. The immediate reduction in income from lower TFP reduces wages, increasing labour supply and ultimately offsetting lower TFP to increase output. The higher cost of issuing debt results in a deleveraging in the Czech economy and investment is increasingly financed through domestic savings resulting in a decline in Czech consumption.

Both active monetary policies are qualitatively the same but have different quantitive results. While negative TFP shock causes an increase in default rates, a future active stimulating policy decreases expectations of future defaults. Active monetary policy stimulates investment through higher volumes of unsecured loans, which with higher repayment rates increases consumption of Europeans. Consumption of Czechs increases as a result of decrease in liquidity costs which encourages trade.

The cyclical monetary policy regime (red starred series) has much larger fluctuations than the static monetary policy driven by the larger immediate decline in Czech consumption as a result of higher investment in capital. The repayment rate is slightly lower under the active policy regime, but rises rapidly. This translates into a faster adjustment in the capital stock to the steady state, as well as wages and consumption. By comparing active monetary policy with lower sensitivity with others, it is clear to see that an appropriate monetary regime can help faster converge to steady state by minimising business cycle fluctuations.

7. Concluding Remarks

Debt forgiveness for Greece which we studied in [Goodhart et al., 2018] was predicated on the possibility of fostering mutual dependence based on existing political ties within the monetary union. For countries outside the union, such possibilities are remote and domestic policies need to be invoked to manage the build-up of systemic risks.

In this paper, we focused on monetary policy, and specifically the liquidity role of monetary policy. Higher interest rates increase the liquidity cost of transactions, reducing trade while lower interest rates increase the efficiency, and, consequently, the quantity of trade. In this manner, and abstracting from important considerations of inflation, monetary policy may stabilise the business cycle and enhance financial stability.

8. References

1. Adrian, Tobias and Nellie Liang (2016), ‘Monetary policy, financial conditions, and financial stability’, Federal Reserve Bank of New York Staff Reports
2. Aliyev, I., B. Bobkova and Z. Stork (2014), ‘Extended DSGE model of the Czech economy’, Working paper. Ministry of Finance of the Czech Republic.
3. Altman, E., D. Cooke and V. Kishore (1999), ‘Defaults and returns on high yield bonds: Analysis through 1998 and default outlook for 1999-2001’, NYU Working Paper.
4. Ardagna, Silvia and Francesco Caselli (2014), ‘The political economy of the greek debt crisis: A tale of two bailouts’, American Economic Journal: Macroeconomics 6(4), 291–323.
5. Benjamin, D. and J. Wright, M. (2013), ‘Recovery before redemption: A theory of delays in sovereign debt renegotiations’.
6. Borio, Claudio (2014), ‘Monetary policy and financial stability: what role in prevention and recovery?’, BIS Working Papers 440.
7. Broner, Fernando, Aitor Erce, Alberto Martin and Jaume Ventura (2014), ‘Sovereign debt markets in turbulent times: Creditor discrimination and crowding-out effects’, Journal of Monetary Economics 61, 114 – 142.
8. De Walque, Gregory, Olivier Pierrard and Abdelaziz Rouabah (2010), ‘Financial (in)stability, supervision and liquidity injections: A dynamic general equilibrium approach’, The Economic Journal 120(549), 1234–1261.
9. Dubey, P., J. D. Geanakoplos and M. Shubik (2005), ‘Default and punishment in general equilibrium’, Econometrica 73.
10. Geanakoplos, J. D. and W. Zame (2014), ‘Collateral equilibrium, i: a basic framework’, Economic Theory 56, 443–492.
11. Goodhart, C. A. E., M. U. Peiris and D. P. Tsomocos (2013), ‘Global imbalances and taxing capital flows’, International Journal of Central Banking. June.
12. Goodhart, C. A. E., P. Sunirand and D.P. Tsomocos (2006), ‘A model to analyse financial fragility’, Economic Theory 27, 107–142.
13. Goodhart, C.A.E., Dimitrios P. Tsomocos and M. U. Peiris (2016), ‘Debt, recovery rates and the Greek dilemma’, Saïd Business School WP 15.
14. Goodhart, C.A.E., M.U. Peiris and D.P. Tsomocos (2018), ‘Debt, recovery rates and the Greek dilemma’, Journal of Financial Stability.
15. Goodhart, C.A.E., P. Sunirand and D.P. Tsomocos (2005), ‘A risk assessment model for banks’, Annals of Finance (1), 197–224.
16. Herber, P. and D. Nemec (2009), ‘Estimating output gap in the Czech Republic: DSGE approach’, Mathematical Methods in Economics .
17. Monetary Policy and Financial Stability (2015), International monetary fund staff report, IMF.
18. Peiris, M. Udara and Dimitrios P. Tsomocos (2015), ‘International monetary equilibrium with default’, Journal of Mathematical Economics 56, 47 – 57.
19. Shubik, M and C. Wilson. (1977), ‘The optimal bankruptcy rule in a trading economy using fiat money’, Journal of Economics 37, 337–354.
20. Smets, Frank (2014), ‘Financial stability and monetary policy: How closely interlinked?’, International Journal of Central Banking .

21. Tsomocos, D. P. (2003), ‘Equilibrium analysis, banking and financial instability’, Journal of Mathematical Economics 39, 619–655.
22. Walsh, Kieran (2015a), ‘Portfolio choice and partial default in emerging markets: A quantitative analysis’.
23. Walsh, Kieran (2015b), ‘A theory of portfolio choice and partial default’.
24. Weill, Laurent (2003), ‘Banking efficiency in transition economies: The role of foreign ownership’, Economics of Transition 11(3) .
25. Woodford, Michael (2012), ‘Inflation targeting and financial stability’, Working Paper 17967, National Bureau of Economic Research.
26. Zettelmeyer, Jeromin, Christoph Trebesch and Mitu Gulati (2013), ‘The greek debt restructuring: an autopsy’, Economic Policy 28(75), 513–563.

A. Appendix. Impulse Responses

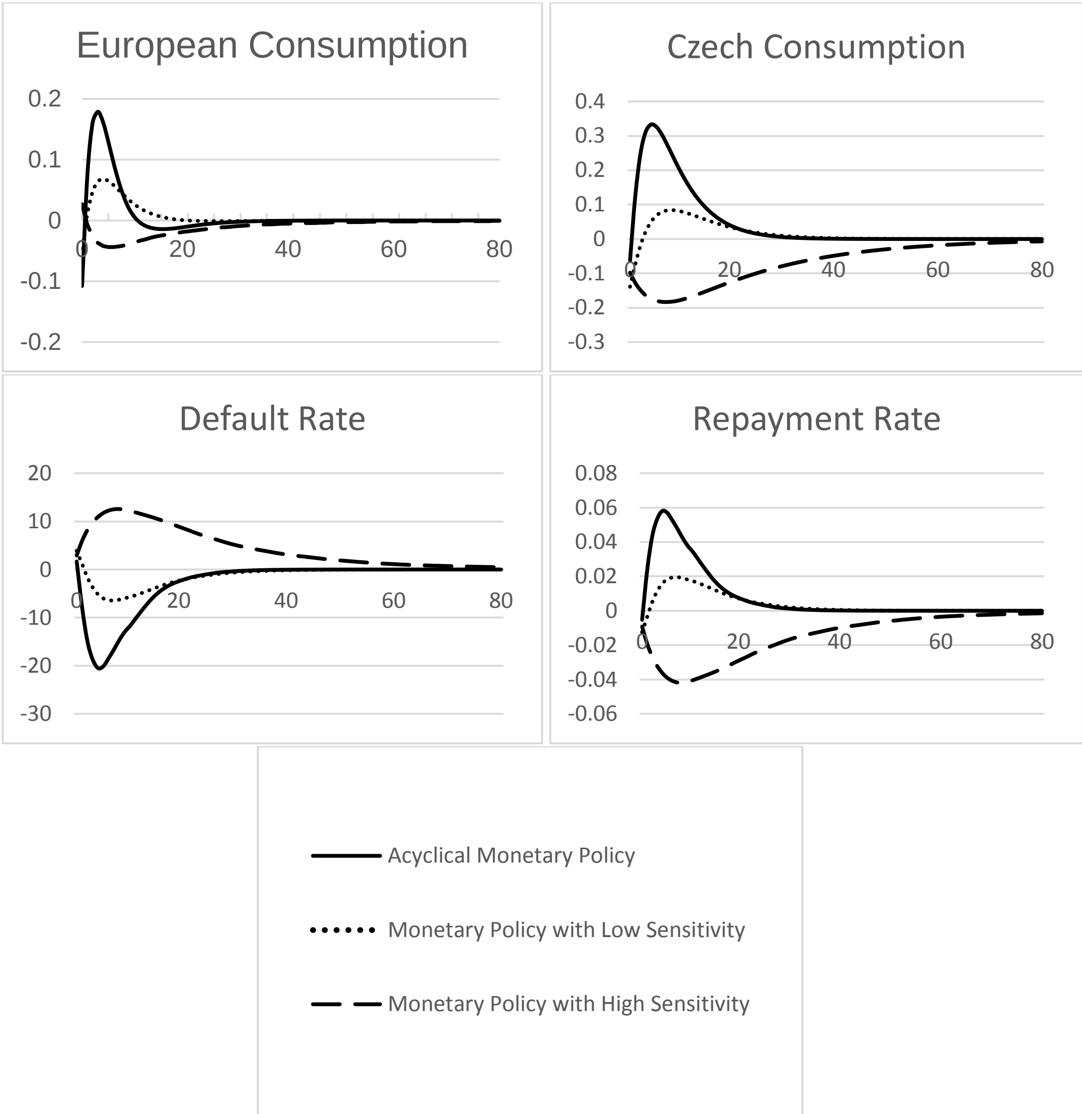

Figure 1: Average stochastic path following negative TFP shock under different policy regimes. Welfare is the conditional welfare series.

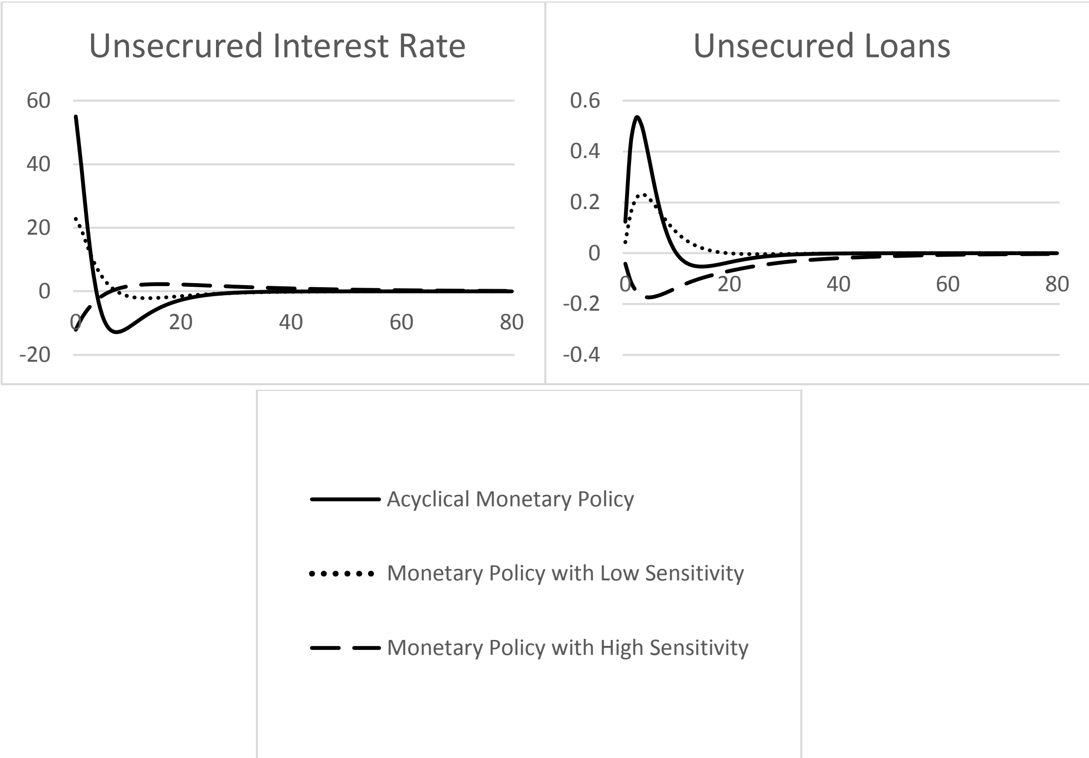

Figure 2: Average stochastic path following negative TFP shock under different policy regimes. Welfare is the conditional welfare series.

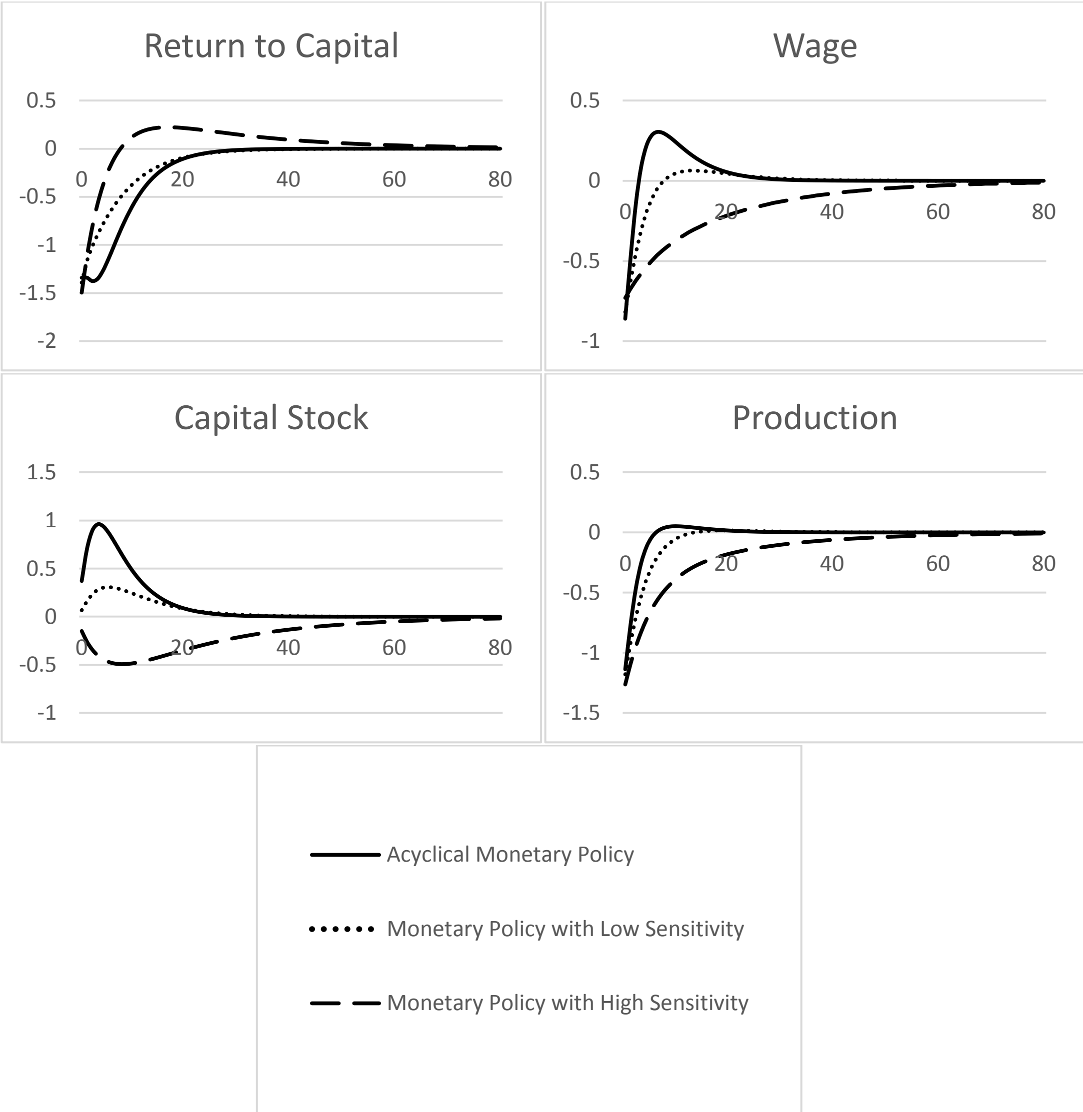

Figure 3: Average stochastic path following negative TFP shock under different policy regimes. Welfare is the conditional welfare series.