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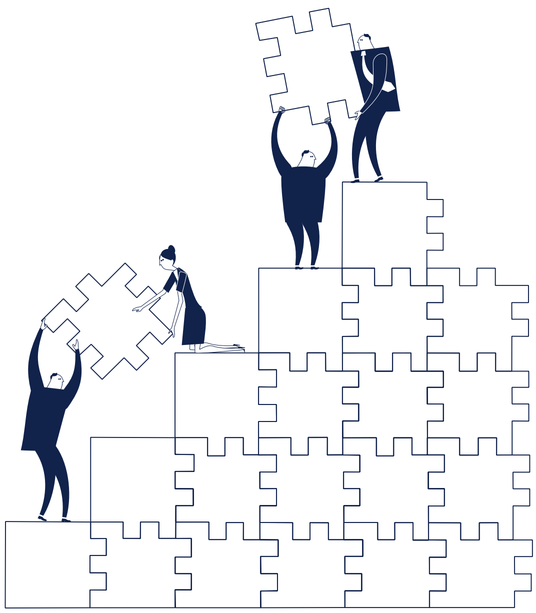

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Debt, Recovery Rates and the Greek Dilemma *

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Abstract

Most discussions of the Greek debt overhang have focussed on the implications for Greece. We show that when additional funds released to the debtor (Greece), via debt restructuring, are used efficiently in pursuit of a practicable business plan, then both debtor and creditor can benefit. We examine a dynamic two country model calibrated to Greek and German economies and support two-steady states, one with endogenous default and one without, depending on creditors expectations. In the default steady state, debt forgiveness lowers the volatility of both German and Greek consumption whereas demanding higher recovery rates has the opposite effect.

Keywords: Debt, Default, Renegotiation, Business Cycles, Open Economy.

JEL Classification: F34 G15 G18

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1 Introduction

In this paper we examine the interaction between a set of debtors, whom we characterize as Greeks, and a set of creditors, whom we term Germans. We outline the circumstances that may make the Greek debtors choose to renege, to default, on an (unsecured) portion of their 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 (Germans) can be more or less tough, (forgiving being the inverse of tough), in imposing penalties on the defaulting Greeks. We model this as a 'recovery' rate, whereby the German 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 focussed on the effects and trade-offs for the debtors' (Greeks), while the effects on creditors have largely been ignored, or assume to be negative [1]. 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 Greece must entail a (net present value) transfer of resources from creditors.

What we show is that, under a set of plausible conditions, greater forgiveness (a lower recovery rate) by the creditors currently can benefit both debtors and lenders. These conditions include reasonable prospects for the profitability of future investment by the debtors (in Greece) and a willingness of the debtors to apply available funds to such investment. If these condi-

[1] See Zettelmeyer et al. (2013), Ardagna and Caselli (2014) and Broner et al. (2014) for analysis of Greek restructuring episodes since 2010.

tions hold, then the short-term loss to the creditors (Germans) from being more forgiving would be more than matched by longer-term higher returns from their remaining investments in Greece, and an overall lower volatility of German consumption (welfare). We, nevertheless, implicitly assume that the Greek economy operates below its potential output and, hence additional investment may generate substantial GNP growth. This may seem paradoxical for the Greek economy as it has contracted in an unprecedented rate of over 25% during the last seven years. However, Greece's growth rates were often exceeding 10% during the 1950s resembling those of modern tiger economies in the late 1990s. Likewise, industrial production increased at a rate of 10% mostly during the 1960s. Greece consistently outperformed most European economies for most of the second world war period[2].

The events of 2009 heralded a paradigm shift in Greece's economic conditions. Prior to this, Greece experienced a prolonged period of economic growth, averaging 5% year-on-year, since the late 1990s and, furthermore, Greek credit-spreads were virtually zero. Creditors and investors viewed Greece as a safe, low-risk, investment destination. Reconciling this period with what followed, is then challenging, particularly from a modelling perspective. Certainly, several different factors contributed to the onset of the crisis in 2009, including fluctuations in credit spreads, a collapse of demand globally, and, most importantly, the realisation that the twin deficits and the national debt-to-gdp ratio were unsustainable.[3] We argue that, in addition to the issues described in Gourinchas et al. (2016), the economic fundamentals of the Greek economy did not

[2] See Bitzenis et al. (2015).

[3] Gourinchas et al. (2016) describes these as the 'Trifecta' of a Sovereign Debt Crisis, Banking Crisis and Sudden Stop.

suddenly change in 2009, rather, expectations were destabilised. Consequently creditor's expectations about the ability of Greeks to honour their contractual obligations radically changed, and, therefore, credit-spreads rose steeply. In addition, a temporary relative decline in productive efficiency, moved the economy from growth and stability to contraction and instability. In our model, we capture these effects by supporting two steady state equilibria. One where default does not occur, and Greece can freely issue debt at the risk-free rate, and another, the one we emphasise, where default and renegotiation occurs.

What this underlines is the need for any such renegotiation to be accompanied by a business plan for the debtors (Greece), indicating how they can use additional funding to grow their way out of their (temporary) hole. A second requirement is for some commitment device to relate the release of additional funding (forgiveness) to the debtor (Greece) to their application of such extra funds to the business plan as originally developed and agreed between debtor and creditor. Put differently, we require that the business plan is time consistent and individually rational. More importantly this plan needs not to be imposed by the creditors but, rather, voluntarily be adopted and committed to fully by the debtors.

The need to come up with such a business plan, and conditionality in releasing funds if, and only if, such plans are carried out, is a commonplace in cases of commercial bankruptcy; but we believe that we are original both in relating this to current Greek sovereign renegotiation, and in doing so in a rigorous model, outlining formally and mathematically the various costs and benefits of default and renegotiation.[4]

[4]Indeed, the argument that restructuring is synonymous with default was put forward by Tsomocos in 2011 on the day of the restructuring of Greek debt ("Skai News Channel",

If such conditions can be met, we would then argue that immediate restructuring that reduces the present value of debt, would benefit both Greece as well as its creditor countries over the medium and long term. We consider a two country RBC model, describing Greece as the debtor nation, and Germany, the main creditor nation. Greek households can issue both secured and unsecured debt to German households and the possibility of renegotiating on unsecured debt exists. Renegotiation occurs because we explicitly model the decision to default and show that the default channel, that exacerbates the volatility of consumption, may actually be reduced with more lenient debt restructuring terms. Put another way, we argue that the dilemma is not whether there is a moral duty of creditor nations to transfer resources to Greece, but whether creditors are willing to trade off short-term losses for medium and long-run gains.

In our model we assume that the Greek capital stock, in addition to internal financing, is externally financed by secured and unsecured debt. Debt can be either secured, in which case failure to honour the debt would invoke bankruptcy proceedings which are ruled out, or unsecured, 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 Greek households can only issue 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

Interview, 27 October, 2011).

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 (2015*a*) and Walsh (2015*b*), 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.[5] Our economy displays the minimum features necessary to highlight the role that an aggregate credit-conditions variable plays in amplifying and propagating financial shocks.

[5]Indeed, that was exactly the misconception that contributed to the unsatisfactory attempt to renegotiate the terms of the agreement during the summer of 2015.

There is a representative Greek household which owns and operates a means of production and a large external lender, described as German 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.

German creditors in our model can seize a proportion of defaulted debt. Thus, borrowers effectively incur two additive costs of 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[6]. 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. We consider how varying the ability of Greece's creditors to seize the value of dishonoured debt affects the adjustment path of the economy. We compare three environments. One where the proportion recovered (recovery rate) is left unadjusted, one where the recovery rate increases, and one where the recovery rate falls. These three environments correspond to potential outcomes following the debt renegotiation process, and the question we focus on is what the

[6]See Geanakoplos and Zame (2014) for an excellent overview of this literature where default occurs in equilibrium

effect on the creditors of the three policy alternatives.

Our results are consistent with many of the empirical findings of debt, default and renegotiation periods documented in Benjamin and Wright (2013). Specifically as in our model, periods of longer defaults are correlated, and the correlation between output and default is slightly negative with default rates reverting once output has recovered to its trend. They emphasise the importance of debt-renegotiations in default episodes and provide a theoretical basis for it using a Nash-bargaining solution in a small open economy framework, also see Eaton and Gersovitz (1981) and Yue (2010), among others.

2 The Model

The economy consists of 2 countries, Greece (the borrower) and Germany (the lender), each inhabited by a continuum of identical infinitely lived agents. German households receive income from a portfolio of Greek and non-Greek assets. We simplify the nature of income generated from non-Greek assets, so German household decisions we model should be viewed as the marginal decisions affected by interactions with Greek financial assets, with income and expenditure decisions from non-Greek 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.

The Greeks own a production technology (firms) requiring labour and capital as inputs. The production function of firms is denoted by $F(cap_t^{GRC}, lab_t^{GRC}) = A_t(cap_t^{GRC})^a(lab_t^{GRC})^{1-a}$, a Cobb-Douglas production function, where A_t is total factor productivity and a and $1 - a$ are the shares of output accruing to capital and household labour respectively. Greek households submit labour, lab_t^{GRC}, to the labour market in return for a competitive wage w_t. Similarly, the capital stock, cap_t^{GRC}, is rented from the capital market in exchange for a competitive rate of return. Greek households smooth intertemporally and finance their investments by issuing senior secured and junior unsecured debt, $b_{s,t}^{GRC}$ and $b_{u,t}^{GRC}$ respectively, from Germany at a competitive interest rate of r_t^s and r_t^u. Unsecured debt is risky as Greeks may choose to renege a fraction def_t^{GRC}. If default occurs, Greeks incur a quadratic cost in renegotiating the remaining amount which depends on the prior scale of of debt. The proportionality factor, Ω_t^{GRC}, reflecting the cost to the default scale, is a macro-variable reflecting credit conditions. In addition, the lender can seize a proportion κ of the outstanding amount from the income or capital stock of the borrower (this is the recovery rate). Greek households pay a cost of adjusting their secured debt positions, reflecting the costs associated with identifying suitable pledgeable assets, while German households pay the cost of adjusting their unsecured loans to Greeks, reflecting the costs of accumulating information on the probabilities of repayment. Throughout this paper we will use 'renegotiation rate' and 'default rate' interchangeably: they refer to the percentage of outstanding debt that Greeks would like to default upon, given the cost of renegotiating this amount. The 'repayment rate' is the percentage of outstanding debt which is repaid: it is 100% less the default rate plus the recovery rate.

The rate of time preference is β and the coefficient of relative risk aversion is σ. Aggregate quantities are mostly denoted in uppercase, prices and aggregate rates have a superscript referring to the market (for wages and interest rates), but in some cases they do not have a superscript (for the aggregate repayment rate on debt); and finally (deterministic) steady state values have a bar.

There is one fundamental source of uncertainty in our economy: shocks to Greek 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 features of experiencing TFP shocks. Certainly it experienced many other shocks including to the political environment (domestic and foreign, such as the refugee crisis) and 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.

2.1 Germany

German households are assumed to have an outside source of income which does not depend on the loan portfolio extended to Greece, and reflects their total net foreign assets (NFA). In addition, they purchase one-period bonds issued by Greeks. Unsecured bonds are risky and there is an expected repayment rate associated with each bond. The net income from (ex-Greece) net foreign assets and bonds finances (marginal) consumption.

Preferences include a CRRA utility function for consumption.

$$\max_{c,b_s,b_u} \sum_{s=0}^{\infty} \beta^s \mathbb{E}_t \left\{ \frac{\left[c_{t+s}^{GER}\right]^{1-\sigma} - 1}{1-\sigma} \right\}, \tag{1}$$

Each period German households earn income, from their (ex Greece) net foreign assets and net Greek assets, and allocate it between consumption (c_t^{GER}) and new assets. Specifically[7],

$$\begin{aligned} c_t^{GER} + b_{u,t}^{GER} + b_{s,t}^{GER} + \frac{adj_u^{GER}}{2}(b_{u,t}^{GER} - \overline{b}_u^{GER})^2 + NFA_t^{GER} \\ = (R_{t-1}^u)(1 - def_t^{GRC})b_{u,t-1}^{GER} + \kappa_t(R_{t-1}^u)(def_t^{GRC})b_{u,t-1}^{GER} \\ + (R_{t-1}^s)b_{s,t-1}^{GER} + NFA_{t-1}^{GER}(R_t^{NFA}). \end{aligned} \tag{2}$$

The ex-Greece Net Foreign Asset position of German households is calibrated and assumed to evolve exogenously (a constant). The return on the NFA portfolio is also assumed to be exogenous and constant.[8] 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. κ is also subject to shocks and follows the following process: $\kappa_t = \overline{\kappa} e^{\varepsilon_t^\kappa}$ where $\varepsilon_t^\kappa = \rho^\kappa \varepsilon_{t-1}^\kappa + u_t^\kappa$ is an autoregressive process subject to shocks u_t^κ.

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

[8] 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 German consumption of their Greek portfolio, independent of unrelated fluctuations in total German income. More importantly, we do not allow German lenders to have alternative opportunities to invest savings. However, the supply of loans is not elastic as Germans still have a legitimate consumption-savings decision, but the trade-off itself is limited to investments in Greece. Nevertheless, alternative investment opportunities would provide a richer framework to study the supply of loans to Greece.

The maximisation programme yields

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

$$\psi_t^{GER}\left\{1 + adj_u^{GER}(b_{u,t}^{GER} - \overline{b}_u^{GER})\right\}$$
$$= \beta^{GER}\mathbb{E}_t\left\{REP_{t+1}R_t^u\psi_{t+1}^{GER}\right\} \tag{4}$$

$$\psi_t^{GER} = \beta^{GER}\mathbb{E}_t\left\{R_t^s\psi_{t+1}^{GER}\right\} \tag{5}$$

where ψ_t^{GER} is the marginal utility of consumption of German households and $REP_{t+1} = 1 - (1 - \kappa_{t+1})(def_{t+1}^{GRC})$ is the net delivery rate including the announced rate of default and the recovery rate. Note that German 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 $\frac{1}{\beta^{GER}} = \overline{R}^s = \overline{REP}\ \overline{R}^u$.

2.2 Greece

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

$$F(cap_{t-1}^{GRC}, lab_t^{GRC}) \equiv A_t(cap_{t-1}^{GRC})^a(lab_t^{GRC})^{1-a}. \tag{6}$$

Capital depreciates at a rate of δ % each period and labour is paid a competitive wage w_t^N. $A_t = e^{\varepsilon_t^A}A$ is the total factor productivity and $\varepsilon_t^A = \rho^A\varepsilon_{t-1}^A + u_t^A$

is an autoregressive process with shock u_t^A. As there is a representative firm, National Production or GDP, is defined as $Y_t = F(cap_{t-1}^{GRC}, lab_t^{GRC})$. Profits of Greek firms are

$$\pi_t^{GRC} \equiv F(cap_{t-1}^{GRC}, lab_t^{GRC}) + (1-\delta)cap_{t-1}^{GRC} - w_t^N lab_t^{GRC} - R_t^k cap_{t-1}^{GRC} \quad (7)$$

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

$$w_t^N = \frac{\partial F(cap_{t-1}^{GRC}, lab_t^{GRC})}{\partial lab_t^{GRC}}, \quad (8)$$

$$R_t^k = \frac{\partial F(cap_{t-1}^{GRC}, lab_t^{GRC})}{\partial cap_{t-1}^{GRC}} + 1 - \delta. \quad (9)$$

Greek households access the international debt market and issue secured (b_s^{GRC}) and unsecured (b_u^{GRC}) claims at competitive interest rates (R^s and R^u are the gross rates, respectively) 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. In Section 4 we detail this fully.

Failure to honour secured debt obligations results in seizure of collateral. Specifically, the amount due on secured debt must be backed by at least

$coll^{GRC}\%$ of the remaining capital stock when it is due.

$$b^{GRC}_{s,t-1}(R^s_{t-1}) \leq coll^{GRC} cap^{GRC}_{t-1}(1-\delta), \tag{10}$$

which is a collateral constraint, as in Kiyotaki and Moore (1997) and Geanakoplos and Zame (2014) among others, though here the margin is fixed at $coll_s$.

The budget constraint of the Greek household requires the allocation of income from profits and labour plus new borrowings to consumption, investment, and repayment of existing debt as follows

$$\begin{aligned} & c^{GRC}_t + cap^{GRC}_t + (R^s_{t-1})b^{GRC}_{s,t-1} + (1 - def^{GRC}_t)(R^u_{t-1})b^{GRC}_{u,t-1} \\ =& \pi^{GRC}_t + R^k_t cap^{GRC}_{t-1} + w^N_t lab^{GRC}_t + b^{GRC}_{s,t} + b^{GRC}_{u,t} \\ & - \frac{adj^{GRC}_s}{2}(b^{GRC}_{s,t} - \overline{b}^{GRC}_s)^2 - \kappa_t def^{GRC}_t (R^u_{t-1}) b^{GRC}_{u,t-1} \end{aligned} \tag{11}$$

where c^{GRC} is consumption, unsecured and secured debt issued is b^{GRC}_u and b^{GRC}_s respectively, at a gross interest rate of (R^u) and (R^s) respectively, and the proportion of unsecured outstanding debt repaid is $(1-def^{GRC})$. $\kappa_t def^{GRC}_t (R^u_{t-1}) b^{GRC}_{u,t-1}$ is the amount lenders seize from the new capital stock, and $\frac{adj^{GRC}_u}{2}(b^{GRC}_{u,t} - \overline{b}^{GRC}_u)^2$ 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. The decision variables are $c, lab, b_s, b_u, def, cap$.

$$W_t^{GRC} = \left[\frac{(c_t^{GRC})^{1-\sigma} - 1}{1-\sigma} - \frac{\eta}{2}(lab_t^{GRC})^2 - \frac{1}{2}\left\{ def_t^{GRC}(R_{t-1}^u) b_{u,t-1}^{GRC} \right\}^2 \Omega_t^{GRC} \right]. \tag{12}$$

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

$$W_t^{GRC} = \sum_{s=0}^{\infty} \beta^s \mathbb{E}_t W_{t+s}^{GRC}. \tag{13}$$

The renegotiation cost enforced on firms that choose to default on $def_t^{GRC}\%$ of their unsecured debt is

$$\frac{1}{2}\left\{ \zeta + def_{t+s}^{GRC}(R_{t+s-1}^u) b_{u,t+s-1}^{GRC} \right\}^2 \Omega_{t+s}^{GRC}, \tag{14}$$

where Ω_t^{GRC} is a pro-cyclical macro-variable which governs the severity of the punishment enforced and $\zeta \to 0$ is an infinitesimally small positive number[9]. Ω_t^{GRC} is given by

$$\Omega_t^{GRC} \equiv \phi^{GRC} \left\{ \frac{(1-\overline{\kappa})\overline{\psi}^{GRC}(1-\overline{def}^{GRC})(\overline{def}^{GRC})^{\gamma-1}}{\overline{CAP}^{GRC}} \right\} \frac{CAP_{t-1}^{GRC}}{B_{u,t-1}^{GRC}(1+r_{t-1}^u)(def_t^{GRC})^{\gamma}}. \tag{15}$$

Ω_t^{GRC} is the shadow cost of renegotiation, or the stochastic discount factor for the cost of renegotiating debt in arrears. $\overline{\psi}^{GRC}$ is the steady state shadow value of consumption for the Greek household. ϕ^{GRC} is what we call the *default*

[9] 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 $\zeta = 0$ but return to it in Section 3.1.

wedge and determines the steady state rate of default. 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^{GRC} turns out to be pro-cyclical, 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 value of default Ω_t^{GRC} is low. When the shadow cost of default is low, the firms default rate is likely to be higher (all else being equal).[10]

Ω_t^{GRC} 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^{GRC} 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 (2015*a*) and Walsh (2015*b*) have Ω_t^{GRC} to be a function of household wealth. As this is dynamic, so is Ω_t^{GRC}. However, there, this is necessary in order to obtain a stationary solution as the marginal cost of default is still linear in Ω_t^{GRC}. 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 spec-

[10] In richer models, where there are heterogenous 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.

ification we have chosen for Ω_t^{GRC} 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[11].

The optimisation yields the following first order conditions, with ψ_t^{GRC} defined as the shadow value of income and λ_t^{GRC} is the Lagrange multiplier for the limit of issuing secured debt at $t-1$, and interpreted as the shadow value of secured debt:

$$\eta lab_t^{GRC} = \psi_t^{GRC} w_t \tag{16}$$

$$\psi_t^{GRC} - coll^{GRC}(1-\delta)\lambda_t^{GRC} = \mathbb{E}_t\beta\left\{\psi_{t+1}^{GRC}(R_{t+1}^k)\right\} \tag{17}$$

$$\frac{\psi_t^{GRC}}{R_t^u} = \mathbb{E}_t\beta\left\{(1-(1-\kappa_{t+1})def_{t+1}^{GRC})\psi_{t+1}^{GRC} + (def_{t+1}^{GRC})^2(R_t^u)b_{u,t}^{GRC}\Omega_{t+1}^{GRC}\right\} \tag{18}$$

$$\psi_t^{GRC} b_{u,t-1}^{GRC}(R_{t-1}^u) = def_t^{GRC}(R_{t-1}^u)^2(b_{u,t-1}^{GRC})^2\Omega_t^{GRC} + \kappa_t(R_{t-1}^u)b_{u,t-1}^{GRC}\psi_t^{GRC} \tag{19}$$

$$\frac{\psi_t^{GRC}}{R_t^s}(1 - adj_s^{GRC}(b_{s,t}^{GRC} - \bar{b}_s^{GRC})) - \lambda_t^{GRC} = \mathbb{E}_t\beta\left\{\psi_{t+1}^{GRC}\right\} \tag{20}$$

Equation 16 is the FOC wrt to labour supplied while 17 is the FOC wrt capital and states that the shadow value of capital equals the marginal effect of capital on profits plus the increase in future capital stock. 18 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 19 is the FOC with respect to the repayment rate

[11] As in Benjamin and Wright (2013)

on loans and equalises the marginal cost on profits of repaying an additional percent of debt to the marginal benefit of reducing the renegotiation cost of defaulting. Equation 20 is the FOC with respect to the secured debt issued.

The first order conditions give:

$$\phi^{GRC}\left\{\frac{def_t}{\overline{def}}\right\}^{1-\gamma} = \frac{1}{1-\overline{def}^{GRC}}\frac{\lambda_t^{GRC}}{\overline{\lambda}^{GRC}}, \tag{21}$$

and in the deterministic steady state

$$\frac{1}{\beta^{GRC}} = \overline{R}^u, \tag{22}$$

and hence

$$1-\overline{def}^{GRC} = \frac{1}{\phi^{GRC}} = \frac{\beta^{GRC}}{\beta^{GER}}. \tag{23}$$

These results will be explained in Section 3.

3 Default and the Business Cycle

3.1 Multiple Equilibria

Assume there exists a steady state where default rates are zero. Such a steady-state can be supported when default penalties are exceedingly harsh. If agents do not default it is because the marginal cost of defaulting is strictly greater than the marginal benefit of defaulting. Alternatively, if the marginal benefit and cost of defaulting are equated, then default obtains in the steady state. In particular, the marginal benefit of defaulting is the marginal increase in wealth from reducing repayments whereas the marginal cost of defaulting is the increase in the renegotiation cost. In our model, when the two are equated, then Equation 19 holds with equality. Note that the limit of $\zeta = 0$ was set in Equation 19. Then, let us postulate the existence of a steady-state where default does not occur and $\zeta > 0$. The marginal benefit of default is the left hand side of Equation 19, $\psi_t^{GRC} b_{u,t-1}^{GRC}(R_{t-1}^u)$, while the marginal cost of defaulting is the right hand side, $(R_{t-1}^u)(b_{u,t-1}^{GRC})(\zeta + def_t^{GRC}(R_{t-1}^u)(b_{u,t-1}^{GRC}))\Omega_t^{GRC} + \kappa_u^{GRC}(R_{t-1}^u)b_{u,t-1}^{GRC}\psi_t^{GRC}$ in the assumed steady-state. Since $def_t^{GRC} = 0$, the marginal cost of defaulting becomes $(R_{t-1}^u)(b_{u,t-1}^{GRC})\zeta\Omega_t^{GRC} + \kappa_u^{GRC}(R_{t-1}^u)b_{u,t-1}^{GRC}\psi_t^{GRC}$. Hence, $\Omega_t^{GRC} = \frac{\phi^{GRC}(1-\overline{\kappa})\overline{\psi}^{GRC}}{B_{u,t-1}^{GRC}(1+r_{t-1}^u)(def_t^{GRC})} = \infty$. In conclusion, when $\zeta > 0$, the marginal cost of default becomes infinite, and therefore there is no default.[12] In this default-free equilibrium, Greek households borrow freely at a risk-free interest rate. However, if creditor's expectations become pessimistic, credit spreads will increase, resulting in default. Nevertheless, a credible and transparent business plan may improve creditors expectations, thus eliminating default.

As our interest is the post-crisis era, we now continue our analysis on the steady-state with default and renegotiation.

3.2 Default Wedge

We term ϕ^{GRC} the *default wedge*. ϕ^{GRC} is the mark-up of the return from capital over the net pecuniary interest cost of debt (after accounting for default). It is a measure of the renegotiation cost of default. In the absence of default, the expected return to capital will equate the return to debt, and hence

[12] We could have avoided using limits for the argument, however this would have required a more cumbursome calibration of values to sustain both steady-states.

$\phi^{GRC} = 1$. $\phi^{GRC} > 1$ implies a higher unsecured interest rate (and hence return on capital), or a lower capital stock and so is the effective tightness of credit conditions because of expectations of default. The reason that the rate of repayment affects steady-state allocations arises from the asymmetry of the way default is modelled here. In the steady state, the lender equates the net-of-default return on debt to their rate of time preference. Thus, a lower repayment rate, or higher default rate, increases the gross interest rate they demand, which, in turn, increases the return on capital and lowers the steady state capital stock.

3.3 Default Accelerator

We term γ the *default accelerator* as it results in the credit conditions variable a decreasing function of aggregate default rates. For $\gamma < 1$, a negative shock to income raises the marginal utility of incomeλ_t^{GRC} which then increases the individual propensity to default def_t^{GRC}, 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^{GRC}.

3.4 Default Premium and Endogenous Liability Structure

If secured debt did not need not be collateralised, $\overline{R}^k = \overline{R}^u > \overline{R}^s$. In other words, the return on capital would be equated to the unsecured bond interest rate which would be strictly higher than the secured (but uncollateralised) bond interest rate. Here, where secured debt must be collateralised by capital we obtain the following relationship

$$\overline{R}^u = \frac{\overline{R}^k - \chi(1-\delta)}{\overline{R}^s - \chi(1-\delta)}\overline{R}_s, \tag{24}$$

which is simply

$$1 - \overline{def} = \frac{1}{\phi^{GRC}} = \frac{\overline{R}^s - \chi(1-\delta)}{\overline{R}^k - \chi(1-\delta)} \tag{25}$$

where $\frac{\overline{R}^k - \chi(1-\delta)}{\overline{R}^s - \chi(1-\delta)}$ is the default premium. An increase in the default wedge (ϕ) increases default rates ($\overline{def}$) which increases the spread of the return to capital over the secured interest rate ($\frac{\overline{R}^k}{\overline{R}^s}$), increasing the required return on capital and and lowering the capital stock ($\overline{CAP}$.) Because of the need for collateral, a fall in the capital stock, leads to a fall in the stock of secured debt issued by the Greek households ($\overline{b}_s^{GRC}$) and the ratio of secured to unsecured debt ($\frac{b_{t,s}^{GRC}}{b_{t,u}^{GRC}}$). In other words, over the business cycle the composition of liabilities issued by Greek households fluctuates via the default channel.

4 Policy Experiment

The repayment policies we consider refer to the recovery rate. The recovery rate (κ_t) is the proportion of debt that Greece would like to default upon, which creditors do not agree to and hence recover. In principle this process can take any form but we focus on policies which respond to fundamentals (TFP specifically). We model the process as $\kappa_t = \overline{\kappa} e^{\varepsilon_t^{\kappa}}$ where $\varepsilon_t^{\kappa} = \rho^{\kappa}\varepsilon_{t-1}^{A} + u_t^{\kappa}$

where ε^A_{t-1} is the previous period's TFP deviation. The policy regimes we consider correspond to modelling the coefficient and shock:

- Constant: $\rho^k = u^\kappa_t = 0$
- Harsh: $\rho^k = -.2\rho^A$, $u^\kappa_t = -10u^A_t$
- Lenient: $\rho^k = .2\rho^A$, $u^\kappa_t = 10u^A_t$

Under the Constant policy, the recovery rate remains at the steady state value. Under the Harsh policy, a negative TFP shock generates an immediate increase in the recovery rate and the recovery rate remains above steady state levels as long as TFP is below it's steady state level. The Lenient policy has the opposite description.

5 Calibration

We have calibrated our economy according to the values provided in previous studies at a quarterly frequency. Here we discuss the calibration with respect to the Constant recovery rate policy for the sake of compactness. The secured interest rate is 2% per annum while the unsecured rate is 12.9% per annum. This compares with the average Germany 10 year yield from January 2010 to October 2014 of 1.916% and Greek 10 year bond yield from January 2010 to January 2015 of 12.81%.[13] The recovery rate on Greek debt was taken from Vrugt (2011) who estimated that the recovery rate on Greek debt to be between 40 and 60 - we have taken the midpoint of 50. This is also the number

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

documented in the cross-country findings of recovery rates found in Benjamin and Wright (2013). The volatility of default rates was taken from the Standard and Poors Ratings Direct study "Default, Transition, and Recovery: 2012 Annual Global Corporate Default Study And Rating Transitions", which gave the mean and standard deviation of annual European Corporate Speculative-Grade Default Rates as 3.1% and 3.46% respectively. The mean and standard deviation of default rates is 5 % and 15.9% while unsecured debt repayment rates in our economy are 97.5% and 7.95% respectively as the repayment rate includes a recovery rate of 50%. 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 $1/.95$ 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 .212%, and the coefficient of relative risk aversion, σ, is 2, following Angelopoulos et al. (2010). In the same paper, the private depreciation rate of capital was 1.75% per quarter. We have chosen a slightly higher rate of 2.5% to increase investment and compensate for the static capital stock due to a lack of growth in our model. Angelopoulos et al. (2010) have a labour share of income of .66, so we choose a to be .34. The labour supply is set to .3544 which is the average value of hours of work in Angelopoulos et al. (2010). The ratio of unsecured to secured debt in our economy is .5. The ratio of short to long term public debt in Greece reported in Karmann and Maltritz (2012) is .25, and we have used this to obtain a rough estimate of the ratio of secured to unsecured debt, assuming that short-term debt needs to be renegotiated more immediately. Eurostat gives the net external debt to GDP ratio of Greece to be 130% in

2013. We directly set the steady-state values of debt to obtain this figure in our calibration. World Bank figures for the Net Foreign Asset (NFA) positions of Greece and Germany gives a ratio of almost 30 in 2010 and almost 60 in 2013 which we use to obtain the ex-Greece NFA for Germany of 30 times Greek total debt. Table 1 lists values and sources.

Parameter	Description	Model Value	Source Value	Reference
u_A	Standard Deviation of TFP Shock	0.00424%	.212%	Angelopoulos et al. (2010)
ρ_A	Persistence of TFP shock	.675	.675	Angelopoulos et al. (2010)
σ	Coefficient of relative risk aversion	2	2	Angelopoulos et al. (2010)
δ	Depreciation rate	2.5%	1.75%	Angelopoulos et al. (2010)
a	Share of Capital Income in Greece	.34	.34	Angelopoulos et al. (2010)
lab	Steady-state labour supply	.353	.353	Angelopoulos et al. (2010)
b_u/b_s	Unsecured-to-Secured Debt	.5	.25	Karmann and Maltritz (2012)
$(b_s+b_u)/Y^{GRC}$	Greek Debt-to-GDP	130%	130%	Eurostat
$NFA/(b_s+b_u)$	Ex-Greece, German Net Foreign Assets	30	29 to 60	World Bank
$E(R^s_t-1)$	Mean Annual Secured interest rate	2%	1.916%	St. Louis/FRED
$E(R^u_t-1)$	Mean Annual Unsecured interest rate	12.9%	12.81%	St.Louis/FRED
$E(def)$	Mean default rates	5%	3.1%	S&P
$StD(def)$	Variance of default rates	15.9%	3.46%	S&P
κ	Recovery rate on unsecured debt	0.5	0.5	Vrugt (2011)

Table 1: List of Calibrated Values

Table 2 below shows the parameterisation of the economy.

Parameter	Description	
β^{GER}	German rate of time preference	0.995
β^{GRC}	Greek rate of time preference	0.970
ϕ^{GRC}	default wedge	$1/.950$
γ	default accelerator	.930
A_t	total factor productivity	1.052
η	household preference for labour	7.656
$coll$	collateral requirement	.1375

Table 2: List of Parameters

6 Business Cycle Properties

In this section[14] we first simulate the 1st 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 apart from the repayment rate is lowest under a Lenient policy. For the correlation with output, capital, labour, and debt are strongly pro-cyclical while consumption becomes less cyclical reflecting large capital outflows and economic contraction in times of crisis. Although the secured interest rate is procyclical, the unsecured rate is strongly countercyclical reflecting the procyclical repayment rate. In other words default occurs in bad times and is consistent with the empirical literature and arguments of Arellano (2008) and Aguiar and Gopinath (2006). Under a Lenient policy , the persistence of the repayment series is the lowest reflecting that the persistence and transmission of the effect of default falls.

[14]Numerical calulations were performed in Dynare. We consider deviations from the level.

	Mean			Standard Deviation		
	Constant	Harsh	Lenient	Constant	Harsh	Lenient
$R_t^s - 1$	0.0050	0.0050	0.0050	0.0431	0.0491	0.0371
$R_t^u - 1$	0.0308	0.0308	0.0308	0.0121	0.0141	0.0102
REP	0.9750	0.9750	0.9750	0.0795	0.1088	0.1153
$R^k - 1$	0.0273	0.0273	0.0273	0.0050	0.0058	0.0042
cap^{GRC}	6.4970	6.4970	6.4970	1.1090	1.2591	0.9595
$wage^{GRC}$	1.8681	1.8681	1.8681	0.1308	0.1465	0.1151
lab^{GRC}	0.3533	0.3533	0.3533	0.0238	0.0282	0.0195
Y^{GRC}	1.0000	1.0000	1.0000	0.0872	0.0971	0.0782
c^{GER}	0.8311	0.8311	0.8311	0.0441	0.0520	0.0362
c^{GRC}	1.1765	1.1765	1.1765	0.1754	0.2039	0.1473
b_s	0.8667	0.8667	0.8667	0.1264	0.1432	0.1097
b_u	0.4333	0.4333	0.4333	2.2930	2.5883	2.0007
	Correlation with Production			First Order Auto-correlation		
	Constant	Harsh	Lenient	Constant	Harsh	Lenient
$R_t^s - 1$	0.3830	0.3234	0.4549	0.9381	0.9442	0.9296
$R_t^u - 1$	-0.5845	-0.5324	-0.6425	0.9749	0.9748	0.9751
REP	0.7328	0.5262	0.5887	0.9792	0.5469	0.4475
$R^k - 1$	-0.7556	-0.7402	-0.7465	0.9740	0.9828	0.9570
cap^{GRC}	0.9135	0.8980	0.9256	0.9950	0.9952	0.9946
$wage^{GRC}$	0.6530	0.6034	0.7108	0.9238	0.9304	0.9150
lab^{GRC}	0.6165	0.6227	0.6214	0.9639	0.9551	0.9752
Y^{GRC}	1.0000	1.0000	1.0000	0.9892	0.9941	0.9793
c^{GER}	0.0395	-0.0196	0.1081	0.9119	0.9121	0.9118
c^{GRC}	0.4521	0.4958	0.4003	0.9110	0.9108	0.9118
b_s	0.9563	0.9574	0.9471	0.9942	0.9945	0.9937
b_u	0.9547	0.9484	0.9581	0.9963	0.9964	0.9958

Table 3: Business Cycle Properties of Simulated Economy

6.2 Impulse Responses

Figures 1 to 3 give the impulse responses following a negative TFP shock. When it occurs, the reduction in income (before an adjustment in labour supply) increases the marginal cost of honouring debt and default rates rise. 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 German consumption or less German 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 Greek economy and investment is increasingly financed through domestic savings resulting in a decline in Greek consumption.

In the following quarters, lower TFP lowers the return on investment, driving down the issuance of debt issued by Greeks partly offset by internal financing, and so Greek consumption remains below steady state values. Default rates above steady state values increases the required rate of return on unsecured debt and consequently return on capital. The large increase in the unsecured interest rate then corresponds to a large decrease in the capital stock and production. The liability structure of the Greek economy also substitutes away from unsecured borrowing to internal financing and the ratio of unsecured to secured debt continues to fall. It is worth noting that while the required return on unsecured debt increases, the required return on secured debt falls. Default rates and the economy overall begin to converge back to steady state values after 20-30 quarters when the credit conditions macro-variable begins to converge back to steady state values.

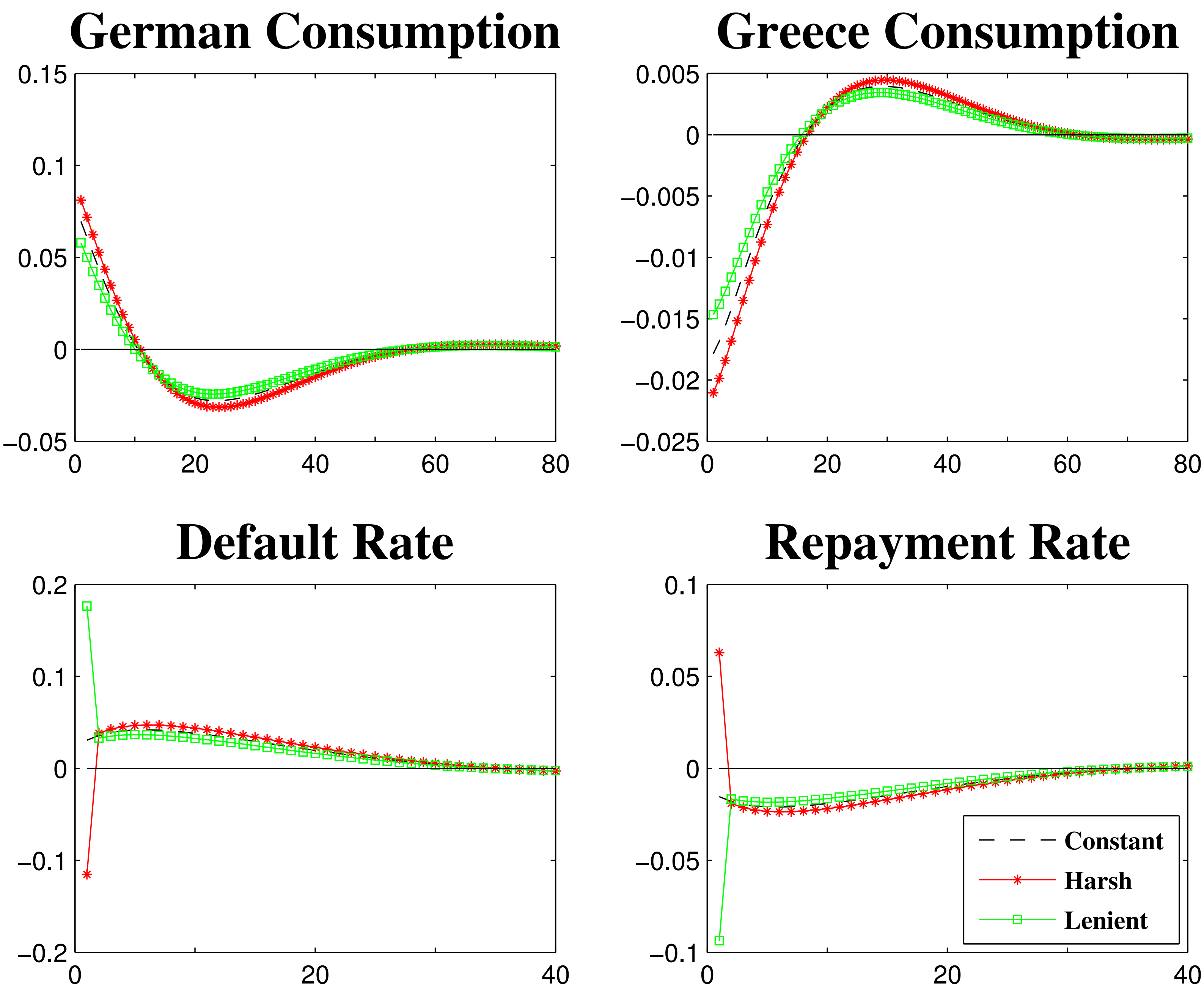
From the lender's (German) point of view, the lower requirement for external financing of the capital stock, increases German net income and consumption initially, but, as the need for external financing subsequently increases, German consumption starts to fall below steady state values. The economy is close to steady state values after 60 quarters.

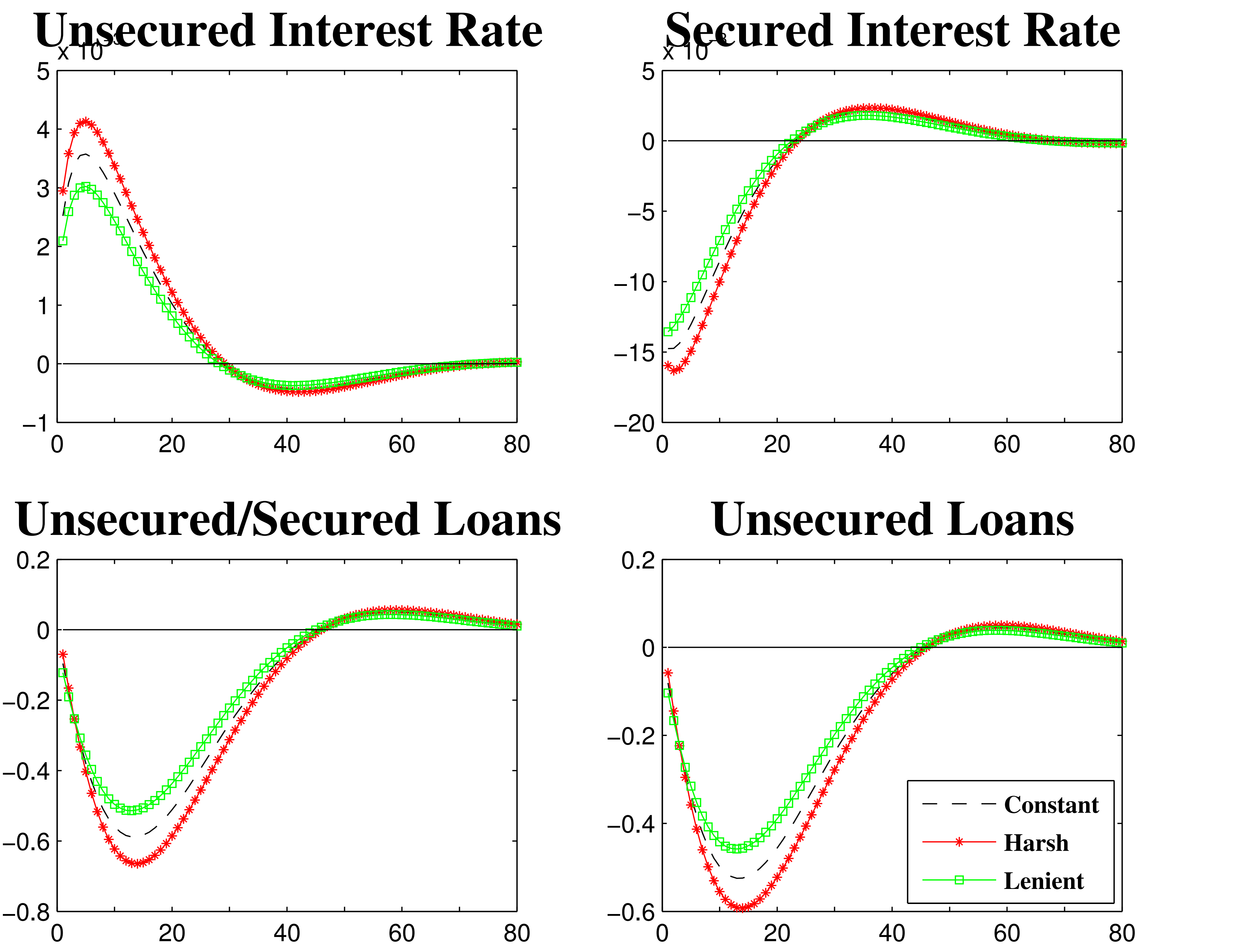
Policy Regimes

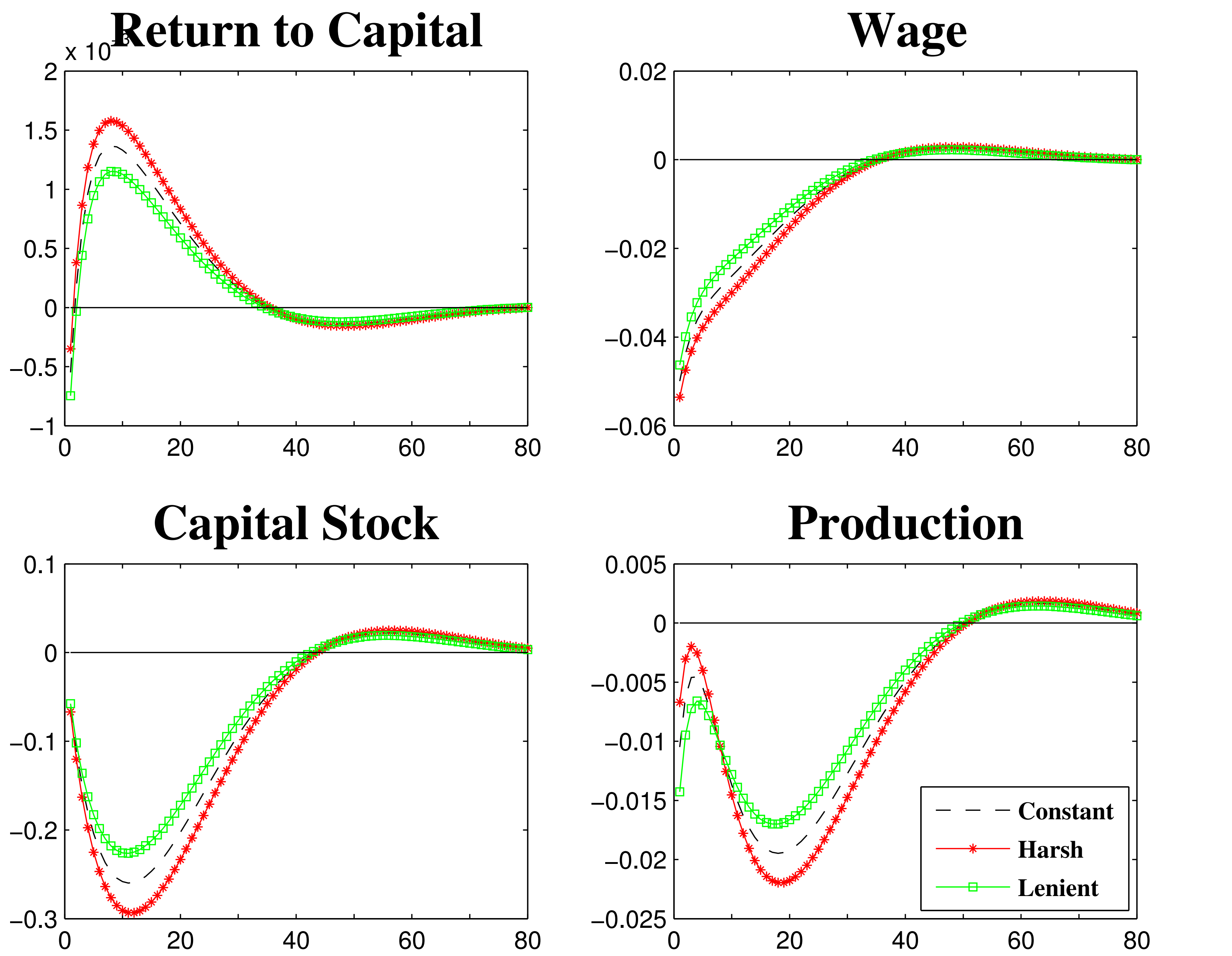
The Harsh policy regime (red starred series) has much larger fluctuations than the other ones, driven by the larger immediate decline in Greek capital and consumption as a result of higher repayment requirements. In contrast, the Lenient policy (green square series) insulate the Greek economy at the cost of an immediate fall in German Consumption. The Lenient policy results in higher immediate Greek default rates (as more of that is recovered) and a higher unsecured interest rate. This translates into a faster downward adjustment in the capital stock but also faster recovery from 20 quarters onwards. Overall, the Lenient recovery rate policy results in smaller fluctuations and faster convergence to the steady state.

7 Concluding Remarks

The dilemma of debt forgiveness versus harsh repayment conditions of an unsustainable debt position has put further strain on the political situation in


German Consumption
Greece Consumption
Default Rate
Repayment Rate
Constant
Harsh
Lenient


Unsecured Interest Rate
Secured Interest Rate
Unsecured/Secured Loans
Unsecured Loans
Constant
Harsh
Lenient


Return to Capital
x 10^-3
2
1.5
1
0.5
0
−0.5
−1
0
20
40
60
80
Wage
0.02
0
−0.02
−0.04
−0.06
0
20
40
60
80
Capital Stock
0.1
0
−0.1
−0.2
−0.3
0
20
40
60
80
Production
0.005
0
−0.005
−0.01
−0.015
−0.02
−0.025
0
20
40
60
80
Constant
Harsh
Lenient

Greece. Initially, the destabilisation of expectations due to the Greek government's inchoate economic policy engendered the crisis. Subsequently, the Greek political landscape has become increasingly fragmented while creditors have wrestled the dilemma of restructuring Greek debt. The government has become weaker and unstable as the latest meetings of the Greek parliament have indicated so vividly. It faces challenging hurdles to restore fiscal sustainability and promote structural reforms. Considering this dimension would reinforce our argument of the need for a practicable business and economic plan and further strengthen results.

The difficult political environment in Greece can be considered as the outcome of an inherent time-inconsistency problem in past agreements. In our model we examine only the time-consistent path of debt agreements, and so abstract away from important considerations of commitment to presumably Pareto-improving potential agreements. Note, however, that the moral hazard aspect of debt is certainly captured since in our model Greeks suffer a cost of reneging on their contractual obligations: the promises themselves are made with a common understanding that reneging on them is possible (alongside their subsequent associated costs).

In our model, funds arising from debt forgiveness are used efficiently. This is in contrast to the popular narrative whereby forgiveness of Greek debt will result in either direct diversion of funds by politicians, or other inefficiencies, leading to deadweight loss[15]. We have conducted an analysis including diversion of a fixed proportion of resources away from the economy and our results remain robust so have not included it here.

[15] See Bortz (2015) for an extensive discussion on the use of bailout money in Greece.

Finally one might argue that quantitative easing and debt monetisation could serve a similar role as our debt restructuring argument. However this neglects the fact that due to the heterogeneity of the Eurozone countries this might increase discord among Eurozone member states. Member states each face different stages of the recovery cycle from the global financial crisis and consequently further quantitative easing and debt monetisation may have heterogenous effects, not to mention adverse effects on inflation. Certainly, the monetary aspect of this issue needs to be studied in the context of a richer framework.

In this paper, we have abstracted from these important dimensions of the current debate and focussed on the economic effects of debt renegotiation. We have presented a novel model that allows us to study the channel through which default rates, and debt renegotiation, affect the accumulation of capital. We believe the features presented in the model, including endogenous default and liability structure, warrant further study on their own in the context of the literature on financial frictions and the business cycle. We have purposely restricted attention on the ability of these features to shed light on the issues that we are most interested in.

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