Vote to Default

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Abstract

Inspired by the political events that followed after the sovereign debt crisis in Greece post 2009, I develop an overlapping generations model with aggregate and idiosyncratic shocks to analyze agent's decisions if each had a vote in whether the country should default or not. The hypothetical economy where agents vote to default almost became a reality in 2015 when Prime Minister of Greece asked the voting population whether the country should remain in the bailout program through a referendum. Model results exhibit similar patterns as the Greek referendum with the young and less wealthy more inclined to vote for default.

Keywords: OLG, sovereign default, Krusell-Smith.

1 Introduction

In this chapter, I will present a model in which a small open economy decides to default or not by majority voting. Since the seminal work of Eaton and Gersovitz (1981) sovereign defaults are usually modeled using a representative agent who defaults if the current and future streams of utility of default is larger than the case of not defaulting. The model I present replaces the representative agent with a population that is heterogeneous in dimensions of age, wealth and productivity. The heterogeneity in multiple dimensions allow for a more rich analysis of the voting outcome than in unitary dimension, where voting outcome is determined by identifiable median voter.

The theoretically model was inspired by Greek elections of 2012. In the election, clear divide occurred between pro-bailout and anti-bailout parties. The pro-bailout parties supported the guidelines set forth by the creditors for new loans, which most of it would be used to service previous debt. Pro-bailout is a misnomer because these parties were in favor of debt repayments in a newly structured manner. The anti-bailout parties wanted to reject the terms of the creditors as they did not believe the consequences to be more severe than the terms of bailout. Greek debt crisis was more complicated than debt repayment. Other issues included continued membership in the European Union, common currency €, capital flight and health of Greek banking institutions. However the central election issue seemed to be debt and the austerity measures, which were guidelines set forth by the creditors. The citizens of Greece were indirectly voting on whether the country should default or not in the elections of 2012. In 2015, Greece debt crisis was still ongoing and impasse between Greece and creditors resulted in a referendum, in which Greek citizens were asked if they should accept the terms for continued bailout. This referendum was highly unusual in that the the population would be voting in a matter usually reserved for elected politicians and finance ministers.

The referendum results showed certain demographics were more likely to have voted‘'No" on the referendum. The model I present will try to explore the impact of age and wealth in an agent's decision to favor default or not in a theoretical setting. There are models that include a political element to sovereign default but these models lack capital accumulation needed to generate a wealth distribution. When heterogeneous agents are embedded within the sovereign default framework, the state space increases dramatically and the solution must be computationally efficient. The paper will be accompanied by efficient codes, which hopefully other researchers can modify to further increase the complexity of economic models as more advanced computing resources become available within a desktop environment.

2 Greek Crisis

In October of 2009, newly elected Prime Minister Papandreou revealed Greece had been under reporting deficits for years in the backdrop of the Great Recession. The news came about as Greek economy was worsening as they would report GDP loss of 4.2% in 2009 after a loss of .3% in 2008. As investors fled Greek bonds, the yields rose sharply (900 basis points over German Bunds) Zettelmeyer et al. (2013). Greece was one of the more indebted nations with debt to GDP over 100%. As the yields rose, it became impractical to finance their budget deficits through the international bond markets. Also debt payments from previous loans were mounting. Greece did not have these funds and sovereign debt crisis was imminent. In April of 2010, Greek government requested financial assistance from the European Union and IMF to meet their debt obligations.

In May of 2010, European Commission, European Central Bank and IMF collectively known as the *troika*, agreed to a rescue package conditional on economic reforms. These conditional economic reforms also known as austerity measures were highly unpopular. Each austerity measure that passed through legislation reduced benefits such as pension and overtime pay and increased taxes from VAT to corporate. These measures were intended to reduce the budget deficits by focusing on expenditure cuts but with the the continued recession, Greece continuously faced budget shortfalls. The economy worsened and Greece needed debt relief once again. Early 2012, Greece "restructured" their debt with private investors taking haircut losses of approximately 60% Zettelmeyer et al. (2013). The private bondholders of Greek debt suffered heavy losses as they lowered Greek debt obligations by more than €100 billion. The bond restructure and further aid from *troika* required Greece to continue to implement austerity measures.

The debt crisis took center stage in Greek politics. On May of 2012 Greece held an election for all the seats in their congress. The austerity measures were the focus of the election. Some parties such as the current majority party New Democracy were in favor of austerity measures. Syriza, holding only 13 of 300 seats pre-election campaigned against austerity measures. Post election, they gained 39 seats and became the major opposition party. This election highlighted the close link between sovereign default and politics, which would become further evident in the events to come.

By 2014, Greek economy improved, reporting positive GDP growth of .65%. Greece even returned to the bond market raising over €6 billion from sale of bonds. Still the government needed tranches from the previous bailouts to finance their budget deficits. The *troika* and Greece started negotiations on Greece's continued implementation of the bailout program as elections were looming.

In January 2015, Greece held an election for all the seats in their congress. The central focus of the elections was the bailout. Some political parties including the current majority New Democracy argued for completing the bailout program. Anti-bailout parties such as Syriza argued to exit the the bailout program and force the *troika* for better terms of the bailout. Syriza, which came into prominence in the election of 2012 won 149 out of 300 seats, nearly capturing absolute majority. Their party leader Alexis Tsipras, who was a prominent voice in the anti-bailout movement became the new Prime Minister.

Greece faced a heavy schedule of debt repayments in early 2015. Without further austerity measures, tranches from earlier bailouts would not be released. Without these tranches, Greece would be the first country to default on IMF debt obligations. Unable to come to agreement with creditors, Greek Prime Minister Alexis Tsipras announced a referendum in June 2015. The referendum asked whether Greece should approve the proposal by the Juncker Commission, IMF, and ECB in regards to future of the Greece's bailout program. The proposal outlined the necessary initiatives, such as pension and public wage cuts, Greece needed to implement for further aid. There were many questions in regards to the legality of the referendum and accuracy of the referendum question as negotiations between the *troika* and Greece were ongoing. The consequences of ''No" on referendum was unclear. Tsipras who recommended a ''No" vote believed Greece can force *troika* to relax their austerity measure requirements by leaving the current bailout program. Others including the European Commission interpreted the referendum as whether Greece wanted to remain in the Eurozone. Although the question was not a direct question on whether Greece should default, the public was asked to decide on a matter usually reserved for high level ministers.

The outcome of the referendum was ''No" as it captured 61.31% of the votes. Soon after the referendum results, Greece proposed to the *troika* a bailout program that required less austerity measures. A week after the referendum Greece agreed to a bailout package that included larger tax increases and pension cuts than the one proposed by the Juncker Commission but future bailout loans included longer payment periods and lower interest rate. The ‘’No” referendum did not result in outright sovereign default nor exit of Greece from Europe as many feared. Given the post referendum results, the referendum was a negotiating tool and whether it was successful or not is unclear. However the referendum was a natural experiment on how different demographics saw the bailout issue. Although the implications of ‘’No” were unclear, the question posed had strong overtones of whether Greece should exit the bailout or not.

The referendum results are displayed in Figure 1. Some interesting features of the results are highlighted. First the younger voting groups heavily favored the ‘’No” vote and negative relationship between age and ‘’No” is apparent. The oldest age group 65 and over favored the ‘’Yes”. This seems odd since ‘’No” was a rejection for austerity measures such as pension reductions and increase in retirement age. The older age groups should favor policies that maximizes the pension, which at the time the ‘’No” referendum was more likely of the two to do so. Second there is negative relationship between wealth and ‘’No” vote. People facing financial difficulty voted 63% in favor of ‘’No” while 52.3% of the people who were living comfortably did. If the referendum was to hurt capital owners in terms of capital flows in and out of Greece or even exit from Europe as some feared, then it would seem rational that capital holders vote for the status quo, which would have been a‘’Yes” on the referendum.

The vote to default model was inspired by the Greek debt crisis and the political drama that unfolded. The Greek debt crisis and the referendum that followed showed elected officials should take into account the distribution of their constituents if they plan to carry out the will of the people, which may differ significantly than maximizing the benefit of the country. The model is an attempt to analyze the distributional effect on sovereign default vote similar to the Greek referendum of 2015.

Greek Referendum 2015 : "NO" voter demographics

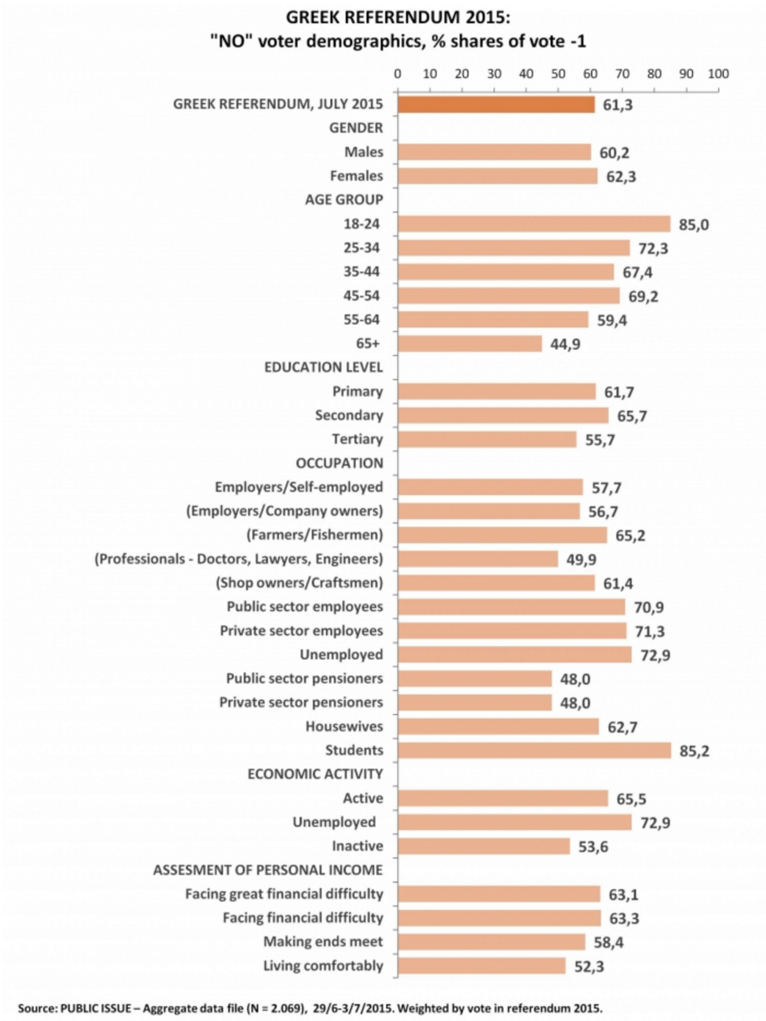

Figure 1: Referendum Results

3 Related Literature

3.1 Sovereign Default

The sovereign default decision at the core is a participation constraint. In the seminal work of Eaton and Gersovitz (1981) defaults occur if the value of autarky is greater than the value of being in good standing with the creditors. The model is the workhorse of many sovereign default models. Their model in recursive form is:

$$V^D(y_t) = \mathbb{E}\sum_{t=0}^{\infty}\beta^t U(y_t^a) \tag{1}$$

$$V^R(y_t, d_t) = \underset{d_{t+1}}{max}\, U(y_t + d_{t+1} - (1+r)d_t) + \beta\mathbb{E}\, max[V^R(y_{t+1}, d_{t+1}), V^D(y_{t+1})] \tag{2}$$

Equation 1 is the value of defaulting. Under autarky the value of default is the infinite sum of discounted utility of autarky endowments denoted as y_t^a. Utility is derived from consumption, which under autarky is just the endowment each period. Equation 2 is the value of staying in the borrower/lender relationship. In an endowment economy, the value of being in good standing has two advantages. One because there is no method for savings in the domestic economy, the loans facilitate consumption smoothing. New loans denoted as d_{t+1} minus previous debt denoted d_t with added interest can augment consumption under no default. Second, the production or endowment under good standing is higher than under default. The punishment for default is $y_t^a < y_t$. The drop off in production may occur in the form of trade retaliation. Bulow and Rogoff (1989) include trade sanctions in the Eaton and Gersovitz (1981) framework to incorporate a more severe punishment than reputation costs alone.

Although lower output is associated with defaults, it is unclear whether defaults lower output for defaulters. In fact, it is even uncertain whether defaults occur during lower output periods according to Tomz and Wright (2007). They reveal in their study only 60% of defaulting countries in their sample defaulted when output was below the trend[1]. Levy-yeyati and Panizza (2006) looked at quarterly growth of defaulting countries and they find defaults are followed by economic growth. The loss in output precedes the default and the trough of the contraction occurs at the default episode. Although the empirical evidence indicate the penalty for default is unclear, the punishment clause is included in most models including this one as generating defaults under computer simulation is difficult without it.

[1] Their data was HP filtered

Beginning of each period, an endowment is realized from a stochastic process. After the realization of the endowment, the borrower decides to participate in the borrower/lender relationship if participation constraint $V^R(\cdot) \geq V^D(\cdot)$ is satisfied, which states that the value of paying off debt has to be better than being autarky. The value of staying in the borrower/lender relationship and value of default along with the constraint fully characterize the model.

First models to extend this framework to match the business cycle were Arellano (2008) and Aguiar and Gopinath (2006). I will focus on the Arellano (2008) as their models are very similar. Arellano (2008) is able to match many empirical moments by adding a pricing kernel and endogenous autarky value.

$$V^o(y_t, d_t) = max[V^R(y_t, d_t), V^D(y_t^a)] \tag{3}$$

$$V^D(y_t) = U(y_t^a) + \beta \mathbb{E}[\theta V^R(y_{t+1}, 0) + (1-\theta)V^D(y_{t+1}^a)] \tag{4}$$

$$V^R(y_t, d_t) = \max_{d_{t+1}} U(y_t + q(d_{t+1}, y_{t+1})d_{t+1} - d_t) + \beta \mathbb{E} V^o(y_{t+1}, d_{t+1}), \tag{5}$$

where θ is exogenous probability of re-entering the lending markets and $q(\cdot)$ is the price of bonds.

Equation 4 is the analog of equation 1, except here the lender has some exogenous probability of re-entering the debt markets with zero debt. The exogenous re-entry is used because defaulting countries return to debt markets soon after they default. Some models such as Yue (2010) replaces the exogenous re-entry with debt renegotiation between creditors and debtors in a Nash bargaining setting. Kletzer and Wright (2000) show how the borrower lender relationship is sustainable even without penalties and exogenous re-entry if both parties have limited commitment. In this model the borrower lender relationship is characterized by consumption smoothing. The lender pays the borrower in low endowment periods and the borrower repays during high endowment periods. If the borrower defaults and tries to re-establish such a state contingent relationship with a new lender, the original lender has the option to "cheat the cheater". The model illustrates how the borrower and original lender can continue to sustain a relationship even if the borrower defaults.

Equation 5 is the analog of equation 2. The innovation here is that by using a pricing kernel of bonds $q(d_{t+1}, y_{t+1})$, she is able to construct a Laffer curve for which the price of bonds drop as country incurs higher debt.[2] The bond prices satisfy the zero profit conditions

[2] Laffer curve here refers to the notional amount the government can borrow $q(\cdot) \times d_{t+1}$.

of the lenders that is they do not earn more than the risk free rate in expectations. Price of the bonds satisfy

$$q(d_{t+1}, y_{t+1}) = \int_{y \in def} \frac{1 - f(y)dy}{1 + rf}. \tag{6}$$

The bond prices are dependent on the amount the country will borrow and the expected shock next period. In period 1, the country decides amount to borrow. In period 2, the country decides whether to repay the borrowed amount in period 1 taking into account the endowment realization of period 2. Therefore the bond pricing is a function of the amount the borrower this period and the expected endowment realization for next period. Every endowment realization that results in default decreases the price of the bonds by the probability of that realization, normalized to the risk free rate. If there are no events that cause defaults than the maximal price of the bonds is the inverse of the risk free rate. The borrower in Eaton and Gersovitz (1981) received 1 unit for every bond unit they borrowed and repaid the unit of bond with added interest. Arellano (2008) uses bonds that are discounted to reflect the probability of the country defaulting that mature to 1 next period. Arellano (2008) model will be the basis for the government problem in the vote to default model.

3.2 Politics and Sovereign Default

Defaults are very much a political process. When elected policy makers have the authority to decide whether a country repays their debt, the decision process is as much political as economic. Borensztein and Panizza (2008) document the possible political costs associated with defaults. They find the executive branch turn over is twice as high after a default. They find similar results for finance ministers after a default. Livshits et al. (2014) find similar results but they are unable to statistically conclude defaults are associated with higher executive turnover.[3] Both studies imply the end of tenure for the current finance ministers when defaults occur during their office. The following section will present some models that try to incorporate a political element to sovereign default decision.

Aguiar and Amador (2011) incorporates political element to sovereign default by adding political turnover to the default decision. The incumbent party prefers higher consumption during their incumbency therefore discount the future by the discount rate and the probability of winning re-election, which is exogenous. Cuadra and Sapriza (2008) develop a two

[3] Note in most models, where politicians maximize length of office, tying defaults to office turnover generate no or few defaults since the cost of default is too high.

party model within the framework of Eaton and Gersovitz (1981). The two parties represent two different types of representative agents in the model. As in Aguiar and Amador (2011) political turnover occurs with exogenous probability. The party in office tries to maximize the utility of the population, weighting one group more than the other. In both models, the political uncertainty and preference to increase consumption during incumbency sustain debt and produce defaults.

Guembel and Sussman (2009) formulate a model in which the sovereign cannot discriminate between domestic and foreign lenders. In their setup, the median voter prefers to debt enforcement, therefore positive foreign debt can be sustained in the absence of any punishment. In contrast to the previous models, the model provides an endogenous political process. The main element however is the inability to discriminate between foreign and domestic debt holders. This idea is formalized in Broner et al. (2010). In this model, the governments debts are traded on secondary exchanges in which domestic and foreign citizens can purchase/sell original debt. In their model, there is no political process, but the model highlights the inability to discriminate between foreign and domestic lenders sustain positive foreign debt.

The heterogeneity in the previous models occurred with respect to parties, individual types or idiosyncratic shocks they faced. Tabellini (1991) models domestic debt distribution within a two period overlapping generation model. Similar to social security, government supplements the income of old with taxes on wage receipts and debt. The young and the old vote on a tax rate. In his model, the young with inheritances and wealthy elders form a coalition to repay debts. The model highlights the different objectives of the young and old, as old wish to maximize the wage tax in order to collect higher pension and the young wish to minimize their tax burden. The vote to default model will explore the two different objectives of the young and old in a sovereign default setting.

Tabellini (1991) and Guembel and Sussman (2009) explicitly use the median voter theorem to analyze the models. Median Voter Theorem developed by Black (1948) is often used in analysis of public choice models. If the median voter exists, then the median voter will decide the policy. However the existence of the median voter is not guaranteed. It is not a certainty the median voter exists, especially if the election turnout is less than 100%. It is also not useful when policy dimension is more than one. In the two dimensional case, median voter can only exist if the population distribution is perfectly symmetric, McKelvey (1979). The vote to default model will have to explicitly sum the votes of the created population since the median voter theorem does not apply.

3.3 Heterogeneous Agents

In the seminal work , Auerbach and Kotlikoff (1987) fiscal policies are analyzed using a multi period overlapping generation model. In an overlapping generation model, each generation has their own budget constraint. Each of these are dynamically linked by capital holdings that carries over each period that is an agent carries over to next period, what she saves this period. The model equations are

$$\max_{k^1_{t+1},k^2_{t+1},\ldots,k^{G-1}_{t+1}} \sum_{s=1}^{s=G} \beta^{s-1} U(c^s_t) \tag{7}$$

$$k^{s+1}_{t+1} = (1+r_t)k^s_t + (1-\tau_t)w_t n^s_t - c^s_t, \quad s = 1, 2, \ldots R-1 \tag{8}$$

$$k^{s+1}_{t+1} = (1+r_t)k^s_t - c^s_t + pen_t, \quad s = R, R+1, \ldots G-1 \tag{9}$$

$$k^G_{t+1} = 0 \tag{10}$$

$$K_t = \sum_{s=1}^{G} k^s_t \tag{11}$$

$$N_t = \sum_{s=1}^{R-1} n^s_t \tag{12}$$

An agent maximizes their lifetime utility, which is the utility from age 1 to age G. During the work years, which is age 1 to $R-1$ they have wage income. During their retirement years, they no longer work but collect pension. Once the agents reach the age G, they do not save anything since they will not survive beyond this age. Equations 11 and 12 are the market clearing conditions. Total capital in the economy is the sum of each generations' capital holdings and total labor in the economy is the sum of the labor hours provided by the generations that work. Market prices r_t and w_t reflect the aggregate holdings of capital and labor. Auerbach and Kotlikoff (1987) model naturally creates a wealth distribution with respect to age as agents save for their retirement. In these type of models, a hump shaped age-wealth profile is generated as agents start and end with 0 wealth with the peak occurring at at age of retirement.

The model of Auerbach and Kotlikoff (1987) is deterministic as there are no stochastic processes in the model. The vote to default model will have two stochastic processes: idiosyncratic and aggregate. Models with idiosyncratic shocks create a wealth distribution that must be accounted when determining the aggregate capital in the economy. In an endowment setting as in Huggett (1993) or in production economy Aiyagari (1995), the distribution of wealth converges to a stationary distribution and the aggregation occurs with respect to the stationary distribution of wealth.

$$K_t = \sum_{i=1}^{2} \int_0^{\infty} af(i,a)da \tag{13}$$

Equation 13 is the analog of the equation 11 in Auerbach and Kotlikoff (1987). The distribution is with respect to individual type denoted i, which can be employment status or productivity type and a, which is her savings or wealth.

In order to apply a heterogeneous agents in a sovereign default setting, aggregate shocks are needed. If state contingent claims exist, there would be no need for foreign bonds to smooth consumption without the presence of aggregate shocks[4]. Smith and Krusell (1998) numerically solve a model with unemployment shocks and aggregate shocks. If the model is solved using first order conditions, agents will neeed to know factor prices for next period which appear in the Euler equation. However the factor prices for next period will be dependent on the agent's capital choices today. The law of motion for aggregate capital stock becomes a state and is endogenous. In their model, they are able to use a linear law of motion for aggregate capital, in which agents' capital savings are consistent with the evolution of aggregate capital. Heer and Maußner (2011) apply the Smith and Krusell (1998) algorithm to an overlapping generations with idiosyncratic shocks and aggregate shocks. Their model is the basis of the household problem in the vote to default.

The models of Arellano (2008) and Heer and Maußner (2011) are computationally expensive. Models with participating constraint are not easily characterized by the first order conditions. Also note equation 3, which is the maximum of the default and no default will be a kinked function. Accurate numerical approximations of kinked functions are difficult and the difference between value of default and no default are quite small analogous to welfare loss being small in real business cycle models. OLG models are also computationally challenging. Solutions to OLG model entail solving difference equations in the order of the number of generations in the model. Finally the stochastic elements included in the model augment the already enlarged state space. The vote to default model will try overcome these computational difficulties.

[4]With lower discount factor than the world, foreign bonds will be demanded to tilt consumption forward but would not generate defaults

4 Numerical Exercises

4.1 Endowment Economy

The endowment economy model of Arellano (2008) is more detailed as it serves the basis for the government problem. The small open economy faces a bond pricing schedule that is decreasing in the amount of outstanding debt $\frac{dq}{dd} < 0$ and increasing in the endowment $\frac{dq}{dy} > 0$. If the lenders are restricted to zero profits, then the lenders will earn the risk free rate in expectations. The price of bonds for any given state will be the expected probability of no default normalized to the risk free rate.

$$q(d_{t+1}, y_{t+1}) = \int_{y \in def} \frac{1 - f(y)dy}{1 + rf_t}, \tag{14}$$

where $f(y)$ is the probability distribution of the endowment process and the integral is taken with respect to the endowment states that are expected to result in defaults.

The country borrows during low endowment periods and and repay the amount next period. For every unit they borrow, they receive the price of the bond $0 \leq p \leq \frac{1}{1+rf}$ and repay the unit borrowed next period at $p = 1$. If they decide not to default they can choose to borrow again. Capital inflow occurs if they choose to borrow an amount greater than the amount repaid $d_t < q(d_{t+1}, y_{t+1})d_{t+1}$.

Figure 4 shows the bond choices for given debt and high or low endowment. During low endowment periods, they are usually net borrowers. During high endowment periods, they borrow less than they did previous period resulting in capital outflows. As they carry forward larger debt balances, the bond price will fall 4. If the bond price is sufficiently low, even in low endowment periods, they will not be able to add to consumption today. If the drop in consumption is sufficiently large, the future value of staying in the relationship will not be enough to offset the consumption loss today, which will result in default. The decision to default increases consumption today at the price of future consumption smoothing.

There are two interesting features in the model that I wish to highlight. First the law of motion for the stochastic process, equation 9 is very important in the default decision. The endowment process has to be volatile enough for the borrower to repay debts. In the case of constant endowment, there will be no need for future consumption smoothing. In this case, the borrower will borrow the maximum in first period and default. Second, the default region predominantly lies in the area of low endowment and high debt 2. Note also the defaults do not occur when the country has a positive balance, that is when they are lenders. As the endowment process becomes less auto-correlated defaults can occur during high endowment periods. In the case of i.i.d. endowments even when the endowment is highest and marginal utility has the least decrease with debt service, the borrower will default if sufficiently in debt. Figure 3 right, shows the bond pricing schedule for an i.i.d. endowment process. The bond prices reflect the incentive for default in high debt regions regardless of the current endowment state.

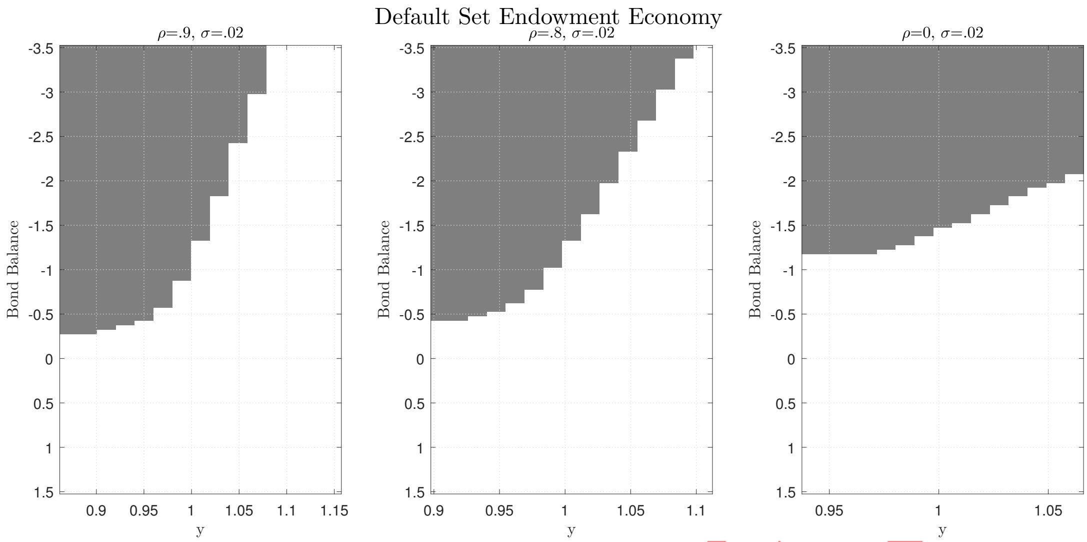

Figure 2: Default Set: Endowment Economy

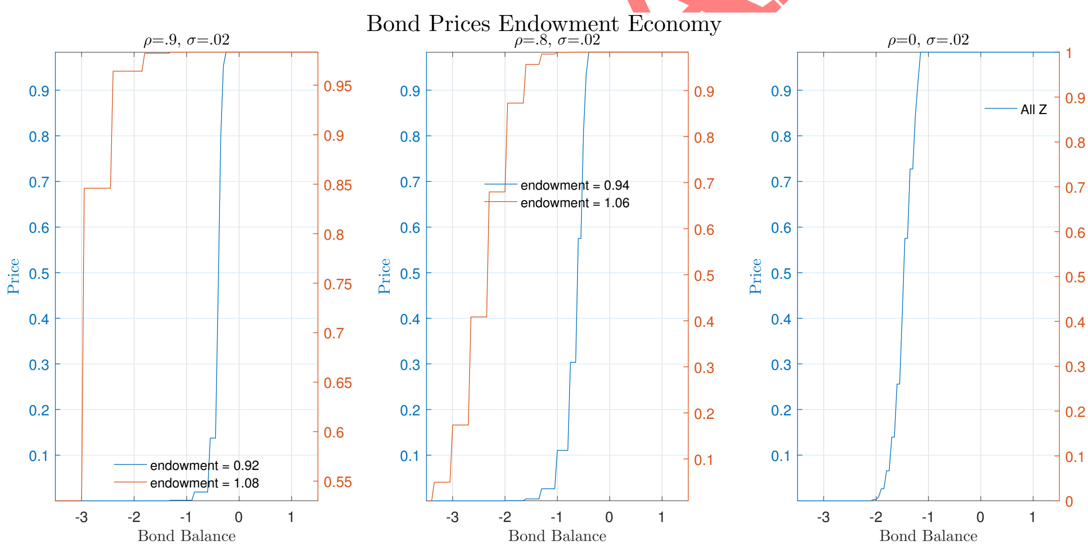

Figure 3: Price Schedule: Endowment Economy

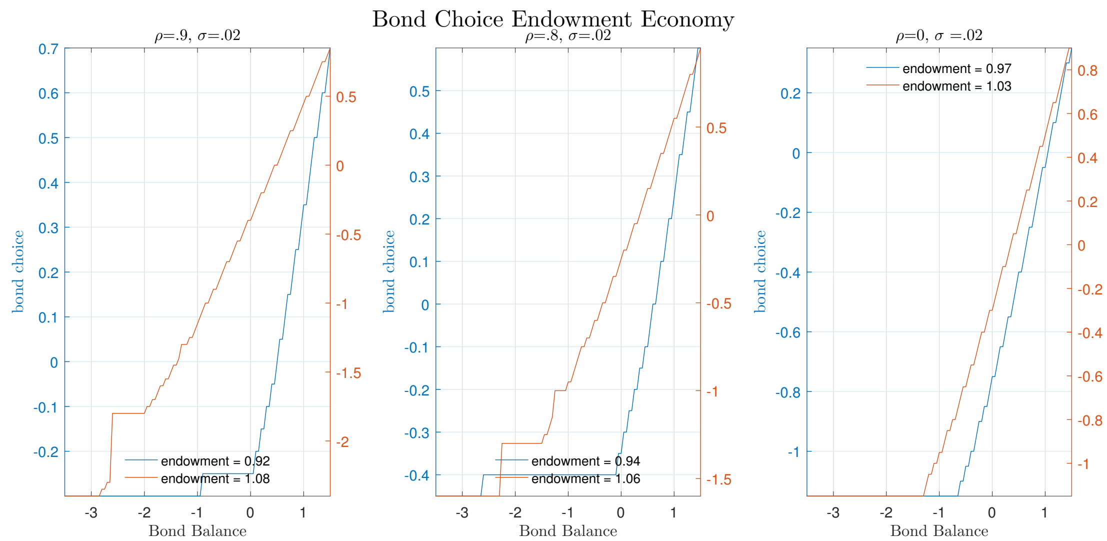

Figure 4: Bond Choice: Endowment Economy

4.2 Production Economy

In the production economy, capital stock adds a new state to the sovereign default problem. The value of default and no default are contingent on the capital stock today. The following equations summarize the model.

$$V_t^o(Z_t,k_t,d_t,k_t^a) = max[V_t^D(Z_t,k_t^a), V_t^R(Z_t,k_t,d_t)] \tag{15}$$

$$V_t^D(Z_t,k_t) = \underset{k^a_{t+1}}{max}\ U(c_t^a) + \beta \mathrm{E}[(1-\theta)\ V^D_{t+1}(Z_{t+1},k^a_{t+1}) + \theta V^R_{t+1}(Z_{t+1},k_{t+1},0)] \tag{16}$$

$$V_t^R(Z_t,k_t,d_t) = \underset{b_{t+1},k_{t+1}}{max}\ U(c_t) + \beta \mathrm{E} V^o_{t+1}(Z_{t+1},k_{t+1},d_{t+1},k^a_{t+1}) \tag{17}$$

$$c_t^a = (1-\tau_k)(r_t^a-\delta)k_t + (1-\tau_w)w_t^a n_t + k_t - k^a_{t+1} \tag{18}$$

$$c_t = (1-\tau_k)(r_t-\delta)k_t + (1-\tau_w)w_t n_t + k_t - k_{t+1} - d_t + q(k_{t+1},d_{t+1},z_{t+1})d_{t+1} \tag{19}$$

$$Y_t(Z_t,k_t,n_t) = Z_t k_t^{\alpha} n_t^{1-\alpha}; r_t = MPK; w_t = MPL \tag{20}$$

$$Y_t^a(Z_t,k_t,n_t) = \psi Z_t k_t^{\alpha} n_t^{1-\alpha}; r_t^a = MPK; w_t^a = MPL; \psi < 1 \tag{21}$$

$$Z_t = \phi Z_{t-1} + \sigma \nu_t; \nu_t \sim N(0,1) \tag{22}$$

The value of default equation 16 is a dynamic problem as savings for next period needs to be chosen. The value of no default equation 17 has two controls, capital and debt. As before, default forces lower output for all time periods ($\psi < 1$ in equation 21). Autarky states and prices are denoted with superscript a. The capital choice for next period k_{t+1} will be different whether the country is in autarky or not as the law of motion for capital differ.

Therefore when evaluating whether to default or not, optimal capital choices for default and no default will be needed to evaluate equations 16 and 17. Note both value of default and no default have the same state of capital stock today. What is different is the capital stock choice next period under default or no default. The bond pricing kernel is now dependent on three states: capital choice this period, bond choice for this period and the expected technology shock next period. But as before, the bond price will reflect the probability of no default under chosen capital stock and bond, normalized to risk free rate.

The problem ignores labor choices and assumes the labor in inelastic. As in business cycle models, elastic labor supply will help propagate shocks. In the problem of sovereign default, the propagation of shocks increases the volatility of capital stock and adds an extra control to the model, which are both difficult to deal with in terms of computation. In order to make the model more tractable labor choice was simplified.

In the endowment economy, there existed no storage technology other than foreign bonds. In a production economy, the capital stock is the main source of consumption smoothing. Access to foreign bonds allows the small open economy to smooth their consumption in conjunction with capital savings and build their capital stock faster. Given lower time preference, the capital stock of the small open economy will be low enough to offer high rental returns. If the implied interest rate by the sovereign bonds are lower than the net rental return on capital, there will be opportunities for the country to use the available bonds to add to the capital stock. Equation 23 is the criteria in which the implied sovereign bond intrest rate is lower than the net capital rental return.

$$(1-\tau_k)(\alpha z_t k_t^{\alpha-1} n_t^{1-\alpha} - \delta) > \frac{1}{q(k_{t+1}, d_{t+1}, z_{t+1})}, \tag{23}$$

where τ_k is capital tax rate and δ is depreciation rate.

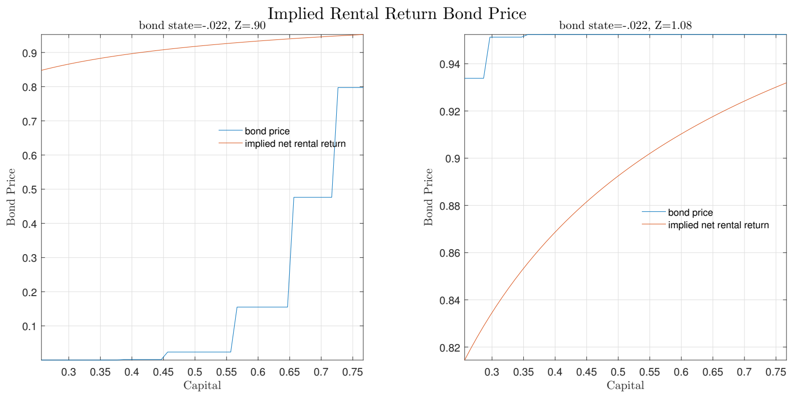

Figure 5: Investment Opportunities

Figure 5 shows the bonds pricing schedule (blue) for two cases, left low technology shock and right high technology shock. The bond prices implied by net capital rental rates are noted in red. In the case of high technology shock, the implied bond prices by net capital rental rates are lower than the sovereign bonds. In this case, the country can borrow and invest the loan proceeds in to their capital stock. Higher the gap between the implied bond prices of sovereign bonds and net capital rental rate, the probability of the investment yielding profits increases. Increases in the capital stock will increase the implied bond prices as the capital returns are lower and fewer opportunities will exist for using bonds to invest in capital. The production economy has an an investment channel which the endowment economy lacked. Before the country borrowed during lower endowment periods 4. In a production economy, the country will borrow in high endowment periods as well given there are investment opportunities. Production also reduces the need for sovereign bonds to smooth consumption. As in the endowment economy, the law of motion for the stochastic process in this case for technology shock is important.

The default set given low debt is depicted in Figure 6 top row. In the case of low capital stock, the default set shrinks as technology shock become less auto-correlated. Low capital stock and high technology shock implies high rental returns but with higher auto-correlation, the reliance on sovereign bonds decrease as higher future production becomes more likely with higher auto-correlation. The ability to consumption smooth using capital stock makes it more attractive to increase to consumption today and forgo the debt service. When capital stock is lowest, consumption is so low, even small additions to consumption will increase marginal utility significantly to make default a more attractive option than servicing debt.

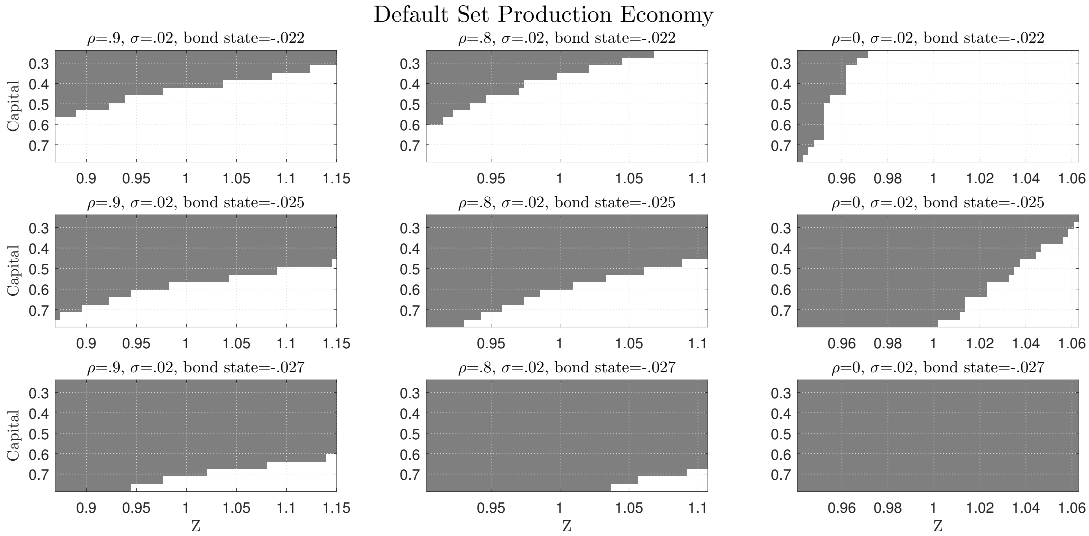

Figure 6: Default Set: Production Economy

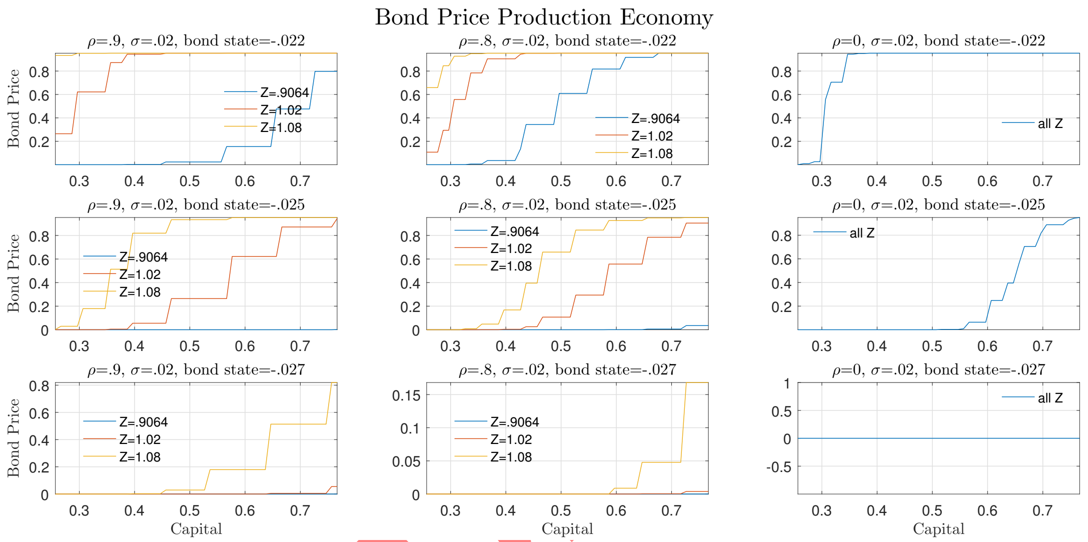

Figure 7: Bond Price: Production Economy

As capital stock increases, default set shrinks as the debt service has smaller effect on marginal utility today. But if the debt is too large, default option is better even with large capital stock. The pricing of the bonds reflect this as bond prices increases with capital stock 7. Bond choices when capital stock is large are smaller than when capital stock is small. Higher capital stock allows more consumption through production so less borrowing is needed. But as the technology shock increases, borrowing increases as bonds can be used for investment if rental returns are sufficiently high and high bond prices make cheap borrowing more attractive.

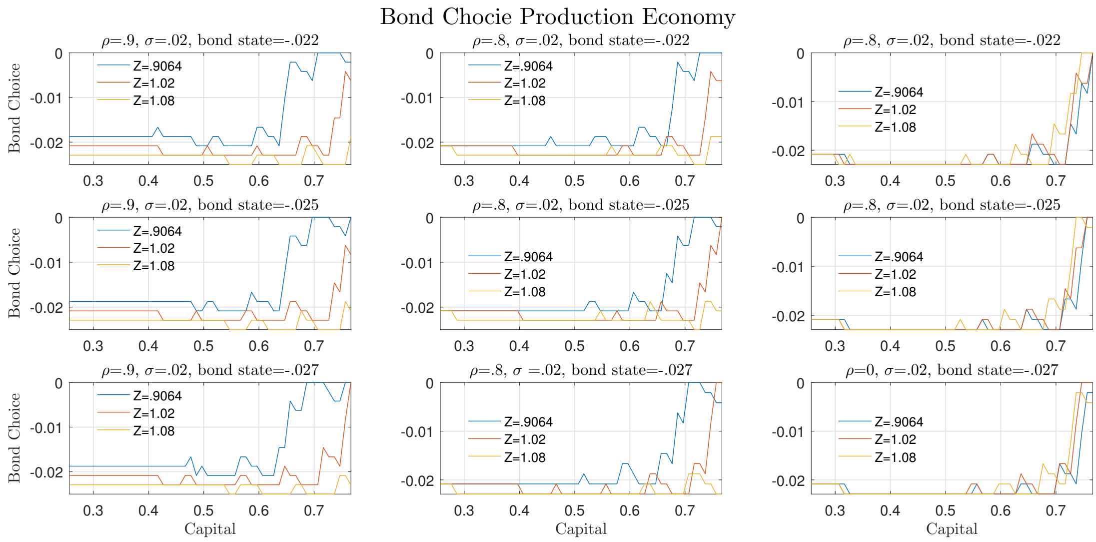

Figure 8: Bond Choice: Production Economy

4.3 Heterogeneous Economy and Voting

In this model, majority voting by the households will make sovereign default decision. Previously the government decided to default or not by comparing the value of default and no default for a representative agent. To create a distribution of votes, multiple agents will be needed. An overlapping generations framework will be used because the distribution with respect to age and wealth is of interest. In a static overlapping generations model, aging naturally creates a wealth distribution. Households accumulate capital for their retirement during the working years and deplete their savings during retirement. In order to create a more rich wealth distribution, Smith and Krusell (1998) variant of the overlapping generations model will be used.

There are high and low productive households. Each type faces a highly persistent idiosyncratic productivity shock that is either high or low. Each household lives up to a maximum age G[5]. In this economy, there is no population growth. Each year, unit mass of households are born. Each year the households face a survival probability of $\phi(s)$, which is age s dependent. For example the new born households survive to year 2 with probability $\phi(1)$[6]. The households will therefore have to discount their future value by the discount rate β and the probability of surviving to next age $\phi(s)$. There are three distinct phases of a household. First is the last age $s = G$. If the household has survived to age G, then the

[5]In the model, G is set to 30.

[6]Survival probability is inferred from the Social Security Administrations Actuarial Life Table for United States 2015.

capital choice and the value next period regardless of default or not is 0 since they can not live past this age. Second is their retirement period excluding the last year of retirement. During the retirement period, their source of income are social security, which is funded by a tax on wages, return on their capital savings and distribution of net loan receipts from the government, which can be negative if there is capital outflow. The last phase is their working years, ages 1 to $R-1$. During the work years, their sources of income are wages, return on capital savings and distribution of net loan receipts from the government.

$$\begin{aligned} &V_t^{o,s}(Z_t, k_t^s, k_t^{a,s}, e_t, i, K_t, K_t^a, B_t) = \\ &\quad max\ [V_t^{D,s}(Z_t, k_t^{a,s}, e_t, i, K_t^a), V_t^{R,s}(Z_t, k_t^s, e_t, i, K_t, B_t)] \end{aligned} \tag{24}$$

Equation 24 is the analogous to equation 15 but there are additional state variables. Lower case variables denote individual states and upper case denote aggregate states. The value for default and no default have age s superscripts since these will be dependent on age. Individual capital stock also have age superscripts since these choices are age dependent. Idiosyncratic shock that is either high or low is denoted e_t. Household productive type that is either high or low is denoted i. Aggregate capital stocks are denoted K_t and K_t^a. Government's dispersion of net loan receipts is denoted $B_t = q(\cdot)D_{t+1} - D_t$.

$$\begin{aligned} V_t^{D,s}(Z_t, k_t^s, e_t, i, K_t, K_t^a) = &\max_{k_{t+1}^{a,s+1}} U(c_t^{a,s}) + \beta \mathrm{E}[(1-\theta)\, V_{t+1}^{D,s+1}(Z_t, k_{t+1}^{a,s+1}, e_t, i, \\ &K_{t+1}, K_{t+1}^a) + \theta V_{t+1}^{R,s+1}(Z_{t+1}, k_{t+1}^{s+1}, e_t, i, K_{t+1}, 0)] \end{aligned} \tag{25}$$

$$\begin{aligned} V_t^{R,s}(Z_t, k_t^s, e_t, i, K_t, B_t) = &\max_{k_{t+1}^{s+1}} U(c_t^s) + \\ &\beta \mathrm{E} V_{t+1}^{o,s+1}(Z_{t+1}, k_{t+1}^{s+1}, k_{t+1}^{a,s+1}, e_t, i, K_{t+1}, K_{t+1}^a, B_{t+1}) \end{aligned} \tag{26}$$

$$\begin{aligned} c_t^{a,s} = &(1-\tau_k)(r_t^a - \delta)k_t^s + (1-\tau_w)(1-\tau_s)w_t^a n_t \Gamma(i, \epsilon_t, s)\mathbb{1}_{s \leq R} \\ &+ k_t^s - k_{t+1}^{a,s+1} + (1-\tau_k)ss_t^a \mathbb{1}_{s>R} \end{aligned} \tag{27}$$

$$\begin{aligned} c_t^s = &(1-\tau_k)(r_t - \delta)k_t^s + (1-\tau_w)(1-\tau_s)w_t n_t \Gamma(i, \epsilon_t, s)\mathbb{1}_{s \leq R} \\ &+ k_t^s - k_{t+1}^{s+1} + B_t + (1-\tau_k)ss_t \mathbb{1}_{s>R} \end{aligned} \tag{28}$$

Equations 25 and 26 are the values under default and no default respectively. The continuation value for both values have aggregate state variables that are of next period.

Aggregate capital stock today is

$$K_t^a = \sum_{i=1}^{2} \sum_{s=1}^{G} k_{t,}^a(s,i) \tag{29}$$

$$K_t = \sum_{i=1}^{2} \sum_{s=1}^{G} k_t(s,i). \tag{30}$$

The aggregate capital stock is the summation of the capital holdings by the age groups and productivity types. During the retirement years, households productivity can be ignored since they do not have wage income. The aggregate capital stock for next period is needed to decide the individual capital choices for next period. Therefore the households will need to know the law of motion for aggregate capital stock under default and no default. Smith and Krusell (1998) parametrize the law of motion for aggregate capital stock with a linear form using current state variables. For this problem, I use a lookup table of that is dependent of current K_t, Z_t and D_t. The lookup table or law of motion needs to be sufficiently accurate such that $K_{t+1} = \sum_{i=1}^{2} \sum_{s=1}^{G-1} k_{t+1}(s,i) \pm tolerance$ [7].

The continuation value for no default is dependent on future net bond receipts B_{t+1}. This is determined by the government bond policy rule that is dependent on K_t, Z_t, and D_t. This will be further detailed under government problem.

Equations 27 and 28 are the budget constraints under default and no default. Under autarky, the income flows are capital rental returns after capital tax, wage receipts after social security and labor tax if households are working ($s \leq R$) and social security disbursements if retired ($s > R$). The gamma function $\Gamma(i, e_t, s)$ adjusts wages for households age s, productivity type i and the idiosyncratic shock e_t. The gamma function exogenously creates a wage-age profile that is hump shaped to capture the hump shaped wage-age profile in the data. The gamma function is normalized to one such that the mean wage of the population is w_t, the marginal product of labor. Under no default the budget constraint includes a flow of net loan disbursements, which can be negative if the government is notionally borrowing less this period than the loan repayment for previous period's borrowing. The social security payments are such that the receipts from the workings are distributed to the the retired and balances every period. In equations 31 and 32, $mass(i,s)$ denote the population of

[7] Due to default decisions which are binary, it is difficult to characterize the aggregate law of motion linearly. If domain of law of motion for aggregate capital lies on a bounded real line, then the default decision for the aggregate capital needs to be well characterized for this domain as well.

productivity type i and age s.

$$ss_t \sum_{s=R+1}^{G} mass(i,s) = \sum_{i=1}^{2} \sum_{s=1}^{R} mass(i,s)\tau_s w_t n_t \tag{31}$$

$$ss_t^a \sum_{s=R+1}^{G} mass(i,s) = \sum_{i=1}^{2} \sum_{s=1}^{R} mass(i,s)\tau_s w_t^a n_t \tag{32}$$

The model economy is taxed heavily. The τ_s, τ_k, τ_w is set to .2, .3, and .3 respectively. Greece economy is also taxed heavily. Social security tax is 28.5% for employers and 16.5% for employees with a cap of €5546, the maximum tax with-holdings[8]. The average tax rate for personal income is 18%[9]. The high taxes in the economy are used in order to limit capital accumulation in the economy. These high tax rates reduce income to invest but also lower future rental returns making investments less attractive. With lower taxes aggregate capital stock will increase/decrease significantly during high and low technology shocks respectively. This is problematic as volatile technology shocks are needed for default analysis. Taxation reduces the volatility of the aggregate capital stock, which allows for easier characterization for the law of motion for aggregate capital stock. A more suitable method for inhibiting capital growth is capital adjustment costs but I was unable to incorporate this feature into the model.

Given the states of the world, government bond redistribution plan and the future evolution of aggregate capital stock under default and no default evolve, the households will have the necessary information to decide whether their value is higher under default or no default.

The government problem is similar that of the production economy except the default decision is tabulated from votes. The government defaults if

$$\sum_{i=1}^{2} \sum_{s=1}^{G} \sum_{a=0}^{\bar{a}} mass(s,i,a) \in V^{D,s}(\cdot) > V^{R,s}(\cdot) > \frac{1}{2}, \tag{33}$$

where $\bar{a}$ is the upper limit of individual savings. If the mass of the population who favors default, that is their value of default is greater than that of no default, is greater than half, then the government defaults. Under default, debt redistribution B_{t+1} is zero. If the vote favors no default then the government solves the following problem equation 34. Solution to the government's problem is the policy function that maps the amount to borrow for given states of the world: K_t, Z_t, and D_t. The policy function determines the amount the

[8] https://www.oecd.org/ctp/tax-policy/Social-Security-Contributions-Explanatory-Annex-May-2015.pdf
[9] https://www.oecd.org/tax/revenue-statistics-greece.pdf

government wants to borrow to maximize stream of representative agent's utility. The net bond receipts B_t are of interest to the households which is $q(Z_{t+1}, K_{t+1}, D_{t+1})D_{t+1} - D_t$. The net bond receipts schedule is used by the households to evaluate the continuation value of no default $V_{t+1}^{r,s+1}$ which requires knowledge of next period's net bond receipts.

$$\begin{aligned} V_t^g(Z_t, K_t, D_t) = \underset{D_{t+1}}{max}\, & U(y_t - K_{t+1} + (1-\delta)K_t - D_t + q(Z_{t+1}, K_{t+1}, D_{t+1})D_{t+1}) \\ & + \beta \mathrm{E} V_{t+1}^g(Z_{t+1}, K_{t+1}, D_{t+1}) \end{aligned} \tag{34}$$

4.4 Heterogeneous Economy Equilibrium

The solution of heterogeneous economy is such that:

- Household choices satisfy the recursive formulation of their problem (equations 25 and 26) given evolution of future aggregate capital, net bond receipts and current states of the world.
- Aggregate capital stock is consistent with the sum of all the household capital savings (equations 29 and 30).
- Household decisions to default or not are such that the no profit condition of the lenders is satisfied.

$$q(Z_{t+1}, K_{t+1}, D_{t+1},) = \int_{z\in def} \frac{1 - f(z)dz}{1 + rf_t}. \tag{35}$$

4.5 Heterogeneous Economy Results

In this economy, default vote tally is the sum of all the households who benefit more under default. The simplest decision is for the the age G year olds who will not survive beyond current period. Their decision depends only upon the current period consumption. In the case of no default their non bond income, which consists of rental returns and pension, is higher pension due to the presence of output loss under default. If the bond disbursement is positive i.e. capital inflows, then their income is even higher. If the economy defaults, the rental returns and pension drop due to the output loss that occurs with default. However if there are capital outflows a default would increase consumption in the amount of foregone debt service. Households of age G will not vote for default in any states in which the government provide positive bond disbursements.

Proposition 1. *Households of age G will only vote default iff* $B_t < 0$.

Proof:

$$
\begin{aligned}
y_t &= (1 + r_t)k_t + ss_t \\
y_t^a &= (1 + r_t^a)k_t + ss_t^a \\
y_t &> y_t^a \quad \forall t \\
V^{R,G} = U(y_t + B_t) &< V^{D,G} = U(y_t^a) \quad iff \quad B_t < 0
\end{aligned}
$$

Corollary 1. *Households of age G will only vote default iff* $-B_t > (r_t - r_t^a)k_t + (ss_t - ss_t^a)$ *and the surplus from defaulting* $V^D - V^R$ *is decreasing in their capital for given* B_t

Proof:

$$
\begin{aligned}
V^{R,G} &= U((1 + r_t)k_t + ss_t + B_t) \\
V^{D,G} &= U((1 + r_t^a)k_t + ss_t^a) \\
V^{D,G} &> V^{R,G} \quad iff \quad -B_t > (r_t - r_t^a)k_t + (ss_t - ss_t^a)
\end{aligned}
$$

Proposition 2. *Let* $y_t = r_t^a k_t + ss_t$

Assuming, Cobb-Douglas production, for the retired, default decreases y_t *iff* $\tau_s \frac{\sum_{i=1}^{R-1} mass(i)}{\sum_{i=R}^{G} mass(i)}$

Proof: By properties of Cobb-Douglas wages and rental returns go down proportionately under default. Substitute the law of motion for social security equation 31 into equation for y_t *to finish the proof.*

Corollary 2. *Reduction in* y_t *for default is decreasing in aggregate capital stock.*

Proof:

Proposition 2 and property of Cobb-Douglas production, $\frac{dr}{dk} < 0$ *finish the proof.*

Figure 9 displays the surplus $V^R - V^D$ of households of age G for some states in which they prefer default. Figure 9 shows for low capital stock, households age G will vote default if they have low wealth. The high rental returns as a result of the low aggregate capital stock will increase the cost of defaults for households with assets. As aggregate capital stock increases, defaults are preferred for higher aggregate shocks. This is due to two reasons. First high aggregate shock lowers the reduction of rental returns due to default. Under low aggregate capital stock, the rental returns are higher making defaults costlier. Second combination of high aggregate shock and aggregate capital stock increase pension enough to offset the loss of rental income.

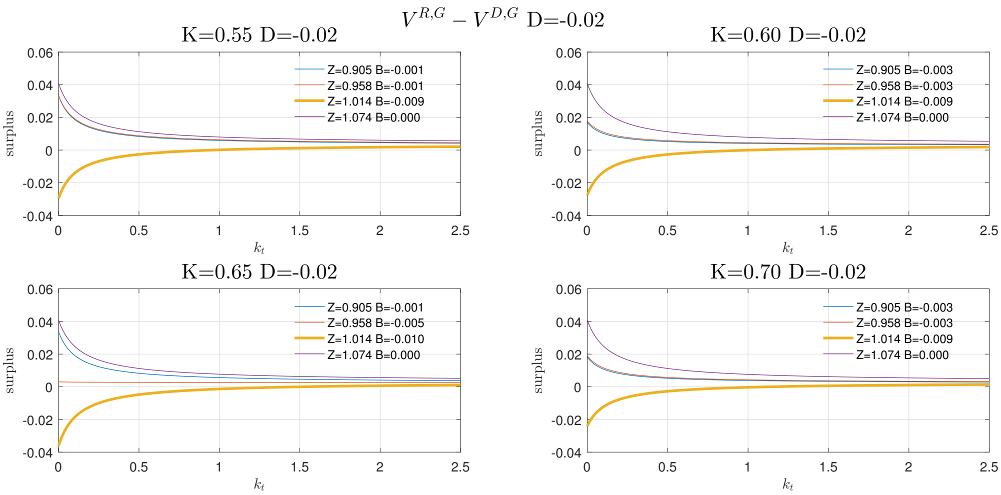

Figure 9: Surplus for Age G

In the case of the Greek referendum, increase in age implied a decrease in probability of ''No" vote. This could be reconciled with a model where production loss occurs with defaults and capital stock is sufficiently low and/or bond pricing schedule is decreasing in aggregate capital stock. A larger capital stock is induced by higher discount rate, which implies less dependence on foreign bonds due to less desire to tilt consumption forward. Less dependence on foreign bonds will make the borrower/lender relationship easier to sever.

For households that are retired of age less than G, their decision to default is dynamic. The increase in consumption current period from default will be offset by the future loss in pension. Future rental return are not necessarily decreasing. For most scenarios rental returns will be decreasing in future periods. The loss of production inhibits future capital accumulation for most periods. For sufficiently low capital stock and high technology shock, the rental rates can be higher next periods than an economy under good standing with same capital stock and technology shock but with some debt balance upper right 12. The higher rental rates can induce savings even though wages are lower. The lower wages however do not lower labor hours as there is no substitution between leisure and labor (inelastic labor supply). Figure 12 shows the comparison of aggregate capital stock for few interesting states. The aggregate capital stock under no default is perfectly horizontal for some debt. This is the result of economy being in default in those states, which implies bond prices will be zero. UR Figure 12 shows a slight increase in aggregate capital stock under default in this scenario.

For households of age $G-1$ and age R their surplus is plotted in Figures 10 and 11 respectively. For households of age R, the asset cutoff for default will be lower than that of households of age $G-1$ and age G. Less wealth is needed to favor default as they will experience lower rental returns for more periods. The age R and $G-1$ households prefer default for higher aggregate shock than the age G household. The high persistence of the stochastic process mitigates the loss of rental returns from default. The surplus from default is decreasing with age for the retired households. The reduction in rental returns in period 1 is mitigated by the higher returns following periods if aggregate capital stock is growing faster than under no default.

The retired in this economy prefer no default reconciling the correlation of lower ''No" with higher age in the Greek referendum. For retired households their preference to default is decreasing in wealth, which reconciles with the referendum results in the general dimension of wealth.

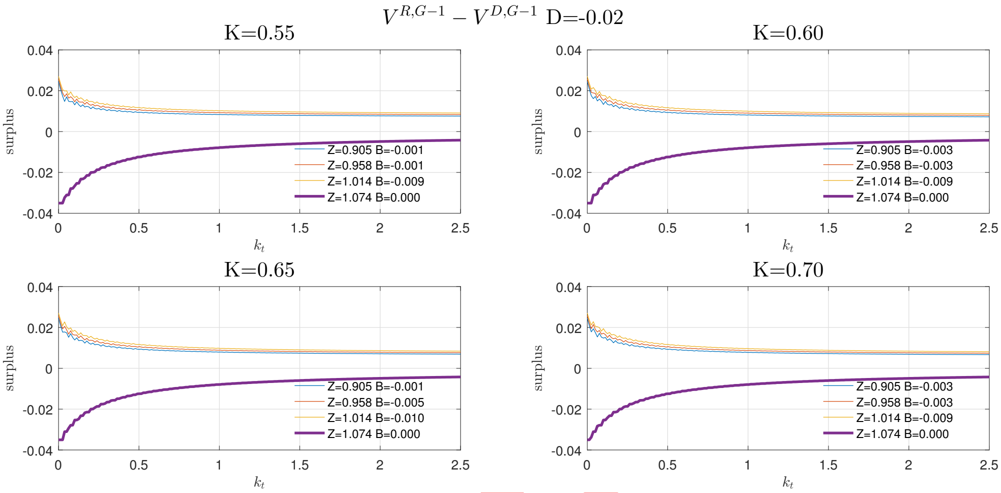

Figure 10: Surplus for Age G - 1

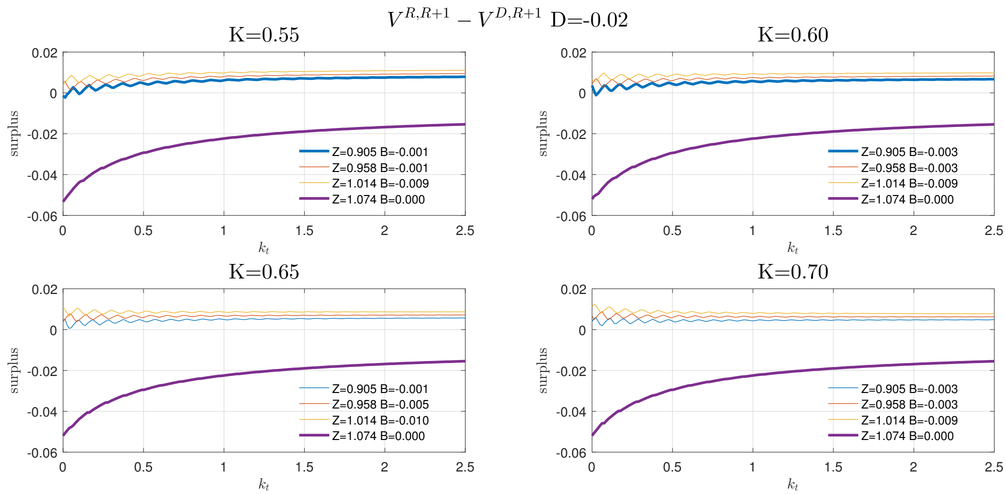

Figure 11: Surplus for Age R

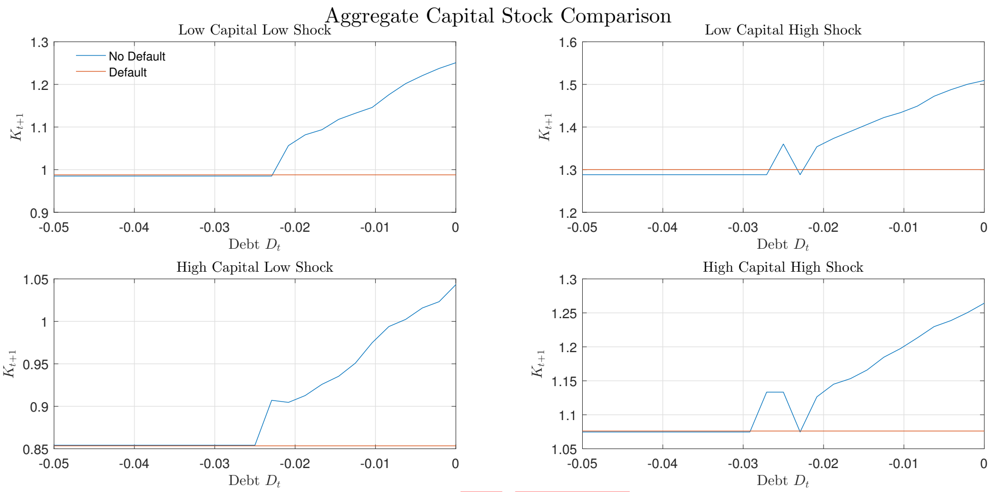

Figure 12: Evolution of Aggregate Capital

In the model economy the retirees account for less than 25% of the population. For the working, their analysis is more complicated as they have to take into account wage income, productivity type, and an idiosyncratic shock which are absent from the retirement problem. At birth, households start with zero wealth as there are no bequests in the model. For young households main source of income is wage as their rental income is low during early stages of capital accumulation. There are two types of households and two types of idiosyncratic shocks. Households that are low productive and experience low idiosyncratic shock are depicted in the UL of Figures 13, 14, and 15. These households have the largest surplus from defaults. Due to their low income, the foregoing of debt service increases marginal utility for the current period more than other types of households. As their wealth increases, the increase in consumption due to default will be less beneficial as they are trading off larger losses on their asset returns. Households that are either more productive or experience high idiosyncratic shock have smaller gain in marginal utility from the increase in current period consumption from default.

The working households prefer default more than the retired households for few reasons. First, the lower rental returns are the not as significant because young households have not accumulated much capital. Second, the lower income households gain larger marginal utility from foregone debt service. Whereas the retired are not differentiated by low and high productivity, half of the working households are low. These households have more to gain from foregone debt service. Although the working households generally favor default, note they also prefer no default with increase in wealth and income. Higher income implies a larger drop in wages due to production loss that occurs with default.

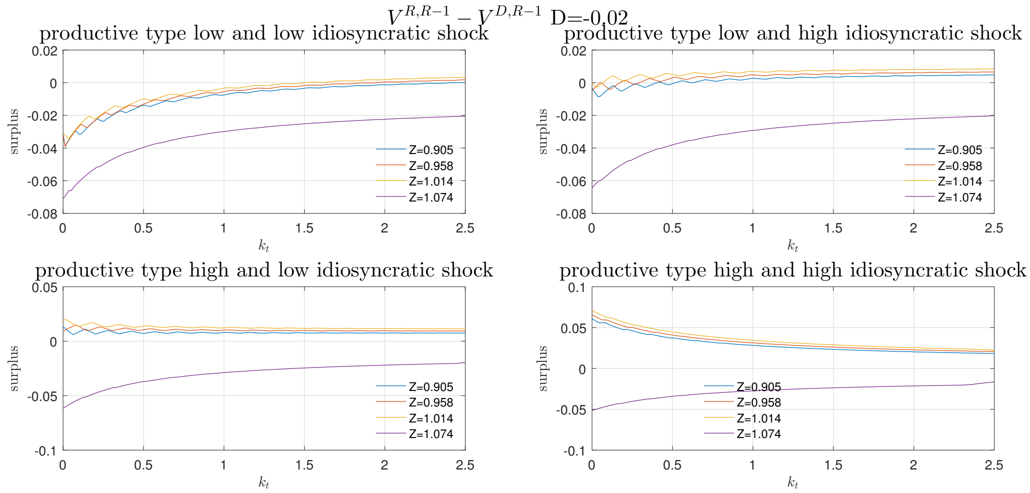

Figure 13: Surplus for Age R-1

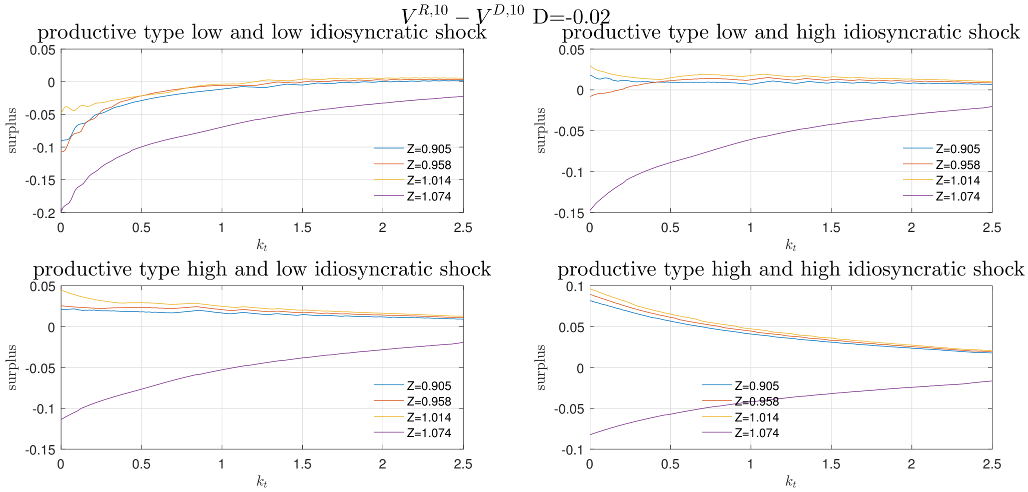

Figure 14: Surplus for Age 10

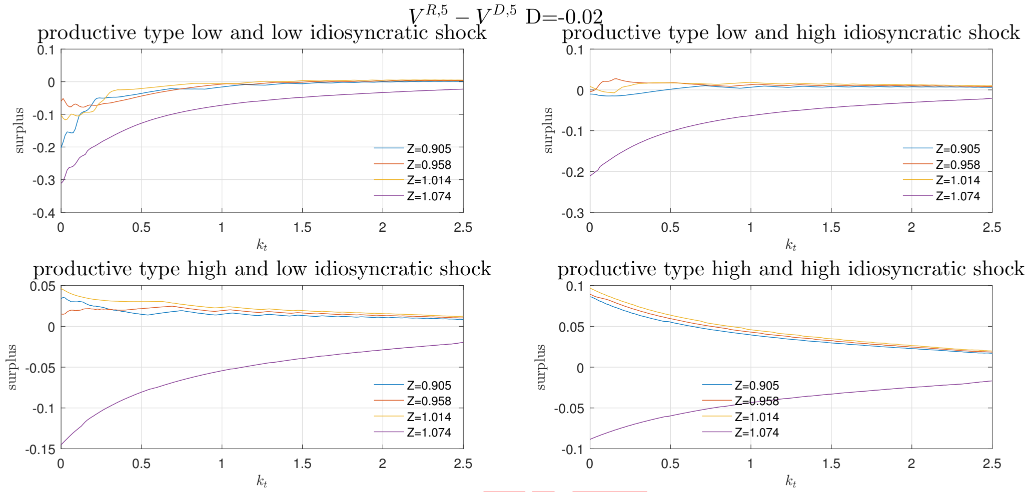

Figure 15: Surplus for Age 5

The model was unable to generate vote results for default that was similar in the range of Greek referendum $\sim 60\%$. A successful default vote was supported by more than 90% of the population. There were some many states in which the voters preferred no default by a margin of less than 10%. Following figures will explore the result of a vote favoring no default with slim margin. Figure 16 shows the proportion of the age groups that voted for default in the model. Under low capital stock and low aggregate shock, the young have a strong preference for default. The older working groups are less inclined to vote for default as they have accumulated wealth. The retirees favor no default in order to increase rental returns on their savings. Figure 17 shows the proportion of population that voted for default by wealth. There is a decreasing trend of vote share for default as wealth increases. Both figures are exhibit similar characteristics with the referendum results: vote share decreasing in age and in wealth.

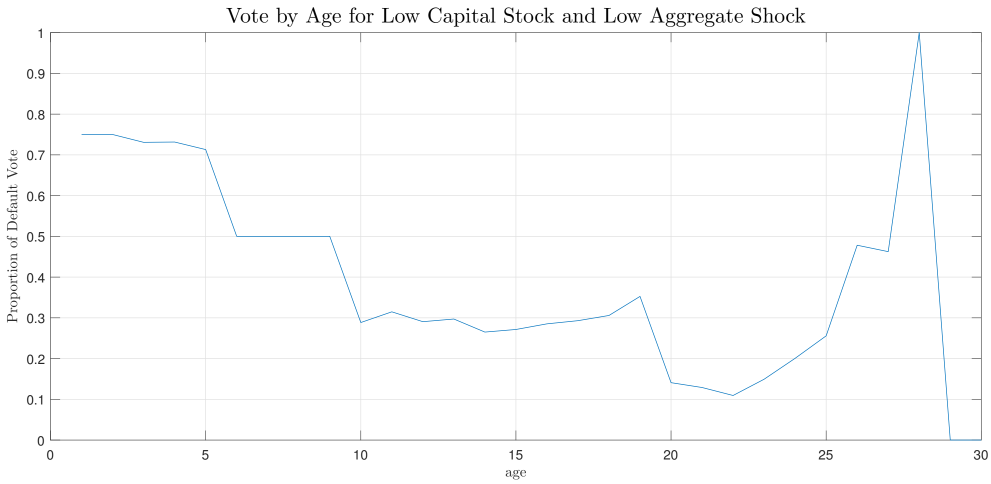

Figure 16: Vote by Age

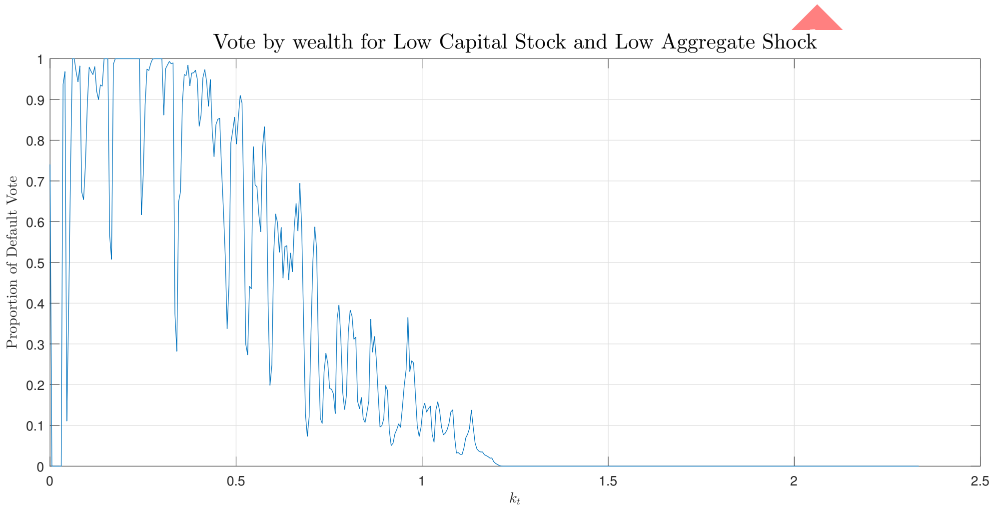

Figure 17: Vote by Wealth

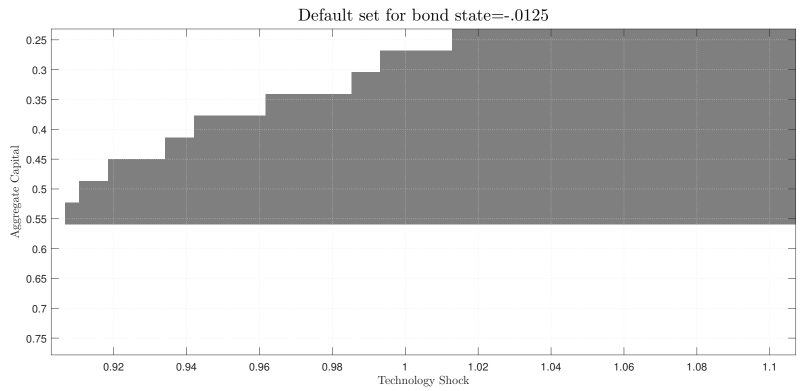

Figure 18: Default Set: Heterogeneous Economy

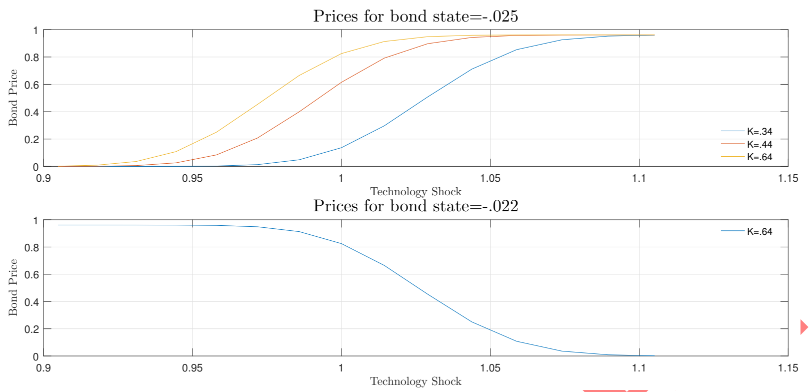

Figure 19: Bond Price: Heterogeneous Economy

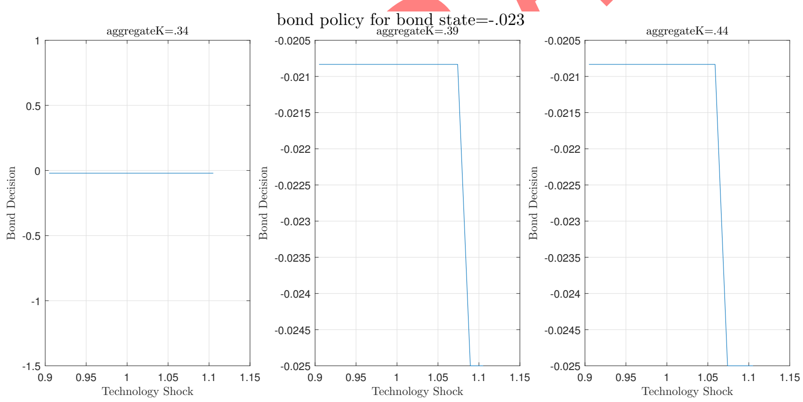

Figure 20: Bond Choice: Heterogeneous Economy

In the model the population had constant birth rate. Figure 21 shows the population density by age for the model economy. A model which exhibits a decreasing birth rate and an increase in survival probabilities a feature in most economies, the population will be older. The results the model imply an aging population is less likely to vote default as the aging population favors scenarios with higher returns on their savings.

The wealth distribution generated by the model is left skewed but does not exhibit high income inequality. The gini coefficient for the model is .4271 not too different from the actual value of .367[10]. The model implies an economy with more concentrated wealth i.e. higher proportion of the population with smaller assets is more likely to favor default.

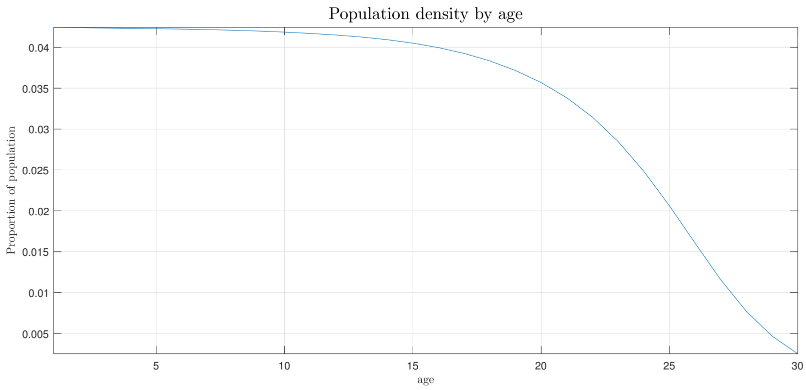

Figure 21: Population Density by Age

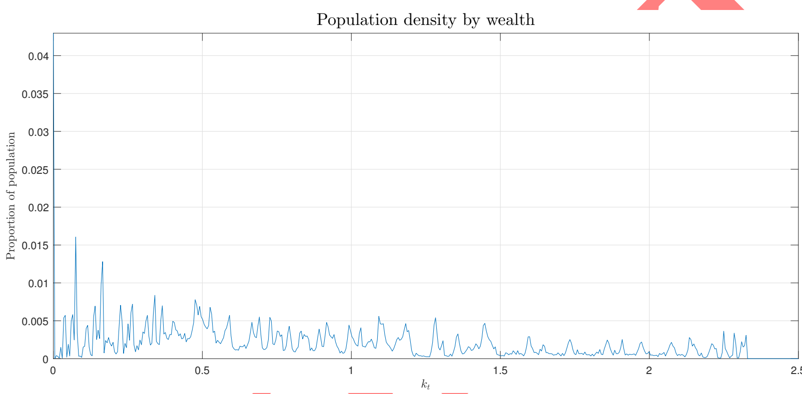

Figure 22: Population Density by Wealth

5 Conclusion

This chapter tried to model an economy with heterogeneous agents in Eaton and Gersovitz (1981) framework. By including age and mechanisms to propagate wealth distribution such as different productive types and idiosyncratic wage shocks, the distribution of wealth and age on sovereign default decision was studied. In similar fashion to the referendum results, the model showed decreasing vote share with wealth and age.

[10]http://data.worldbank.org/indicator/SI.POV.GINI?locations=GR

6 Appendix

The codes for the paper are hosted on https://github.com/slee126/votetodefault.

Calibration

Parameter	Description	Value
β	Discount rate	.95
δ	Depreciation rate	.1
α	capital share of output	.33
τ_w	wage tax	.3
τ_k	other income tax (pension and capital)	.3
τ_p	social security tax	.2
ρ^a	AR(1) persistence of stochastic aggregate process	.8
σ^a	standard deviation of stochastic aggregate process	.02
π^{hl}	Transition matrix for idiosyncratic process	$\begin{bmatrix} 0.9604 & .0396 \\ .0396 & 0.9604 \end{bmatrix}$
$i = l$	low productivity type wage share	.57
$i = h$	high productivity type wage share	1.43
$e_t = l$	low productivity shock wage share	.68
$e_t = h$	high productivity shock wage share	1.32
G	maximum age of household	30
R	age of retirement	20
n_t	inelastic labor provided	.33
θ	exogenous probability of re-entry to debt market	.3
ψ	production output multiplier under default	.969

Table 1: Calibrated values in the model

References

Aguiar, M. and Amador, M. (2011), “Growth in the Shadow of Expropriation,” *The Quarterly Journal of Economics*, 126, 651–697.

Aguiar, M. and Gopinath, G. (2006), “Defaultable Debt, Interest Rates and Current Account,” *Journal of International Economics*.

Aiyagari, R. (1995), “Optimal Capital Income Taxation with Incomplete Markets , Borrowing Constraints , and Constant Discounting,” *Journal of Political Economy*, 103, 1158–1175.

Arellano, C. (2008), “Default Risk and Income Fluctuations in Economies Emerging,” *American Economic Review*, 98, 690–712.

Auerbach, A. and Kotlikoff, L. (1987), “Dynamic Fiscal Policy,” *Cambridge University Press.*

Borensztein, E. and Panizza, U. (2008), “The Costs of Sovereign Default,” *IMF Working Paper.*

Broner, B. F., Martin, A., and Ventura, J. (2010), "Sovereign Risk and Secondary Markets," *American Economic Review*, 100, 1523–1555.

Bulow, J. and Rogoff, K. (1989), "A Constant Recontracting Model of Sovereign Debt," *Journal of Political Economy*, 97, 155.

Cuadra, G. and Sapriza, H. (2008), "Sovereign default, interest rates and political uncertainty in emerging markets," *Journal of International Economics*, 76, 78–88.

Eaton, J. and Gersovitz, M. (1981), "Debt with Potential Analysis Repudiation : Empirical Theoretical and," *The Review of Economic Studies*, 48, 289–309.

Guembel, A. and Sussman, O. (2009), "Sovereign debt without default penalties," *Review of Economic Studies*, 76, 1297–1320.

Heer, B. and Maußner, A. (2011), "The Burden of Unanticipated Inflation: Analysis of an Overlapping-Generations Model With Progressive Income Taxation and Staggered Prices," *Macroeconomic Dynamics*, 16, 278–308.

Huggett, M. (1993), "The risk-free rate in heterogeneous-agent incomplete-insurance economies," *Journal of Economic Dynamics and Control*, 17, 953–969.

Kletzer, K. and Wright, B. (2000), "Sovereign Debt as Intertemporal Barter," *American Economic Review*, 90.

Levy-yeyati, E. and Panizza, U. (2006), "The Elusive Costs of Sovereign Defaults," .

Livshits, I., Phan, T., and Trebesch, C. (2014), "Sovereign Default and Political Turnover (preliminary and incomplete)," .

McKelvey, R. (1979), "General Conditions for a Global Intransitivities in Formal Voting Models," *Econometrica*, 47.

Smith, A. A. and Krusell, P. (1998), "Income and Wealth Heterogeneity in the Macroeconomy," *Journal of Political Economy*, 106, 867–896.

Tabellini, G. (1991), "The Politics of Intergenerational Redistribution ," *Journal of Political Economy*, 99, 335–357.

Tomz, M. and Wright, M. L. J. (2007), "Do Countries Default in Bad Times? ," *Journal of the European Economic Association*, 5, 352–360.

Yue, V. Z. (2010), "Sovereign default and debt renegotiation," *Journal of International Economics*, 80, 176–187.

Zettelmeyer, J., Trebesch, C., and Gulati, M. (2013), "The Greek debt restructuring: An autopsy," *Economic Policy*, 28, 513–563.