Regulations on timing of sovereign credit ratings

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PRELIMINARY

Abstract
This paper studies the effect of the European Union regulations on sovereign credit ratings that came into force in January 2014, which require credit rating agencies to set up a calendar at the beginning of each year indicating when sovereign credit ratings might change for Member States. The regulations also state that deviations from the announced calendar should not happen routinely. I develop a model of sovereign default, private information and sovereign credit ratings to gain insight into the possible effects of these regulations. I show that if there is no cost associated with deviating from the calendar, whenever changes in the rating are not allowed, a country finds it optimal to deviate by soliciting a rating. In that case, the effect of the regulations is null. I also show that if there is a punishment associated with deviating from the calendar, a country may not find it optimal to solicit a rating whenever changes in the rating are not allowed. In this case, the regulations do have an impact on a country's economy. In a quantitative exercise calibrated to Greece, I find that the regulations would not have prevented Greece's default during the recent European sovereign debt crisis.

Keywords: Credit rating agencies, sovereign credit ratings, regulations, sovereign debt crisis
JEL classification: F30, G01, G24, H63

1 Introduction

Up until 2013 sovereign credit ratings could change at any time. During the recent European sovereign debt crisis, the European Parliament approved a series of regulations that placed restrictions on when sovereign credit ratings can be changed for EU countries. The regulations, which were implemented for the first time in January 2014, involve credit rating agencies (CRAs) publishing a calendar at the beginning of each year indicating the dates in which a country's sovereign credit rating might change due to an unsolicited rating[1] or a solicited rating[2]. The regulations also state that deviations from the announced calendar should not happen routinely.

A press release issued by the European Parliament immediately after the regulations were approved stated: *'Parliaments' negotiators ensured that sovereign debt ratings will not come out of the blue, at the most inappropriate times, by fixing three set dates per year when CRAs may issue them.'* The regulations come at a time in which many European economies have experienced an increase in the number of changes in their sovereign credit ratings. Figure 1 illustrates the average number of changes in the sovereign credit rating per year by Standard & Poor's for Cyprus, Greece, Ireland, Portugal and Spain. Although the regulations do in principle not restrict the annual number of changes in the sovereign credit ratings, they do certainly restrict the time at which sovereign credit ratings change.

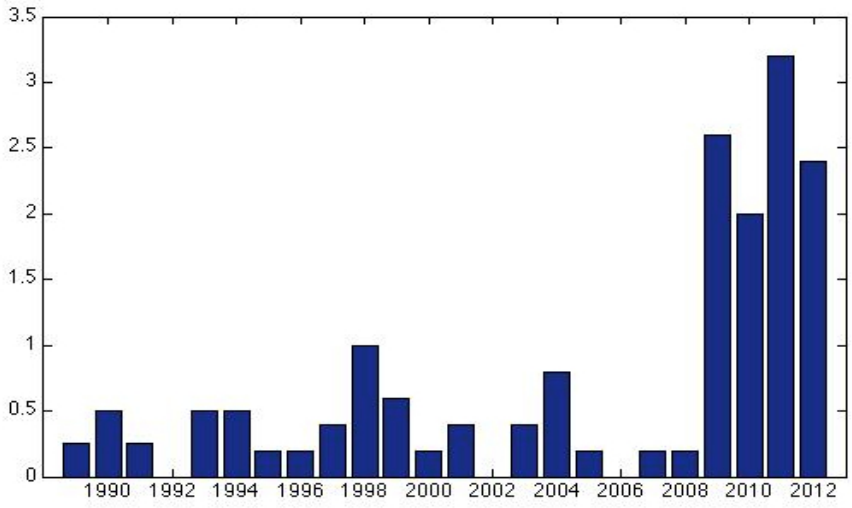

Figure 1: Average number of changes in the sovereign credit rating per year

This paper develops a model of sovereign default, private information and sovereign credit ratings. I present a model in which a country that receives a stochastic stream of income borrows from risk-neutral competitive lenders who do not know what the income realization of the country is. In this paper, sovereign credit ratings have the role of disclosing the country's probability of

[1]Unsolicited ratings are ratings that are neither requested nor paid for by the borrower.

[2]Solicited ratings are ratings which are requested and paid for by the borrower.

default through disclosing the country's income realization[3]. A solicited credit rating occurs when the country decides to disclose its income realization to the lenders whereas an unsolicited credit rating occurs when the income realization is exogenously disclosed to the lenders (without the country having requested it).

I compare the results of two models, one reflecting the situation before the regulations are implemented and another one which reflects the situation under the regulations. In the first model, changes in the rating are always allowed. I make the simplifying assumption that if changes in the rating are allowed in a given period, then the lenders get to know what the current income realization in that period is and therefore they know what the country's true probability of default in the next period is. Basically, we are assuming that whenever changes in the rating are allowed, there is either a solicited rating or an unsolicited rating. Given this assumption, in the model with no regulations there is perfect information. I also assume that the cost of soliciting a rating is zero. This implies that when changes in the rating are allowed, the country does not incur the cost of soliciting a rating.

By contrast, the model that reflects the situation after the regulations are implemented has periods in which changes in the rating are allowed and periods in which they are not allowed. The periods in which changes in the rating are allowed correspond to periods in which the calendar allows the rating to change whereas the periods in which changes in the rating are not allowed correspond to periods in which the calendar doesn't allow the rating to change. The calendar, in the model, is exogenous. As before, when changes in the rating are allowed lenders get to know what the current income realization is. However, when changes in the rating are not allowed, lenders may or may not know what the current income realization is. In such periods, the country may benefit from deviating from the calendar and soliciting a rating, i.e. the country may benefit from deviating from the calendar and disclosing its true probability of default to the lenders through disclosing it's current income realization. If the country decides not to solicit a rating in a period when changes in the rating are not allowed, then the current income realization is not disclosed to the lenders. In these cases, lenders compute beliefs over the current income realization given the information they have about the country (last period's income realization, the debt level, the amount of debt borrowed in the current period and the fact that the country didn't solicit a rating). While deviating from the calendar by soliciting a rating may have the benefit of disclosing the current income realization, it also has a cost. This cost can be interpreted as the punishment for having deviated from the calendar.

I calibrate the two models to Greece and I use them as a laboratory to evaluate the effect of the regulations. I find that if the cost of deviating from the calendar is zero, it is always optimal for the country to solicit a rating whenever changes in the rating are not allowed. Given any belief the lenders may have over the current income realization, if the country gets the highest income realization, it always prefers to deviate and solicit a rating as this gives the country an interest

[3]In this setting, the only private information is the country's income realization, so if this information is disclosed to the lenders, then the lenders can compute what the country's actual probability of default is.

rate lower or equal the one it would get if it doesn't solicit a rating. Therefore, if the country gets the second highest income realization, it again always prefers to solicit a rating. Repeating this argument, it becomes apparent that the country always prefers to deviate and solicit a rating. Hence, when the punishment associated with deviating from the calendar is zero the regulations have no effect.

This paper also finds that if there is a positive cost associated with deviating from the calendar, the country may not find it optimal to solicit a rating whenever changes in the rating are not allowed. In particular, the country has a higher incentive to solicit a rating when its income realization is relatively high. In this setting, the regulations do have an impact on the country's economy: the regulations induce a trade-off in terms of probability of default. As the European Parliament stated after the regulations were approved, ratings now do not come at the most inappropriate times. Basically, when changes in the rating are not allowed, if the country suddenly receives a relatively bad income shock it may be able to borrow at an interest rate which is lower than if there were no regulations, by not soliciting a rating. Therefore, the regulations may make it easier for the country to roll-over its debt, which will decreases its incentive to default. However, when changes in the rating are not allowed and the country borrows at a relatively cheap interest rate, the country tends to over-borrow. That makes the country more likely to default in the next period.

Finally, in an event analysis, I feed the actual GDP series into the model with no regulations. I find that the model predicts a default from Greece during the European sovereign debt crisis. I then feed the same GDP series into the model with regulations. I find that the regulations are not able to avoid the default. Moreover, the regulations do not create any additional default during the analyzed period either.

The literature shows that sovereign credit ratings have a significant impact on interest rate spreads and therefore, it seems likely that the regulations will have an impact on the economies of the regulated countries. Afonso, Furceri and Gomes (2011) find a significant response of interest rate spreads to changes in sovereign credit ratings in a sample of twenty four European countries. Reisen and Maltzan (1999) also arrive to the same conclusion by examining a sample of OECD countries which includes a few emerging economies. Several other works in the literature are related to my paper. In fact, the model that has no regulations, which involves a setting of perfect information, coincides with the model in Arellano (2008). Another related paper is d'Erasmo (2012), which introduces private information into a sovereign default model. In his paper, lenders can observe everything except for the government's type. The lenders then try to predict the government's type based on its borrowing and default decisions. In d'Erasmo's paper, a sovereign credit rating is defined as the probability of default, which depends on the observables and on the lender's belief about the government type. In d'Erasmo's setting it is not clear what it would mean to have a period with changes in the sovereign credit rating not being allowed. Similarly, the concepts of unsolicited and solicited sovereign credit ratings can't be defined. Another work related to my paper is Chatterjee, Corbae and Rios-Rull (2011) which develops a theory of credit score for consumers in a similar way as d'Erasmo (2012). Their paper defines the consumer credit score as

the consumer's probability of default, which depends on some observables and on the lender's belief of the consumer's type.

2 Model

The world consists of a single country that receives a stochastic stream of income y each period which follows a Markov process $\pi(y', y)$. The country trades bonds b' with risk neutral competitive lenders. Debt contracts are not enforceable and the country can choose to default on its debt at any time. If the country defaults, it is assumed to be temporarily excluded from financial markets and to incur direct output costs. The income realization is private information of the country. In the model, the role of the sovereign credit ratings is to disclose the country's probability of default to the lenders by disclosing the current income realization of the country. A solicited credit rating occurs when the country decides to disclose its income realization to the lenders whereas an unsolicited credit rating occurs when the income realization is exogenously disclosed to the lenders (without the country having requested it). Lenders have access to an international credit market in which they can borrow or lend as much as needed at a constant international interest rate $r > 0$. Every period lenders choose loans b' to maximize expected profits ϕ, taking prices as given. The expected profits of the lenders are defined as:

$$\phi = \frac{1-\delta}{1+r}b' - qb'$$

where δ is the probability of default.

I present two models, one which corresponds to the situation of an economy that faces the regulations proposed by the European Parliament and another one which corresponds to the situation of an economy in which such regulations do not apply. We make the simplifying assumption that if changes in the rating are allowed in a given period, then the lenders get to know what the current income realization in that period is and therefore they know what the country's true probability of default next period is. Basically, we are assuming that whenever changes in the rating are allowed, there is either a solicited rating or an unsolicited rating.

2.1 Regulations on sovereign credit ratings

The model that corresponds to an economy that faces the regulations proposed by the European Parliament has periods in which changes in the rating are allowed and periods in which changes in the rating are not allowed. The calendar, in the model, is exogenous. When changes in the rating are not allowed, the country may find it profitable to deviate from the calendar and solicit a rating.

The state variables for the country are the following: the income realization y, the level of debt b, the information that was given to the lenders in the last period regarding the country's income realization, x; and the number of past consecutive periods in which changes in the rating were allowed h. The variable x' is then the information that is given to the lenders regarding the

current income realization of the country. The state variable h takes integer values from 0 until λ, with λ being a parameter that will be calibrated later, which determines how frequent periods with changes in the rating not allowed are.

The timing of events in this economy is as follows. The country starts each period with either a good credit standing or a bad credit standing. If the country has a good credit standing its state variables are: the income realization y, the level of debt b, the information that was given to the lenders in the last period regarding the country's income realization, x; and the number of past consecutive periods in which changes in the rating were allowed h. If $h < \lambda$ changes in the rating are allowed in the current period whereas if $h = \lambda$ changes in the rating are not allowed. The country then chooses whether to default or not ($d \in \{0, 1\}$). If changes in the rating are allowed and the country repays then $x' = y$, $h' = h + 1$, the country chooses a new level of debt b', borrows at a price $q(b', y, h')$ and starts the next period with a good credit standing. If changes in the rating are not allowed and the country repays then the country chooses whether to solicit a rating or not ($s \in \{0, 1\}$). If the country solicits a rating then $h' = 0$, the country chooses a new level of debt b', borrows at a price $q(b', y, h' = 0)$ and starts the next period with a good credit standing. If the country doesn't solicit a rating then $h' = 0$, the country chooses a new level of debt b', borrows at a price $\widehat{q}(b', b, x)$ and starts the next period with a good credit standing. If at the beginning of the period the country decides instead to not to repay, it goes into autarky (i.e. the country is not allowed to borrow or lend). In the next period, it will come back to financial markets with probability θ and it will remain in autarky with probability $1 - \theta$. If the country starts a period with a bad credit standing, then it is in autarky and its only state variable is y. The country remains in autarky for the current period, and again, it will come back to financial markets next period with probability θ and it will remain in autarky with probability $1 - \theta$.

2.1.1 Borrowing country

The value of the country when it starts a period with a good credit standing is:

$$V(b, y, x, h) = \mathbb{1}_{h<\lambda} \cdot V^a(b, y, h) + \mathbb{1}_{h=\lambda} \cdot V^{na}(b, y, x)$$

When the number of past consecutive periods with changes in the rating allowed is smaller than λ, changes in the rating are allowed and the country's value is $V^a(b, y, h)$. By contrast, when the number of past consecutive periods with changes in the rating allowed is equal to λ, changes in the rating are not allowed and the country's value is $V^{na}(b, y, x)$. The parameter λ will later be calibrated to equal three, which implies that there is a period in which changes in the rating are not allowed after three consecutive periods in which changes in the rating were allowed. Therefore, we will have the following sequence: three periods in which changes in the rating are allowed, one period in which they are not allowed, three periods in which they are allowed, one period in which they are again not allowed, and so on. The value of the country when changes in the rating are allowed is defined as:

$$V^a(b,y,h) = \max_{d\in\{0,1\}} \Big\{ d \cdot v^d(y) + (1-d) \cdot v^c_a(b,y,h) \Big\}$$

where $v^d(y)$ is the value of defaulting and $v^c_a(b,y,h)$ is the value of repaying. The value of repaying when changes in the rating are allowed is defined as:

$$v^c_a(b,y,h) = \max_{b'} u(y + q(b',y,h')b' - b) + \beta \sum_{y'} \pi(y'|y) V(b',y',x',h')$$

$$s.t. \quad x' = y$$

$$h' = h + 1$$

When changes in the rating are allowed, the income realization is disclosed to the lenders. Moreover, the country decides how much to borrow (b') to maximize utility taking as given the bond price schedule $q(b',y,h')$ which is determined later by using the lenders' break even condition. Let $b'(b,y,h')$ denote the country's borrowing decision rule when changes in the rating are allowed.

The value of the country when changes in the rating are not allowed is:

$$V^{na}(b,y,x) = \max_{d\in\{0,1\}} \Big\{ d \cdot v^d(y) + (1-d) \cdot v^c_{na}(b,y,x) \Big\}$$

where $v^d(y)$ is the value of defaulting and $v^c_{na}(b,y,x)$ is the value of repaying. The value of repaying when changes in the rating are not allowed is defined as:

$$v^c_{na}(b,y,x) = \max_{s\in\{0,1\}} \Big\{ s \cdot v^s(b,y) + (1-s) \cdot v^{ns}(b,y,x) \Big\}$$

When the country repays and changes in the rating are not allowed, the country chooses whether to solicit a rating or not. The country's value is $v^s(b,y)$ if it solicits a rating and $v^{ns}(b,y,x)$ if it doesn't solicit a rating. The value of soliciting a rating is defined as:

$$v^s(b,y) = \max_{b'} u(y + q(b',y,h')b' - b - c) + \beta \sum_{y'} \pi(y'|y) V^a(b',y',h')$$

$$s.t. \quad h' = 0$$

The value of not soliciting a rating is defined as:

$$v^{ns}(b,y,x) = \max_{b'} u(y + \widehat{q}(b',b,x)b' - b) + \beta \sum_{y'} \pi(y'|y) V^a(b',y',h')$$

$$s.t. \quad h' = 0$$

When changes in the rating are not allowed, the information the lenders get depends on whether

the country decides to deviate from the calendar by soliciting a rating or not. If the country decides to solicit a rating, the lenders get to know what the income realization of the country is. If the country decides not to solicit a rating, the current income realization is not going to be disclosed to the lenders. In those cases, lenders compute their belief over what they think is the current income realization given the information they have about the country (last period's income realization, the debt level, the amount of debt borrowed in the current period and the fact that the country didn't solicit a rating). When the country decides to solicit a rating, it incurs a cost c, which is a punishment for having deviated from the calendar. Moreover, the country decides how much to borrow (b') to maximize utility taking as given the bond price schedule $q(b', y, h' = 0)$ which is determined later by using the lenders' break even condition. When the country decides not to solicit a rating, it decides how much to borrow (b') to maximize utility taking as given the bond price schedule $\widehat{q}(b', b, x)$ which is again determined later by using the lenders' break even condition. Following a period in which changes in the rating are not allowed, there will be a period in which changes in the rating are allowed[4] and in particular, $h' = 0$. Let $b'_s(b, y)$ and $b'_{ns}(b, y, x)$ denote the country's borrowing decision rules when changes in the rating are not allowed and the country solicits a rating and does not solicit a rating respectively.

The value of the country when it decides to default is:

$$V^d(y) = u(h(y)) + \beta \sum_{y'} \pi(y'|y) \Big[\theta V^a(b', y', h') + (1 - \theta) V^d(y) \Big]$$

$$s.t. \quad h' = 0$$

When the country defaults it consumes its autarky income $h(y)$ and it is not allowed to borrow or save. In the next period, the country will go back to financial markets with probability θ and stay in autarky with probability $1 - \theta$. We assume that if the country goes back to financial markets, changes in the rating will be allowed and in particular $h' = 0$. Finally, let $D^a(b, h)$ be the default set when changes in the rating are allowed and let $D^{na}(b, x)$ be the default set when changes in the rating are not allowed:

$$D^a(b, h) = \Big\{ y \in Y : v^d(y) > v^c_a(b, y, h) \Big\}$$

$$D^{na}(b, x) = \Big\{ y \in Y : v^d(y) > v^c_{na}(b, y, x) \Big\}$$

2.1.2 Lenders

Lenders, who are assumed to be risk neutral and competitive, choose loans b' to maximize expected profits every period. Lenders observe everything except for the current income realization of the country, which may be disclosed to them or not depending on the situation. Let $\delta(b', y, h')$ denote the country's probability of default:

[4] We are assuming $\lambda > 0$. If $\lambda = 0$ changes in the rating would never be allowed, but this is not an interesting case.

$$\delta(b', y, h') = \begin{cases} \sum_{y' \in D^a(b', h')} \pi(y'|y) & \text{if } h' < \lambda \\ \sum_{y' \in D^{na}(b', x')} \pi(y'|y) & \text{if } h' = \lambda \end{cases}$$

We first derive the bond price schedule for the cases in which lenders are informed about the current income realization, i.e. we derive the bond price schedule for the case in which changes in the rating are allowed and for the case in which changes in the rating are not allowed but the country deviates from the calendar and solicits a rating. We denote this bond price schedule $q(b', y, h')$ and we derive it by using the break-even condition of the lenders:

$$q(b', y, h') = \frac{1 - \delta(b', y, h')}{1 + r}$$

We now derive the bond price schedule for the case in which changes in the rating are not allowed and the country does deviate from the calendar and solicit a rating. Let $\psi_i(b', b, x)$ be the probability lenders assign to the current income realization being y_i when changes in the rating are not allowed and the country doesn't default, doesn't solicit a rating, chooses to borrow b', started the period with a debt level b, and the income realization in the previous period was x. When changes in the rating are not allowed and the country doesn't solicit a rating, the probability with which lenders think the country is going to default in the next period is defined as:

$$\widehat{\delta}(b', b, x) = \sum_i \psi_i(b', b, x) \cdot \delta(b', y_i, h' = 0)$$

By using the break-even condition of the lenders, we can then find $\widehat{q}(b', b, x)$, i.e. the bond price schedule that lenders apply in this case:

$$\widehat{q}(b', b, x) = \frac{1 - \widehat{\delta}(b', b, x)}{1 + r}$$

2.1.3 Definition of equilibrium

We define the equilibrium for this economy as follows:

Definition 1. *A Markov Perfect Bayesian Equilibrium for this economy is defined as the country's borrowing decision $b'(b, y, h')$, $b'_s(b, y)$ and $b'_{ns}(b, y, x)$, the country's decision of whether to solicit a rating $s(b, y, x)$, the default sets $D^a(b, h)$ and $D^{na}(b, x)$, value functions $V^a(b, y, h)$ and $V^{na}(b, y, x)$, the lenders' beliefs $\psi_i(b', b, x)$ for all i, and the bond price schedules $q(b', y, h')$ and $\widehat{q}(b', b, x)$ such that:*

1. *Given lenders' beliefs, the bond price schedules and the value functions, the government decision rules and the default sets are consistent with the government's optimization problem.*

2. *The bond price schedule that lenders apply in periods in which the income realization of the*

country is disclosed to them, $q(b', x, h')$, is consistent with lenders making zero profits in expectation in such periods.

3. *The bond price schedule that lenders apply in periods in which the income realization of the country is not disclosed to them, $\widehat{q}(b', b, x)$, is consistent with lenders making zero profits in expectation in such periods.*

4. *The functions $\psi_i(b', b, x)$ defined for all i must be consistent with Bayes' rule (whenever possible)*

The function $\psi_i(b', b, x)$ is defined as:

$$\begin{aligned}\psi_i(b', b, x) &\equiv \Pr(y_i|d = 0, s = 0, b', b, x) \\ &= \frac{\Pr(d = 0, s = 0, b', b, x|y_i)\Pr(y_i)}{\Pr(d = 0, s = 0, b', b, x)} \\ &= \frac{\Pr(d = 0, s = 0, b'|b, y_i, x)\Pr(y_i|b, x)}{\sum_{s=1}^{N} \Pr(d = 0, s = 0, b'|b, y_s, x)\Pr(y_s|b, x)}\end{aligned}$$

2.2 No regulations on sovereign credit ratings

Changes in the rating are always allowed in the model that corresponds to the situation of an economy that doesn't face the regulations proposed by the European Parliament. Thus, lenders get to observe the country's income realization every period. Therefore, under no regulations we have perfect information and this model coincides with the model of Arellano (2008). In this case, the state variables for the country are the income realization y and the level of debt b.

The timing of events in this economy is as follows. The country starts each period with either a good credit standing or a bad credit standing. If the country has a good credit standing its state variables are the income realization y and the level of debt b. At the beginning of the period, the country decides whether to default on its debt or not ($d \in \{0, 1\}$). If the country repays, it then chooses a new level of debt b'. Also, the country maintains its good credit standing for next period. If at the beginning of the period the country decides instead to not to repay, it then goes into autarky (i.e. the country is not allowed to borrow or lend) and next period it will come back to financial markets with probability θ and it will remain in autarky with probability $1 - \theta$. If the country starts a period with a bad credit standing, then its only state variable is y, the country remains in autarky for the current period, and again, it will come back to financial markets next period with probability θ and it will remain in autarky with probability $1 - \theta$.

2.2.1 Borrowing country

If the country starts the period with a good credit standing then its value function is:

$$V(b, y) = \max_{d \in \{0,1\}} \Big\{ d \cdot V^d(y) + (1 - d) \cdot V^c(b, y) \Big\}$$

where $V^d(y)$ is the value of defaulting and $V^c(b,y)$ is the value of not defaulting. The value of not defaulting is defined as

$$V^c(b,y) = \max_{b'} u(y + q(b',y)b' - b) + \beta \sum_{y'} \pi(y'|y) V(b',y')$$

When the country decides not to default, it then decides how much to borrow (b') to maximize utility taking as given the bond price schedule $q(b',y)$ which is determined below by using the lenders break even condition.

The value of defaulting is defined as:

$$V^d(y) = u(y^{def}) + \beta \sum_{y'} \pi(y'|y) \Big[\theta V^c(0,y',y) + (1-\theta) V^d(y)\Big]$$

Finally, let $D(b,r)$ be the set of income levels such that default is optimal for the country given a debt level b:

$$D(b) = \Big\{y \in Y : V^d(y) > V^c(b,y)\Big\}$$

2.2.2 Lenders

Lenders, who are assumed to be risk neutral and competitive, choose loans b' to maximize expected profits every period. Under no regulations, lenders observe everything, i.e. there is no private information. Let $\delta(b',y)$ denote the country's probability of default:

$$\delta(b',y) = \sum_{y' \in D(b')} \pi(y'|y)$$

By using the break-even condition of the lenders, we can then find the bond price schedule $q(b',y)$:

$$q(b',y) = \frac{1 - \delta(b',y)}{1+r}$$

2.2.3 Definition of equilibrium

We define a recursive equilibrium for this economy as follows:

Definition 2. *The recursive equilibrium for this economy is defined as the country's borrowing decision $b'(b,y)$, the default decision $d(b,y)$, the default set $D(b)$, value functions $V^c(b,y)$ and $V^d(y)$, and the bond price schedule $q(b',y)$ such that:*

1. *Given the bond price schedule and the value functions $V^c(b,y)$ and $V^d(y)$, the country's borrowing decision $b'(b,y)$ and the default set $D(b)$ are consistent with the country's optimization problem.*

2. *The bond price schedule $q(b',y)$ is consistent with lenders making zero profits in expectation.*

3 Quantitive Analysis

I now analyze the quantitative implications of the model. I first calibrate the model to match data from Greece.

3.1 Calibration

The utility function for the country is $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$. The risk aversion coefficient σ is set to 2, which is a common value used in real business cycle studies. The length of a period is one quarter. The risk free interest rate r is set to 1.93% per annum, which is the average quarterly interest rate of a five-year German bond from 1995 Q1 to 2013 Q4. The stochastic process for income is a log-normal AR(1) process, $\log(y_{t+1})=\rho\log(y_t)+\epsilon^y_{t+1}$ with $E[(\epsilon^y)^2] = \eta^2$. We discretize the shocks into a ten-state Markov chain using a quadrature-based procedure (Tauchen 1986). We use quarterly series of GDP from 1995 Q1 to 2013 Q2 taken from the Statistical Data Warehouse of the European Central Bank to calibrate the volatility of income. Due to the short sample, rather than estimating the autocorrelation coefficient we choose an autocorrelation coefficient for the income process of 0.95, which is in line with standard estimates for developed countries. The probability of re-entry is taken from Arellano (2008).

The parameter λ is set to equal three. Given that this is a quarterly model, setting $\lambda = 3$ implies that every year there is a quarter in which changes in the rating are not allowed and 3 quarters in which they are allowed. In 2014, each of the main three CRAs (Standard & Poor's, Moody's and Fitch) set a calendar for each country that had between two to three dates. This implies that in 2014 every country has at most nine months which contain a date in which changes in the rating are allowed by one of the main CRAs. Actually, this number is often lower than nine as some of the CRAs chose to rate the country in the same month. Therefore, in reality, we have at least three months every year in which the main three CRAs won't be allowed to change a country's rating. Given that this is a quarterly model, it is then reasonable to set $\lambda = 3$, i.e. there is one quarter every year in which changes in the rating are not allowed. I also set $c = 0.001$, which corresponds to 0.1% of average GDP. Robustness checks will be done later to see how the results change when the punishment associated with soliciting a rating outside the calendar changes.

Regarding the output costs of the country during default, I follow Arellano (2008) (among others) and set the output during default periods as $h(y) = \min\{y, \omega E(y)\}$ where $E(y)$ is the unconditional expectation of the endowment process and $\omega > 0$. I then calibrate two parameters: the country's discount rate β and the output costs of the country during default ω to match the following two moments: the mean of Greece's spread and the standard deviation of the Greece's trade balance over GDP, which are 2.37% (for the period 1995 Q1 - 2013 Q4) and 2.82 (for the period 2000 Q1 - 2013 Q1) respectively.

Table 1 summarizes the parameter values.

Table 1: Parameter values

	Values	Target
Risk aversion	$\sigma = 2$	Standard value
Risk-free interest rate	$r = 0.0193$	German 5-year bond quarterly yield
Stochastic structure for shocks	$\rho = 0.95$, $\eta = 0.0046$	Greek GDP
Probability of re-entry	$\theta = 0.282$	Arellano (2008)
Unsolicited ratings parameter	$\lambda = 3$	EU sovereign credit ratings' regulations
Calibrated parameters		
Discount factor	$\beta = 0.86$	Mean of spread
Output cost while in default	$\omega = 0.94$	Standard deviation of TB over GDP

The calibration of the discount factor and the output cost while in default has been made using the Method of Simulated Moments using the model with no regulations on sovereign credit ratings.

3.2 Results when $c = 0$

When the cost of deviating from the calendar and soliciting a rating is equal to zero, the country always prefers to solicit a rating when changes in the rating are not allowed. Given any belief the lenders may have over the current income realization, if the country gets the highest income realization, it always prefers to deviate and solicit a rating as this gives the country an interest rate lower or equal the one it would get if it doesn't solicit a rating. Therefore, if the country gets the second highest income realization, it again always prefers to solicit a rating. Repeating this argument, it becomes apparent that the country always prefers to deviate and solicit a rating except for the lowest income realization, for which it is indifferent between soliciting a rating and not. Therefore, in our model, when the punishment associated with deviating from the calendar and soliciting a rating is zero, there is perfect information at any period and hence, the regulations have no effect.

3.3 Results when $c > 0$

When the country suffers a cost from deviating from the calendar and soliciting a rating, its optimal decision may not always be to solicit a rating. Figure 2 plots the decision of whether to solicit a rating $s(b, y, x)$. The function $s(b, y, x)$ equals one if the country solicits a rating and zero otherwise. Given the information given to to the lenders in the previous period x, the country is more likely to solicit a rating when its debt level is high. The borrowing decision rule of the country is such that the higher the debt level, the higher the amount of money the country wants to borrow. When the country wants to borrow a high amount of money it gets a higher benefit from the lower interest rate that may come from soliciting a rating and therefore, it tends to solicit ratings more often. Given x, the country is also more likely to solicit a rating when its income level is high as in this

case, the decrease in the interest rate that may come from soliciting a rating is larger. Finally, given a debt level b and an income realization y, the country has a higher incentive to solicit a rating if x is low. If x has a low value, the lenders assign a high probability to the country getting a low income realization. Thus, if the country got an income realization higher than x it is likely that it will find it optimal to solicit a rating. By contrast, if x is high, the lender assigns a high probability to the country getting a high income realization. Therefore, if the country got a high income realization, it has less incentive than in the previous case to solicit a rating. Given that, the lower type benefits from not soliciting a rating either as the lender is assigning a positive probability to the country having a high income realization.

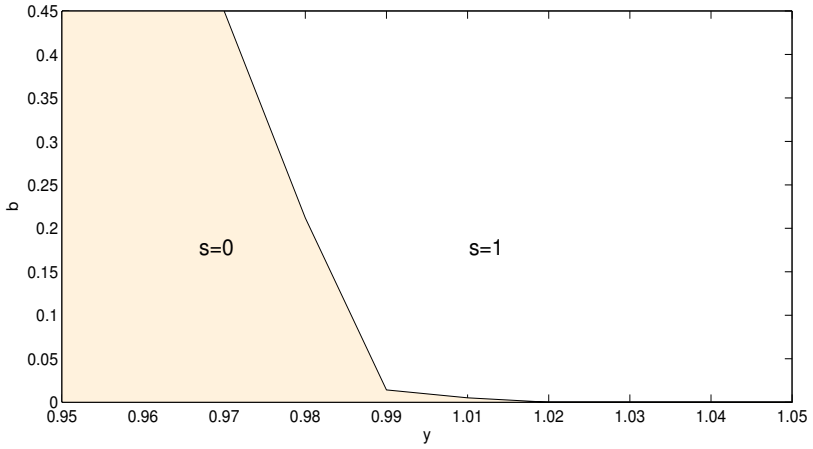

Figure 2: Decision of whether to solicit a rating s(b,y,x=4)

As it was mentioned before, a press release issued by the European Parliament immediately after the regulations were approved stated that the regulations would ensure that sovereign credit ratings would not come at the most inappropriate times. Given $c > 0$, when changes in the rating are not allowed and the country happens to get a bad income shock compared to the previous period, the country may get to borrow at a cheaper rate than under no regulations by not soliciting a rating. That makes it easier for the country to roll-over its debt and decreases its incentive to default. As we can see in Figure 3, the country's default set is smaller the higher the x that was given to the lenders in the previous period, i.e. the higher the income realization that the country got in the previous period.

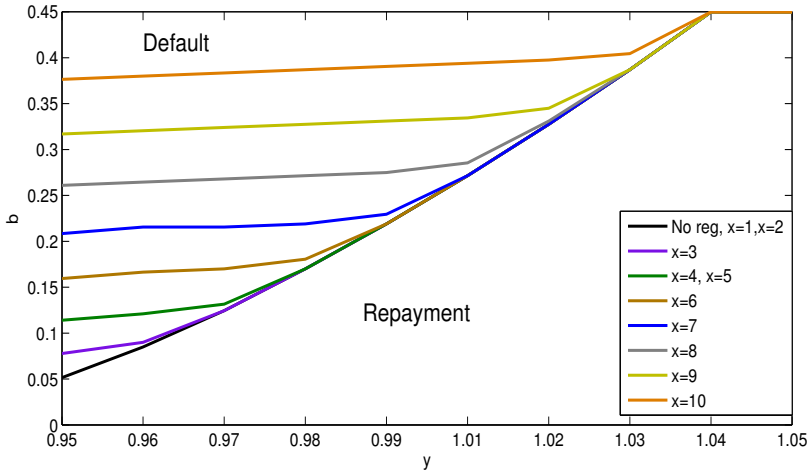

Figure 3: Default sets

Figure 4 plots the borrowing decision rules of the country given $x = 10$ and a debt level b equal to the average debt level that was obtained during the simulations that are presented later. When the country solicits a rating (i.e. $s = 1$) we compare the borrowing decision rule of the country under no regulations and the borrowing decision rule of the country under regulations conditional on soliciting a rating. As we can see in Figure 5, those two borrowing decision rules coincide. However, when the country decides not to solicit a rating (i.e. $s = 0$), the borrowing decision rule under no regulations and the borrowing decision rule under regulations conditional on not soliciting a rating are considerably different. Basically, the 'low-type' wants to mimic the behavior of the 'high-type' so that lenders cannot identify it's a 'low-type'. In this case, if the income realization is lower or equal than 1.03, the country doesn't solicit a rating. Then, if the country gets an income realization lower than 1.03, it has an incentive to borrow the same amount that it would borrow if its income realization was 1.03 as by doing that, the lender can't tell if the country's income realization is 1.03 or lower than that. By not soliciting a rating and mimicking the behavior the the 'high-type' the country gets to borrow at a lower interest rate than if there were no regulations. Moreover, the probability of default of the country increases due to the fact that the country is now over-borrowing compared to when there are not regulations.

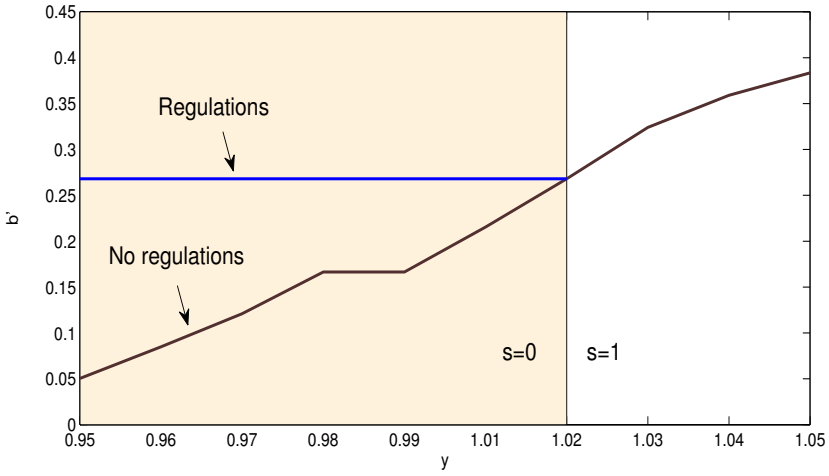

Figure 4: Borrowing decision rules, x=8

To sum up, when deviating from the calendar by soliciting a rating is costly, the regulations induce a trade-off in terms of probability of default. On the one hand, when changes in the rating are not allowed, if the country receives a relatively bad income shock it may be able to borrow at an interest rate lower than if there were no regulations. That makes it easier for the country to roll-over its debt and decreases its incentive to default. On the other hand, when unsolicited ratings are not allowed and the country borrows at a relatively cheap interest rate, the country tends to over-borrow. That increases the country's probability of default.

3.4 Simulation Results

I feed into the model with no regulations the time series of Greece's GDP starting in 1995 Q1 and the model predicts a default in the first quarter of 2010[5]. I then feed into the model with regulations the same GDP series to see whether the regulations can avoid Greece defaulting during the European sovereign debt crisis. We also want to see if the regulations create any extra default during this period.

Under the current calibration, the regulations are not able to avoid a default from Greece during the European Sovereign debt crisis. Moreover, the regulations do not create any extra default during the period that I study.

4 Robustness checks

The results are robust to different specifications of the income process. In particular, they are robust to using the autocorrelation coefficient and standard deviation estimated using Greece's short GDP series data, which are $p = 0.78$ and $\sigma = 0.0091$ respectively. The results are also robust

[5]According to S&P's definition of default, Greece defaulted both in the first and fourth quarters of 2012.

to the number of income grid points, i.e. our results are robust to the number of different sovereign credit ratings. Finally, I check whether the results also robust to the value of the parameter lambda. The parameter values $\lambda = 1$ and $\lambda = 2$ are both reasonable values that lambda could take. In the first case, the country would be having two quarters every year with sovereign credit ratings not allowed. In the second case, the country would be having either two or three quarters every year with sovereign credit ratings not allowed. The results are robust to these changes.

I also make robustness checks to see how the results change when the parameter c changes. As it was shown in the results, when $c = 0$, the country has an incentive to always solicit a rating whenever changes in the rating are not allowed. In this case, the model with regulations and the model without regulations give the same results. The higher the cost c, the lower the incentive of the country to solicit a rating and therefore, the smaller the region $s = 1$ in Figure 2.

5 Conclusion

[To be completed]

6 Appendix

6.1 Computational algorithm for the model with regulations

The computational algorithm for the model which incorporates regulations on sovereign credit ratings is the following:

1. Start by setting grid points for the state variables: 250 grid points for b, 10 grid points for y, 10 grid points for r and λ+1 grid points for h.

2. Make a guess for the bond price schedules q_0 and $\widehat{q}_0$, for the lenders' beliefs $\psi_{i0}(b', b, x)$ for all i and for the country's continuation value.

3. Given q_0, $\widehat{q}_0$, $\psi_{i0}(b', b, x)$ for all i, and the country's continuation value, solve the country's problem to find the country's decision rules and the value functions.

4. Given the country's decision rules and the value functions, find the new lenders' beliefs $\psi_{i1}(b', b, x)$ for all i, the new bond price schedules q_1 and $\widehat{q}_1$, and the new country's continuation value.

5. If a convergence criterion for the bond price schedule and the value functions is satisfied, then we are done. Otherwise we set $q_0 = q_1$, $\widehat{q}_0 = \widehat{q}_1$, $\psi_{i0}(b', b, x)$=$\psi_{i1}(b', b, x)$ for all i, the old value functions to equal the new value functions, and return to point 3.

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