Austerity*

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Abstract

We use the standard sovereign debt model, augmented to include private information about credit risk, to shed light on the function, properties and optimal size of austerity. We define austerity as the shortfall of consumption from its complete information level. When a sovereign's creditworthiness is private information, low credit risk governments can employ austerity to secure more favourable loan packages. Optimal austerity is associated with over-investment, and thus higher growth, even when investment does *not* create collateral. Our analysis accommodates costly signalling for gaining credibility; it assigns a novel role to spending multipliers in the determination of optimal austerity; and it implies that the amount of new loans obtained by a sovereign may not be a reliable measure of austerity suffered.

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1 Introduction

What is austerity? What is its main function? What are its implications for welfare and macroeconomic performance? Does it have an optimal size?

These questions have occupied center stage throughout the Euro area debt crisis. Their treatment in the extant literature, however, has been rather ad hoc, narrow and devoid of a theoretical framework. The prevailing approach is to define austerity as a reduction in the government budget deficit aimed at shrinking the public-debt-to-GDP ratio, and to examine (mostly using data on past debt consolidations) whether a targeted deficit reduction can achieve debt stabilization or not. Opponents of austerity doubt its usefulness because of its alleged adverse effects on growth and tax revenues, especially during recessions. Proponents argue that austerity can succeed if it signals to credit markets a resolve to tidy public finances, thus lowering borrowing costs and encouraging investment and growth (in particular when the consolidation focuses on public spending rather than taxation).

The standard definition of austerity as well as the emphasis on debt stabilization can be questioned on several grounds. First, this definition may not be in line with the common perception of austerity as "belt tightening." For instance, a reduction in the budget deficit that is not accompanied by a decline in consumption fails this criterion. Second, the standard definition cannot capture the notion that belt tightening may be excessive, for instance, in the sense that it exceeds what is justified by the repayment capacity of the borrower. Finally, stabilization of the debt-to-GDP ratio does not represent a standard welfare criterion. To evaluate an austerity program and determine its optimal size, one needs to conduct proper welfare analysis.

The objective of this paper is to develop a coherent framework that provides a useful measure of austerity and utilizes proper welfare criteria to evaluate its optimal characteristics. Our model builds on the standard sovereign debt framework in which creditors' beliefs about a country's ability and willingness to honor obligations give rise to borrowing constraints that translate into restrictions on the size of current account (and budget) deficits. As argued above such debt limits per se cannot be interpreted as disproportionate. To allow the model to capture the popular notion that austerity, while justifiable, could also be excessive we therefore introduce an additional element, namely incomplete information about credit risk. Our model then gives rise to shortfalls of debt limits relative to repayment capacity and thus contains the ingredients needed to produce interesting, empirically plausible answers to the questions raised in the opening paragraph above.

Our definition of austerity is stated in terms of a consumption rather than a debt gap.[1] Namely, we define austerity as the gap between actual consumption and the level of consumption that would have obtained under complete information about a country's repayment capacity.[2] In other words, austerity refers to a situation where a country

[1]As we elaborate later, the two definitions often have the same implications. But with endogenous investment, the consumption based definition is more general and more accurate than the debt based one.

[2]The time of the appearance of the consumption gap—austerity—does not have to coincide with a debt crisis period. A country may opt for "preemptive" austerity in order to signal its creditworthiness

consumes less than the amount supported by its level of credit risk. Note that the standard sovereign debt model (Eaton and Gersovitz, 1981; Obstfeld and Rogoff, 1996, ch. 6) features zero austerity according to our definition.

Our baseline model has two periods. We assume that debtors differ with regard to their—unobserved by creditors—willingness to honor debt commitments which can be high or low. In the first period, a government inherits an amount of debt and decides whether to repay or not. If the government defaults, it suffers the type specific cost. Following the default decision, the government may borrow fresh funds in the form of non-state contingent debt that is due for repayment in the second period. The amount and price of these fresh funds reflect the perceptions of creditors about the type of debtor government they face. In turn, these perceptions depend on the government's default decision in the first period. Creditors are risk neutral and operate under perfect competition.

We focus on the equilibrium that generates the highest level of welfare for the borrower. Depending on parameter values, the optimal equilibrium may be a pooling one where both types take the same action in the first period and a single amount and price of fresh funds is offered. Or, the optimal equilibrium may be a separating one in which the government's type is revealed by its default decision in the first period, and the loan contract is type specific. In general, a large (small) probability of facing a high type government makes the pooling (separating) equilibrium more likely to emerge.

In the pooling equilibrium, the high type borrower suffers austerity because he cross-subsidizes low types. More interestingly, he also faces austerity in the *separating* equilibrium.[3] The culprit of austerity here is the self-selection constraint of a low type government: The loan to the high type must be capped at a level that makes it unprofitable for the low type to mimic (by honoring debt in the first period). As long as governments face different costs of repudiating debt, and these costs are private information, the most committed governments invariably suffer austerity independently of whether they reveal their type or not.

Next, we introduce endogenous investment in order to analyze the relation between austerity and growth. Investment can be chosen either before or after the loan has been made. If the creditors can condition the loan size on the scale of the investment, then type separation becomes easier and the welfare of a creditworthy government increases even when the return on the investment *cannot* serve as collateral (unlike in the standard sovereign debt model). The optimal loan-investment package requires *over-investment* relative to the case where the government can choose the investment level under discretion. Moreover, the over-investment takes a special form: For any fresh funds offered above a certain level, investment must increase by more than one-to-one with such funds. That is, beyond some level, more debt and larger deficits coincide with *harsher* austerity.

The key to this result lies in the fact that low credit risk borrowers have a higher

(as the UK did in 2010).

[3]An important result in the credit rationing literature is that the availability of a menu of contracts conditioned on observed collateral is sufficient to induce sorting and eliminate credit rationing (Bester, 1985). In our case, there is incomplete information on collateral (the default cost) and thus rationing also obtains in the optimal separating equilibrium.

propensity to invest because they need resources in the second period to repay debt due. Consequently, increasing investment beyond the conditionally optimal level hurts a less creditworthy, mimicking type more than a high type. Over-investment then represents a costly signal that the high type can employ in order to distinguish himself from a mimicking low type, paving the way for obtaining more funds. While these additional funds cannot be used to increase consumption and close the consumption gap, they are still valuable because they help close the investment gap as a debt constrained sovereign also under-invests relative to the first best.

The role of investment as a separating device has several implications. First, it makes austerity a non-monotone function of the amount of new loans. As this amount increases, austerity initially decreases. But beyond a certain level of new debt, it starts to increase. The optimal level of austerity is found in the increasing range so more austerity is associated with higher welfare for creditworthy borrowers. Second, investment creates an ambiguous relationship between the severity of austerity and economic growth: the same level of austerity may be associated with different rates of growth. At the optimum, austerity is more severe but investment and growth are higher than in the equilibrium in which the investment instrument cannot be used in the loan package. And third, investment drives the discrepancy between debt based (credit rationing) and consumption based (austerity) gaps. With forced investment, credit rationing—the distance between actual debt and the level under complete information—decreases with the amount of fresh funds while austerity increases.

We also consider alternatives to over-investment as costly signals of one's type. Reform requirements in loan packages can serve such a function. We argue that having the borrower undertake costly—in the short term—reforms can increase the flow of funds. But contrary to popular thinking, reforms accompanied by the relaxation of fiscal stance do not necessarily prevent the loss of current consumption. There may not be a clear relationship between the amount of new funding and austerity when funding is conditional on things such as investment and reforms.

Our analysis helps understand the "German" view in the current debates on austerity. This view, as has been expressed by German officials, is that a creditworthy government can signal its type by choosing austerity over default, thus lowering default premia and increasing the flow of fresh funds. Interestingly, the same signaling mechanism allows our model to provide ammunition to austerity critics by offering a new, informational perspective on the role of spending multipliers. In particular, we show that the size of these multipliers may matter for the terms of financing and the default decision by affecting the identification of credit risks. A large multiplier may thus make severe austerity undesirable even when it does not matter for a country's *future* income level and thus, ability to repay.[4]

Our theory also provides good lenses for viewing the credit relationship between official creditors ("Germany") and sovereign borrowers during the recent (and ongoing) Eurozone debt crisis, specifically Greece. Germany refused to reduce the size of required austerity in Greece in 2014 in spite of the fact that the coalition government at the time was widely

[4]The standard argument of opponents of austerity is that austerity may actually reduce repayment capacity because of negative, Keynesian, macroeconomic implications. Our model abstracts from this role of multipliers because it does not have the right structure—DSGE—to properly capture it.

perceived as being a high type, growth had turned positive, and Greece was for the first time able to borrow limited amounts from the private credit markets. This is consistent with our result that due to incomplete information about credit risk, a country suffers austerity even when default risk is low.

Austerity in Greece became more severe following the victory of Syriza in the national elections of January 2015: While the third "financial assistance" program signed by the new Syriza government in summer 2015 foresees 86 billion EUR of German disbursements (nearly half of Greek GDP) it also postulates much more ambitious budget targets, namely surpluses of 0.5%, 1.75%, and 3.5% for 2016, 2017 and 2018, respectively, and carries stringent reform requirements. Our model attributes this to an increase in the risk that the Greek government will default in the future: It predicts more severe austerity when the probability of facing a low type borrower goes up.

The latest loan agreement with Greece makes loan size and dispersion conditional on the implementation of reforms, a feature that was effectively missing from previous packages which only paid lip service to reforms. According to our model such conditionality is to be expected and in the borrower's interest. Conditioning the amount of loans on reforms has better welfare properties than not conditioning it, as reforms signal high creditworthiness (and may additionally enhance future repayment by making default costlier).[5] As our model makes clear this holds true even when the reforms "buy" additional loans that do *not* lessen austerity.

Finally, the latest package negotiated between Greece and her creditors has been sufficiently generous to prevent—so far—a default by the Syriza government while at the same time, stingy and reform laden enough to contain Germany's exposure to capital losses. A three-period extension of our model predicts such a judicial choice of austerity and its evolution over time. The equilibrium arrangement involves sufficient refinancing by creditors to prevent default even by a low type as long as the premium due to long-term default risk remains manageable for a creditworthy borrower. Refinancing is particularly attractive if lenders regard it as likely that a low type borrower might eventually switch type, for instance after an election. But the conditions of the arrangement are adjusted over time as growth prospects or other observable fundamentals change.

While thus being consistent with the view that Germany and Greece have carefully calibrated the loan package and reform demands, the three-period extension of the model also points to possible fragility of the credit arrangement. After a sufficient deterioration of growth prospects the arrangement features separation of types because high types prefer a smaller loan with low interest rates over a larger one with a high risk premium. Should the Syriza government be of the low type, a further tightening of the credit constraint by creditors thus could trigger default.

In light of our model, three factors will determine whether Greece will default (again). First, the outcome of the current debate between Greece and its creditors about whether the 3.5% surplus requirement contractually ends in 2018 (the Greek position) or in another 10 years (the German position); and whether certain labor market, tax and social

[5] This is in line with the views of the German council of economic advisors, see Feld, Schmidt, Schnabel and Wieland (2016). They argue that "the loans for reforms rationale underlying the rescue approach was not only sensible .... It also worked and substantially improved matters."

security reform measures are part of the loan package (the German position) or not (the Greek position). Second, Germany's assessment of the Greek government's type, not least against the background of the mentioned debate. And third, future growth prospects.

The rest of the paper is organized as follows: Section 2 reviews related literature. Section 3 lays out the basic model and characterizes the pooling and separating equilibria. Section 4 introduces costly signalling and in section 5, we analyze the consequences of contractible and non-contractible investment. Section 6 contains the three-period extension of the model and additional discussions, including on multipliers. Section 7 concludes.

2 Related Literature

Our paper combines elements from the sovereign debt literature, the literature on credit rationing in models with heterogeneous borrowers and incomplete information, and the literature on monetary policy games. As in the standard sovereign debt model, the maximum level of debt that can be issued is sub-optimally low, constrained by the country's willingness to repay. But unlike the standard model, where investment relaxes the debt ceiling by creating collateral and thus increasing the cost of default (Obstfeld and Rogoff, 1996, ch. 6), in our model investment relaxes the tightened debt ceiling by mitigating an information friction.

Concerning the analysis of informational frictions in the sovereign debt literature, the closest precursor to our work is Cole, Dow and English (1995) which assumes incomplete information about the government's discount factor, as well as Atkeson's (1991) imperfect information model and, in a similar spirit, Dovis (2016). While these models were designed for other purposes and do not deal with austerity they could conceivably accommodate the concept based on our definition (deviation from complete or symmetric information outcome). Nonetheless, we believe that our specification is better suited to the analysis of austerity, in particular with regard to the Euro area debt crisis, because it contains all of the following ingredients:

First, our assumption that governments come in different types in terms of their willingness to repay allows the default choice to be uncoupled from the state of the business cycle. This is consistent both with Tomz and Wright's (2007) finding that many defaults occur during boom periods[6] and with the events during the Euro area debt crisis which were not triggered by some serious, adverse output growth shock(s).

Second, in our specification, sufficient generosity by lenders may preserve a pooling equilibrium (which is ruled out in the other models), averting default. As we argued above, the actions of the official creditors and the borrowing country during the Greek crisis seem consistent with this scenario.

Third, the borrower's creditworthiness (as related to the willingness to pay) and lenders' incomplete information about it are explicitly present and play a key role in our analysis, as they appear to do in actual credit markets. Moreover, it is the creditwor-

[6]Tomz and Wright (2007, p. 356) report that "only one-third of debtors lapsed into default when falling on extremely hard times, and roughly one-fifth defaulted while experiencing a boom in which output exceeded trend by more than 10 percentage points."

thy types that are rationed in our model. This allows us to capture the commonly held view that during the recent Euro area debt crisis, some countries may have inadvertently suffered austerity in spite of being prepared and able, to fully honor their debt obligations.

The credit literature with incomplete information has pre-occupied itself primarily with the existence of rationing, a concept closely related to our definition of austerity. While the seminal paper of Stiglitz and Weiss (1981) exhibits credit rationing in equilibrium, subsequent work has demonstrated that rationing is not present under alternative assumptions about the incidence of informational asymmetry (i.e., risk versus return, see Meza and Webb (1987)) or, that it can be solved with a rich enough menu of financial contracts[7] (see Bester (1985), Milde and Riley (1988), and Brennan and Kraus (1987)). Such menus can induce self-selection and support a separating equilibrium in which information is revealed and there is *no* credit rationing. Unlike the results in this literature, we obtain that "credit rationing" remains a feature of the separating equilibrium that is required to deter the less creditworthy type from mimicking. The use of this sanction to deter cheating is akin to that employed by Green and Porter (1984) where punishment is imposed following certain events in spite of the fact that there is no cheating in equilibrium. In our model, the sanction (credit rationing) is essential in order to support the truthful revelation of type.

Our analysis also relates to the literature on monetary policy credibility (specifically, Backus and Driffill, 1985; Canzoneri, 1985; Vickers, 1986). As in our setup, these models contain two types of policymakers (a "hard nosed" and a "wet" one), each with its own welfare function.[8] Type is unobserved but may be revealed through the actions taken. The objective of the public is to infer the type they face in order to form inflation expectations. Canzoneri (1985) relies on Green and Porter's (1984) model to argue that some punishment (too high inflation expectations by the public) always is present in order to discourage opportunistic behavior, even if it is known that no such behavior occurs in equilibrium. Vickers (1986) applies the model of Cho and Kreps (1987). His analysis of costly signalling and the characterization of pooling and separating equilibria is related to the versions of our model with costly signalling.

3 Basic Model

3.1 Environment

The economy lasts for two periods, $t = 1, 2$. It is inhabited by a representative taxpayer, a government and foreign investors. Taxpayers neither save nor borrow. Their utility is given by

$$\mathbb{E}\left[\sum_{j\geq t}\delta^{j-t}u(\bar{y}_j-\tau_j)|\mathcal{I}_t\right],$$

[7] For instance, contracts that impose restrictions on capital structure, require co-investment and so on.

[8] The two types are formally modelled in Vickers (1986). In Canzoneri (1985) the version with the conservative policymaker can be interpreted as a two type game.

where $\bar{y}_t$ denotes pre-tax income, τ_t taxes and $\mathcal{I}_t$ the information set (to be specified below).

Foreign investors are competitive and risk neutral, require a risk free gross interest rate $\beta^{-1} > 1$ and hold all government debt (since taxpayers do not save).[9] To guarantee positive debt positions, we assume $\delta < \beta$ as is standard in the sovereign debt literature.[10]

The government maximizes the welfare of taxpayers. In period t, it chooses the repayment rate on maturing debt, r_t, issues zero-coupon, one period debt, b_{t+1}, and residually levies taxes. Without loss of generality, public spending other than debt repayment is set to zero. The government cannot commit its successors (or, future selves). Short-sales are ruled out.

A sovereign default—a situation where the repayment rate falls short of unity—triggers a contemporaneous, temporary income loss for taxpayers (see, e.g., Arellano, 2008). More specifically, a default in period t reduces the exogenous income y_t by the fraction $\lambda \geq 0$ so that $\bar{y}_t = y_t$ when there is no default and $\bar{y}_t = y_t(1-\lambda)$ when there is default. For simplicity, we treat y_t as deterministic. There is *no* exclusion from credit markets following default.

The default cost parameter λ takes one of two values, λ^h or λ^l, with $0 \leq \lambda^l < \lambda^h$. We refer to a government facing λ^h (λ^l) as a government with high (low) creditworthiness or simply as a "high (low) type." The values of λ^h and λ^l are common knowledge but the type of government is private information. The prior probability that a given country has a high type government equals $\theta \in (0, 1)$.

Events unfold as follows. In the beginning of the first period, the government chooses the repayment rate $r_1 \in \mathcal{R} \subseteq [0, 1]$ on maturing debt b_1. Lenders observe this choice, form the posterior belief θ_1 that they face a high type, and buy new debt $b_2 \in \mathcal{B} \equiv [0, \infty)$ at price $q_1 \in [0, \beta]$. For brevity, we let $\mathcal{F}_1 \equiv (q_1, b_2)$ denote this financing arrangement. Finally, taxes $\tau_1 = b_1 r_1 - q_1 b_2$ are levied. In the second period, the government chooses the repayment rate $r_2 \in \mathcal{R}$ on debt b_2 and levies taxes $\tau_2 = b_2 r_2$.

The indirect utility function of taxpayers in a country with government of type $i = h, l$ (or "country of type i" for short) in period $t = 2$ can be expressed as

$$U_2^i(\mathcal{F}_1, r_2) = u\left(y_2(1 - \lambda^i \mathbf{1}_{\{r_2<1\}}) - b_2 r_2\right)$$

where $\mathbf{1}_{\{x\}}$ denotes the indicator function for event x. Welfare of type $i = h, l$ is given by

$$U_1^i(r_1, \mathcal{F}_1) = u\left(y_1(1 - \lambda^i \mathbf{1}_{\{r_1<1\}}) - b_1 r_1 + q_1 b_2\right) + \delta \max_{r_2 \in \mathcal{R}} U_2^i(\mathcal{F}_1, r_2).$$

3.2 Equilibrium

An *equilibrium* is a repayment rate for each type in the first period, $r_1^i, i = h, l$; a posterior belief and a financing arrangement that depend on the repayment rate in the first period, $\theta_1(\cdot) : \mathcal{R} \to [0, 1]$ and $\mathcal{F}_1(\cdot) : \mathcal{R} \to \mathbf{R}_+^2$, respectively; and a repayment rate for each type

[9] The assumption that the sets of taxpayers and investors do not "overlap" simplifies the analysis and does not matter for the main results.

[10] For recent examples, see Aguiar and Gopinath (2006) or Arellano (2008).

in the second period that depends on the financing arrangement, $r_2^i(\cdot) : \mathbf{R}_+^2 \rightarrow \mathcal{R}, i = h, l$, such that the following conditions are satisfied:[11]

i. For each $\mathcal{F}_1$ and each type, the repayment rate in the second period is optimal,

$$r_2^i(\mathcal{F}_1) = \arg\max_{r_2 \in \mathcal{R}} U_2^i(\mathcal{F}_1, r_2);$$

ii. for each type, the repayment rate in the first period is optimal conditional on $\mathcal{F}_1(\cdot)$,

$$r_1^i = \arg\max_{r_1 \in \mathcal{R}} U_1^i(r_1, \mathcal{F}_1(r_1));$$

iii. the posterior belief satisfies Bayes' law where applicable,

$$\theta_1(r_1) = \text{prob}(i = h | r_1, \mathcal{F}_1(\cdot));$$

iv. for each r_1, the financing arrangement $\mathcal{F}_1(\cdot)$ satisfies the break even condition of lenders given their posterior,

$$q_1(r_1) = \beta\{\theta_1(r_1) r_2^h(\mathcal{F}_1(r_1)) + (1 - \theta_1(r_1)) r_2^l(\mathcal{F}_1(r_1))\}.$$

Since Bayes' law constrains lenders' beliefs only along the equilibrium path, there exists (as usual) a multiplicity of equilibria. We distinguish between *pooling* and *separating equilibria*. In a pooling equilibrium, both types choose the same repayment rate in the first period and lenders therefore do not update their beliefs. In a separating equilibrium, first-period repayment rates differ across types and the posterior beliefs of lenders either equal zero or unity. In both types of equilibrium, the repayment rate in the second period may differ across types.[12]

The number of equilibria can be reduced via specific refinements (see, for example, Cho and Kreps, 1987). We focus on the *optimal equilibrium*, that is, the equilibrium that maximizes the social welfare function $W(\cdot)$ defined as

$$W(r_1^h, r_1^l, \mathcal{F}_1(\cdot)) \equiv \theta U_1^h(r_1^h, \mathcal{F}_1(r_1^h)) + (1 - \theta)\omega U_1^l(r_1^l, \mathcal{F}_1(r_1^l)).$$

The parameter ω in the social welfare function $W(\cdot)$ denotes the relative weight of low types; for $\omega = 0$, the equilibrium is optimal for high types.

Since the cost of default is independent of whether default is full, $r_2 = 0$, or partial, $0 < r_2 < 1$, the optimal repayment rate in the second period equals either zero or unity. In particular, equilibrium requirement (i) implies

$$r_2^i(\mathcal{F}_1) = \begin{cases} 1 & \text{if } \lambda^i y_2 \geq b_2 \\ 0 & \text{if } \lambda^i y_2 < b_2 \end{cases}, i = h, l. \tag{1}$$

[11] We specify $r_2^i(\cdot)$ to be a function of $\mathcal{F}_1$ rather than only b_2 to render the notation consistent across the different sections of the paper. In a subsequent section, the repayment rate will depend on an additional argument that is also part of $\mathcal{F}_1$.

[12] While we describe the equilibrium in terms of a signalling equilibrium we are not tied to this type of equilibrium. With some minor modifications, our analysis can alternatively be conducted in the context of a model of screening. See Bolton and Dewatripont (2005, ch. 2, 3) for a discussion of signalling and screening equilibria.

We refer to conditions (1) as the repayment constraints. Consistent with (1), we restrict the choice set of borrowers in the first and second period and thus, the domain of $\mathcal{F}_1(\cdot)$ to $\mathcal{R} \equiv \{0, 1\}$.

Equilibrium requirement (ii) implies

$$U_1^i(r_1^i, \mathcal{F}_1(r_1^i)) \geq U_1^i(r_1, \mathcal{F}_1(r_1)), \forall r_1 \in \mathcal{R}, i = h, l. \tag{2}$$

We refer to conditions (2) as the (self-)selection constraints. We assume that

$$\lambda^l < b_1/y_1 \leq \lambda^h \tag{L}$$

that is, the immediate cost of defaulting is lower than the cost of repaying the initial debt for a low type, but higher for a high type. Repayment of debt due in the first period generates a net immediate loss for the low type but a net immediate gain for the high type. Consequently, if we were to think of repayment as serving as a signal, this signal would be costly for the low and costless for the high type. We examine later the case where it is also costly for the high type to signal. Our key result that the separating equilibrium involves austerity turns out to be independent of this consideration.

In addition, we assume that the following condition holds:

$$b_2^{l\,\text{fb}} \equiv \arg\max_{b_2^l} u(y_1(1-\lambda^l) + \beta b_2^l) + \delta u(y_2 - b_2^l) > \lambda^l y_2. \tag{B}$$

Condition (B) implies that the low type is borrowing constrained independent of whether he defaults in the first period or not. We make this assumption in order to guarantee that we always operate in an economy characterized by binding borrowing constraints under perfect information, which is the relevant reference point for our analysis. The condition is satisfied if $\beta \gg \delta$ or $y_2 \gg y_1$ and if λ^l is small. Since the first-best financing arrangement for the high type involves a loan size that exceeds $b_2^{l\,\text{fb}}$, $b_2^{h\,\text{fb}}$ say, condition (B) also implies that $b_2^{h\,\text{fb}} > \lambda^l y_2$.

The break even requirement (iv) and the repayment constraints (1) imply that the price satisfies

$$q_1(r_1) = \begin{cases} \beta & \text{if } b_2(r_1) \leq \lambda^l y_2 \\ \beta\theta_1(r_1) & \text{if } \lambda^l y_2 < b_2(r_1) \leq \lambda^h y_2 \\ 0 & \text{otherwise} \end{cases}. \tag{3}$$

In conclusion, an equilibrium is given by the tuple $(r_1^h, r_1^l, \theta_1(\cdot), \mathcal{F}_1(\cdot), r_2^h(\cdot), r_2^l(\cdot))$ that satisfies conditions (1), (2), (3) as well as Bayes' law (where applicable).

We define *austerity* as the difference between the actual level of consumption and the level of consumption that would have been achieved in the economy without incomplete information.[13] Let $b_2^{i\,\text{ci}}$ denote the level of debt under complete information. It is given by

$$b_2^{i\,\text{ci}} = \arg\max_{b_2^i \in \mathcal{B}} u\left(y_1 - \min[\lambda^i y_1, b_1] + \beta b_2^i\right) + \delta u(y_2 - b_2^i) \;\; \text{s.t.} \;\; b_2^i \leq \lambda^i y_2$$

[13]Note that the latter level of consumption falls short of the first best level due to the absence of repayment commitment.

The corresponding level of consumption, $c_t^{i\,\mathrm{ci}}$, is $c_1^{i\,\mathrm{ci}} \equiv y_1 - \min[\lambda^i y_1, b_1] + \beta b_2^{i\,\mathrm{ci}}$ and $c_2^{i\,\mathrm{ci}} \equiv y_2 - b_2^{i\,\mathrm{ci}}$ for $i = h, l$. Austerity a_t^i for type $i = h, l$ in period t is then given by

$$a_t^i \equiv c_t^{i\,\mathrm{ci}} - c_t^i.$$

When referring to austerity without specifying a particular period, we mean austerity in the first period.

3.2.1 Pooling Equilibrium

In pooling equilibrium, both types select the same first-period repayment rate, $r_1^h = r_1^l = r_1^p$. Conditional on observing this repayment rate, lenders form the posterior belief $\theta_1(r_1^p) = \theta$ and extend the loan $\mathcal{F}_1(r_1^p) = (q_1(r_1^p), b_2(r_1^p))$. Off the equilibrium path, a choice of $r_1 = 1 - r_1^p$ induces the posterior belief $\theta_1(1 - r_1^p)$ and lenders extend the loan $\mathcal{F}_1(1 - r_1^p) = (q_1(1 - r_1^p), b_2(1 - r_1^p))$. In both cases, condition (3) must hold. The selection constraints (2) take the form

$$U_1^i(r_1^p, \mathcal{F}_1(r_1^p)) \geq U_1^i(1 - r_1^p, \mathcal{F}_1(1 - r_1^p)), i = h, l, \tag{4}$$

where $q_1(r_1)$ satisfies (3) subject to the specified posterior beliefs.

A pooling equilibrium is fully characterized by $\kappa^p \equiv (r_1^p, q_1(r_1^p), b_2(r_1^p), \theta_1(1-r_1^p), q_1(1-r_1^p), b_2(1-r_1^p))$.[14] The set of pooling equilibria, $K^p \subseteq \mathcal{R} \times [0,1] \times \mathcal{B} \times [0,1]^2 \times \mathcal{B}$, is composed of all κ^p satisfying both (3) and (4) subject to $\theta_1(r_1^p) = \theta$. Accordingly, the optimal pooling equilibrium $\kappa^{p\star}$ solves

$$\kappa^{p\star} = \arg \max_{\kappa^p \in K^p} W(r_1^p, r_1^p, \mathcal{F}_1(\cdot)).$$

Note that while Bayes' law pins down the posterior belief along the equilibrium path, $\theta_1(r_1^p) = \theta$, it does not pin down the posterior belief after a deviation, $\theta_1(1-r_1^p)$. Similarly, the break even condition (3) does not pin down the loan size after a deviation, $b_2(1 - r_1^p)$. Both these objects can be chosen to relax the selection constraints.

To avoid unnecessary complications that distract from the central questions of interest we assume that $\lambda^h = \infty$.[15] This implies that high types never default and their selection constraint never binds. Low types therefore do not default in the first period either[16] and $b_2(1)$ maximizes $W(1, 1, \mathcal{F}_1(1))$ subject to (3) with $\theta_1(1) = \theta$. There are two possibilities, either $b_2(1) = \lambda^l y_2$ (a smaller value for $b_2(1)$ is ruled out by condition (B)) and $q_1(1) = \beta$ or $b_2(1) > \lambda^l y_2$ and $q_1(1) = \beta\theta$. In the former case, the objective function takes the value

$$\underline{W}^p = (\theta + (1 - \theta)\omega)\{u(y_1 - b_1 + \beta\lambda^l y_2) + \delta u(y_2(1 - \lambda^l))\}.$$

In the latter case, it equals

$$\overline{W}^p = (\theta + (1 - \theta)\omega)u(y_1 - b_1 + \beta\theta b_2(1)) + \delta\theta u(y_2 - b_2(1)) + \delta(1 - \theta)\omega u(y_2(1 - \lambda^l)),$$

[14] The repayment rates in the second period are given by (1).

[15] Throughout the analysis, we state the problem for general λ^h and λ^l but assume $\lambda^h = \infty$ when characterizing equilibrium.

[16] Whether a pooling equilibrium exists or not depends on the posterior beliefs as well as the loan contract offered in the case of default.

where $b_2(1) > \lambda^l y_2$ satisfies the first-order condition

$$(\theta + (1-\theta)\omega)u'(y_1 - b_1 + \beta\theta b_2(1))\beta\theta = \delta\theta u'(y_2 - b_2(1)).$$

Note that the high type suffers austerity in both cases: In the former due to a low quantity of fresh funds and in the latter due to a low price of debt. In the latter case, a large quantity of funds benefits both types, but it brings greater benefits to the low type as he does not repay. In fact, any loan in excess of $\beta\lambda^l y_2$ contains a transfer from high to low types. The high type suffers austerity if the loan issued, $b_2(1)$, is such that $\theta\beta b_2(1) < \beta b^{h\,\mathrm{ci}}$.[17]

3.2.2 Separating Equilibrium

In a separating equilibrium, the high and low type choose different repayment rates in the first period, $r_1^h \neq r_1^l$. Lenders form the posterior belief $\theta_1(r_1^h) = 1$ and $\theta_1(r_1^l) = 0$ and, based on this belief, they extend financing $\mathcal{F}_1(r_1^h) = (q_1(r_1^h), b_2(r_1^h))$ or $\mathcal{F}_1(r_1^l) = (q_1(r_1^l), b_2(r_1^l))$ subject to (3). The selection constraints (2) take the form

$$U_1^i(r_1^i, \mathcal{F}_1(r_1^i)) \geq U_1^i(r_1^j, \mathcal{F}_1(r_1^j)), i = h, l; i \neq j, \tag{5}$$

subject to (3) and the specified posteriors.

A separating equilibrium is fully characterized by $\kappa^s \equiv (r_1^h, r_1^l, q_1(r_1^h), b_2(r_1^h), q_1(r_1^l), b_2(r_1^l))$. The set of separating equilibria, $K^s \subseteq \mathcal{R}^2 \times [0,1] \times \mathcal{B} \times [0,1] \times \mathcal{B}$, is composed of all κ^s satisfying both (3) and (5) subject to $\theta_1(r_1^h) = 1$ and $\theta_1(r_1^l) = 0$. Accordingly, the optimal separating equilibrium $\kappa^{s\star}$ solves

$$\kappa^{s\star} = \arg\max_{\kappa^s \in K^s} W(r_1^h, r_1^l, \mathcal{F}_1(\cdot)).$$

The only feasible separating equilibrium is one where the high type chooses $r_1^h = 1$ and the low type $r_1^l = 0$.[18] The loans in the optimal separating equilibrium therefore satisfy

$$\begin{aligned}
(b_2(1), b_2(0)) \quad &= \quad \arg\max_{(b_2^h, b_2^l)\in\mathcal{B}^2} W(1, 0, ((\beta, b_2^h), (\beta, b_2^l)) \\
\text{s.t.} \quad & \quad U_1^h(1, (\beta, b_2^h)) \geq U_1^h(0, (\beta, b_2^l)), \\
& \quad U_1^l(0, (\beta, b_2^l)) \geq U_1^l(1, (\beta, b_2^h)), \\
& \quad b_2^h \leq \lambda^h y_2, \\
& \quad b_2^l \leq \lambda^l y_2.
\end{aligned}$$

[17] This condition is satisfied unless the relative weight attached to the welfare of the low type, ω, is very large and consequently, $b_2(1)$ and the transfer component are very high. If $\omega = \infty$ then the welfare criterion does not value consumption of the high type in the second period at all and thus $b_2(1) = y_2$. Moreover, for sufficiently large θ it could be the case that $\theta\beta y_2 > \beta b^{h\,\mathrm{ci}}$, that is, no austerity is suffered in the first period. This "perverse" austerity result disappears if the high type may reject loans that make him worse off.

[18] A separating equilibrium with $r_1^h = 0$ and $r_1^l = 1$ is not feasible because of the selection constraints. Making the high type better off when he defaults requires a larger loan after default than after no default (from condition (L)); making the low type better off when he does not default requires a larger loan after no default than after default (from condition (L)).

As before, we let $\lambda^h = \infty$. The selection and repayment constraints of the high type then do not bind and can be ignored. There are two possibilities. Either the low type receives the loan $b_2(0) = \lambda^l y_2$ and the high type a loan that is equal to the amount he would have received under complete information, $b_2^{h\,\text{ci}}$. This can happen only if the selection constraint of the low type does not bind at this loan level. Or, the low type receives the loan $b_2(0) = \lambda^l y_2$ and the high type receives less than $b_2^{h\,\text{ci}}$ because the selection constraint of the low type binds.[19]

In either case, $b_2(0) = \lambda^l y_2$ and $b_2(1) \geq b_2(0)$.[20] The latter inequality implies $U_2^l((\beta, b_2(0)), 1) = U_2^l((\beta, b_2(1)), 0)$. Accordingly, the selection constraint of the low type reduces to the requirement that first-period consumption of the low type when defaulting and receiving $\mathcal{F}_1(0)$ must be greater or equal to consumption when repaying and receiving $\mathcal{F}_1(1)$. Formally, the constraint reduces to $y_1(1-\lambda^l) + \beta b_2(0) \geq y_1 - b_1 + \beta b_2(1)$ or

$$b_2(1) \leq b_2(0) + \frac{b_1 - y_1\lambda^l}{\beta}. \tag{6}$$

Condition (6) caps the loan that can be extended to the high type without encouraging mimicking by the low type; if the condition were violated, mimicking would generate more funds to the low type in the first period at no cost in the second period (since the low type defaults in the second period if the loan exceeds $\lambda^l y_2$). The constraint is tighter and the maximal loan that can be extended to the high type is smaller for lower values of initial debt, b_1, and for lower growth rates, y_2/y_1 (recall that $b_2(0) = \lambda^l y_2$). Interestingly, it is also tighter, the larger the current level of output, that is, austerity is procyclical. This is due to the fact that the incentive of the low type to mimic is procyclical because the cost of default is an increasing function of output. In the special case where $\lambda^l = 0$ the constraint reduces to $b_2(1) \leq b_1/\beta$. That is, the high type country must produce a budget surplus or equivalently, a *current account surplus.*

In conclusion, the separating equilibrium satisfies $b_2(0) = y_2\lambda^l$ and either $b_2(1) = b_2^{h\,\text{ci}}$ with (6) not binding, or $b_2(1) = (\lambda^l(\beta y_2 - y_1) + b_1)/\beta$ with (6) binding. In the relevant case with a binding selection constraint the high type suffers austerity because the loan size is smaller than it would have been under complete information. The low type, in contrast, does not suffer austerity.

The objective function takes the value

$$\begin{aligned} W^s &= (\theta + (1-\theta)\omega)u(y_1(1-\lambda^l) + \beta\lambda^l y_2) \\ &\quad + \delta\left\{\theta u\left(y_2(1-\lambda^l) - \frac{b_1 - \lambda^l y_1}{\beta}\right) + (1-\theta)\omega u(y_2(1-\lambda^l))\right\}. \end{aligned}$$

This can be compared to the value obtained in the pooling equilibrium. For $\theta \to 1$, the optimal pooling equilibrium is associated with a loan size and price that converge to the financing arrangement extended to a high type under complete information. Hence, both types prefer the optimal pooling equilibrium over the optimal separating equilibrium

[19] If the selection constraint binds, the repayment constraint of the low type must bind as well. Otherwise, one could increase $b_2(0)$ and, from the relaxed selection constraint of the low type, $b_2(1)$ too.

[20] When the selection constraint binds, this follows from condition (L).

in this limiting case. For $\theta \to 0$, in contrast, the optimal pooling equilibrium fares worse than the optimal separating equilibrium. There exists a critical value of θ, above (below) which pooling gives higher (lower) welfare than separation.

4 Costly Signalling

In the model presented so far, the creditworthy borrower always repays outstanding debt in the first period and has no concern about establishing creditworthiness because the immediate cost of default exceeds the debt obligation (assumption (L)); there exists no interesting choice between default and repayment. One could think of an alternative environment, though, in which the level of outstanding debt is high enough as to make the short run gains from default exceed the short term losses. Under what conditions would a creditworthy type choose to suffer this first-period net loss, by repaying outstanding debt, in order to signal his type and secure a better loan contract? We address this question in a simple variant of our endowment model; this extension directly speaks to arguments in the policy debate which suggest that austerity may serve as a costly prerequisite for establishing "credibility" and thus securing a better loan package.

We modify condition (L) to

$$\lambda^l < \lambda^h < b_1/y_1, \tag{L'}$$

so that the direct cost of debt repayment exceeds the default losses in the first period, independently of the type of government. A separating equilibrium with $r_1^h = 1$, $r_1^l = 0$ and $b_2(1) \geq b_2(0) = y_2\lambda^l$ is feasible if

$$\begin{aligned}
&u(y_1 - b_1 + \beta b_2(1)) + \delta u(y_2 - b_2(1)) \geq u(y_1(1-\lambda^h) + \beta y_2\lambda^l) + \delta u(y_2(1-\lambda^l)),\\
&b_2(1) \leq y_2\lambda^h,\\
&b_2(1) \leq y_2\lambda^l + \frac{b_1 - y_1\lambda^l}{\beta}.
\end{aligned}$$

The first and second constraint represent the selection and repayment constraint of the high type—which can no longer be ignored under condition (L') where $\lambda^h < \infty$—and the last constraint represents the selection constraint of the low type which is unchanged relative to section 3. The new element here is that the first equation generates a lower bound on the amount of fresh loans that is needed in order to induce the high type to not default in the first period. Consequently, the austerity level required to support a separating equilibrium can be neither too light (because the low type would then mimic) nor too severe (because the high type would default in the first period).

In order to produce a more concrete example we set $\lambda^l = 0$, $\omega = 0$. We saw earlier that in this case, the best separating equilibrium involved a fresh loan $\beta b_2(1) = b_1$ at price β if there were no default, and a loan of zero if there were default. Can this menu of contracts still support separation, that is, make the high type choose to honor debt? The condition for an affirmative answer is

$$\begin{aligned}
U_1^h(1,(\beta,b_2(1))) &\geq U_1^h(0,(\beta,0)),\\
\Rightarrow u(y_1 - b_1 + \beta b_2(1)) + \delta u(y_2 - b_2(1)) &\geq u(y_1(1-\lambda^h)) + \delta u(y_2).
\end{aligned}$$

A sufficiently high y_2/y_1 ratio or a low b_1/λ^h ratio make this condition satisfied. Consequently, the requirements for a separating equilibrium now become more stringent as the selection constraint of the high type must also be satisfied. But the properties of the optimal separating equilibrium remain the same.

5 Investment

5.1 Environment

We now introduce a decreasing returns to scale technology $f(\cdot)$ that transforms investment $I_1 \in \mathcal{I} \equiv [0, \infty)$ in the first period into output $f(I_1)$ in the second. We interpret investment broadly: It might represent physical investment in productive capacity or, investments in institutions that increase future productivity. In line with either interpretation, we allow for the possibility that investment might make default costlier in the second period, by giving rise to a cost $\tilde{\lambda}^i f(I_2)$ in addition to the income losses $\lambda^i y_2$. As is well known, if $\tilde{\lambda}^i > 0$, then investment increases the collateral of a borrowing country and this alleviates the borrowing constraint. In order to highlight the fact that the main mechanism at work in our model concerns the role of investment as a signalling device rather than as collateral enhancer we will study both the case of $\tilde{\lambda}^i = 0$ and of $\tilde{\lambda}^i = \lambda^i$ whenever this distinction is relevant.

5.2 Equilibrium with Contractible Investment

We first consider the case of contractible investment before turning to the case of non-contractible investment in the subsequent subsection. With contractible investment, a financing arrangement specifies a level of investment in addition to the price and quantity of debt, $\mathcal{F}_1 = (q_1, b_2, I_1)$. Utility of type $i = h, l$ in period $t = 2$ now is given by

$$U_2^i(\mathcal{F}_1, r_2) = u\left(y_2(1 - \lambda^i \mathbf{1}_{\{r_2<1\}}) + f(I_1)(1 - \tilde{\lambda}^i \mathbf{1}_{\{r_2<1\}}) - b_2 r_2\right)$$

and welfare of type $i = h, l$ equals

$$U_1^i(r_1, \mathcal{F}_1) = u\left(y_1(1 - \lambda^i \mathbf{1}_{\{r_1<1\}}) - b_1 r_1 + q_1 b_2 - I_1\right) + \delta \max_{r_2 \in \mathcal{R}} U_2^i(\mathcal{F}_1, r_2).$$

The definition of *equilibrium* is the same as in the basic model. The repayment constraints (1) are modified to

$$r_2^i(\mathcal{F}_1) = \begin{cases} 1 & \text{if } \lambda^i y_2 + \tilde{\lambda}^i f(I_1) \geq b_2 \\ 0 & \text{if } \lambda^i y_2 + \tilde{\lambda}^i f(I_1) < b_2 \end{cases}, i = h, l, \tag{7}$$

while the selection constraints (2) (which take the form (4) in pooling equilibrium and (5) in separating equilibrium) remain unchanged. The price therefore satisfies

$$q_1(r_1) = \begin{cases} \beta & \text{if } b_2(r_1) \leq \lambda^l y_2 + \tilde{\lambda}^l f(I_1(r_1)) \\ \beta\theta_1(r_1) & \text{if } \lambda^l y_2 + \tilde{\lambda}^l f(I_1(r_1)) < b_2(r_1) \leq \lambda^h y_2 + \tilde{\lambda}^h f(I_1(r_1)) \\ 0 & \text{otherwise} \end{cases}. \tag{8}$$

5.2.1 Pooling Equilibrium

In addition to the objects introduced in the previous section, a pooling equilibrium now also involves the levels of investment, $I_1(r_1^p)$ and $I_1(1-r_1^p)$. The selection constraints are still given by (4). A pooling equilibrium is characterized by $\kappa^p \equiv (r_1^p, q_1(r_1^p), b_2(r_1^p), I_1(r_1^p), \theta_1(1-r_1^p), q_1(1-r_1^p), b_2(1-r_1^p), I_1(1-r_1^p))$ and the set of pooling equilibria, $K^p \subseteq \mathcal{R} \times [0,1] \times \mathcal{B} \times \mathcal{I} \times [0,1]^2 \times \mathcal{B} \times \mathcal{I}$, is composed of all κ^p satisfying both (4) and (8) subject to $\theta_1(r_1^p) = \theta$. Accordingly, the optimal pooling equilibrium $\kappa^{p\star}$ solves

$$\kappa^{p\star} = \arg\max_{\kappa^p \in K^p} W(r_1^p, r_1^p, \mathcal{F}_1(\cdot)).$$

We again assume that $\lambda^h = \infty$, implying that $r_1^p = 1$. The quantities $(b_2(1), I_1(1))$ maximize $W(1, 1, \mathcal{F}_1(1))$ subject to (8) with $\theta_1(1) = \theta$. As before, two cases can be distinguished: Either $b_2(1)$ equals $\lambda^l y_2 + \tilde{\lambda}^l f(I_1(1))$ with $q_1(1) = \beta$; or, it exceeds that value and $q_1(1) = \beta\theta$.

If $b_2(1) \leq \lambda^l y_2 + \tilde{\lambda}^l f(I_1(1))$, the objective function takes the value

$$W^p = (\theta + (1-\theta)\omega)\{u(c_1) + \delta u(c_2)\}$$

with $c_1 \equiv y_1 - b_1 + \beta b_2(1) - I_1(1)$ and $c_2 \equiv y_2 - b_2(1) + f(I_1(1))$. Here, $I_1(1)$ solves

$$u'(c_1) = \delta f'(I_1(1))u'(c_2) + \tilde{\lambda}^l f'(I_1(1))[u'(c_1)\beta - \delta u'(c_2)]$$

and the term multiplying $\tilde{\lambda}^l$ reflects the binding repayment constraint of the low type. If investment contributes collateral ($\tilde{\lambda}^l > 0$), investment is distorted upwards in order to increase collateral.[21] Note that for any level of debt, the low type's preferred investment falls short of that of the high type because the former defaults in the second period and thus has lower marginal utility, whereas the latter does not.

If $b_2(1) > \lambda^l y_2 + \tilde{\lambda}^l f(I_1(1))$, the objective function takes the value

$$W^p = (\theta + (1-\theta)\omega)u(c_1) + \delta\{\theta u(c_2^h) + (1-\theta)\omega u(c_2^l)\}$$

with $c_1 \equiv y_1 - b_1 + \beta\theta b_2(1) - I_1(1)$, $c_2^h \equiv y_2 - b_2(1) + f(I_1(1))$ and $c_2^l \equiv y_2(1-\lambda^l) + f(I_1(1))(1-\tilde{\lambda}^l)$ where $(b_2(1), I_1(1))$ solves

$$(\theta + (1-\theta)\omega)u'(c_1)\beta\theta = \delta\theta u'(c_2^h),$$
$$(\theta + (1-\theta)\omega)u'(c_1) = \delta f'(I_1(1))\{\theta u'(c_2^h) + (1-\theta)\omega u'(c_2^l)(1-\tilde{\lambda}^l)\}.$$

The implications for austerity for the high type are similar to those discussed previously, in the model without investment.

[21] This case corresponds to the situation with a single type that has been studied in the literature, see Obstfeld and Rogoff (1996, 6.2.1.3).

5.2.2 Separating Equilibrium

A separating equilibrium is characterized by $\kappa^s \equiv (r_1^h, r_1^l, q_1(r_1^h), b_2(r_1^h), I_1(r_1^h), q_1(r_1^l), b_2(r_1^l), I_1(r_1^l))$ and the selection constraints are given by (5) subject to (8) as well as the posterior beliefs $\theta_1(r_1^h) = 1$ and $\theta_1(r_1^l) = 0$. The set of pooling equilibria, $K^s \subseteq \mathcal{R}^2 \times [0,1] \times \mathcal{B} \times \mathcal{I} \times [0,1] \times \mathcal{B} \times \mathcal{I}$, is composed of all κ^s satisfying both (5) and (8) subject to the stated posteriors. The optimal separating equilibrium $\kappa^{s\star}$ solves

$$\kappa^{s\star} = \arg\max_{\kappa^s \in K^s} W(r_1^h, r_1^l, \mathcal{F}_1(\cdot)).$$

As before, the only separating equilibrium is one where the high type chooses $r_1^h = 1$ and the low type $r_1^l = 0$. The loan sizes and investment levels in the optimal separating equilibrium therefore solve

$$\begin{aligned}
(b_2(1), b_2(0), I_1(1), I_1(0)) \quad &= \quad \arg \max_{(b_2^h, b_2^l, I_1^h, I_1^l) \in \mathcal{B}^2 \times \mathcal{I}^2} W(1, 0, ((\beta, b_2^h, I_1^h), (\beta, b_2^l, I_1^l))) \\
\text{s.t.} \quad & U_1^h(1, (\beta, b_2^h, I_1^h)) \geq U_1^h(0, (\beta, b_2^l, I_1^l)), \\
& U_1^l(0, (\beta, b_2^l, I_1^l)) \geq U_1^l(1, (\beta, b_2^h, I_1^h)), \\
& b_2^h \leq \lambda^h y_2 + \tilde{\lambda}^h f(I_1^h), \\
& b_2^l \leq \lambda^l y_2 + \tilde{\lambda}^l f(I_1^l).
\end{aligned}$$

As before, we assume that $\lambda^h = \infty$. Accordingly, the selection and repayment constraints of the high type (first and third constraints respectively) do not bind and can be ignored.

Investment Does Not Enhance Collateral We establish two important results. First, there is over-investment even if investment does not increase collateral ($\tilde{\lambda}^i = 0$), because investment serves as a means of mitigating the adverse selection friction. And second, this over-investment is so severe as to make the high type's consumption lower than it would have been were it not possible to use investment as a device for that purpose. Stated differently, investment helps the high type partly overcome the adverse selection friction, but it does so at the cost of even more severe austerity.

In general, distorted investment creates a welfare loss. But in the presence of adverse selection the high type benefits from distorted investment because this slackens the selection constraint of the low type and thus, makes it possible for the high type to obtain a larger loan. Although at the margin the increased loan size is more than fully absorbed by higher investment, the high type still enjoys a net benefit from higher consumption in the future.

These results differ from the standard result in the sovereign debt literature that over-investment is useful because it relaxes the repayment constraint (see Obstfeld and Rogoff (1996, 6.2.1.3) and the discussion in the preceding subsection of pooling equilibrium when the loan size is small). The latter, well-known result requires the assumption that investment serves to increase collateral ($\tilde{\lambda}^i > 0$). Our result has a different source (the existence of adverse selection) and role (the mitigation of the resulting friction) and holds independently of whether $\tilde{\lambda}^i = 0$ or not.

Consider the optimal separating equilibrium above with $\lambda^h = \infty$. Let μ and ν denote the multipliers associated with the low type's selection and repayment constraints, respectively, and let $c_1^h \equiv y_1 - b_1 + \beta b_2(1) - I_1(1)$, $c_2^h \equiv y_2 - b_2(1) + f(I_1(1))$, $c_1^l \equiv y_1(1-\lambda^l) + \beta b_2(0) - I_1(0)$ and $c_2^l \equiv y_2 - b_2(0) + f(I_1(0))$ denote the first- and second-period consumption levels of the high and low type in equilibrium. The Lagrangian is given by

$$\begin{aligned}\mathcal{L} &= \theta\{u(c_1^h) + \delta u(c_2^h)\} + (1-\theta)\omega\{u(c_1^l) + \delta u(c_2^l)\} + \nu\{\lambda^l y_2 - b_2(0)\} \\ &\quad + \mu\{u(c_1^l) + \delta u(c_2^l) - u(c_1^h) - \delta u(y_2(1-\lambda^l) + f(I_1(1)))\},\end{aligned}$$

where μ and ν denote non-negative multipliers. In addition to the complementary slackness conditions, we have the following first-order conditions:

$$\begin{aligned}
b_2(1):&\quad \theta\{u'(c_1^h)\beta - \delta u'(c_2^h)\} = \mu\beta u'(c_1^h),\\
b_2(0):&\quad ((1-\theta)\omega + \mu)\{u'(c_1^l)\beta - \delta u'(c_2^l)\} = \nu,\\
I_1(1):&\quad \theta\{-u'(c_1^h) + \delta f'(I_1(1))u'(c_2^h)\} = \mu\{-u'(c_1^h) + \delta f'(I_1(1))u'(y_2(1-\lambda^l) + f(I_1(1)))\},\\
I_1(0):&\quad ((1-\theta)\omega + \mu)\{-u'(c_1^l) + \delta f'(I_1(0))u'(c_2^l)\} = 0.
\end{aligned}$$

The first condition states that the high type's consumption profile is distorted $(u'(c_1^h)\beta > \delta u'(c_2^h))$, that is, the high type is borrowing constrained, whenever the selection constraint of the low type binds, $\mu > 0$.[22] The second condition indicates that the shadow cost of the low type's repayment constraint, ν, is strictly positive if he is borrowing constrained $(u'(c_1^l)\beta > \delta u'(c_2^l))$ and either $\omega > 0$ or $\mu > 0$ (the selection constraint binds).

The third condition states that investment of the high type is *distorted*—conditional on the loan received—if the low type's selection constraint binds and a low type would be forced to over- or under-invest were he to try to mimic the high type. Intuitively, the cost of distorting investment upwards for the high type is balanced by the benefit of relaxing the selection constraint of the low type; this in turn requires that the low type's investment be distorted when he mimics. Finally, the last constraint states that if separation is costly, $\mu > 0$, or, if the low type's welfare is valued, $\omega > 0$, the low type is allowed to choose his investment level optimally.

Consider first the case where the selection constraint does not bind, $\mu = 0$. The first and third first-order conditions then imply that the presence of asymmetric information is of no consequence for the high type. For this outcome to obtain it must be that $U_1^l(0, (\beta, \lambda^l y_2, I_1(0))) \geq U_1^l(1, (\beta, b_2^{h\,\mathrm{ci}}, I_1^{h\,\mathrm{ci}}))$ where $I_1(0)$ is the low type's optimal investment conditional on $r_1^l = 0$ and $b_2(0) = \lambda^l y_2$.

If, in contrast, the latter inequality is violated, then the selection constraint binds and $\mu > 0$. In this case, the equilibrium involves undistorted investment for the low type along the equilibrium path but distorted investment when there is mimicking. Combining the first and third first-order conditions gives

$$\frac{u'(c_1^h)\beta - \delta u'(c_2^h)}{\beta u'(c_1^h)} = \frac{u'(c_1^h) - \delta f'(I_1(1))u'(c_2^h)}{u'(c_1^h) - \delta f'(I_1(1))u'(y_2(1-\lambda^l) + f(I_1(1)))} > 0. \tag{9}$$

[22] The consumption profile would further be distorted if the repayment constraint limited borrowing by the high type. Our assumption that $\lambda^h = \infty$ rules this out.

The numerator on the right-hand side of condition (9) measures the investment distortion for the high type while the denominator measures the investment distortion for the low type when mimicking. The two wedges have the same sign. Proposition 1 establishes that this sign is positive, that is, there is *over-investment*—conditional on loan size—for the high type when the selection constraint of the low type binds.

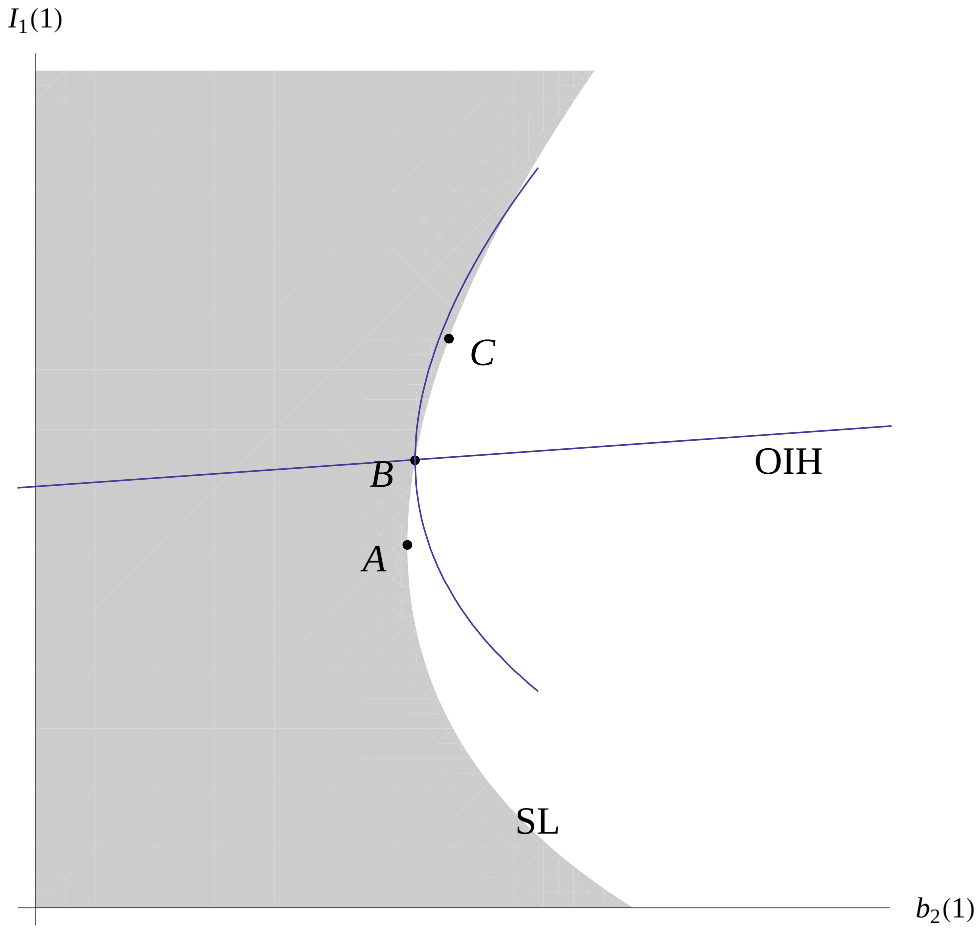

Figure 1: Separating equilibrium with contractible investment.

Proposition 1. *Suppose that investment is contractible and does not create collateral;* $\lambda^h = \infty$*; and the low type's selection constraint binds,* $\mu > 0$*. Then:*

(a) Investment of the high type is distorted upwards conditional on loan size, $u'(c_1^h) > \delta f'(I_1(1))u'(c_2^h)$*.*

(b) At the margin, investment of the high type increases by more than one-to-one with new funds. That is, at the margin, consumption falls and austerity increases *as funding increases.*

(c) Investment of the high type is strictly smaller than the first-best investment level I_1^{fb} *which satisfies* $\beta f'(I_1^{\text{fb}}) = 1$*. Moreover, the loan for the high type is strictly smaller than in the first best.*

Proof. Part (a): Consider figure 1. Curve SL represents the selection constraint of the low type with equality, namely, the locus of $(b_2(1), I_1(1))$ combinations that satisfy $u(y_1 - b_1 + \beta b_2(1) - I_1(1)) + \delta u(y_2(1-\lambda^l) + f(I_1(1))) = u(y_1(1-\lambda^l) + \beta y_2\lambda^l - I_1(0)) + \delta u(y_2(1-\lambda^l) + f(I_1(0)))$. Here, $I_1(0)$ represents the optimal investment level of a low type who reveals his type by defaulting in the first period and receives a loan of size $y_2\lambda^l$. All loan-investment combinations in the shaded area to the left of the SL-locus are incentive compatible. The slope of the SL-locus is given by

$$\frac{dI_1(1)}{db_2(1)}|_{\mathrm{SL}} = \frac{\beta}{1 - \delta f'(I_1(1))\frac{u'(y_2(1-\lambda^l)+f(I_1(1)))}{u'(y_1-b_1+\beta b_2(1)-I_1(1))}}.$$

Under standard assumptions, this slope is negative at low and positive at high levels of investment. Let point A correspond to the loan-investment combination where the slope equals zero. This is the only point on the locus where the mimicking low type's investment level is conditionally optimal.

The OIH-curve in figure 1 gives the optimal level of investment of the high type for any level of debt. It has a positive slope and thus intersects the SL curve at a point B that lies above A. This is due to the fact, noted above, that for any level of debt the optimal investment of the high type exceeds the optimal investment of the mimicking low type, due to the debt repayment in the second period. By construction, the slope of the high type's indifference curve at B is infinite while that of the selection constraint is finite. A marginal, upward move away from B along the SL-locus therefore leaves the mimicking low type indifferent but increases the welfare of the high type. Such a move involves over-investment as the SL-locus lies above the OIH-curve in that region.

Part (b): Since point B lies on the OIH-curve, investment at this point satisfies the first-order condition for investment of the high type, $u'(y_1 - b_1 + \beta b_2(1) - I_1(1)) = \delta f'(I_1(1))u'(y_2 - b_2(1) + f(I_1(1)))$. Substituting this equality into the expression for the slope of the SL-locus, $dI_1(1)/db_2(1)|_{\mathrm{SL}}$, we find that $dI_1(1)/db_2(1)|_{\mathrm{SL}} > \beta$ at point B. That is, each extra unit of fresh debt which generates β units of current funds requires additional investment of more than β units. Consequently, consumption of the high type decreases at the margin. To the right of point B and the left of point C along the SL-locus, the slope $dI_1(1)/db_2(1)|_{\mathrm{SL}}$ decreases but it is bounded from below by β.

Part (c): Let $\alpha \equiv 1/[\beta f'(I_1(1))]$ where $\alpha < 1$ indicates under-investment relative to first best and let M^h and M^l, respectively, denote the normalized marginal rates of substitution between first- and second-period consumption, $\delta u'(c_2)/[\beta u'(c_1)]$, of the high type and the mimicking low type. The left-hand side of condition (9) can then be expressed as $1 - M^h$ and the right-hand side as

$$\frac{u'(c_1^h) - \delta u'(c_2^h)/(\alpha\beta)}{u'(c_1^h) - \delta u'(y_2(1-\lambda^l) + f(I_1^h))/(\alpha\beta)} \quad \text{or} \quad \frac{\alpha - M^h}{\alpha - M^l}.$$

Condition (9) therefore reduces to

$$1 - M^h = \frac{\alpha - M^h}{\alpha - M^l} \quad \text{or} \quad \alpha = 1 + M^l\left(1 - \frac{1}{M^h}\right).$$

Since the high type is borrowing constrained, $M^h < 1$. This implies $\alpha < 1$ and thus, under-investment relative to first best.

Let a "tilde" denote values in point B and a "bar" values in point C. As shown earlier, $\tilde{I}_1^h$ is optimal (conditional on $\tilde{b}_2^h$) and the increase $\bar{b}_2^h - \tilde{b}_2^h$ is associated with a change $\bar{I}_1^h - \tilde{I}_1^h > \beta(\bar{b}_2^h - \tilde{b}_2^h)$. This implies $\bar{b}_2^h < \tilde{b}_2^h + (\bar{I}_1^h - \tilde{I}_1^h)/\beta$. Since first-best, first-period consumption is higher than first-period consumption under $(\tilde{b}_2^h, \tilde{I}_1^h)$ we have $\beta b_2^{h\,\text{fb}} - I_1^{h\,\text{fb}} > \beta\tilde{b}_2^h - \tilde{I}_1^h$ or $b_2^{h\,\text{fb}} > \tilde{b}_2^h + (I_1^{\text{fb}} - \tilde{I}_1^h)/\beta$. Combining these inequalities and using the fact that $\bar{I}_1^h < I_1^{h\,\text{fb}}$ implies $\bar{b}_2^h < b_2^{h\,\text{fb}}$. □

Investment Enhances Collateral Suppose now that the output generated from investment also serves as collateral, $\tilde{\lambda}^l = \lambda^l$. This has two implications for the Lagrangian. First, the repayment constraint of the low type changes from $\lambda^l y_2 \geq b_2(0)$ to

$$\lambda^l(y_2 + f(I_1(0))) \geq b_2(0).$$

And second, the low type's selection constraint becomes

$$u(c_1^l) + \delta u(c_2^l) \geq u(c_1^h) + \delta u((y_2 + f(I_1(1)))(1 - \lambda^l))$$

instead of $u(c_1^l) + \delta u(c_2^l) \geq u(c_1^h) + \delta u(y_2(1 - \lambda^l) + f(I_1(1)))$, reflecting the fact that a mimicking low type that defaults in the second period suffers losses on the return on investment in addition to those on the exogenous income.

The first-order conditions with respect to $b_2(1)$ and $b_2(0)$ are not affected by these changes. In contrast, the first-order conditions with respect to the investment levels change to

$$\begin{aligned}
I_1(1): \quad & \theta\{-u'(c_1^h) + \delta f'(I_1(1))u'(c_2^h)\} \\
& \qquad = \mu\{-u'(c_1^h) + \delta f'(I_1(1))(1 - \lambda^l)u'((y_2 + f(I_1(1)))(1 - \lambda^l))\}, \\
I_1(0): \quad & ((1 - \theta)\omega + \mu)\{-u'(c_1^l) + \delta f'(I_1(0))u'(c_2^l)\} = -\nu\lambda^l f'(I_1(0)).
\end{aligned}$$

The first expression indicates that the marginal return on investment for a mimicking low type—who defaults in the second period—equals $f'(I_1(1))(1-\lambda^l)$ rather than $f'(I_1(1))$ as was the case before. The term on the right-hand side of the second first-order condition reflects the fact that investment of the low type slackens his repayment constraint.

The central results established in the setting without a collateral contributing role for investment continue to hold. In particular, when the selection constraint does not bind, $\mu = 0$, the presence of asymmetric information does not affect the financing arrangement for the high type. When it binds ($\mu > 0$), investment of the high type is conditionally distorted as in the case where investment proceeds do not serve as collateral. In this case, combining the first-order conditions with respect to $b_2(1)$ and $I_1(1)$ yields a version of equation (9) that only differs insofar as the denominator on the right-hand side reflects the modified marginal return on $I_1(1)$ for a mimicking low type.

When the selection constraint binds, investment of the high type is conditionally distorted upwards, exactly for the same reasons as before. Moreover, at the margin, a larger loan size for the high type continues to go hand in hand with a rise of investment by more than one-to-one. At the margin, a larger loan size therefore continues to imply harsher austerity for the high type. Finally, relative to first best, the investment level and loan size of the high type continue to be depressed. All the results derived in the setting without a collateral contributing role for investment still obtain. These results derive from the presence and properties of the low type's selection constraint, in particular with respect to the interaction between $b_2(1)$ and $I_1(1)$, and this interaction is not altered in important ways when investment enhances collateral.

Structural Reform and Austerity The management of the Greek sovereign debt crisis has recently witnessed a shift of emphasis away from fiscal towards structural reform measures. Greece's official creditors have offered her a relaxation of the fiscal requirements that were already agreed previously, essentially allowing the country to run above target budget deficits financed by the official creditors, in exchange for the implementation of a package of reforms drawn up by the task force and the OECD. This development has been greeted as a relaxation of austerity. But is it? As we noted above, structural reform could be an example of some sort of investment, requiring resources in the short run but generating returns in the long run. In light of these results, and for the same reasons, it is clear that a high type government would be more willing to engage in structural reform than a low type, and that a high type could be best off exhibiting "excessive" reform zeal in order to reveal her type and get more funds. What supports such action is that high creditworthiness governments value resources in the future more than the low types do.

5.3 Equilibrium with Non-Contractible Investment

If investment is not contractible, the financing arrangement only specifies the price and quantity of debt, $\mathcal{F}_1 = (q_1, b_2)$, as it was the case in the baseline model without investment. Investment is chosen by the sovereign after the lenders have extended the loan. It is therefore a function of $\mathcal{F}_1$ and r_1 rather than of r_1 only as in the case with contractible investment. The repayment rate in the second period is still a function of (q_1, b_2, I_1).

This change implies an additional equilibrium condition: Investment must be optimal for the sovereign conditional on the loan size and price. Referring back to figure 1, this restriction adds the requirement that the equilibrium must lie at the intersection of the SL- and OIH-curves, that is, at point B.

If investment is not contractible, then its level cannot be used to assist separation. Consequently, the insights arising in this case do not differ from those obtained in the model without investment.

6 Extensions

6.1 Three-Period Model

By its nature, a two-period model exhibits limited dynamics. In order to accommodate richer patterns in debt and default we now consider a three-period extension of our setup.

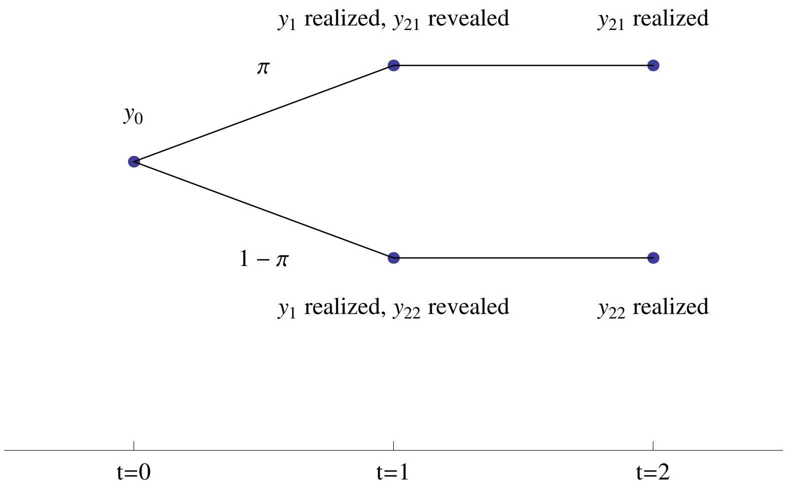

Figure 2: Event tree

Three periods allow the model to generate persistent pooling and to make the persistence a function of the economy's state. In particular, pooling may persist as long as economic conditions such as the level of risk free world interest rates or domestic income growth remain sufficiently favorable and financing ample. But pooling may give way to a separation of types with depressed levels of funding and potentially default, when economic conditions worsen. As we argued in the introduction, the former scenario corresponds to the path observed in Greece during recent years; but the latter scenario may still emerge, in particular if official creditors deem it likely that Syriza is of the low type. We now illustrate these two possibilities.

We focus on the effects of a change in expected output growth but similar results would obtain if we let other parameters, such as the level of world risk free interest rates or the probability of low type, vary. The environment is as follows: There are three periods, $t = 0, 1, 2$, with period $t = 0$ being the "new" period relative to the setting considered so far. Output growth between the first and second period is positive. Output growth between the second and third period is stochastic and revealed in the beginning of period $t = 1$. For the sake of exposition, we let y_2 take only two values, y_{21} or y_{22}, where $y_{21} > y_{22}$ and the higher value occurs with probability π, see the event tree in figure 2. For simplicity, we let $\lambda^l = 0$ and $\lambda^h = \infty$ and we abstract from investment.

Consider first an equilibrium with pooling in periods $t = 1$ and $t = 2$ and with repayment in all nodes, except by the low type in the last period. The equilibrium prices then satisfy $q_0 = \beta$ and $q_{11} = q_{12} = \beta\theta$. Let $V_0^h(b_1, b_{21}, b_{22})$ and $V_0^l(b_1, b_{21}, b_{22})$ denote the value at time $t = 0$ for a high or low type, respectively, of following the equilibrium strategy. We have

$$\begin{aligned} V_0^h(b_1, b_{21}, b_{22}) &= u(y_0 - b_0 + b_1 q_0) + \delta\pi\{u(y_1 - b_1 + b_{21}q_{11}) + \delta u(y_{21} - b_{21})\} \\ &\quad + \delta(1-\pi)\{u(y_1 - b_1 + b_{22}q_{12}) + \delta u(y_{22} - b_{22})\}, \\ V_0^l(b_1, b_{21}, b_{22}) &= u(y_0 - b_0 + b_1 q_0) + \delta\pi\{u(y_1 - b_1 + b_{21}q_{11}) + \delta u(y_{21})\} \\ &\quad + \delta(1-\pi)\{u(y_1 - b_1 + b_{22}q_{12}) + \delta u(y_{22})\}. \end{aligned}$$

Incentive compatibility implies three constraints. When y_{21} is revealed, it must be in the interest of low types to repay rather than default,

$$u(y_1 - b_1 + b_{21}q_{11}) + \delta u(y_{21}) \geq u(y_1) + \delta u(y_{21}) \quad \text{or} \quad b_{21}q_{11} \geq b_1, \tag{10}$$

where we assume that off the equilibrium path, no debt is issued after a default. A parallel condition must be satisfied when y_{22} is revealed:

$$u(y_1 - b_1 + b_{22}q_{12}) + \delta u(y_{22}) \geq u(y_1) + \delta u(y_{22}) \quad \text{or} \quad b_{22}q_{12} \geq b_1. \tag{11}$$

Finally, immediate default and financial autarky must be suboptimal in period $t = 0$,

$$V_0^l(b_1, b_{21}, b_{22}) \geq u(y_0) + \delta u(y_1) + \delta^2\{\pi u(y_{21}) + (1-\pi)u(y_{22})\}. \tag{12}$$

The best equilibrium for high types in this class thus maximizes $V_0^h(b_1, b_{21}, b_{22})$ subject to (10)–(12). Intuitively, for pooling to be sustainable, the value of outstanding debt must increase over time; otherwise, low types would find it profitable to default rather than to roll over, see conditions (10) and (11).

Clearly, this type of equilibrium exists, and is the best equilibrium for high types, when the probability of facing a low type is sufficiently small and the growth prospects in the bad state are not too bad. In particular, if growth in the bad state is sufficiently high for the complete information debt policy to feature $\beta b_{22} \geq b_1$ then the equilibrium implements the first best for high types as $\theta \to 1$.

Consider alternatively an equilibrium that features both pooling and separation along the equilibrium path. In period $t = 0$, high and low types pool. In period $t = 1$, high and low types continue to pool if the prospects for output growth remain good (which happens with probability π) but separate when prospects deteriorate. In the latter case, only the high type repays and issues new debt. In this second equilibrium, $q_0 = \beta(\theta + (1-\theta)\pi)$ since low types only repay in period $t = 1$ when growth prospects remain good; $q_{11} = \beta\theta$, as before; and $q_{12} = \beta$ because low types do not issue bonds when y_{22} is revealed.

The conditions characterizing this second equilibrium differ threefold from the previous ones. First, as already mentioned, q_0 is lower and q_{12} higher than in the first equilibrium. Second, the expression for $V_0^l(b_1, b_{21}, b_{22})$ is altered,

$$\begin{aligned} V_0^l(b_1, b_{21}, b_{22}) &= u(y_0 - b_0 + b_1 q_0) + \delta\pi\{u(y_1 - b_1 + b_{21}q_{11}) + \delta u(y_{21})\} \\ &\quad + \delta(1-\pi)\{u(y_1) + \delta u(y_{22})\}. \end{aligned}$$

And third, the inequality in the incentive compatibility constraint (11) is reversed such that low types find it profitable to default rather than roll over when y_{22} is revealed. All other expressions and conditions are the same.

Tables 1 and 2 provide a numerical example that illustrates the second type of equilibrium. For the parameters given in table 1 the optimal equilibrium features debt growth as long as prospects remain good but smaller loans –which induce a low-type to default– when prospects turn bad.[23] The incentive constraint at the node with bad growth prospects, the modified condition (11), binds. That is, where the low type chooses to default is where the high type is rationed.

Table 1: Three-period model with pooling and separation: Parameter values

β	δ	θ	b_0	y_0	y_1	y_{21}	y_{22}	π
0.9	0.6	0.8	0.1	1.0	1.5	2.0	1.0	0.5

Table 2: Three-period model with pooling and separation: Debt dynamics

b_0	b_1	q_0	b_{21}	q_{21}	b_{22}	q_{22}
0.10	0.73	0.81	1.01	0.72	0.30	0.90

Note that in our analysis, the participation constraint of lenders holds subject to their (correct) belief that the government type is permanent. In reality, lenders may expect that the government in the borrowing country will eventually be replaced by a type that is less inclined to default. This expectation might render an equilibrium with persistent pooling—the first type of equilibrium considered above—more plausible.[24]

6.2 Multipliers

Returning to the two-period setting, the model can also be extended to address the role of multipliers in the determination of the optimal degree of austerity. Rather than embedding the mechanism outlined so far into a standard DSGE model of the New Keynesian variety—an approach that seems both daunting and unnecessary—we introduce a simple modification that allows the model to provide some insights on the relationship between the size of the multiplier and the optimal degree of austerity. We derive the main implications in the context of a simple version of the endowment economy of section 3, but the main insights carry over to the more general case.

The essence of the concept of multiplier is that an autonomous change of spending in the public sector can have an amplified effect on spending and income in the economy at

[23] We have verified that the equilibrium with pooling in the good *and bad* state generates a lower value for the high type. .

[24] In a rational expectations equilibrium the incumbent and foreign lenders assign the same probability to a future change of government. The likelier such a change, the lower the attractiveness of a debt rollover rather than default for a low type incumbent, but the greater the attractiveness for foreign lenders. Nevertheless, a rational expectations equilibrium may exist for a wide set of parameters, for example when lenders do not discount the future as highly as the incumbent government.

large. We capture this by assuming that disposable income and consumption in the first period are given by $y_1(1-\lambda^i \mathbf{1}_{\{r_1<1\}})+m(q_1 b_2-b_1 r_1)$ with $m \geq 1$; in the baseline model, we posited $m = 1$.[25] Consequently, in the presence of the multiplier, the selection constraint of the low type, condition (6), generalizes to $y_1(1-\lambda^l) + m\beta b_2(0) \geq y_1 + m(\beta b_2(1) - b_1)$ or

$$b_2(1) \leq b_2(0) + \frac{b_1 - y_1\lambda^l/m}{\beta}.$$

Two points are worth making. First, allowing for multiplier effects does not alter the role of austerity as a device for inducing separation. That is, the amount of debt issued in the absence of default is constrained to be below the level under complete information. Second, the multiplier matters for the degree of austerity suffered by influencing the tightness of the selection constraint of the low type. If it loosens the constraint then it decreases optimal austerity, if it tightens it then it increases it. This property represents a novel argument in the debate on multipliers and optimal austerity.

Whether the optimal loan size $b_2(1)$ and austerity is increasing or not in m depends very much on which types of expenditure affect disposable income and by how much. In the case considered above, larger multipliers make optimal austerity milder. If, instead, the multiplier effects also apply to the income losses arising from default then the relative size of the corresponding multiplier, n say, matters. Disposable income is given by

$$y_1(1 - n\lambda^i \mathbf{1}_{\{r_1<1\}}) + m(q_1 b_2 - b_1 r_1)$$

in this case and the self-selection constraint takes the form

$$b_2(1) \leq b_2(0) + \frac{b_1 - y_1\lambda^l n/m}{\beta}.$$

In the special case where $m = n$ the optimal level of austerity is invariant to the size of the multiplier.[26]

7 Conclusions

The debate on the role and implications of austerity seems to be conducted in a haphazard manner due to the lack of a suitable theoretical framework. There exists no model based definition of austerity that can accommodate the various functions it allegedly has. The present paper aims at filling this gap by providing a unified approach that combines the standard sovereign debt model with that on credit rationing under incomplete information about credit risk. We have offered a coherent definition of austerity, namely, the drop in consumption due to the incomplete information friction.

The fusion of the two literatures gives rise to properties that are different from those obtained in the constituent parts. For instance, unlike in the sovereign debt literature

[25] The assumption that $m > 1$ may also be motivated by distorting taxation.

[26] In a model with investment that creates collateral, the multiplier would again matter. This is a well known argument in the literature and there is no need to repeat it here.

where the optimal degree of austerity is zero and investment supports larger loans exclusively through its capacity to create collateral, in our model the optimal degree of austerity is non-zero and investment supports larger loans even without collateral creation. Unlike in the credit rationing literature, in our model there is credit rationing and austerity even in separating equilibria where the sovereign's credit risk is revealed. Austerity is necessary in order to deter the misrepresentation of credit risks and to support separation.

Our analysis has a number of novel, useful implications. First, it demonstrates that low credit risk sovereigns may prefer more severe austerity—brought about by a commitment to over-invest fresh funds obtained—to the lighter austerity they would have suffered if they forewent such a commitment. Second, the same property is present when governments can use reforms instead of investment. Committing to financially costly—in the short term—reforms can increase the flow of funds but does not alleviate the loss of current consumption. Consequently, the model implies the absence of a clear relationship between the size of new funding and austerity. Nonetheless, the relationship is unambiguously negative when such costly signals of high creditworthiness are not available (as is the case in the absence of commitment to invest). And third, the analysis provides a novel perspective on the relationship between the size of spending multipliers and the severity of austerity suffered. In particular, it establishes that multipliers may be linked to austerity because their size matters for the *identification* of credit risk even when their alleged effects on economic growth and ability to pay are limited.

References

Aguiar, M. and Gopinath, G. (2006), 'Defaultable debt, interest rates and the current account', *Journal of International Economics* **69**(1), 64–83.

Arellano, C. (2008), 'Default risk and income fluctuations in emerging economies', *American Economic Review* **98**(3), 690–712.

Atkeson, A. (1991), 'International lending with moral hazard and risk of repudiation', *Econometrica* **59**(4), 1069–1089.

Backus, D. and Driffill, J. (1985), 'Inflation and reputation', *American Economic Review* **75**(3), 530–538.

Bester, H. (1985), 'Screening vs. rationing in credit markets with imperfect information', *American Economic Review* **75**(4), 850–855.

Bolton, P. and Dewatripont, M. (2005), *Contract Theory*, MIT Press, Cambridge, Massachusetts.

Brennan, M. and Kraus, A. (1987), 'Efficient financing under asymmetric information', *Journal of Finance* **42**(5), 1225–1243.

Canzoneri, M. B. (1985), 'Monetary policy games and the role of private information', *American Economic Review* **75**(5), 1056–1070.

Cho, I.-K. and Kreps, D. M. (1987), 'Signaling games and stable equilibria', *Quarterly Journal of Economics* **102**(2), 179–221.

Cole, H. L., Dow, J. and English, W. B. (1995), 'Default, settlement, and signalling: Lending resumption in a reputational model of sovereign debt', *International Economic Review* **36**(2), 365–385.

Dovis, A. (2016), Efficient sovereign default. Mimeo, Pennsylvania State University.

Eaton, J. and Gersovitz, M. (1981), 'Debt with potential repudiation: Theoretical and empirical analysis', *Review of Economic Studies* **48**(2), 289–309.

Feld, L., Schmidt, C., Schnabel, I. and Wieland, V. (2016), Causes of the eurozone crisis: A nuanced view. Blog post, retrieved from http://voxeu.org/article/causes-eurozone-crisis-nuanced-view.

Green, E. J. and Porter, R. H. (1984), 'Noncooperative collusion under imperfect price information', *Econometrica* **52**(1), 87–100.

Meza, D. d. and Webb, D. C. (1987), 'Too much investment: A problem of asymmetric information', *Quarterly Journal of Economics* **102**(2), 281–292.

Milde, H. and Riley, J. G. (1988), 'Signaling in credit markets', *Quarterly Journal of Economics* **103**(1), 101–129.

Obstfeld, M. and Rogoff, K. (1996), *Foundations of International Macroeconomics*, MIT Press, Cambridge, Massachusetts.

Stiglitz, J. E. and Weiss, A. (1981), 'Credit rationing in markets with imperfect information', *American Economic Review* **71**(3), 393–410.

Tomz, M. and Wright, M. L. J. (2007), 'Do countries default in "bad times"?', *Journal of the European Economic Association* **5**(2–3), 352–360.

Vickers, J. (1986), 'Signalling in a model of monetary policy with incomplete information', *Oxford Economic Papers* **38**(3), 443–455.