Appendices

A Construction of the Dataset

A detailed description of the data construction is available on a not-for-publication online appendix to the paper.

- IMF Data for Cyprus, Greece, Ireland, and Portugal comes from the IMF website (https://www.imf.org/), which reports actual and projected disbursements, repayments of principal, and interest payments. Spain did not receive IMF assistance.

- EFSF and ESM Disbursements and Repayment schedules for Cyprus, Greece, Ireland, Portugal, and are available from the ESM website (https://www.esm.europa.eu/). For interest payments, we apply the blended rate for December 2019 to the series of outstanding debt over the lifetime of the lending cycle. We are grateful to Corsetti, Erce and Uy (2017) for initially sharing this data, which we have extended via the ESM website.

- EFSM data for Ireland come from the Irish Treasury website. EFSM data for Portugal come from the European Commission website (https://ec.europa.eu/info/). Realized interest payments are calculated by applying lending rates from European Commission (2012). For future interest payments, we include a term premium calculated using euribor OIS rates relative to the last observed euribor 3-month rate. We use the Bloomberg Tickers as in Du, Im and Schreger (2018).

- Data for the Greek Lending Facility (GLF) for Greece comes from the European Commission website and various reports therein. To calculate interest rates, we add the reported margins to the end of period 3-month Euribor rate. To forecast 3-month Euribor rates, we again use the euribor OIS rates from Du, Im and Schreger (2018) to calculate a term premium.

- Although we do not calculate the transfer, our information on bilateral loan data to Ireland come from the United Kingdom Treasury and the Sweden, and Denmark Ministry of Finances:
  - https://www.gov.uk/government/organisations/hm-treasury
  - https://www.government.se/government-of-sweden/ministry-of-finance/
  - https://m.fm.dk/ministryoffinance/home

B Characterizing the Laffer Curve

This appendix provides a full characterization of the Laffer curve in the basic model.

The Laffer curve satisfies :

$$D(b) \quad = \quad \beta b\left(1-\pi_d(b)\right)+\beta\rho\bar{y}_1^i\left(\pi\int_{\underline{\epsilon}(b)}^{\bar{\epsilon}(b)}\epsilon dG\left(\epsilon\right)+\int_{\epsilon_{\min}}^{\underline{\epsilon}(b)}\epsilon dG\left(\epsilon\right)\right)+\overline{\lambda}^i$$

where the cut-offs are defined as:

$$\bar{\epsilon}(b) \quad = \quad \frac{(1-\alpha^{i,i})b/\bar{y}_1^i}{\Phi+\rho(1-\alpha^{i,i})}$$

Borrower	Lender	Start Date
Cyprus	ESM	May, 2013
Cyprus	IMF	May, 2013
Greece	EC	May, 2010
Greece	EFSF	March, 2012
Greece	ESM	August, 2015
Greece	IMF	May, 2010
Hungary	BoP	December, 2008
Hungary	IMF	November, 2008
Ireland	EFSF	February, 2011
Ireland	EFSM	January, 2011
Ireland	IMF	January, 2011
Latvia	BoP	February, 2009
Latvia	IMF	December, 2008
Portugal	EFSF	June, 2011
Portugal	EFSM	May, 2011
Portugal	IMF	May, 2011
Romania	BoP	July, 2009
Romania	IMF	May, 2009
Spain	ESM	December, 2012

Table A.1: Starting Date by Programme.
Note that in the case of Greece, we treat both IMF Programs as one lending cycle. Programme 2 officially begins in May 2012.

Borrower	Quota	Share of Quota
Cyprus	140	567%
Greece	823	3,374%
Hungary	1,038	735%
Ireland	838	2,322%
Latvia, Republic of	127	775%
Portugal	867	2,645%
Romania	1,030	1,026%

Table A.2: IMF Quotas (in thousands of SDR) and Share of Quotas.
Note: Share of Quotas defined as Total IMF disbursements divided by total quota as of January 2010. Source: IMF.

$$\underline{\epsilon}(b) = \frac{\alpha^{i,u}b/\bar{y}_1^i - \kappa y_1^g/\bar{y}_1^i}{\Phi + \rho\alpha^{i,u}}$$

and the probability of default is:

$$\pi_d(b) = G(\underline{\epsilon}(b)) + \pi(G(\bar{\epsilon}(b)) - G(\underline{\epsilon}(b)))$$

There are a number of cases to consider:

- When $b \leq \underline{b} \equiv y_{\min}^i \left(\Phi/(1-\alpha^{i,i}) + \rho\right)$. In that case $\bar{\epsilon} \leq \epsilon_{\min}$ and i's output is always sufficiently high that i prefers to repay even without any transfer from g. This makes i's debt riskless and

$$D\left(b\right) = \beta b + \bar{\lambda}^i$$

- If $\bar{b} \equiv ((\Phi + \rho\alpha^{i,u})y_{\min}^i + \kappa y_1^g)/\alpha^{i,u} \leq \hat{b} \equiv y_{\max}^i \left(\Phi/(1-\alpha^{i,i}) + \rho\right)$. This is a condition on the parameters. It can be rewritten as:

$$\kappa y_1^g/\bar{y}_1^i \leq \alpha^{i,u}\rho(\epsilon_{\max} - \epsilon_{\min}) + \Phi/(1-\alpha^{i,i})(\alpha^{i,u}\epsilon_{\max} - \epsilon_{\min}(\alpha^{i,u} + \alpha^{i,g}))$$

  - When $\underline{b} < b \leq \bar{b} < \hat{b}$. In that case, we have $\underline{\epsilon} \leq \epsilon_{\min} < \bar{\epsilon} < \epsilon_{\max}$. When $b = \bar{b}$, $\underline{\epsilon} = \epsilon_{\min} < \bar{\epsilon} < \epsilon_{\max}$. Default can occur if $\epsilon_1^i \leq \bar{\epsilon}$ and ex-post transfers are forbidden. It follows that

$$D\left(b_1\right) = \beta[b_1\left(1 - \pi G\left(\bar{\epsilon}\right)\right) + \rho\bar{y}_1^i\pi\int_{\epsilon_{\min}}^{\bar{\epsilon}} \epsilon dG\left(\epsilon\right)] + \bar{\lambda}^i$$

  and the slope of the Laffer curve is given by

$$D'\left(b_1\right) = \beta\left[1 - \pi G\left(\bar{\epsilon}\right) - \frac{\pi\bar{\epsilon}g\left(\bar{\epsilon}\right)\Phi}{\Phi + \rho(1-\alpha^{i,i})}\right]$$

  For these intermediate debt levels, default is a direct consequence of the commitment *not* to bail-out country i in period $t = 1$. The derivative of the Laffer curve is discontinuous at $b = \underline{b}$ if the distribution of shocks is such that $g\left(\epsilon_{\min}\right) > 0$ and the can write the discontinuity as:

$$\begin{aligned} D'(\underline{b}^+) - D'(\underline{b}^-) &= \beta\left(-\underline{b} + \rho y_{\min}^i\right)\pi g(\epsilon_{\min})\left.\frac{d\bar{\epsilon}}{db}\right|_{b=\underline{b}} \\ &= -\beta\frac{\pi\epsilon_{\min}g(\epsilon_{\min})\Phi}{\Phi + \rho(1-\alpha^{i,i})} \leq 0 \end{aligned}$$

  The intuition for the discontinuity is that at $b = \underline{b}$, a small increase in debt increases the threshold $\bar{\epsilon}$ beyond $\epsilon_{\min}$, so a default is now possible. This happens with probability $\pi g(\epsilon_{\min})d\bar{\epsilon}$. In that case, investors' discounted net loss is $\beta(-\underline{b} + \rho y_{\min}^i)$.

  It is possible for the Laffer curve to *decrease* to the right of $\underline{b}$ if $\pi\epsilon_{\min}g(\epsilon_{\min})\Phi/(\Phi + \rho(1-\alpha^{i,i})) > 1$. In that case the increase in default risk is so rapid that the interest rate rises rapidly and i's revenues $D(b)$ decline as soon as $b > \underline{b}$. Given that i can always choose to be on the left side of the Laffer curve by choosing a lower b_1^i, there would never be any default or bailout. We view this case as largely uninteresting.

This case can be ruled out my making the following assumption *sufficient* to ensure $D'(\underline{b}^+) > 0$:

Assumption 2. *We assume the following restriction on the pdf of the shocks and the probability of bailout*

$$\pi \epsilon_{\min} g(\epsilon_{\min}) < 1$$

[Note: (a) this condition cannot be satisfied with a power law and $\pi = 1$ (i.e. no transfers); (b) this condition is satisfied for a uniform distribution if $\pi < \epsilon_{\max}/\epsilon_{\min} - 1$. A sufficient condition for this is $\epsilon_{\min} < 2/3$.[66]]

The second derivative of the Laffer curve is:

$$D''(b) = -\beta\pi \frac{d\bar{\epsilon}}{db}\left[g(\bar{\epsilon}) + \frac{\Phi}{\Phi + (1-\alpha^{i,i})\rho}(g(\bar{\epsilon}) + \bar{\epsilon} g'(\bar{\epsilon}))\right]$$

If we want to ensure that $D''(b) < 0$ a *sufficient* condition is:

Assumption 3. *We assume that g satisfies*

$$\frac{\epsilon g'(\epsilon)}{g(\epsilon)} > -2$$

[Note: we can replace this condition by a condition on the slope of the monotone ratio: $\pi g(\epsilon)/(1 - \pi G(\epsilon))$.]

[Note: (a) that sufficient condition is not satisfied for $\rho = 0$ and a power law; (b) it is always satisfied for a uniform distribution since $g'(\epsilon) = 0$.]

The value of $D'(\bar{b}^-)$ is:

$$D'(\bar{b}^-) = \beta\left[1 - \pi G\left(\bar{\epsilon}(\bar{b})\right) - \frac{\pi\Phi\bar{\epsilon}(\bar{b}) g\left(\bar{\epsilon}(\bar{b})\right)}{\Phi + \rho(1-\alpha^{i,i})}\right]$$

We can ensure that this is positive (so that the peak of the Laffer curve has not been reached) by assuming that:

$$1/\pi > G\left(\bar{\epsilon}(\bar{b})\right) + \frac{\Phi\bar{\epsilon}(\bar{b}) g\left(\bar{\epsilon}(\bar{b})\right)}{\Phi + \rho(1-\alpha^{i,i})}$$

This condition is always satisfied when there is no default ($\pi = 0$). Otherwise, a *sufficient* condition is:

Assumption 4. *We assume that the distribution of shocks satisfies:*

$$1 > G\left(\bar{\epsilon}(\bar{b})\right) + \bar{\epsilon}(\bar{b}) g\left(\bar{\epsilon}(\bar{b})\right)$$

[Note: with a uniform distribution, the condition above becomes $\bar{\epsilon}(\bar{b}) < \epsilon_{\max}/2$. Substituting for $\bar{\epsilon}(\bar{b})$, this can be ensured by choosing $\epsilon_{\min}$ such that

$$\frac{1-\alpha^{i,i}}{\Phi + (1-\alpha^{i,i})\rho} \frac{(\Phi + \rho\alpha^{i,u})\epsilon_{\min} + \kappa y_1^g / \bar{y}_1^i}{\Phi + \rho\alpha^{i,u}} < 1 - \frac{\epsilon_{\min}}{2}$$

This can be ensured with $\epsilon_{\min}$ sufficiently small, provided $(\Phi + (1-\alpha^{i,i})\rho)\alpha^{i,u} > (\Phi + \rho\alpha^{i,u})(1-\alpha^{i,i})\kappa y_1^g/\bar{y}_1^i$.]

[66] To see this, observe that since $E[\epsilon] = 1$ we can solve for $\epsilon_{\min} < 2/(2+\pi)$.

Under assumptions 2 -4, the Laffer curve is upward sloping, decreasing in b, discontinuous at $\underline{b}$ and has not yet reached its maximum at $\bar{b}$.

– When $\bar{b} < b \leq \hat{b}$ then we have $\epsilon_{\min} < \underline{\epsilon} < \bar{\epsilon} \leq \epsilon_{\max}$. It's now possible to default even with optimal transfers and the Laffer curve satisfies

$$D(b_1) = \beta \left[b_1 \left(1 - G(\underline{\epsilon}) - \pi \left(G(\bar{\epsilon}) - G(\underline{\epsilon})\right)\right) + \rho \bar{y}_1^i \left(\pi \int_{\underline{\epsilon}}^{\bar{\epsilon}} \epsilon dG(\epsilon) + \int_{\epsilon_{\min}}^{\underline{\epsilon}} \epsilon dG(\epsilon) \right) \right] + \bar{\lambda}^i$$

with slope:

$$D'(b_1) \quad = \quad \beta \left[1 - \pi_d - \frac{\pi g(\bar{\epsilon}) \bar{\epsilon} \Phi}{\Phi + \rho(1 - \alpha^{i,i})} - (1 - \pi) g(\underline{\epsilon}) \frac{\Phi \underline{\epsilon} + \kappa y_1^g / \bar{y}_1^i}{\Phi + \rho \alpha^{i,u}} \right]$$

One can check immediately that the slope of the Laffer curve is discontinuous at $b = \bar{b}$ as well, if $\pi < 1$ and $g(\epsilon_{\min}) > 0$, with:

$$\begin{aligned} D'(\bar{b}^+) - D'(\bar{b}^-) &= \beta \left(-\bar{b} + \rho y_{\min}^i\right) (1 - \pi) g(\epsilon_{\min}) \left.\frac{d\underline{\epsilon}}{db}\right|_{b=\bar{b}} \\ &= -\beta (1 - \pi) g(\epsilon_{\min}) \frac{\Phi \epsilon_{\min} + \kappa y_1^g / \bar{y}_1^i}{\Phi + \rho \alpha^{i,u}} \leq 0 \end{aligned}$$

The interpretation is the following: when $b = \bar{b}$, a small increase in debt makes default unavoidable, i.e. default probabilities increase from π to 1, since the debt level is too high for transfers to be optimal. The probability of default jumps up by $(1 - \pi) g(\epsilon_{\min}) d\underline{\epsilon}$. The discounted investor's loss in case of default is $\beta(-\bar{b} + \rho y_{\min}^i)$.

The second derivative of the Laffer curve is:

$$\begin{aligned} D''(b) &= -\beta \pi \frac{d\bar{\epsilon}}{db} \left[g(\bar{\epsilon}) + \frac{\Phi}{\Phi + (1 - \alpha^{i,i})\rho} (g(\bar{\epsilon}) + \bar{\epsilon} g'(\bar{\epsilon})) \right] \\ & \quad -\beta (1 - \pi) \frac{d\underline{\epsilon}}{db} \left[g(\underline{\epsilon}) + \frac{\Phi}{\Phi + \rho \alpha^{i,u}} g(\underline{\epsilon}) + g'(\underline{\epsilon}) \frac{\Phi \underline{\epsilon} + \kappa y_1^g / \bar{y}_1^i}{\Phi + \rho \alpha^{i,u}} \right] \end{aligned}$$

The first term is negative under assumption 3. The second term is also negative under assumption 3, unless $g'(\epsilon)$ becomes too negative.

Assumption 5. *The parameters of the problem are such that $D''(b) < 0$ for $b < \hat{b}$.*

[Note: with a uniform distribution, this condition is satisfied since $g'(\underline{\epsilon}) = 0$.]

We can check that:

$$D'(\hat{b}^-) \quad = \quad \beta \left[(1 - \pi)(1 - G(\underline{\epsilon})) - \frac{\pi g(\epsilon_{\max}) \epsilon_{\max} \Phi}{\Phi + \rho(1 - \alpha^{i,i})} - (1 - \pi) g(\underline{\epsilon}) \frac{\Phi \underline{\epsilon} + \kappa y_1^g / \bar{y}_1^i}{\Phi + \rho \alpha^{i,u}} \right]$$

– As $\hat{b} < b \leq \tilde{b}$ where $\tilde{b} \equiv ((\Phi + \rho \alpha^{i,u}) y_{\max}^i + \kappa y_1^g) / \alpha^{i,u}$, we have $\epsilon_{\min} < \underline{\epsilon} \leq \epsilon_{\max} < \bar{\epsilon}$ and now the only way for i to repay its debts is with a transfer from g.

$$D(b)=\beta\left(b(1-\pi)(1-G(\underline{\epsilon}))+\rho\bar{y}_1^i\left(\pi\int_{\underline{\epsilon}(b)}^{\epsilon_{\max}}\epsilon dG\left(\epsilon\right)+\int_{\epsilon_{\min}}^{\underline{\epsilon}(b)}\epsilon dG\left(\epsilon\right)\right)\right)+\overline{\lambda}^i$$

The derivative satisfies:

$$D'\left(b\right)=\beta\left[(1-\pi)(1-G(\underline{\epsilon}))-(1-\pi)g(\underline{\epsilon})\frac{\Phi\underline{\epsilon}+\kappa y_1^g/\bar{y}_1^i}{\Phi+\rho\alpha^{i,u}}\right]$$

Evaluating this expression at $b=\hat{b}^+$, there is an *upwards discontinuity* in the Laffer curve:

$$\begin{aligned}D'(\hat{b}^+)-D'(\hat{b}-) &= \beta\left(\hat{b}-\rho y^i_{\max}\right)\pi g(\epsilon_{\max})\left.\frac{d\bar{\epsilon}}{db}\right|_{b=\hat{b}} \\ &= \beta\pi\frac{\Phi g(\epsilon_{\max})\epsilon_{\max}}{\Phi+\rho(1-\alpha^{i,i})}\geq 0\end{aligned}$$

This upwards discontinuity arises because, at $b=\hat{b}$, an infinitesimal increase in debt pushes $\bar{\epsilon}$ above $\epsilon_{\max}$. The increase in the threshold becomes inframarginal and does not affect the value of the debt anymore (since the realizations where $\epsilon>\bar{\epsilon}$ cannot be achieved anymore).

At $b=\tilde{b}$, the derivative of the Laffer curve satisfies:

$$D'(\tilde{b}^-) = -\beta(1-\pi)g(\epsilon_{\max})\frac{\Phi\epsilon_{\max}+\kappa y_1^g/\bar{y}_1^i}{\Phi+\rho\alpha^{i,u}}\leq 0$$

so the peak of the Laffer curve occurs necessarily at or before $\tilde{b}$.

The second derivative satisfies:

$$D''(b) = -\beta(1-\pi)\frac{d\underline{\epsilon}}{db}\left[g(\underline{\epsilon})+\frac{\Phi}{\Phi+\rho\alpha^{i,u}}g(\underline{\epsilon})+g'(\underline{\epsilon})\frac{\Phi\underline{\epsilon}+\kappa y_1^g/\bar{y}_1^i}{\Phi+\rho\alpha^{i,u}}\right]$$

which is still negative under assumption 5.

The discontinuity at $\hat{b}$ could be problematic for our optimization problem. Consequently, we make assumptions to ensure that the peak of the Laffer curve occurs at or before $\hat{b}$. A sufficient assumption is that $D'(\hat{b}^+)<0$.

Assumption 6. *We assume that the parameters of the problem are such that*

$$D'(\hat{b}^+)=\beta(1-\pi)\left[1-G(\underline{\epsilon})-g(\underline{\epsilon})\frac{\Phi\underline{\epsilon}+\kappa y_1^g/\bar{y}_1^i}{\Phi+\rho\alpha^{i,u}}\right]<0$$

Under this assumption, the Laffer curve reaches its maximum at $0<b_{\max}<\hat{b}$ such that $0\in\partial D(b_{\max})$, where $\partial D(b)$ is the sub-differential of the Laffer curve at b. The peak of the Laffer curve cannot be reached at $\hat{b}$ or beyond since $D'(\hat{b}^-)<D'(\hat{b}^+)<0$, so $0\notin\partial D(\hat{b})$ and $D''(b)<0$ for $b<\tilde{b}$. It follows immediately that $b_{\max}<\hat{b}$.

The economic interpretation of this assumption is that we restrict the problem so that the maximum revenues that i can generate by issuing debt in period 0 do not correspond to levels of debt so elevated that no realization of ϵ would allow i to repay on its own. In other words, the implicit transfer and the recovery value of debt are limited.

- As $b > \tilde{b}$ we have $\epsilon_{\max} < \underline{\epsilon}$ so that default is inevitable, even with transfers and the Laffer curve becomes:

$$D(b) = \beta\rho\bar{y}_1^i + \overline{\lambda}^i$$

which does not depend on the debt level. Note that there is an upwards discontinuity at $\tilde{b}$ since $D'(b) = 0$ for $b > \tilde{b}$.

To summarize, under assumptions 2-6, the Laffer curve reaches its peak at $b_{\max}$ with $\bar{b} \le b_{\max} < \hat{b}$. The Laffer curve is continuous, convex and exhibits two (downward) discontinuities of $D'(b)$ on the interval $[0, b_{\max}]$. Since i will never locate itself on the 'wrong side' of the Laffer curve ($b > b_{\max}$), we can safely ignore the non-convexity associated with the upward discontinuities of the $D'(b)$ at $\hat{b}$ and $\tilde{b}$.

- For the sake of completeness, the remaining discussion describes what happens if $\bar{b} > \hat{b}$ (the reverse condition on the parameters). In that case, as b increases, the country stops being able to repay on its own first. This leads to a somewhat implausible case where the only reason debts are repaid is because of the transfer. We would argue that this is not a very interesting or realistic case.

  - When $\underline{b} < b \le \hat{b} < \bar{b}$. In that case, we have $\underline{\epsilon} < \epsilon_{\min} \le \bar{\epsilon} < \epsilon_{\max}$. When $b = \hat{b}$, $\underline{\epsilon} < \epsilon_{\min} < \bar{\epsilon} = \epsilon_{\max}$. Default can occur if $\epsilon_1^i \le \bar{\epsilon}$ and ex-post transfers are forbidden. It follows that

$$D\left(b_1\right) = \beta[b_1\left(1 - \pi G\left(\bar{\epsilon}\right)\right) + \rho\bar{y}_1^i\pi\int_{\epsilon_{\min}}^{\bar{\epsilon}} \epsilon dG\left(\epsilon\right)] + \bar{\lambda}^i$$

and the slope of the Laffer curve is given by

$$D'\left(b\right) = \beta\left[1 - \pi G\left(\bar{\epsilon}\right) - \frac{\pi\bar{\epsilon}g\left(\bar{\epsilon}\right)\Phi}{\Phi + \rho(1 - \alpha^{i,i})}\right]$$

As before, default is a direct consequence of the commitment *not* to bail-out country i in period $t = 1$. The derivative of the Laffer curve is discontinuous at $b = \underline{b}$ if the distribution of shocks is such that $g\left(\epsilon_{\min}\right) > 0$ and $\pi > 0$.[67]

Under the same assumptions as before, the Laffer curve slopes up at $b = \underline{b}$.

The second derivative of the Laffer curve is:

$$D''(b) = -\beta\pi\frac{d\bar{\epsilon}}{db}\left[g(\bar{\epsilon}) + \frac{\Phi}{\Phi + (1 - \alpha^{i,i})\rho}(g(\bar{\epsilon}) + \bar{\epsilon}g'(\bar{\epsilon}))\right]$$

and we can to ensure that $D''(b) < 0$ with:

$$\frac{\epsilon g'(\epsilon)}{g(\epsilon)} > -2$$

[67]To see this, observe that: $D'(\underline{b}^+) = \beta\left[1 - \frac{\pi\epsilon_{\min}g(\epsilon_{\min})\Phi}{\Phi + \rho(1-\alpha^{i,i})}\right] < \beta$ when $g(\epsilon_{\min}) > 0$ and $\pi > 0$.

- When $\hat{b} < b < \bar{b}$, we have $\underline{\epsilon} \leq \epsilon_{\min} < \epsilon_{\max} < \bar{\epsilon}$. It follows that

$$D(b) \quad = \quad \beta b(1-\pi) + \beta\pi\rho\bar{y}_1^i + \overline{\lambda}^i$$

which has a constant positive slope $\beta(1-\pi)$. At $b = \hat{b}$ the slope is discontinuous, with

$$D'\left(\hat{b}^-\right) = \beta\left[1 - \pi - \frac{\pi\epsilon_{\max} g\left(\epsilon_{\max}\right)\Phi}{\Phi + \rho(1-\alpha^{i,i})}\right]$$

so there is an upwards discontinuity in the slope at $b = \hat{b}$.

- for $\bar{b} < \tilde{b}$ we have $\epsilon_{\min} < \underline{\epsilon} < \epsilon_{\max} < \bar{\epsilon}$ and it is now possible to default even with optimal transfers. The Laffer curve satisfies

$$D\left(b_1\right) = \beta\left[b_1\left((1-\pi)(1-G\left(\underline{\epsilon}\right)\right) + \rho\bar{y}_1^i\left(\pi\int_{\underline{\epsilon}}^{\epsilon_{\max}}\epsilon dG\left(\epsilon\right) + \int_{\epsilon_{\min}}^{\underline{\epsilon}}\epsilon dG\left(\epsilon\right)\right)\right] + \bar{\lambda}^i$$

with slope:

$$D'\left(b_1\right) \quad = \quad \beta(1-\pi)\left[(1 - G(\underline{\epsilon}) - g(\underline{\epsilon})\frac{\Phi\underline{\epsilon} + \kappa y_1^g/\bar{y}_1^i}{\Phi + \rho\alpha^{i,u}}\right]$$

One can check that the slope of the Laffer curve is discontinuous also at $b = \bar{b}$ as long as $\pi < 1$ and $g(\epsilon_{\min}) > 0$ with:

$$D'(\bar{b}^+) - D'(\bar{b}^-) = -\beta(1-\pi)g(\epsilon_{\min})\frac{\Phi\epsilon_{\min} + \kappa y_1^g/\bar{y}_1^i}{\Phi + \rho\alpha^{i,u}} < 0$$

At $b = \tilde{b}$, the derivative satisfies:

$$D'(\tilde{b}^-) \quad = \quad -\beta(1-\pi)g(\epsilon_{\max})\frac{\Phi\epsilon_{\max} + \kappa y_1^g/\bar{y}_1^i}{\Phi + \rho\alpha^{i,u}} < 0$$

so the peak of the Laffer curve *needs* to occur before $\tilde{b}$.

The second derivative satisfies:

$$D''(b) \quad = \quad -\beta(1-\pi)\frac{d\underline{\epsilon}}{db}\left[g(\underline{\epsilon}) + \frac{\Phi}{\Phi + \rho\alpha^{i,u}}g(\underline{\epsilon}) + g'(\underline{\epsilon})\frac{\Phi\underline{\epsilon} + \kappa y_1^g/\bar{y}_1^i}{\Phi + \rho\alpha^{i,u}}\right]$$

which is still negative as long as $g'(\underline{\epsilon})$ is not too negative.

- As $b > \tilde{b}$ we have $\epsilon_{\max} < \underline{\epsilon}$ so that default is inevitable, even with transfers and the Laffer curve becomes:

$$D(b) = \beta\rho\bar{y}_1^i + \overline{\lambda}^i$$

which does not depend on the debt level.

C Optimal Debt

Let's consider the rollover problem of country i. The first order condition is

$$\begin{aligned} 0 \quad \in \quad & \mu_1 + (1-\alpha^{i,i})\partial D(b_1^i)(1+\nu_0) - \beta(1-G(\bar{\epsilon}))(1-\alpha^{i,i}) \\ & \nu_0 c_0^i = 0 \\ & \mu_1 b_1^i = 0 \end{aligned}$$

We consider first an interior solution and ignore the non-continuity of $D'(b)$ at $\underline{b}$ and $\bar{b}$. The first-order condition becomes:

$$D'(b_1^i) = \beta\left(1 - G(\bar{\epsilon})\right) \tag{C.1}$$

Both sides of this equation are decreasing in b.

- Consider first the region $0 \leq b_1^i < \underline{b}$. Over that range, debt is safe: $D'(b) = \beta$ and $G(\bar{\epsilon}) = 0$. The first order condition is trivially satisfied: since debt is safe, risk neutral agents price the debt at β and i is indifferent as to the amount of debt it issues as long as it can ensure positive consumption.

- Consider now the interval $\underline{b} < b_1^i < \bar{b}$. We need to consider two cases.

  - when $\pi = 0$, g always bails out i and i's debt is safe. This implies $D'(b_1^i) = \beta$ and

    $$D'(b) - \beta(1 - G(\bar{\epsilon})) = \beta G(\bar{\epsilon}) > 0$$

    so there is no solution in that interval: i would always want to issue more debt.

  - when $\pi = 1$, i defaults when $b > \underline{b}$. Going back to the definition of $D'(b_1^i)$ and $\bar{\epsilon}$ we can check that

    $$D'(b) - \beta(1 - G(\bar{\epsilon})) = -\beta \frac{\Phi}{\Phi + \rho(1-\alpha^{i,i})} g(\bar{\epsilon})\bar{\epsilon} < 0$$

    from which it follows that there is no solution in that interval: i would always want to issue less debt to remain safe.

  - In the intermediate case where $0 < \pi < 1$, it is possible to find a solution to the first-order condition. However, under reasonable conditions the second-order condition of the optimization problem will not be satisfied. This will be the case if $D'(b) - \beta(1 - G(\bar{\epsilon})$ is increasing. A sufficient condition is that g/G is monotonously decreasing. To see this, observe that for $\underline{b} < b \leq \bar{b}$, we have $\underline{\epsilon} < \epsilon_{\min}$ and therefore we can write:

    $$D'(b) - \beta(1 - G(\bar{\epsilon})) = \beta(1-\pi)G(\bar{\epsilon})\left[1 - \frac{\pi}{1-\pi}(b - \rho\bar{y}_1^i\bar{\epsilon})\frac{g(\bar{\epsilon})}{G(\bar{\epsilon})}\frac{d\bar{\epsilon}}{db}\right]$$

    The term in brackets is increasing in $\bar{\epsilon}$ when g/G is decreasing. If this condition is satisfied, then there is no solution in the interval $(\underline{b}, \bar{b})$. [Note: this condition is satisfied for a uniform distribution.]

- Consider next the interval $\bar{b} \leq b < \hat{b}$. We already know under the assumptions laid out in section B that we only need to consider the subinterval $(\bar{b}, b_{\max})$ where $b_{\max}$ is the value of the debt that maximizes period 1 revenues. Let's consider the various values of π again:

– for $\pi = 0$, we have $D'(\bar{b}^-) = \beta$ and $D'(b_{\max}) = 0$. Since $D'(b) - \beta(1 - G(\bar{\epsilon}))$ is continuous over that interval, then there is at least one solution to the first-order condition, possibly at $b = \bar{b}$. This solution is unique if $D'(b) - \beta(1 - G(\bar{\epsilon}))$ is strictly decreasing over that interval. Recall that over that interval we have:

$$
\begin{aligned}
D'(b) - \beta(1 - G(\bar{\epsilon})) &= \beta\left[G(\bar{\epsilon}) - G(\underline{\epsilon}) - g(\underline{\epsilon})(b - \rho\bar{y}_1^i\underline{\epsilon})\frac{d\underline{\epsilon}}{db}\right] \\
&= \beta\left[G(\bar{\epsilon}) - G(\underline{\epsilon}) - g(\underline{\epsilon})\frac{\Phi\underline{\epsilon} + \kappa y_1^g/\bar{y}_1^i}{\Phi + \rho\alpha^i, u}\right]
\end{aligned}
$$

The condition that $D'(b) - \beta(1 - G(\bar{\epsilon}))$ is decreasing over this range is satisfied for a uniform distribution if $\alpha^{i,g}$ is not too high.

Let's denote the unique solution b_{opt}. If $D'(\bar{b}^+) < \beta(1 - G(\bar{\epsilon}))$ then the solution is $b_{opt} = \bar{b}$.

– for $\pi = 1$ (no bailout), we can check that in that interval we can write

$$
D'(b) - \beta(1 - G(\bar{\epsilon})) = -\beta g(\bar{\epsilon})(b - \rho\bar{y}_1^i\bar{\epsilon})\frac{d\bar{\epsilon}}{db} < 0
$$

Since $D'(\bar{\epsilon}^+) < \beta(1 - G(\bar{\epsilon}))$, it follows that there is no solution over that interval.

– For intermediate values of π, as long as π is not too high, we will have a unique solution b_{opt} as before. b_{opt} is decreasing in π for $\pi < \pi_c$. Above this critical value, this equilibrium disappears and the only remaining solutions are for $b \leq \underline{b}$. π_c is characterized by the condition that $D'(\bar{b}^-) = \beta(1 - G(\bar{\epsilon}))$. Substituting, we obtain:

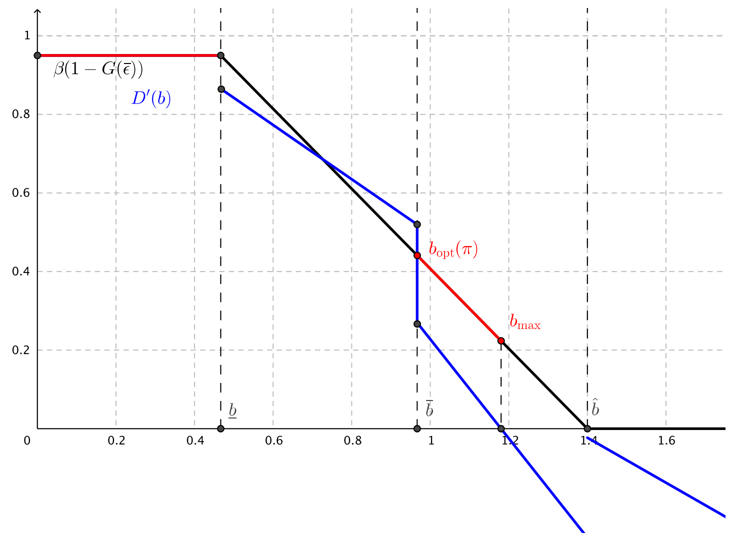
$$
\pi_c = \frac{G(\bar{\epsilon})}{G(\bar{\epsilon}) + \frac{\Phi g(\bar{\epsilon})\bar{\epsilon}}{\Phi + \rho(1 - \alpha^{i,i})}}
$$

In the case where there is no recovery, the formula for π_c simplifies to

$$
\pi_c = \frac{1}{1 + g(\bar{\epsilon})\bar{\epsilon}/G(\bar{\epsilon})}
$$

These results are summarized in Fig. 9. The figure reports, for the case of a uniform distribution the function $\beta(1 - G(\bar{\epsilon}(b)))$ (in black) and the function $D'(b)$ (in blue). There are two discontinuities of the function $D'(b)$ at $b = \underline{b}$ and $b = \bar{b}$. In red, the figure reports the possible optimal equilibrium debt levels. For $b \leq \underline{b}$ the debt is safe and any level -if sufficient to rollover the debt– provides equivalent level of utility; $b_{opt} \geq \bar{b}$ is the optimal level of risky debt when the rollover constraint ($c_0^i \geq 0$) does not bind. Finally, $b_{opt} < b \leq b_{\max}$ obtains when the rollover constraint binds (i.e. $c_0^i = 0$ and $D(b) = x_0^i$.[68]

[68] As can be seen on the figure, there is another solution to the first order condition between $\underline{b}$ and $\bar{b}$. However, this solution does not satisfy the second-order conditions.



$D'(b)$ and $\beta(1-G(\bar{\epsilon}))$ for $\pi = 0.5$.
[Uniform distribution with $\rho = 0.6$, $\Phi = 0.2$, $\kappa = 0.05$, $\epsilon_{\min} = 0.5$, $\beta = 0.95$, $\bar{y}_1^i = 1$, $y_1^g = 2$, $\alpha^{i,i} = 0.4$, $\alpha^{i,g} = \alpha^{i,u} = 0.3$. $\underline{b} = 0.47$, $\bar{b} = 0.97$ and $\hat{b} = 1.4$]

Figure 9: Optimal Debt Issuance

D Exit and Default

D.1 Proof of Proposition 6.

Proof. Denote D/ND the decision to default/repay and E/NE the decision to exit/stay in the currency union. Denote $\hat{b}$ the amount of debt held abroad, scaled by potential output: $\hat{b} = (1-\alpha^{i,i})b_1^i/\bar{y}_1^i$. Denote also $\hat{\rho} = \rho(1-\alpha^{i,i})$ the foreign debt holder's recovery rate per unit of output. i prefers ND/NE to D/NE whenever:

$$-\Phi_d \epsilon_1^i + \hat{b} - \hat{\rho}\epsilon_1^i \leq 0 \iff \epsilon_1^i \geq \bar{\epsilon} = \frac{\hat{b}}{\Phi_d + \hat{\rho}}$$

Similarly, i prefers ND/E to D/E whenever

$$-\Phi_e \epsilon_1^i + \Delta\hat{b} \geq -(\Phi_d + \Phi_e) + (1+\Delta)\hat{b} - \hat{\rho} \iff \epsilon_1^i \geq \bar{\epsilon}^d$$

It follows that $\bar{\epsilon}^d$ represents the cut-off for default decisions, regardless of exit decisions.

Now, by a similar reasoning, we can show that i chooses to stay in the currency union whenever $\epsilon_1^i \geq \bar{\epsilon}^e$, regardless of the decision to default.
Under the assumption $\Delta/\Phi_e > 1/(\Phi_d + \rho)$, we have $\bar{\epsilon}^d > \bar{\epsilon}^e$ for all $\hat{b}$ and the proposition follows. □

D.2 Proof of Proposition 7

Proof. Let's define the minimal transfer to avoid a default $\underline{\tau}_1^d$ and the minimal transfer to avoid an exit $\underline{\tau}_1^e$. They satisfy:

$$\begin{aligned} \underline{\tau}_1^d &= (b_1^i - \rho y_1^i)(1-\alpha^{i,i}) - \Phi_d y_1^i \\ \underline{\tau}_1^e &= \Delta b_1^i(1-\alpha^{i,i}) - \Phi_e y_1^i \end{aligned}$$

Now, define $U_g(ND, NE, \tau_1)$ the utility of g if there is no default (ND), no exit (NE) and transfer τ_1. It satisfies:

$$U_g(ND, NE, \tau_1) = x_1^g + b_1^i \alpha^{i,g} - \tau_1$$

where $x_1^g = y_1^g + b_1^{s,g} - b_1^g$ is constant regardless of the transfers and i's decision. Similarly, we can define:

$$\begin{aligned} U_g(D, NE, \tau_1) &= x_1^g - \kappa_d y_1^g + \rho y_1^i \alpha^{i,g} - \tau_1 \\ U_g(ND, E, \tau_1) &= x_1^g - \kappa_e y_1^g + b_1^i \alpha^{i,g} - \Delta b \alpha^{i,g} - \tau_1 \\ U_g(D, E) &= x_1^g - (\kappa_d + \kappa_e) y_1^g + \rho y_1^i \alpha^{i,g} - \Delta b \alpha^{i,g} \end{aligned}$$

where we note that g will never make a transfer if i defaults and exits. Consider now the following cases:

- When $\epsilon_1^i \geq \bar{\epsilon}^d$. Since i does not want to default or exit, no transfer is necessary: $\tau_1 = 0$.
- When $\bar{\epsilon}^d > \epsilon_1^i \geq \bar{\epsilon}^e$, i prefers to default and exit. To prevent this, g must make a transfer $\underline{\tau}_1^d$. This is optimal as long as $U_g(ND, NE, \underline{\tau}_1^d) > U_g(D, NE, 0)$. This condition takes the form:

  $$\Phi_d y_1^i + \kappa_d y_1^g \geq (b_1^i - \rho y_1^i)\alpha^{i,u}$$

  or equivalently:

  $$\epsilon_1^i \geq \underline{\epsilon}^d \equiv \frac{\alpha^{i,u} b_1^i / \bar{y}_1^i - \kappa_d y_1^g / \bar{y}_1^g}{\Phi_d + \rho \alpha^{i,u}}$$

  where $\underline{\epsilon}^d < \bar{\epsilon}^d$. It follows that:

  - When $\bar{\epsilon}^d > \epsilon_1^i \geq \underline{\epsilon}^d$, g makes the transfer $\underline{\tau}_1^i$ and there is no default
  - When $\underline{\epsilon}^d > \epsilon_1^i \geq \bar{\epsilon}^e$, g does not make a transfer ($\tau_1 = 0$), i defaults, but without exiting.
- $\bar{\epsilon}^e > \epsilon_1^i$, i prefers to default and exit without transfer. g can consider two types of transfer: $\underline{\tau}_1^e$ to avoid the exit (but not the default) or $\underline{\tau}_1^d + \underline{\tau}_1^e$ to avoid both default and exit. Consider first a transfer to avoid exit. This is optimal as long as $U_g(D, NE, \underline{\tau}_1^e) > U_g(D, E)$. This condition takes the form:

  $$\Phi_e y_1^i + \kappa_e y_1^g > \Delta b \alpha^{i,u}$$

  or equivalently

  $$\epsilon_1^i \geq \underline{\epsilon}^e \equiv \frac{\Delta \alpha^{i,u} b_1^i / \bar{y}_1^i - \kappa_e y_1^g / \bar{y}_1^i}{\Phi_e}$$

where $\underline{\epsilon}^e < \bar{\epsilon}^e$, and it yields the following utility for g:

$$U_g(D, NE, \underline{\tau}_1^e) = x_1^g - \kappa_d y_1^g + \rho y_1^i \alpha^{i,g} - \Delta b_1^i (1 - \alpha^{i,i}) + \Phi_e y_1^i$$

Now, within that region, g prefers to make a transfer $\underline{\tau}_1^d + \underline{\tau}_1^e$, to avoid both default and exit as long as $U_g(ND, NE, \underline{\tau}_1^d + \underline{\tau}_1^e) \geq U_g(D, NE, \underline{\tau}_1^e)$ which takes the form:

$$\Phi_d y_1^i + \kappa_d y_1^g \geq (b_1^i - \rho y_1^i) \alpha^{i,u}$$

or equivalently:

$$\epsilon_1^i \geq \underline{\epsilon}^d$$

It follows that:

- When $\bar{\epsilon}^e > \epsilon_1^i > \underline{\epsilon}^e$ and $\epsilon_1^i \geq \underline{\epsilon}^d$, g prefers to make the transfer $\underline{\tau}_1^d + \underline{\tau}_1^e$ to avoid default and exit.
- When $\bar{\epsilon}^e > \epsilon_1^i > \underline{\epsilon}^e$ and $\epsilon_1^i < \underline{\epsilon}^d$, g makes the transfer $\underline{\tau}_1^e$, i defaults but stays in the currency union
- When $\underline{\epsilon}_1^e > \epsilon_1^i$, g makes no transfer ($\tau_1 = 0$), i defaults and exits.

□

E Debt Monetization

This appendix provides a full characterization of the different cases that arise with possible debt monetization within a monetary union. They depend on the output shock realization ϵ_1^i and on the ranking of the output thresholds. We first analyze the decision to default of i for a given transfer and inflation/monetization rate. If i repays the ECB chooses the rate z and if i defaults it chooses the rate $\hat{z}$. The budget constraint in period 1 of the i households becomes:

$$\begin{aligned} c_1^i &= y_1^i - T_1^i + \left(b_1^{i,i} + b_1^{g,i}\right)(1-z) - \delta z y_1^i + b_1^{u,i} \quad \text{if } i \text{ repays} \\ c_1^i &= y_1^i (1-\Phi) - T_1^i + b_1^{g,i}(1-\hat{z}) - \delta \hat{z} y_1^i + b_1^{u,i} \quad \text{if } i \text{ defaults} \end{aligned}$$

Government i constraint in $t = 1$ is:

$$\begin{aligned} T_1^i + \tau_1 &= b_1^i (1-z) \quad \text{if } i \text{ repays} \\ T_1^i &= 0 \quad \text{if } i \text{ defaults} \end{aligned}$$

Consolidating the private and public budget constraints, we again proceed by backward induction. At $t = 1$, i can decide to default after the shock ϵ_1^i has been revealed and the transfer τ_1 announced. Taking b_1^i and τ_1 as given, i repays if and only if:

$$y_1^i [\Phi - \delta(z - \hat{z})] \geq b_1^i \left(1 - \alpha^{i,i}\right)(1-z) + (z - \hat{z}) b_1^g \alpha^{g,i} - \tau_1 \tag{E.1}$$

For g, the budget constraint is:

$$c_1^g = y_1^g - T_1^g + \left(b_1^{i,g} + b_1^{g,g}\right)(1-z) - \delta z y_1^g + b_1^{u,g} \quad \text{if } i \text{ repays}$$

$$c_1^g = y_1^g(1-\kappa) - T_1^g + b_1^{g,g}(1-\hat{z}) - \delta \hat{z} y_1^g + b_1^{u,g} \quad \text{if } i \text{ defaults}$$

and g government constraint in $t=1$ is:

$$\begin{aligned} T_1^g - \tau_1 &= b_1^g(1-z) \quad \text{if } i \text{ repays} \\ T_1^g &= b_1^g(1-\hat{z}) \quad \text{if } i \text{ defaults} \end{aligned}$$

We now detail the different relevant thresholds:

- **No default, no monetization, no transfer**. Comparison made when $z=0$ in no default and default. Necessary conditions on output shock:

$$\begin{aligned} \epsilon_1^i &> \frac{b_1^i \alpha^{iu} - \kappa y_1^g}{\Phi \overline{y}_1^i} \equiv \overline{\epsilon}'' \quad \text{ECB and g prefer no default to default with } z=0 \text{ in both cases} \\ \epsilon_1^i &> \frac{b_1^i \alpha^{iu} + b_1^g \alpha^{gu}}{\delta \overline{y}_1^i} - \frac{y_1^g}{\overline{y}_1^i} \equiv \overline{\overline{\epsilon}} \quad \text{ECB prefers } z=0 \text{ in no default} \\ \epsilon_1^i &> \frac{\alpha^{gu} b_1^g - \delta y_1^g}{\delta \overline{y}_1^i} \equiv \hat{\epsilon} \quad \text{ECB chooses } z=0 \text{ in case of default} \\ \epsilon_1^i &> \frac{b_1^i\left(1-\alpha^{ii}\right)}{\Phi \overline{y}_1^i} \equiv \overline{\epsilon}' \quad i \text{ repays with zero transfer and } z=0 \end{aligned}$$

- **No default, no monetization, positive transfer** Necessary conditions on output shock:

$$\begin{aligned} \epsilon_1^i &> \overline{\epsilon}'' \quad \text{ECB and g prefer no default to default with } z=0 \text{ in both cases} \\ \epsilon_1^i &> \overline{\overline{\epsilon}} \quad \text{ECB prefers } z=0 \text{ in case of no default} \\ \epsilon_1^i &< \overline{\epsilon}' \quad i \text{ repays only with transfer and } z=0 \end{aligned}$$

- **No default, monetization at maximum rate, no transfer** Comparison made when $z=\overline{z}$ in no default and $z=0$ in case of default.

$$\begin{aligned} \epsilon_1^i &< \overline{\overline{\epsilon}} \quad \text{ECB prefers } z=\overline{z} \text{ in no default} \\ \epsilon_1^i &> \frac{\left(1-\alpha^{ii}\right) b_1^i (1-\overline{z}) + \alpha^{gi} b_1^g \overline{z}}{(\Phi - \delta \overline{z})\, \overline{y}_1^i} \equiv \tilde{\epsilon} \quad i \text{ repays with zero transfer with } z=\overline{z} \end{aligned}$$

- **No default, monetization at maximum rate, positive transfer** Comparison made when $z=\overline{z}$ in no default and $z=0$ in case of default.

$$\begin{aligned} \epsilon_1^i &< \overline{\overline{\epsilon}} \quad \text{ECB prefers } z=\overline{z} \text{ in no default} \\ \epsilon_1^i &> \frac{\alpha^{iu} b_1^i (1-\overline{z}) - \alpha^{gu} b_1^g \overline{z} - y_1^g(\kappa - \delta \overline{z})}{(\Phi - \delta \overline{z})\, \overline{y}_1^i} \equiv \underline{\epsilon}' \quad g \text{ prefers no default, transfer and } z=\overline{z} \end{aligned}$$

$$\epsilon_1^i < \frac{\left(1-\alpha^{i,i}\right) b_1^i \left(1-\overline{z}\right) + \alpha^{gi} b_1^g \overline{z}}{\left(\Phi - \delta\overline{z}\right) \overline{y}_1^i} \equiv \tilde{\epsilon} \quad i \text{ repays only with transfer with } z = \overline{z}$$

In this case, the transfer is the minimum that leaves i indifferent between default and no default (see equation 34).

- **Default, no monetization, no transfer**

  Comparison made when $z = \overline{z}$ in no default and $z = 0$ in case of default.

$$\begin{aligned} \epsilon_1^i &< \overline{\overline{\epsilon}} \quad \text{ECB prefers } z = \overline{z} \text{ in no default} \\ \epsilon_1^i &< \frac{\alpha^{iu} b_1^i \left(1-\overline{z}\right) - \alpha^{gu} b_1^g \overline{z} - y_1^g \left(\kappa - \delta\overline{z}\right)}{\left(\Phi - \delta\overline{z}\right) \overline{y}_1^i} \equiv \underline{\epsilon}' \quad g \text{ prefers default, no transfer} \\ \epsilon_1^i &> \frac{\alpha^{gu} b_1^g - \delta y_1^g}{\delta \overline{y}_1^i} \equiv \hat{\epsilon} \quad \text{ECB chooses } z = 0 \text{ in default} \end{aligned}$$

- **Default, monetization, no transfer**

  Comparison made with $z = \overline{z}$ in both cases:

$$\begin{aligned} \epsilon_1^i &< \frac{\alpha^{iu} b_1^i \left(1-\overline{z}\right) - \kappa y_1^g}{\Phi \overline{y}_1^i} \equiv \underline{\epsilon}'' \quad g \text{ prefers default, no transfer and } z = \overline{z} \\ \epsilon_1^i &< \frac{\alpha^{g,u} b_1^g - \delta y_1^g}{\delta \overline{y}_1^i} \equiv \hat{\epsilon} \quad \text{ECB chooses } z = \overline{z} \text{ in default} \end{aligned}$$

There are therefore 7 thresholds for output realizations: $\overline{\overline{\epsilon}}; \overline{\epsilon}'; \overline{\epsilon}''; \hat{\epsilon}; \tilde{\epsilon}; \underline{\epsilon}'; \underline{\epsilon}''$. In addition, we assume there is a minimum and maximum output realization ϵ^{max} and ϵ^{min}.

We can rank some of them under the assumption that $\Phi > \kappa > \delta$: $\underline{\epsilon}' < \overline{\epsilon}'; \underline{\epsilon}'' < \overline{\epsilon}''; \hat{\epsilon} < \overline{\epsilon}'; \underline{\epsilon}'' < \underline{\epsilon}'; \tilde{\epsilon} > \underline{\epsilon}'$

To simplify the analysis, we focus on parameter configurations that are most interesting and most plausible for the situation of the eurozone, we rank these thresholds based on the following general assumptions : b_1^g is small relative y_1^g and to b_1^i.

Assumptions on parameters: We can compare different cases with different degrees of fiscal dominance. **Fiscal dominance** would apply if the ECB inflates the eurozone debt even if i defaults so that only g debt remains. This is not a very interesting or plausible case so we ignore it and assume $\hat{\epsilon} < \epsilon^{min}$ which means that we concentrate as before on relatively low levels of debt to GDP levels in g and relatively high levels of the distortion costs δ. Another polar case is one of **monetary dominance**. This is a situation with low levels of g debt relative to GDP and high distortion costs δ. A sufficient condition is: $\overline{\overline{\epsilon}} < \epsilon^{min}$. The ECB never inflates the debt in a situation where transfers are possible because transfers are sufficient and the ECB would never want to avert a default if it was not in g interest which is also the interest of the Eurozone as whole. This case is identical to the one analyzed in section (4) where the role of the ECB was ignored.

- $\hat{\epsilon} < \epsilon^{min}$ which insures that the ECB will choose a zero inflation rate in the case of default. This excludes the case of strong fiscal dominance.

$$\frac{b_1^g}{y_1^g} < \frac{\delta}{\alpha^{gu}} \left(1 + \frac{y_1^i}{y_1^g} \epsilon^{min}\right)$$

  The condition on parameters is such that the debt to GDP ratio for g is small enough.

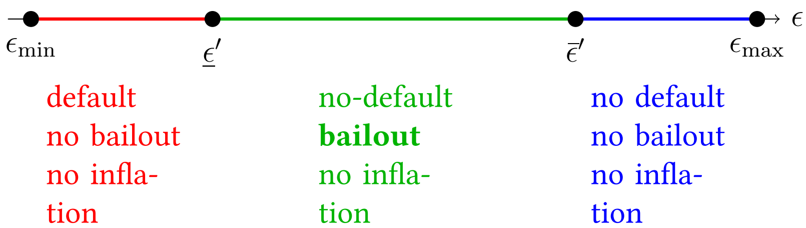


Figure 10: Bailout under Monetary Dominance

We then examine two cases: monetary dominance and weak fiscal dominance/.

- Monetary dominance: If $\overline{\overline{\epsilon}} < \underline{\epsilon}'$, then when transfers are possible, the ECB never chooses positive inflation. This case is valid with high y_1^g and δ, and low b_1^g.

- Weak fiscal dominance: If $\overline{\epsilon}' > \overline{\overline{\epsilon}} > \underline{\epsilon}'$, then when transfers are possible, the ECB may choose positive inflation. This is the case with intermediate levels of y_1^g and δ, and low b_1^g.

Under monetary dominance, the possible equilibria are shown in figure 10. Only binding thresholds are indicated. Monetary policy does not affect transfers and the decision whether to default or not.

Under weak fiscal dominance, possible equilibria are shown in figure 7. In this case, when output realization in i is sufficiently high ($\epsilon_1^i > \overline{\epsilon}'$), there is no default, no inflation and no transfer. If it is lower, i requires a transfer in order not to default ($\overline{\epsilon}' > \epsilon_1^i > \overline{\overline{\epsilon}}$) but there is no inflation. For $\overline{\overline{\epsilon}} > \epsilon_1^i > \underline{\epsilon}'$), the ECB partly inflates the debt, g makes a transfer to avoid the default. For $\epsilon_1^i < \underline{\epsilon}'$, the default is optimal and there is no more incentive to inflate the debt.

There are several conditions on output realizations and parameters for such a situation to exist:

$$
\begin{aligned}
\epsilon_1^i &< \overline{\overline{\epsilon}} \\
\epsilon_1^i &> \frac{\alpha_1^{i,u} b_1^i \left(1-\overline{z}\right) - \alpha_1^{gu} b_1^g \overline{z} - y_1^g \left(\kappa - \delta \overline{z}\right)}{\left(\Phi - \delta \overline{z}\right) \overline{y}_1^i} \equiv \underline{\epsilon}' \\
\epsilon_1^i &< \frac{\left(1-\alpha_1^{i,i}\right) b_1^i \left(1-\overline{z}\right) + \alpha_1^{g,i} b_1^g \overline{z}}{\left(\Phi - \delta \overline{z}\right) \overline{y}_1^i} \equiv \tilde{\epsilon} \\
\hat{\epsilon} &< \epsilon^{min} < \underline{\epsilon}' < \overline{\overline{\epsilon}} < \tilde{\epsilon}
\end{aligned}
$$

The first condition says that the output realization is such that the ECB sets $z = \overline{z}$, the second that g prefers no default and transfer and the third that indeed i requires a transfer when $z = \overline{z}$. These conditions apply for intermediate levels of the output realization i. The last condition on the ranking of thresholds requires in particular intermediate levels of debt (see appendix for details).

Finally, when transfers are excluded (and $\overline{\overline{\epsilon}} < \underline{\epsilon}'$ so that monetary dominance applies with zero inflation in presence of transfers) the possible equilibria are shown in figure 8. When output realization in i is sufficiently high ($\epsilon_1^i > \overline{\epsilon}'$), there is no default and no inflation. If it is lower, i requires a positive inflation rate in order not to default ($\overline{\epsilon}' > \epsilon_1^i > \tilde{\epsilon}$). For $\epsilon_1^i < \tilde{\epsilon}$, the default is optimal and there is no more incentive to inflate the debt.

ONLINE DATA APPENDIX. Not for Publication

The outline of this appendix is as follows. Section F documents how the data was constructed. Section G presents a historical overview of the bailouts for Cyprus, Greece, Ireland, Portugal, and Spain. Section I presents details regarding the "rolling" estimate of the size of the transfer for Greece over time.

F Construction of the Dataset

Depending on the official lender (e.g., IMF, ESM, etc.), the level of detail regarding the timing of disbursements, the repayment projections, and the estimated interest payments varies. Here, we report broadly how we construct disbursements, repayments, and interest payments by lender, and relegate specific details to Section G.

IMF Data for Cyprus, Greece, Ireland, Portugal, Hungary, Latvia, and Romania comes from the IMF website, which reports actual disbursements, actual and projected repayments of principal, and actual and projected interest payments. We use the listed SDR amounts for disbursements, repayments, and interest payments and convert these amounts to Euros by using the average realized EUR/SDR exchange rate prevailing during the month of the disbursement. For forecasted payments, we use the last observed date for the SDR/EUR exchange rate of October 2018.[69]

Realized flows come from the "Flows" database. Disbursements are those listed as "GRA Purchases," repayments are those listed as "GRA Repurchases," and interest payments are those listed as "GRA Charges." These include both GRA Charges and GRA Burden Sharing Charges.[70] Projections come from the "Projections" database. Projected repayments are those listed as "GRA Repurchase." Interest payments are those listed as "GRA Charges".[71]

EFSF and ESM Data for Cyprus, Greece, Ireland, and Portugal are available from the ESM website (the EFSF data is kept updated on this website as well). Actual disbursements and actual and projected repayment schedules are typically reported. In our baseline specification, we use the actual numbers and projections as of December 2019 to calculate the size of the transfer. For interest payments, we apply the historical blended rates as of December 2019, one each for EFSF and ESM loans, to the outstanding level of debt. We go into more detail on this interest rate in the Historical Overview section.

EFSM Data for disbursements and repayments, both realized and projected, for Ireland and Portugal come from the European Commission website.[72] For interest payments, we apply the average cost of funding as of 2012. Realized interest payments are calculated by applying lending rates from European Commission (2012). For future interest payments, we include a term premium calculated using euribor OIS rates relative to the last observed euribor 3-month rate. We use the Bloomberg Tickers as in Du, Im and Schreger (2018).

GLF Data for Greece comes from the European Commission website and various reports therein. Data on disbursements and repayment schedules are available. To calculate interest rates, we add the reported margins to the end of period 3-month Euribor rate. To forecast 3-month Euribor rates, we again use the euribor OIS rates used in Du, Im and Schreger

[69]Since around 2008, there has been a secular depreciation of the Euro. To the extent that the Euro continues to depreciate, this would increase the size of the transfer payments. We therefore view our estimates as a lower bound with respect to this source of bias.

[70]This also includes one GRA SCA-1 Charge, which is listed as -1.

[71]This excludes "SDR Assessments," which are levied annually to reimburse the IMF SDR department, and "Net SDR Charges," which are charges if a member holds too few SDRs.

[72]Note that Greece also benefitted from a one-month bridge loan from the EFSM in August 2015. However, due to the short nature of the loan, we do not model its transfer component.

(2018) to calculate the term premium.

GDP Data for all countries comes from the Eurostat annual national accounts.

Inflation Data for all countries comes from the World Bank

G Historical Overview

The European Sovereign Debt Crisis dates back to at least March 2010, when Greece formally requested assistance from the rest of Europe. However, financial assistance to countries within Europe occurred earlier, during the Global Financial Crisis, at least since 2008. In this section, we follow the main text and discuss the details of the the lenders and borrowers during this time period, with an emphasis on the construction of our dataset. We begin by documenting broadly how the major lenders structured financial assistance during the European debt crisis. We then give a broad overview of the lending programmes for the Eurozone borrowers (Cyprus, Greece, Ireland, Portugal, and Spain).[73] Finally, we discuss the lending programmes for the Non-Eurozone borrowers.

G.1 The Lenders

Established in 1945, the IMF's primary purpose is to "ensure the stability of the international monetary system."[74] The IMF's lending structure is discussed at length in Joshi and Zettelmeyer (2005). The countries involved in the Eurocrisis are not low-income countries, which means their lending came through non-concessional facilities. The shorter programme available was the Stand-By Arrangement (SBA) where repayment is typically due within 3-5 years. However, most borrowing eventually came through the Extended Fund Facility (EFF), which allows for repayment within 4.5-10 years. Both of these facilities come with conditionality on achieving structural improvements.(IMF, 2016*a*)

The maximum amount a country can borrow through either the SBA or the EFF is 145% of their quota annually or 435% over the lifetime of a programme. During the European debt crisis, countries typically went over this amount by being given "exceptional access". The interest rate on these loans is a floating rate based on the SDR interest rate. The base rate is the standard rate of charge, which is given by the weekly SDR rate plus a margin (currently 100bp). On top of this, there is a surcharge for equal to 200bp on amounts greater than 187.5% of quota, and a higher surcharge of 300bp if the amount above 187.5% of quota is outstanding for at least 51 months.(IMF, 2017)

In addition to this variable rate, there are also two important fees. First, there is a one-time service charge of 50bp when ever a disbursement is drawn. Additionally, there is an upfront commitment fee based on the size of the programme (15bp if less than 115% of quota, 30bp if at least 115% but less than 575%, and 60bp if greater than 575%). This commitment fee is refunded over the lifetime of the programme. (IMF, 2018*a*)

Other than the IMF, the European community as the largest source of financial aid to distressed countries during the European debt crisis. The European Commission provided direct aid to Greece through the Greek Loan Facility and to Latvia, Hungary,a nd Romania through the Balance of Payments financial assistance facility. By direct aid, we refer to aid given not through the special purpose vehicles of the EFSF or the ESM, which we consider as separate loans. We discuss the Greek Loan Facility at length in Section I.

These loans carried similar interest rate schemes across the difference loan facilities. Interest rates for EFSF and ESM loans are equal to the cost of funding plus a margin. The cost of funding is typically given as a weighted average of interest rates on outstanding borrowing from investors. As discussed in this appendix, the margin was gradually reduced over time

[73] For another treatment of this history, see Corsetti, Erce and Uy (2017).

[74] See the "IMF at a Glance" on the IMF website. Note that since 2012 its mandate was updated to expand beyond exchange rates and balance of payments and include all macroeconomic and financial sector issues that bear on global stability.

until, in most cases, it was equal to 0. Just like in the case of the IMF, there is also a commitment fee and an upfront service fee of 50bp.[75]

The Medium-term Balance of Payments financial assistance facility was established on February 18, 2002 by EC No. 332/2002, and subsequently updated by EC No. 431/2009. This facility is for states who have not adopted the Euro. This lending is concessionary, which means a memorandum of understanding listing the required structural reforms is a precondition for aid, as well as monitoring during and after the country receives funds. Post-programme surveillance is required until at least 70% of the loan is repaid.[76] Lending through the balance of payments financial assistance facility can be one of two types. In our sample, we study almost exclusively loans, however precautionary loans were also available for countries like Romania.

G.2 Eurozone Programmes

G.2.1 Greece

Greece entered three different programmes. The first programme came in the form of a series of bilateral loans from other Europea countries via the newly created Greek Loan Facility (GLF) and the International Monetary Fund (IMF) between 2010-2011. A second round of bailouts (Programme 2) came from the European Financial Stability Fund (EFSF) and the IMF between 2012-2015. Finally, a third round of bailouts (Programme 3), came from the European Stability Mechanism (ESM) between 2015-2018. This last programme ended in August 2018. In this section, we outline the state of the three Greek programmes as of August 2018. In Section I, we go into detail about the evolution of the Greek programmes in order to calculate the change in the NPV of the transfer over time.

The buildup to programme 1 involved substantial debate regarding its form, size, and participation. Although Greek's economic position was in dire straights by the end of 2009, it was not until March 2010 that the EC and ECB included the IMF due to the EC's inability to provide the amount of funding and expertise necessary for Greece. Programme 1 therefore involved disbursements by the IMF and the GLF. Disbursements by the IMF totaled €20.1 Billion over six tranches.[77][78] The European Member states committed a total of €80 bn to Programme 1, although not all was disbursed. (EC (2012*b*),Eurogroup (2010)) The first disbursement of Programme 1 was in May 2010, with the sixth and final disbursement of Programme 1 coming in December 2011. Programme 1 disbursements totaled €52.9 bn by the European Members, with Germany (€15.17 Billion), France (€11.39 Billion), and Italy (€10.00 Billion) contributing the most. (EC (2012*c*)) Originally, Ireland and Portugal were slated to contribute to Programme 1. However, their own fiscal struggles caused them to eventually drop out. Of the remaining members, Slovakia was the only to never participate.

The original loan agreement between Greece and the European Commission stipulated the structure of principal repayment and interest. This original loan agreement was officially amended three times: in June 2011, February 2012, and December 2012. (EFSF (2014), EFSF (2015), ESM (2017)) The December 2012 agreement extended the maximum weighted average maturity to 30 years. The February 2012 agreement lowered the interest rate margin to only 50 basis points each

[75] There are also a number of other fees. For example, in the initial FFA for Greece, there exited a guarantee commission fee of 10bp, that was later cancelled in the case of Greece. There was also an annual service fee of 0.5bp

[76] The statistic varies according to the source. The 70% statistic is taken from EC (2017*a*). However, 75% can be seen in Article 15 of EU (2013*a*)

[77] The IMF lends in Special Drawing Rights (SDRs). Throughout, we convert the SDR value to Euros using the prevailing SDR/EUR exchange rate at the time of the disbursement. For realized interest payments, we use the prevailing SDR/EUR exchange rate. For forecasted interest payments, we use the last observed value of the exchange rate.

[78] Whenever possible, we use the net disbursement amount, which is the financial assistance amount less the sum of issuance costs, upfront service fees, and negative carry costs.The exact details are stipulated in the FFAs for each country. These are the amounts expressed on the official websites.

year.[79]. In calculating interest rates, we follow the amendments closely by using the prevailing margin at the time of the interest payment. We use the 3-month annualized Euribor as the base rate and add a 50bp margin. Interest is calculated as a quarterly rate derived from the annualized rate and paid in March, June, September, and December until outstanding debt is equal to zero.

The IMF's lending structure is discussed at length in Joshi and Zettelmeyer (2005). The countries involved in the Euro-crisis are not low-income countries, which means their lending came through non-concessional facilities. Greece originally borrowed through a Stand-By Arrangement (SBA) where repayment is typically due within 3-5 years. However, eventually all of their borrowing came through the Extended Fund Facility (EFF), which allows for repayment within 4.5-10 years. Both of these facilities come with conditionality on achieving structural improvements. (IMF (2016*a*)) The maximum amount a country can borrow through the EFF is typically 145% of a their quota annually or 435% over the lifetime of a programme. Programme 1, with €30 bn committed, was around 3,200% of Greece's total Quota. Greece was permitted to go over the quota limit due to the IMF's special circumstances.[80] The lending rate on all non-concessional facilities is tied to the Basic Rate of Charge, which is the SDR rate plus a premium that depends on the size of the loan relative to a country's quota. The margin is 100bp for loans less than 187.5% of Quota, 200bp for credit above 187.5% of Quota, and 300bp for credit above 187.5% of Quota for more than 51 months. (IMF (2017))

Programme 2 still involved the IMF, however the Eurogroup operated through the newly created EFSF. The EFSF committed a total of €144.7 Billion to Programme 2 over 2012-2014. (EC (2012*b*)) A total of approximately €141.8 Billion was disbursed, although €10.9 Billion was returned, leaving a net outstanding as of June 2018 of €130.9 Billion.[81] Details on lending rates and maturties are given in the Master Financial Facility Agreement (FFA). Lending rates were calculated as the EFSF cost of funding plus some margin, although currently all margins are eliminated. The weighted average maturity of the loans, which had fallen to approximately 28 years, was lengthened to "update" the weighted average maturity back to the maximum permitted 32.5 years. The agreement also reduced interest rate risk via bond exchanges, swap arrangements, and matched funding. In June 2018, this agreement was modified again. While the official repayment schemes have not yet been determined, the maximum weighted average maturity was extended to 42.5 years, and interest payments were deferred by twenty years.[82]

In calculating interest payments, we set interest payments to begin in 2033. All interest payments prior to this time period, with the exception of the PSI loans, are rolled forward into a new loan set to be disbursed at that time. We set the annualized interest rate to be equal to the last value available from the ESM in August 2018 of 135bp. This interest paid annually in March. Our assumption implies both that all loans amortize at the same rate and that interest rates will not rise over the lifetime of the loans. This latter assumption is most likely false, as the base rate is tied to the cost of funding by the EFSF plus a margin, where the cost of funding includes borrowing rates by the EFSF. However, given the current very low interest rate environment, it is probable that interest rates will rise, implying that our interest payments are an upper bound on the size of the transfer in this respect. In robustness checks, we use market expectations of future interest rates. Note that as part of two debt relief agreements, interest payments were deferred for 10 years each. Hence, interest payments will be accumulated through 2033, at which point they will be amortized. We therefore treat the twenty years

[79]Note that, because Portugal and Ireland were also receiving assistance, the interest rate was not lowered for their loans that had already been disbursed. However, due to the difficult nature of disentangling payments and because their contributions were relatively small, we simply lower all the margins on all loans to 50bp.

[80]The "No More Argentinas Rule" was put in place following the Argentinean defaulted, when the IMF attempted rescue of Argentina led to default a short time later. This rule stipulated that a country's debt would need to be sustainable in order to warrant a large loan. For a discussion of the IMF eventually overcame this rule, see Blustein (2015).

[81]The €10.9 Billion consisted of bonds that were to be used to recapitalize Greek banks through the Hellenic Financial Stability Fund.

[82]This includes ten years from the December 2012 agreement plus ten years in this agreement.

of deferred interest as an additional disbursement in January 2033 that is to be repaid over constant amortisation over 20 years.

Disbursements by the IMF for the second programme totalled €8.33 Billion over four tranches, although they planned to contribute €28 Billion. The first loan was in 2010 and the last loan was in May 2010 from the SBA. The last loan listed from the IMF was on June 3, 2014 from the EFF. Greece received one bridge loan from the European Finacial Stability Mechanism (EFSM) when it missed a payment on its loans to the IMF in July 2015. This was a three-month loan for €7.16 Billion given to allow Greece time to transition to the third Programme and receive assistance from the ESM. This loan was repaid when ESM assistance was given. Because of the short-term nature of this loan, we do not model it.

Programme 3 began in August 2015 and ran through August 2018. This programme consisted of new loans by the ESM only (although debt relief on earlier loans by other officials has also occurred). The ESM committed €86 Billion to Greece but only disbursed €61.9 Billion.[83]

In calculating interest payments for the ESM, interest is paid annually in, we assume, March of each year. We calculate the outstanding level of debt for each year and multiply this value by the annualized interest rate equal to the last value available from the ESM in August 2018 of 163bp.

Figure 11 shows the realized and projected disbursements and realizations as of August 2018. We include our forecast of repayments under the June 2018 extension of the WAM. Recall that we treat the deferred interest payments as a new disbursement in the year following the end of the deferral.

G.2.2 Ireland

Ireland's bailout programme ran from 2010-2013, although disbursements did not begin until 2011. Total commitments were €85 Billion, comprised of €17.7 Billion from the EFSF, €22.5 Billion from the EFSM, €22.5 Billion from the IMF, and €4.8 Billion from Bilateral Loans (United Kingdom, Sweden, and Denmark)[84] (EU (2011*e*)) Therefore, €67.5 Billion was committed externally. All of this was eventually disbursed.

IMF disbursements amounted to around 2,322% of Ireland's quota. IMF assistance to Ireland was under the EFF. (IMF (2010*b*)) These loans were via the EFF, described above in the section on Greece.

EFSF disbursements occurred between February 2011 and December 2013, when the programme was concluded. EFSF lending rates were equal to the EFSF funding costs plus a margin. The original FFA had a margin of 247bp with a maximum weighted average maturity of 7.5 years. In July 2011, the maximum weighted average maturity of 15 years and margins were reduced to 0. Finally, in June 2013, the maximum weighted average maturity was officially extended to 22 years.

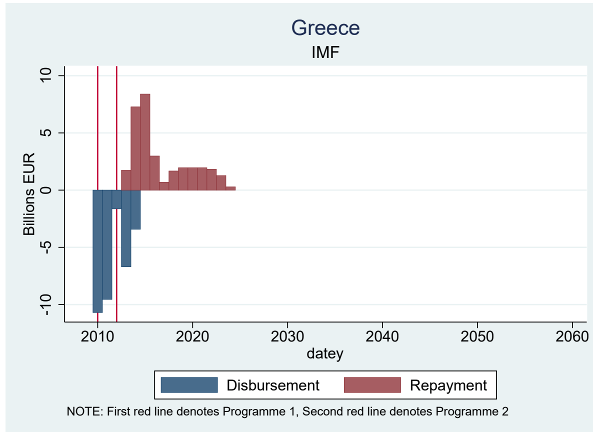
The EFSM disbursed its first tranche of funding in January 2011, and their last tranche was disbursed in March 2014. Interest Rates for the EFSM loans were originally equal to cost of funding for the European Union plus 292.5bp. (EU (2011*e*)) In October 2011, all EFSM margins were set to 0 and the maximum weighted average maturities were extended to 12.5 years. (EU (2011*c*)) In June 2013, the maximum weighted average maturity was extended to 19.5 years. (EU (2013)) This last decision also extended the maturity of the initial disbursement by splitting this disbursement into three tranches and extending each one. We set the interest rate on the EFSM loans to Ireland equal to 3.10.[85]

Finally, there were also bilateral loans to Ireland. Sweden committed and disbursed €600 Million in four tranches in 2012 and 2013. The United Kingdom committed €3,830 Million (£3.23) in December 2010 and disbursed this amount between October 2011 and September 2013 in 8 disbursements of £403,370,000 each. Denmark offered a loan of €400 Million in four

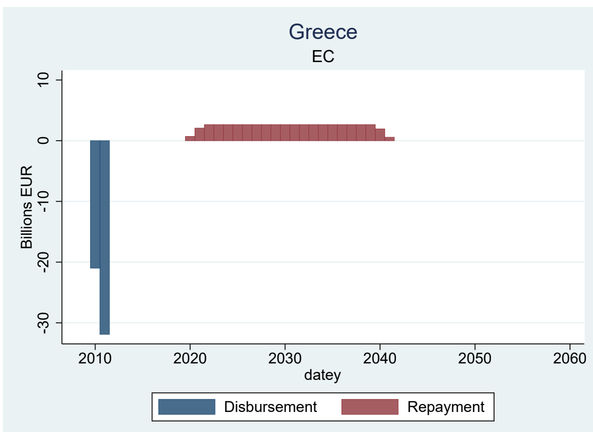
[83] There was one cashless loan for bank recapitalization of €5.4 Billion. For this loan, originally there was supposed to be a €2.2 Billion has an interim maturity in 2018.

[84] Ireland also had to commit €17.5 Billion itself. This money was taken from, among other sources, their pension program.

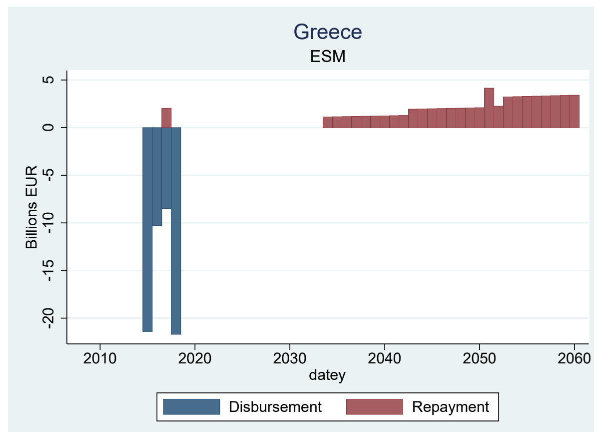
[85] This number comes from a parliamentary question by the European Union to Olli Rehn in 2012, where he states that the average interest rate on Irish loans is 3.1%.



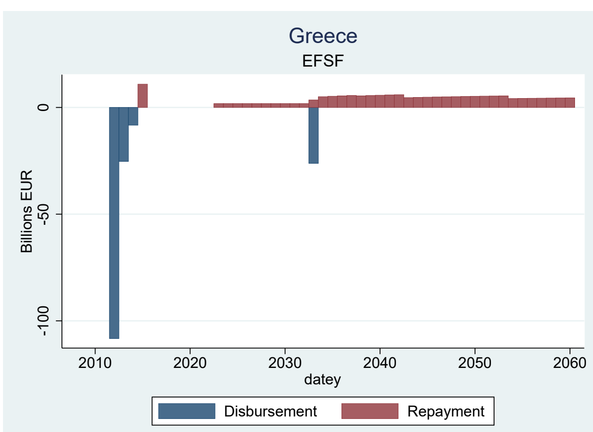
(a) IMF



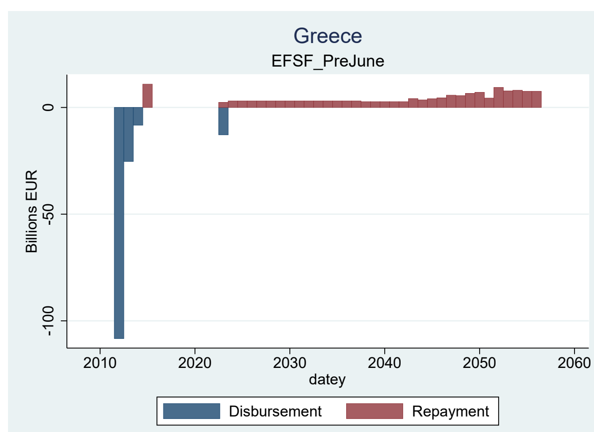
(b) EC



(c) ESM

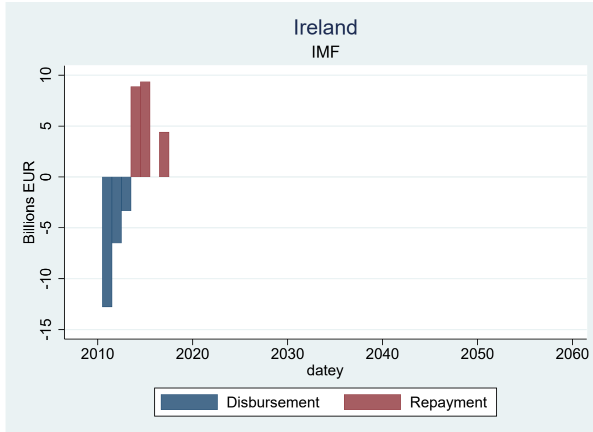


(d) EFSF

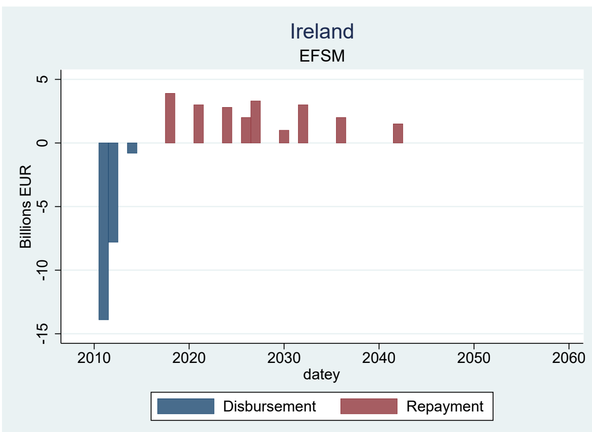


(e) EFSF (Pre June Agreement)

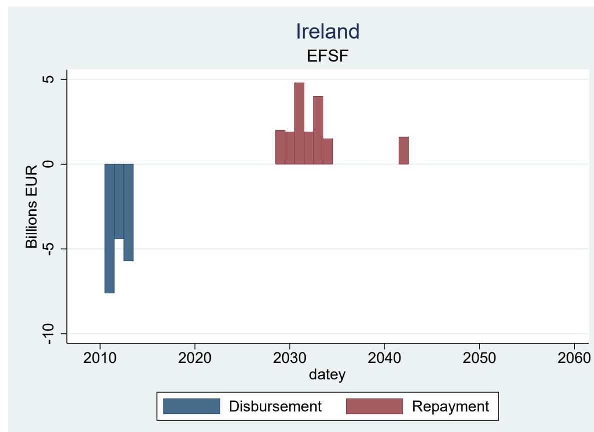
Figure 11: Greece Programmes



(a) IMF



(b) EFSM



(c) EFSF

Figure 12: Irish Programmes

tranches between March 2012 and November 2013. Sweden offered a loan of €600 Million in four tranches between June 2012 and November 2013. We do not calculate the size of the transfer for these loans because they are relatively small and becuase details regarding interest payments are difficult to find.[86]

Figure 12 plots the disbursements and repayment schedules for Ireland.

G.2.3 Portugal

Portugal requested aid from the EFSF, the IMF, and the European Union via the EFSM in April 2011 and was approved for a programme in May 2011. Portugal officially exited in June 2014 when they allowed the programme to lapse without taking the last available tranche of funding. The three groups each committed approximately €26 Billion out of a total of €78

[86] There is detailed information for the United kingdom. For bilateral loans, the interest rate for the UK loans was the "the semi-annual swap rate for Sterling swap transactions..." plus a margin of 229bp per annum. (UK Treasury (2010)) In 2012, the interest rate was reduced to a service fee of 18bp per annum plus the cost of funding. (UK Treasury (2012)) £7,668,903.59 was rebated to Ireland as a consequence by reducing the interest payment due at the following interest payment date. From other testimonies, we can piece together that the interest rate on Sweden and Denmark loans was tied to the 3-month Euribor rate plus a margin of 100bp. However, there is little other information publicly available at this time.

Billion. (EC (2016))

IMF disbursements amounted to around 2,306% of Portugal's quota, and were disbursed through the EFF. (IMF (2011*a*)) Interest payments for IMF loans are provided by the IMF.

EFSF disbursements began in 2011 and ended in 2014. The initial FFA in April 2011 set the terms of the loans, in particular the lending rates and the maximum weighted average maturities. The lending rates for the EFSF were equal to the EFSF Cost of Funding plus a Margin, which in the beginning of the programme (May 2011) was equal to 208bp. The initial maximum weighted average maturity at this time was 7.5 years. In July 2011, the margin was reduced to 0bp and the maximum weighted average maturity was lengthened to 15 years. In June 2013, the maximum weighted average maturity was officially extended to 22 years.

For EFSF loans, the month of annual interest payments for each disbursement is given at the time of the disbursement. To simplify the analysis, we assume that all interest payments are made in March. We set the interest payment for interest periods prior to and including September 2018 equal to the prevailing blended rate of 176bp multiplied by the total outstanding level of debt.

Lending rates for the EFSM were equal to the EU's cost of funding plus, originally in May 2011, a 215bp margin. Initially, the weighted average maturity was 7.5 years. In November 2011 Portugal the average maturities of Portugal's EFSM loan were extended to 12.5 years and margins were eliminated. (EU (2011*b*)) In 2013, the average maturities were again extended to 19.5 years. (EU (2011*a*)) We use 3% as the average cost of funding.[87]

Figure 13 plots the disbursements and repayment schedules for Portugal. The programmes are relatively similar in size, however the repayment schedule is much more front-loaded for the IMF programme relative to the EFSM and EFSF repayment schedules. For the IMF, full repayment is expected by 2025, however the EFSM and EFSF repayment schedules now extend through 2040.

G.2.4 Cyprus

Cyprus officially asked for assistance in 2012 and was approved for a programme in May 2013. Cyprus officially exited its programme in March 2016. The program's total financing envelope was €10 Billion, with the ESM committing €9 Billion and the IMF committing approximately €1 Billion through . In total, The ESM disbursed €6.3 Billion between May 2013 - October 2015, while the IMF disbursed all of its commitment. (ESM (2016))

The ESM loans were not amortized, with the lump sum owed at the date of maturity. Interest rates were equal to the cost of funding plus some margin. We use the blended rate taken from the ESM in August 2018 of 91bp applied to the outstanding principal. IMF lending terms are described above.

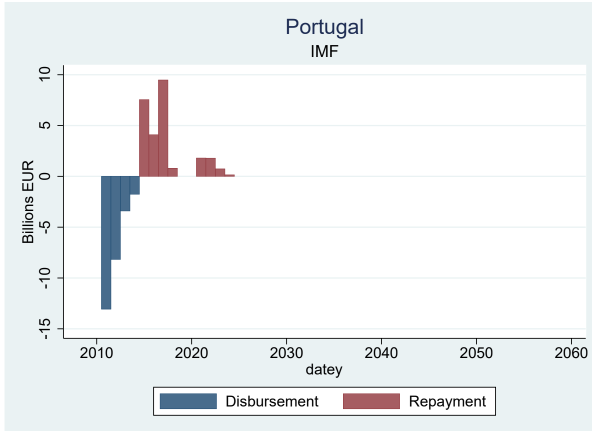
Cyprus's post-programme surveillance began in September. There have been five such surveillance missions as of October 2018, although as of this time the fifth PPS report has not been released.

Figure 14 plots the disbursements and repayment schedules for Cyprus. The IMF loans are scheduled to be repaid over the period 2020 to 2025, while the ESM loans don't start to be repaid until closer to 2025. The approximately €0.26 billion early repayment was done in a bid to reduce debt servicing costs, as Cyprus was able to issue debt a lower interest rate. (CNA News Service (2017))

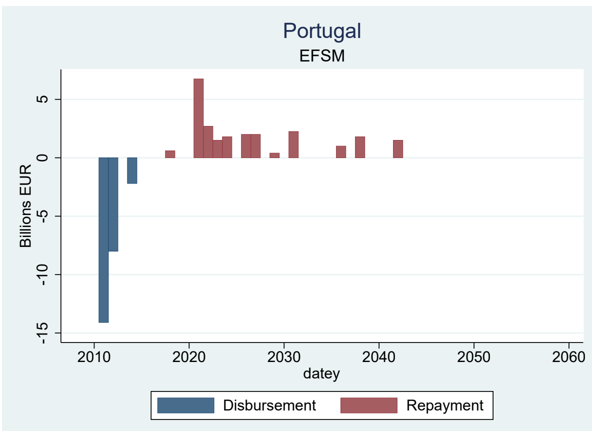
G.2.5 Spain

Spain received assistance from only the ESM. Loans were approved in July 2012, with two disbursements in December 2012 and February 2013. The ESM committed €100 Billion, although only €41.3 Billion was used. The assistance came in the form of bonds, which were used to recapitalize the banking sector. Spain has made some voluntary early repayments on

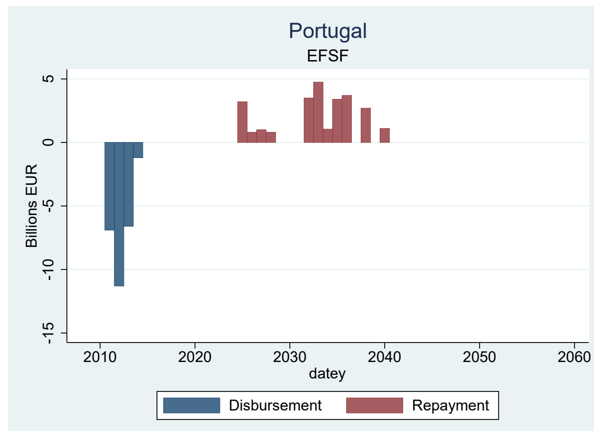
[87] This number comes from the same statement by Olli Rehn in 2012 as the number for Ireland.



(a) IMF

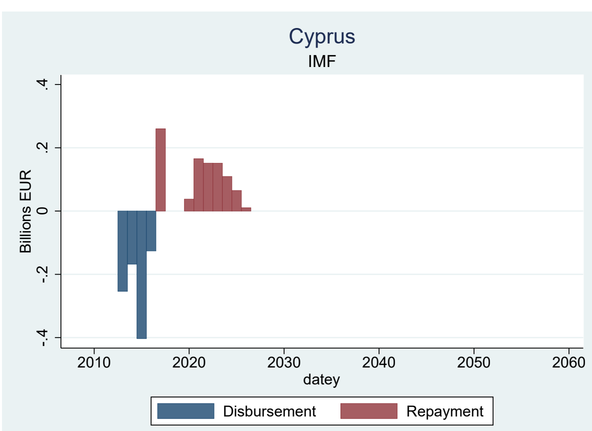


(b) EFSM

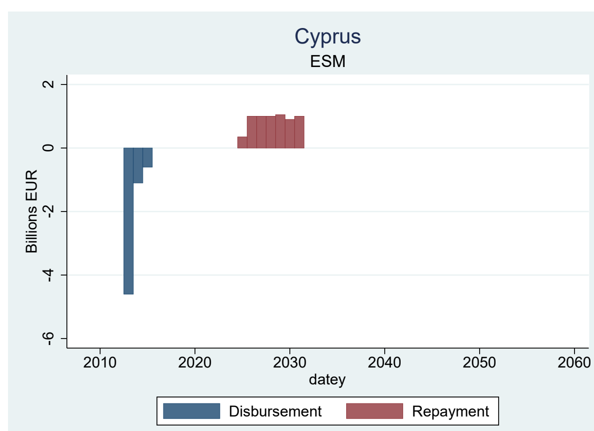


(c) EFSF

Figure 13: Portugal Programmes

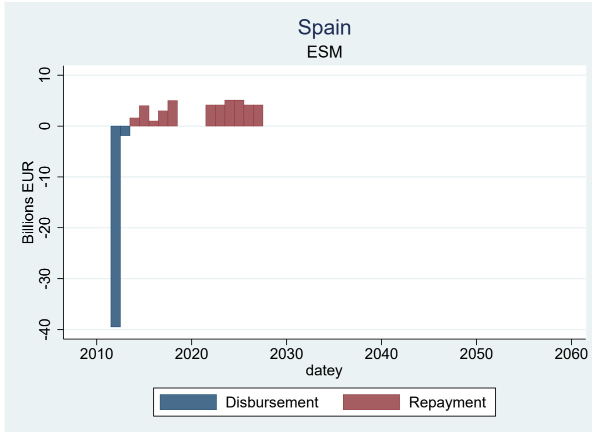


(a) IMF



(b) ESM

Figure 14: Cyprus Programmes



(a) ESM

Figure 15: Spain Programme

these loans. (ESM (2013)) Otherwise, we use the blended rate taken from the ESM in August 2018 of 111bp applied to the outstanding principal. Figure 15 plots the ESM assistance to Spain as of August 2018.

Spain's post-programme surveillance began in March 2014. There have been ten such surveillance missions as of October 2018, with the eleventh scheduled for Spring 2019.

G.3 Other European Programmes

G.3.1 Hungary

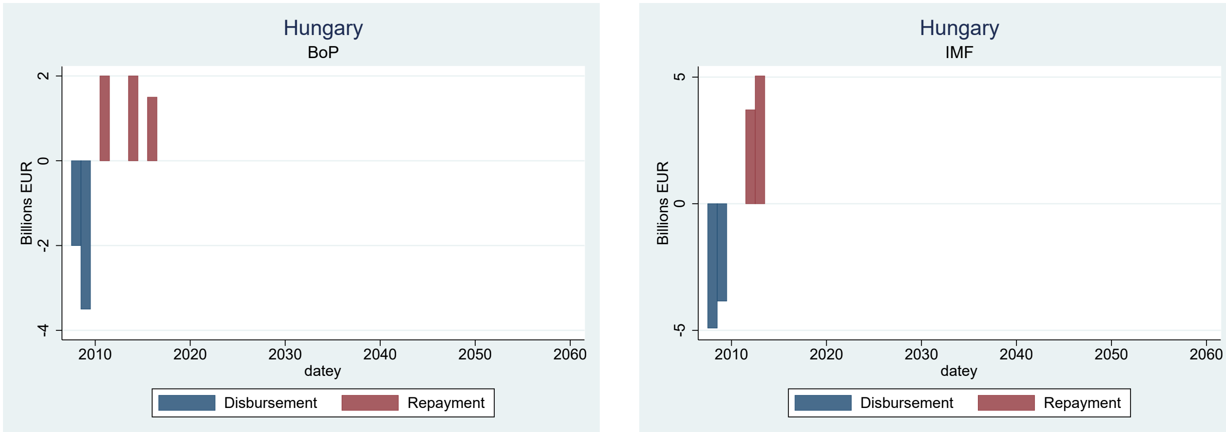
Talks regarding financial assistance to Hungary began as early as October 2008, when IMF Director Dominique Strauss-Kahn issued a statement discussing the issues facing Hungary. By the end of the month, both the IMF and the EC issued press releases and formal recommendations for Hungary to receive medium-term assistance. (IMF (2008*c*),EU (2008*a*)) This assistance was formally granted whith the IMF Executive Board's approval of a maximum of SDR10.5 bn (approximately €12.5 bn) the EC's decision providing a maximum of €6.5, both in Early November. (IMF (2008*a*), EU (2008*b*)) These loans were conditional on Hungary implementing a number of structural policies, such as expenditure ceilings and expanded deposit insurance programs.

Assistance from the EC was under its medium-term balance of payments program.[88] The realized EC loans were comprised of three installments given over the course of December 2008 to July 2009, each with a maturity between three and six years.[89] For the IMF, approximately SDR7.6 bn was disbursed through the SBA between November 2008 and September 2009 and was repaid between February 2012 and August 2013.

From the IMF, Hungary received approximately €8.2 billion (SDR 7.6 billion) through the SBA. As explained above, these loans are typically around three years, have interest payments tied to the basic rate of charge, and are conditional on structural reforms occurring. Repayment was on schedule through August 2013, at which point Hungary chose to repay early obligations due in 2013 and 2014 in order to generate interest savings. The data series for IMF disbursements, repayment, and interest come from the IMF website. This data is in SDR, and are converted to EUR at the prevailing

[88]We focus on actual disbursements, so the second round of assistance in July 2012, which did not result in any assistance, is excluded from our analysis.

[89]The original agreement stipulated a maximum of five installments over at most two years with a weighted average maturity of 5 years. The MoU only mentioned four installments.



(a) BoP (b) IMF

Figure 16: Hungary Programme

monthly exchange rate using an average of the daily rates. As Hungary repaid its loans by the end of 2013, no projections of repayment/interest or forecasted exchange rates are used.

Although €1 billion of loans were authorized from the World Bank, none were realized.

Post-programme assistance began in April 2011 and ended in November 2014. There were six review missions in total. As of November 2014, Hungary had repaid more than 70% of its EU loan, and hence was not subject to post-programme surveillance.

Figure 16 plots the disbursement and repayment schedules for Hungary. The repayment schedule for Hungary ended in 2013, while the Balance of Payment programme ran through 2016. Note that Hungary's first repayment was

G.3.2 Latvia

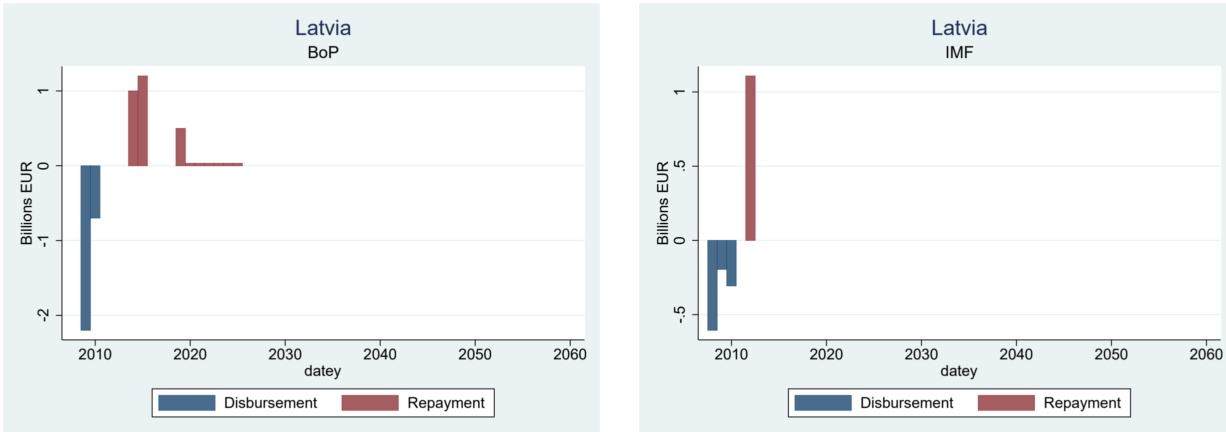
Latvia came under financial pressure around the same time as Hungary. As early as November 2008, Latvia had requested aid from the EC and other lending institutions. (IMF (2008*d*)) Such assistance was formalized in January 2009 when a total of €7.5 bn was made available. This programme was in large part designed to maintain the exchange rate peg between the Latvian Lat (LVL) and the Euro. Of this amount, €3.1bn came from the EC, SDR1.5 bn (approximately €1.7 bn) came from the IMF through the SBA, €1.9 bn came from the Nordic countries (Sweden, Denmark, Finland, Estonia, and Norway), and the remainder came from the World Bank, the European Bank of Reconstruction and Development, the Czech Republic, and Poland. (EU (2009*a*,*b*)) For the EC, financial assistance came in four installments for a total of €2.9 bn between February 2009 and October 2010. For the IMF, approximately SDR1 bn was disbursed between 2008 and 2010 and was repaid in 2013.

The repayment schedule for the EC is constructed using the PPS mission reviews and information from the EC website. We set the repayment date of the first disbursement to be March 2014 and the repayment date of the second disbursement to be January 2015 to match the information from the EC website.[90] For the third disbursement, we assume it will be repaid in lump sum in March 2019. For the fourth and final disbursement, we assume a constant amortization over the period 2020-2025. These last two disbursements match the information provided in the PPS mission reports.[91]

Interest payments for the EC BoP programme are calculated using an interest rate of 3.2% on the outstanding balance

[90] See Financial assistance to Latvia

[91] These reports document repayment in LVL until PPS 4 in January 2014, when Latvia formally joined the Eurozone and replaced its currency with the Euro. As usual, we report all results in Euro using prevailing exchange rates.



(a) BoP (b) IMF

Figure 17: Latvia Programme

until repayment. We use the values in EUR to calculate the levels of outstanding debt.

For the IMF, there were six planned series of disbursements, however only the first four were actually released. These disbursements occurred in December 2008 (the initial agreement), August 2009, February 2010, and August 2010. (IMF (2008*d*), IMF (2008*b*), IMF (2009), IMF (2010*c*), IMF (2010*d*), IMF (2011*b*), IMF (2011*c*)) As for repayments, Latvia made a series of early repayments to the IMF in 2012. In September 2012, Latvia made an early repayment of obligations due in 2012-14. (IMF (2012*b*)) Latvia repaid its obligations early by announcing in December 2012 its intent to repay in 2013 the obligations that would have been due in 2015. (IMF (2012*a*)) Officially, these loans were repaid in December 2012, and as such *all* IMF reimbursals are in 2012. As Latvia repaid its loans by the end of 2012, no projections of repayment/interest or forecasted exchange rates are used.

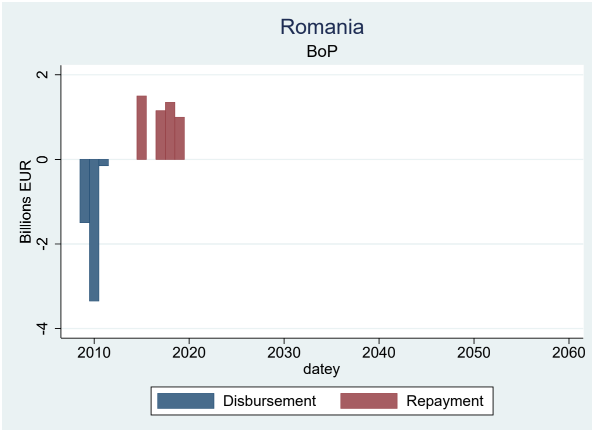
Figure 17 plots the disbursement and repayment schedules for Latvia. For the Balance of Payments programme, most repayment was in 2014 and 2015, although there are some minor payments scheduled through 2025. For Latvia, as mentioned above, all repayment was officially complete by 2012.

G.3.3 Romania

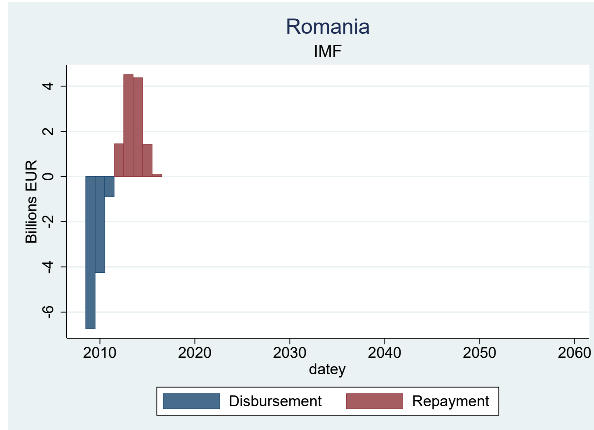
Romania, the final Non-Eurozone country we study, also experienced financial pressures in mid-2009. Assistance was formalized in May 2009 when a maximum of €20 was made available, with €5 bn from the EC through the balance of payments programme, SDR11.443 bn (approximately €12.95 bn) from the IMF through the SBA, €1 bn from the World Bank, and €0.5 bn each from the European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD).[92] (EU (2009*c*)) We focus in this paper on the Balance of Payments programme and the IMF.

Romania entered three BoP programmes between 2009-2015, however only the first programme of 2009-2011 saw realized disbursements. Post-programme surveillance commenced in October 2015 and consisted of three surveillance missions (May 2016, March 2017, and November 2017). Romania exited post-programme surveillance in April 2018 following repayment of 70% of its EU loan. We set the repayment and interest rate schedule according to the EC's post-programme

[92]Note that this is technically only Programme 1, with two more programmes (2011-2013 and 2013-2015) later. However, the 2011-2013 and 2013-2015 programmes were approved on a precautionary basis, and featured no disbursements by the IMF or the EC. The disbursements by the EIB and EBRD continued through 2012, but are small and not taken into account in our analysis. We also do not calculate the transfer from the World Bank.



(a) BoP



(b) IMF

Figure 18: Romania Programme

evaluation. (EC (2015)) The interest rate is approximately 3%. We set the repayment dates to be the same as the issuance date for each loan. For interest, we assume interest is paid in same quarter the loan is disbursed beginning the following year until, and including, the repayment date. Interest payments are calculated using an interest rate of 3.2% on the outstanding balance.

Romania was approved for assistance from the IMF in May 2009 through the SBA.[93] Romania received financial assistance over six disbursements including May 2009 (the initial agreement), September 2009, February 2010, July 2010, September 2010, and January 2011.[94] In March 2011, Romania was approved for the seventh disbursement and a new SBA, however these were precautionary and never drawn upon. IMF Lending terms for the SBA are described above in the section on Greece. The data series for IMF disbursements, repayment, and interest come from the IMF website. This data is in SDR, and are converted to EUR at the prevailing monthly exchange rate using an average of the daily rates. As Romania repaid its loans by the end of 2016, no projections of repayment/interest or forecasted exchange rates are used.

Figure 18 plots the disbursement and repayment schedules for Romania. The balance of payment programme has slightly longer durations, with repayment between 2014 and 2019, while the IMF only ran through 2016.

H Methodology

To estimate total transfers $Tr_t^{i,j}$ for lender i to borrower j at time t, we calculate the difference between the present value of the sequence of net transfers discounted at some benchmark internal rate of return and the present value of the sequence of net transfers discounted at its actual internal rate of return. By definition, this latter term is zero, and so we can write the transfer as

$$Tr_{t_0}^{i,j} = \sum_{t=t_0}^{T} \frac{1}{(1+\bar{r})^t} NT_t^{i,j} \tag{H.1}$$

where T is the date of the last net transfer flow (always a repayment). $\bar{r}$ is the (risk-free) discount or reference rate at time t. In practice, we set this discount rate to the internal rate of return on the IMF's lending for borrower j during the Eurozone

[93]Romania is no stranger to using the SBA programme via the IMF. In particular, Romania received assistance via the SBA between October 2001 and October 2003, and a precautionary SBA ending in June 2006. (IMF (2007))

[94]The February 2010 combined both the second and third disbursements.

crisis. $NT_t^{i,j}$ are net transfers from lender i to borrower j at time t.

We follow Joshi and Zettelmeyer (2005) and construct net transfers as

$$-NT_t^{i,j} = R_t^{i,j} - D_t^{i,j} + i_{t-1}^{i,j}(D^o)_{t-1}^{i,j} + \ldots + i_{t-\tau}^{i,j}(D^o)_{t-\tau}^{i,j} \tag{H.2}$$

where τ denotes the maturity of each disbursement. D^o is the *outstanding* balance remaining on each disbursement. Then, the internal rate of return $irr^{i,j}$ is the value that sets the sequence of net transfers to zero. The series of net transfers $NT_t^{i,j}$ is also used to calculate the size of the present discounted value of the transfer.

To calculate the internal rate of return, we follow Joshi and Zettelmeyer (2005). We begin by establishing a *lending cycle* for each country-lender pair. A lending cycle is a sequence of disbursements, repayments, and interest payments between a lender and a borrower during which the level of outstanding debt is positive. Unlike Joshi and Zettelmeyer (2005), who in some cases have multiple lending cycles per country-IMF pair, we only have one lending cycle for each country as, once a country requested assistance, they have since maintained an outstanding balance.

We make two key assumptions when calculating the internal rates of return. The first key assumption is that the current specification of repayments and interest rates will coincide with the realized outcome, and there will be no more debt renegotiations. Any changes to the current agreement that makes the terms more favorable for Greece, such as delaying interest payments or extending the overall maturity, would result in a larger transfer than we calculate. The second key assumption is that for loans with variable interest rates that depend on the international institutions borrowing rate, we assume that they can roll over debt at the same interest rate. Whether the current environment featuring low global interest rates is here to stay is beyond the scope of this paper, but if global interest rates were to rise, both the IMF and the Europeans lenders would most likely be affected similarly. Hence, it is unlikely that these changes in the interest rate are a source of concern in our estimation.

I Time-Varying NPV for Greece

In this section, we outline the evolution of the Greek debt programmes by rescue fund. This provides the background information regarding why the NPV for Greece had changed so much over time. It also provides sources for where we take forecasts of repayment from.

In calculating the NPV over time, we use equation H.1 and calculate the size of the transfer for each $s \in \{t^{start}, t^{start}+1, \ldots, T-1, T\}$, where t^{start} is defined as the quarter of the start of each programme and T is defined as 2018Q3. Expanding on Equation H.1, we therefore write the size of the net present value of the series of as of time s:

$$Tr_s^{i,j} = \sum_{t=s}^{T} \frac{1}{(1+\overline{r}_s)^t} NT_{s,t}^{i,j}, \quad s \in \{t^{start}, t^{start}+1, \ldots, T-1, T\} \tag{I.1}$$

where $NT_{s,t}$ denotes the expected net transfer of the series as of time s:

$$NT_{s,t} = E_s\left[R_t^{i,j} - D_t^{i,j} + i_{t-1}^{i,j}(D^o)_{t-1}^{i,j} + \ldots + i_{t-\tau}^{i,j}(D^o)_{t-\tau}^{i,j}\right]$$

By using this notation, note that for $t > s$, then we use the realized disbursements, repayments, and interest payments at time t.

The "risk-free" rate $\overline{r}_s$ in Equation I.1 is the internal rate of return for the expected sequence of net transfers to the IMF as of time s. Hence, the risk-free rate we use to discount the sequence of transfers is time varying as well.

To further understand this exercise, consider the following example. In December 2012, there was an official debt relief agreement reached between the EFSF and Greece that included, among other things, a smoothing of the repayment profile by Greece to extend the weighted average maturity of the programme (this agreement is discussed in more detail below). This change affects the expectation of future repayments by shifting repayment schedules R further into the future. As an example, assume away interest payments and suppose that all disbursements have been made. Suppose a repayment of €1 bn that was originally set for January 2030 is now moved to January 2040. In the language above, this means that initially, we have[95]:

$$NT_{2012Q4,Jan2030} = E_{2012Q4}\left[R_{Jan2030}\right] = 1 NT_{2012Q4,Jan2040} = E_{2012Q4}\left[R_{Jan2040}\right] = 0$$

In the next quarter, following the release of details regarding the repayment schemes, we now have

$$NT_{2013Q1,Jan2030} = E_{2013Q1}\left[R_{Jan2030}\right] = 0 NT_{2013Q1,Jan2040} = E_{2013Q1}\left[R_{Jan2040}\right] = 1$$

Hence, the sequence of net transfers used to calculate the size of the transfer has been adjusted.

I.1 Greek Loan Facility

While assistance was formally requested in April 2010, no funds were disbursed at this time. On May 9, 2010 the IMF agreed to a Stand-By Agreement (SBA) with Greece. On May 18, 2010, the euro-area Member states disburse the first installment of their pooled loans to Greece. From the beginning, the full amount of the programme was expected to be disbursed. Therefore, we assume that, beginning in May 2010, investors expected the programme to run its fully scheduled course. This implies that, for our quarterly NPV series, Q2 of 2010 is the first observation.

The full schedule of disbursements is set out on page 27 of Occasional Papers 61 (EC (2010*a*)). In each subsequent review (Occasional Papers 68, 72, 77, 81, 87) there is a similar table that lists the expected disbursement schedul (EC (2010,*a*,*c*, 2011*a*,*b*,*c*)). For all quarters up to and including Q3 of 2011, we use this table to forecast future disbursements. However, with the introduction of the EFSF in mid-2011, occasional paper 87 only lists the first six tranches as planned disbursements. As these reviews were quarterly, we assume in October 2011 the EFSF is expected to take over all future loans, and that only the first six tranches are expected to be part of the the GLF package to Greece. Therefore, we use this abbreviated forecast beginning in Q4 of 2011.

As for repayments and interest, we use the realized repayment schedule as soon as the loan is disbursed. However, for loans not yet disbursed, we begin by using the requirements set out in the Euro Loan Facility Act and its amendments. Under the original terms, the repayment schedule was to mirror that of the IMF's SBA with a three year grace period followed by repayment of constant maturity over eight quarters. According to the original Euro Area Loan Facility Act (dated in May 2010), the loan terms were five years. We therefore assume that for each disbursement, the loans are amortized over the eight quarters beginning after the three year grace period. Interest payments for this period are tied to the 3-month Euribor rate with a margin of 300bp for the first three years and 400bp for the last two years. This affects the forecasts up to and including 2011Q2.

In the Euro Area Loan Facility Act of June 2011, the grace period was extended to four years and six months. The term of each loan was also extended to ten years. We therefore assume that, following this period, future loans have a constant amortization over the five and a half years (22 quarters) after each grace period.[96] As for realized loans, a detailed amended schedule is included in the Act. Additionally, the margin was lowered to 200bp for the first three years and 300bp

[95] I suppress the i, for the EFSF, and j, for Greece for clarity

[96] For the 2011Q3, 2011Q4, and 2012Q1 forecasts, this only affects the forecasted disbursements of €8.7 bn in July 2011 and €5.8 bn in November 2011.

following. These two changes affect calculations for loan schedules beginning in Q3 of 2011. This amendment also revises the repayment dates for the original loans.

In the Euro Area Loan Facility Act of February 2012, the grace period was again extended to ten years. The terms were extended to fifteen years. At this point, all six loans had been disbursed, and the EFSF programme was scheduled to begin soon. Hence, we only need worry about the realized loans. As for realized loans, a detailed amended schedule is included in the Act. The margin was lowered to 150bp for all periods. These two changes affect calculations for loan schedules beginning in Q2 of 2012.

In the Euro Area Loan Facility Act of December 2012, the terms were extended to thirty years. For realized loans, a detailed amended schedule is included in the Act. The margin was lowered to 50bp for all periods. These two changes affect calculations for loan schedules beginning in Q1 of 2013. Note that this was the last agreement related to GLF funding, and so we use this forecasted repayment schedule for all future periods.

I.2 European Financial Stability Fund

The European Financial Stability Facility Act of 2010 created the EFSF, although loans were not extended to Greece until March 2012.

For forecasted disbursements, beginning with EC (2012*b*) in March 2012, forecasts include the additional funding for an overall €144.7 billion.[97] We therefore begin our EFSF series in Q1 2012 using the series from this paper as our forecast. We also use this paper for the Q2 and Q3 forecasts. However, note that there were actually more disbursements in Q1 and Q2 of 2012 then expected. I subtract the difference from the end of the forecasted time series.[98] Occasional Paper 123 (the first review) in December 2012 details all of the disbursements in 2012, and also forecasts the month of each tranche for the second disbursement in Q1 2013, as well as a quarterly forecast series (EC (2012*b*)). This quarterly series also updates the actual disbursements from 2012. We therefore use this series as the forecasted series for Q4 2012.[99,100] The forecasts for Q2 and Q3 of 2013 use the same forecast as Q1 of 2013. However, at the end of Q3 it was apparent that there would be no disbursements that quarter even though 3.4 was expected. We simply assign this 3.4 to Q4.[101] Occasional Paper 148 came out in May 2013, so we use its forecast starting in Q2 2013. Occasional Paper 159 came out in July 2013, so we use its

[97] Table 19 on Page 56.

[98] The first occasional paper forecasted 74.0/29.6 in Q1/Q2. The actual disbursements were 72.1/37.5, which is €6 billion more. For the 2012Q2 forecast, this means that the Q2, Q3, and Q4 disbursements in 2014 are reduced to zero, and the Q1 disbursement is reduced from 10.7 to 8.9. This is repeated for the 2012 Q3 forecast. Note that the 72.1 includes the €35 billion for collateral that was returned early, as explained below, and is eliminated from our forecasts completely beginning in 2012Q3.

[99] Note that there is a slight difference between this series and our series. In their series, they assign the early April tranches to Q1, and we assign them to Q2. This accounts for the difference between the 40.5/33.5 in Q1/Q2 in the Occasional Paper and the 37.1/36.7 in our series.

[100] Using the Internet Archive Wayback Machine, we can view the dates of disbursements and download the EFSF Newsletters (which seem to be quarterly). This is what we use to fill the actual disbursements in Q2 and Q3 2012. The big difference seems to be that there was a slight delay in releasing some of the funds relative to expectations, and so the actual disbursement schedule was not as frontloaded as expected. This may somewhat affect our estimates of the internal rates of return between 2012 Q1 and 2012 Q2, since we assume that the Q1 forecast uses the Occasional Paper's quarterly series, but the Q2 series uses the actual disbursements as of May 2012 (the first available date from the Wayback Machine). Recall that when using quarterly forecasts, we assume the disbursements take place at the end of the quarter.

[101] There is also an error in that the 2013 Q1 disbursements are assigned to Q4 in Occasional Paper 123. We correct this by adding the 14.8 expected in Q1 to the 4.2 forecasted in order to keep the total constant. This is somewhat corrected in Occasional Paper 148, although at this point the realized disbursements from Q1 2013 were included, so the Q1 total is only 12.0

forecast beginning in Q3 2013.[102] Occasional Paper 192 came out in April 2014, so we use its forecast beginning in Q1 2014. Occasional Paper 192 is the last official document, and other than a redelivery of bonds, there were no new disbursements from the EFSF after August 2014. However, in Q1 2014, there was a forecasted €10.2 billion still to be disbursed, so we carry this forward as before under the assumption that investors always expect the remaining money to be disbursed in the following quarter.[103] There were two €1 billion disbursements in July and August of 2014, and so we forecast €1.9 billion for each subsequent quarter until the programme was formally ended in July 2015. Hence, beginning in Q3 2015, we assume there will be no further disbursements.

There are a number of "gray areas." One gray area is how to deal with the three disbursed tranches of the private sector involvement (PSI) participation, which includes an approximately €29.7 billion sweetener, €4.8 billion of accrued interest, and in particular €35 billion of ECB collateral. This is a gray area because the tranches were disbursed in March and April while the loan modification at the end of 2012 bundles them all being into one loan. However, the EFSF website does state which tranches of each disbursement were assigned to which program, so we assign repayment to be in the same month as the disbursed tranche's month.[104,105] A second gray area for the EFSF loans is how to handle the €35 billion given to Greece as collateral in March 2012, but was subsequently returned in July 2012. We assume that for the Q1 and Q2 forecasts in 2012, this €35 billion was expected to be used and paid back accordingly. Then, beginning in Q3, we assume that the sequence of transfers includes the fact that all €35 billion was repaid early. A third gray area is how to handle to handle the €7.2 billion made available for bank recapitalization in January 2013. We do not assign this as a loan in January, as it does not appear the Greek government called upon it at that time. This contrasts with Occasional Paper 148, which lists this 7.2 billion as a realized disbursement in Table 7 and Table 9. In Occasional Paper 159, Q1 2013 disbursements are reduced down to 4.8 from 12.0, but it is still included in Table 7 as it was drawn upon in May 2013. We therefore list is as disbursed in May 2013. Another gray area concerns how to deal with "roll-over loans." For now, we assume that they are repaid instead of rolled over.[106]

For realized repayments, other than the €35 billion listed above, there has only been a €10.9 billion repayment. This repayment includes €7.2 billion from the bank recapitalization listed above as well as €3.7 billion of the loan tranche in December 2012 (€16 billion), both in February 2015.

For forecasted repayments, we follow the EFSF's repayment scheme.[107] Initially, most loans have full repayment on a single maturity date, while others have linear amortization after 10 year grace period. For forecasted loans that have not yet been disbursed, we assume that they will be repaid in lump sum 15 years following disbursement.[108] This assumption is made because the initial terms of the EFSF stipulated a minimum of a 15 year repayment scheme in July 2011. As for the month of repayment, it is unclear in most cases what the Principal Repayment Dates are. Hence, for *all* loans, we assume

[102] For Q4 2013, we use Occasional paper 159. As before, we take the difference between what is actually disbursed and what is forecasted, and assume it will be distributed the following quarter.

[103] In practice, this means that, because €6.3 billion was disbursed in April 2014, then we forecast €3.9 billion in Q3 2014.

[104] The web site lists a 10 year grace period followed by a maturity. We therefore assume a linear amortization following the grace period. This results in a 20 year amortization period for the PSI sweetener. The accrued interest is repaid in lump sum after 15 years.

[105] Note again that this only affects the 2012 forecasts, as beginning in 2013 the loans are combined into one, which we assume to be disbursed in March (see below).

[106] Rollover loans include Disbursement 3, Tranche 2. Beginning in 2017, this loan is fully amortized between 2051 and 2056.

[107] When possible, we use the repayment scheme from the EFSF websites at the time of the forecasted internal rate of return.

[108] Some loans had longer maturities. Others, such as those to be used for bank recapitalization, did not have a schedule for repayment. This is because they were funded with loans issued by the EFSF and such loans were scheduled to be rolled over. We assume 15 years for these disbursement. For the €7.2 billion disbursement in 2013, it was repaid early.

the annual amortization on the anniversary of the disbursements.[109]

Interest payments are calculated using the EFSF blended rate prevailing at that quarter.[110] We apply the average blended rate over the quarter prevailing at the time of the forecast forward until the outstanding debt balance is equal to zero. This is equivalent to assuming that all loans have the same interest rate.

There were four modifications to the original loan agreement. In December 2012, maturities were extended by 15 years. Additionally, interest payments were deferred for 10 years and rolled into a new loan. It does not look to be have been updated on the EFSF website until after January 2013. Hence, we assume that this modification affects the forecast being in Q1 2013.[111] In January 2017, two important changes were made.[112] First, there was a smoothing of the repayment profile. Maturities were extended back to 32.5 years.[113] Second, the step-up margin of 200 basis points on the €11.3 billion tranche was waived. This tranche was issued in December 2012. These two measures therefore affect forecasts beginning in Q1 of 2017.[114]

I.3 European Stability Mechanism

Greece first requested ESM support in July 2015, so we begin our series for Greek ESM assistance in 2015Q3. The total financing envelope is €86 billion. For forecasted disbursements, we begin by assuming that the total envelope will be disbursed, although eventually the ESM reports that not all funding will be needed.

The first approved tranche was for €16 billion from August 2015 through the end of 2015, so we take the actual disbursements as the forecasted disbursements for that year. Additionally, €25 billion was available for bank recapitalization, however only €5.4 billion was ever drawn upon.[115] This is consistent with the first tranche proposal of August 2015, although they only give a maximum date for which disbursements must be made by. There is little information about forecasted disbursements following this date. We therefore make assumptions on forecasted disbursements. First, of the €86 bn envelope, in 2015 €26 bn was expected to be disbursed, as explained above. This leaves approximately €60 bn to be disbursed in the years following. For the 2015Q3 forecast, we assume that all €25 bn of the bank recapitalization will be disbursed eventually. We assume that the €60 bn will be disbursed evenly through 2018. This means that €5 bn is forecasted to be disbursed each quarter for the 2015Q3 forecast. We do not assume that the €25 bn for bank recapiltalization will be

[109] An exception occurs if the date given for the final maturity is different than the disbursement. In all of these cases, we use the listed date of the final maturity.

[110] This data is available from Corsetti, Erce and Uy (2017), who graciously made their data available.

[111] The following changes are made: i. the PSI and Accrued Interest are combined and amortized over 20 years through 2042. The combined amount listed on the website is 34.6, which is a slight overestimate of the 34.5 that was actually disbursed. We use the actual disbursement to calculate repayment so as not to overestimate repayment. (Note that this only affects the accrued interest, and also results in the March/April tranches being combined into one. We follow this by having all be due in March of each year beginning in 2023.); ii. The €5.9 billion changed to 2047 from 2032; iii. The €3.3 billion changed to 2041 from 2027; iv. The amortization period of the €25 billion for bank recapitalization changed from 2023-2032 to 2034-2039 and 2043-2046; v. The €4.2 billion changed to 2042 from 2027; vi. The €1 billion changed to 2040 from 2027.

[112] We do not consider the reduction of interest rate risk to be as important. While this certainly would constitute a transfer to Greece, it is not obvious how to model it.

[113] Almost all maturities were affected. The new maturities are the current ones listed on the EFSF website.

[114] The modifications were discussed as early as Q4 2016. Because the maturity extension mostly affects the long horizon, the Q1 2017 number would be a close approximation to the Q4 2016 number.

[115] Note that of the €10 billion for bank recapitalization, only €5.4 billion was drawn upon in December. We assume that the full €10 billion was forecasted to be drawn upon in December for the 2015Q3 forecast, but beginning in 2015Q4 we assume that none of this amount, nor the remaining €15 billion will be drawn. This is because, beginning in the first compliance report, there is no forecasted series for the disbursement of the remaining bank recapitalization funds as they are expected to be unused.

disbursed for the 2015Q4 and 2016Q1 forecasts.Instead, these forecasts will only have €66.4 bn.[116] We then take the €45 bn (86 - 19.6) remaining for the 2015Q4 and 2016Q1 forecasts and assume that it will be fully disbursed by the end of 2018. Therefore, €3.75 bn for the 2015Q4 and 2016Q1 forecasts.[117] We do so by assuming a constant disbursement amount for each quarter, which seems to match the long-term forecasts of the ESM in the later compliance reports.

The first compliance report was completed in June 2016, and we use this as the basis for our 2016Q2 forecast (EC (2016*b*)). Although Greece was originally forecasted to receive a second tranche of €11.2 billion between December 2015 and June 2016, there were no disbursements until June 2016 due to "[t]he long delay in completing the first review."[118] From the first compliance report in June 2016, we see that this tranche was reduced from €11.2 billion to €10.3 billion. For the forecast, we assume that the tranches will be distributed in Q2 and Q3 of 2016 as listed in the Compliance Report.[119] We then use the compliance report to build the forecast forward through 2018. Note that now, the ESM assumes that €19.6 bn of the original €86 bn will be unused, so we continue to not include this amount in our forecasts. We also use the forecast from the first compliance report as our assumed forecast for 2016Q3, 2016Q4, and 2017Q1 by applying forward the undisbursed forecasts to the following quarter.

The second compliance report was completed in June 2017, and we use this as the basis for our 2017Q2 forecast (EC (2017*b*)).[120] In this report, the ESM now assumes that €27.4 bn of the original €86 bn financing envelope will go unused, which gives a total forecasted disbursed amount of €58.6 bn. We also use this forecast as our assumed forecast for 2017Q3 and 2017Q4 by applying forward the undisbursed forecasts to the following quarter.

The third compliance report was completed in March 2018, and we use this as our 2018Q1 forecast (EC (2018*b*)). In this report, the ESM again assumes that €27.4 bn of the original €86 bn financing envelope will go unused, which gives a total forecasted disbursed amount of €58.6 bn. The ESM assumes that the remaining €11.7 bn of this amount will be disbursed in July 2018, so we include that forecast.[121]

The fourth compliance report was first issued in June 2018 and updated in July 2018. We use this as our 2018Q2 forecast (EC (2018*a*)). At this point, €46.9 bn had been disbursed. Here, the ESM anticipates lending slightly more for the final disbursement in August 2018 of €15 bn, which brings the total back up to around €61.9 bn. Note that this forecast is for a disbursement of July. For the 2018Q2 forecast, we therefore assume a date of July.[122] For the 2018Q3 forecast, we assume the final disbursement of €15 bn will be given in August 2018, which is the end of the programme.

Repayment of disbursed amounts is given on the ESM website, and we assume that Greece will repay all debts where listed. For undisbursed amounts, we assume that they carry 15 year maturities with no amortization, which is around 5 years less than what the disbursed amounts have, and around half of what the maximum average maturity is allowed to be in the Financial Assistance Facility Agreement. There was an early repayment of €2 Billion in February 2017 coming from the sale of assets.[123] Using the wayback machine, these repayments were applied to the final tranches in 2058 and 2059 of each disbursed loan, which we use as well.

According to the ESM website, the blended interest rate has been rising steadily over the lifetime of the programme. For this reason, interest payments are again calculated using the ESM blended rate prevailing at that quarter. We apply the

[116]Recall that €5.4 bn was disbursed, so we subtract the remainder, €19.6 bn, from the envelope

[117]Note that for the 2016Q1 forecast, we add the forecasted amount that wasn't disbursed in 2016Q1 to 2016Q2, assuming that the ESM wants to disburse the loans as soon as possible.

[118]First Compliance Report, Page 16.

[119]First Compliance Report, Table 5.

[120]Table 5 of the report displays the forecast.

[121]This number comes from the fact that the ESM writes that the cash buffer for Greece is expected to be insufficient.

[122]There is some debate as to whether the forecast should be July or August, as the Eurogroup statement on June 22, 2018 forecasts August as well. We choose July to be consistent with the methodology throughout this exercise.

[123]The National Bank of Greece had to sell a subsidiary, Finansbank, as part of the conditions for receiving bank recapitalization loans.

average blended rate over the quarter prevailing at the time of the forecast forward until the outstanding debt balance is equal to zero. This is equivalent to assuming that all loans have the same interest rate. Note that the Corsetti, Erce and Uy (2017) data on blended rates only goes forward to August 2015, the date of the first ESM disbursement. Therefore, we use the ESM website to approximate the increase of interest rates through the current 1.62%.

Other than the short-term financial assistance in January 2017, there do not seem to be any substantial revisions to the ESM's loan agreements. This short-term agreement mainly focused on EFSF loans, described above, but for the ESM they included modifications to the interest rate scheme that should reduce forecasted ESM payments. Specifically, back-to-back loans held by Greek banks were exchanged for long-term fixed notes and cash; swap agreements by the ESM to stabilize the cost of funding charged to Greece, and matched funding for future disbursements. As it is not immediately clear how to factor these modifications into our calculations, we ignore them. Additionally, the ESM exchanged floating rate notes for cash, which affected the repayment profile. We implement this change beginning in 2018Q1 using the forecasted repayment scheme from the ESM website available June 25, 2018. This does not affect the total amount of disbursements, only the repayment profile by reducing interest rate risk. The forecasted repayments were not available on the ESM website immediately, and we use the available data from June 2018.

JUNE 2018: This is because modifications to these loans would involve negotiations with the private sector. Second, for the ESM programme, the step-up margin related to the debt buy-back tranche was eliminated. This step-up margin had been temporarily waived, but now was abolished. The third major change, which is not included in our calculations, is the transfer of approximately €2 billion in profits from the ESM segregated account to Greece.

I.4 International Monetary Fund

Greece first requested IMF support in the form of a Stand-By Agreement (SBA), and was approved on May 9, 2010, so we begin our series in 2010Q2. Beginning in March 2012, Greece moved from an SBA to an Extended Fund Facility (EFF). The key difference between the two is that the EFF features a longer duration of support and longer maturities for the loans than the SBA, but the spreads over the 3-month SDR rate are identical. We end our forecast series in 2016Q1, when the EFF was cancelled.[124]

For forecasted disbursements, we mostly rely on IMF publications. For forecasts in 2010Q2, we use the forecasted request for funding.[125] For forecasts in 2010Q3, we use Occasional Paper 68 in August 2010 (EC (2010)). For forecasts in 2010Q4, we use Occasional Paper 72 (EC (2010*c*)). For forecasts in 2011Q1 and 2011Q2, we use Occasional Paper 77, For forecasts in 2011Q3, we use Occasional Paper 81 (EC (2011*b*)).[126] For forecasts in 2011Q4, we use Occasional Paper 87 (EC (2011*a*)).[127] However, this paper was published during the transition from Programme 1 and the GLF to Programme 2, which involved the EFSF.

This was also the time when the IMF switched from using the SBA to the EFF. At this point, with Programme 2 in full effect, the IMF was projected to make €28 bn in equally phased disbursements over four years. As with the SBA, EFF disbursements would not be made without a round of reviews. The first/second reviews were published in December 2012. For the first three quarters, we use the proposed disbursement schedule from the March 2012 statement, which

[124] In July 2017, Greece requested SBA funding. We do not include this in our forecasts.

[125] Table 7 of the Staff Report on Request for Stand-By Arrangement (IMF (2010*a*)).

[126] For this forecast, Occasional Paper 81 was written in July 2011 and there was also a forecasted disbursement in that same month. The Occasional Paper was not worried about this disbursement, and it was actually disbursed in July. However, there is also a forecasted disbursement in September, which did not actually occur. For this reason, this forecast is not as of the end of the quarter, like the others, but more as of the middle.

[127] Like the forecast before, this will take place in the middle of the quarter as there is a forecasted disbursement in November which doesn't actually occur until December.

forecasts €1.6 bn each quarter through 2016Q1. We also use this forecast for 2012Q2 and 2012Q3. However, after the €1.6 bn in March was disbursed, there was not another disbursement until December 2012. As there do not appear to be any other IMF communications during this time period, we therefore "roll forward" each €1.6 bn until December under the assumption that investors think this will be disbursed as soon as possible. For 2012Q4 we use Occasional Paper 123 to make our forecast.[128] For the 2013Q1 forecast, we use the IMF's first/second review of the EFF, published in December 2012, to make the forecast. There was a disbursement in January 2013 following completion of these reviews, and we assume that this was forecasted in December for the 2012Q4 forecast. There is also a forecasted disbursement in February 2013. We leave this one in, but note that it was never actually made. For the 2013Q2 forecast, we use the EFF Third Review in June 2013. The forecasts did not change, but there was a disbursement of €1.8 bn For the 2013Q3 forecast, we use the EFF Fourth Review in July 2013. Note that this is only one month later, but it resulted in the release of the next disbursement in July. The next actual disbursement was not until June 2013, so for the 2013Q4 and 2014Q1 forecasts, we roll forward the forecasted amounts to match this realization. For the 2014Q2 forecast, we use the EFF Fifth Review in June 2014. This June 2013 would be the final IMF disbursement, but the EFF program was not cancelled until January 2016. As such, we maintain the forecasts until 2016Q1 by rolling forward the anticipated amounts. The 2016Q1 forecast is the final forecast.

For actual repayments, we use the data available from the IMF website. Because there have been no modifications to the disbursements, these are accurate at the time of disbursement. To calculate projected repayments of a series not yet disbursed, we use the fact that, up until March 2012, the IMF was using the SBA. This means that the loans had a three year grace period before maturity repayment, and following this point they were then repaid over a two year span. Taken together, the SBA loans were expected to be fully repaid in exactly 5 years. We take this same approach for forecasted SBA loans, and assume that they will be repaid, after a three year grace period, over a two year period, quarterly, with a constant amortization. As for EFF loans, which began to be used as of the 2012Q1 forecast, these has much longer maturities and so had a four year grace period. They are then repaid at a semi-annual rate and are forecasted to be fully repaid over the next 6 years. Taken together, the EFF loans were expected to be fully repaid in exactly 10 years. We take thsi approach for forecasted EFF loans, and assume they will be repaid, after a four year grace period, over a six year period, semi-annually, with a constant amortization. Principal repayments for both SBA loan and EFF loans are assumed to be in the three/six month intervals beginning after the disbursement date.

For interest rates, the IMF lends at the market-related interest rate, which is the basic rate of charge. This interest rate is calculated by taking the market-determined Special Drawing Rights (SDR) interest rate and adding a margin of 100bp. Added to this charge is a 200bp surcharge for all amounts above 187.5% of quota, which after three years rises to 300bp. For all disbursed loans, the IMF gives a projected interest payment schedule, and we use this whenever possible. Otherwise, we use Greece's quota to calculate the interest rate (on all outstanding debt), (SDR1.1 bn). We use the rate of charge prevailing in the last day of the sample as our estimate of future interest rates. This is almost certainly a lower bound (see Figure 19), so in practice our estimate of the internal rate of return is also a lower bound.

In practice, only two events move the internal rate of return substantially. First, the shift from using the SBA to the EFF and the introduction of Programme 2 affected both the amount of disbursements and the expected interest payments. Second, the IMF programme was officially cancelled in January 2016, eliminating all future disbursements and with them repayments and interest.

[128] It looks like the EFSF assumed that the first and second reviews would be disbursed on schedule (although they were not) in Q4. Then, they assumed €1.8 bn going forward, which is what is in the first/second review. This is a result forecasting fewer reviews, since the November 2012 review waas skipped.

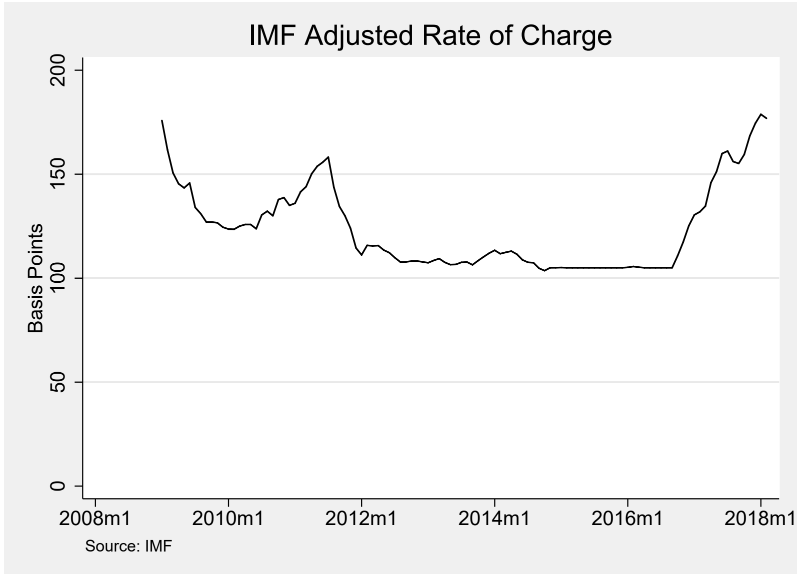
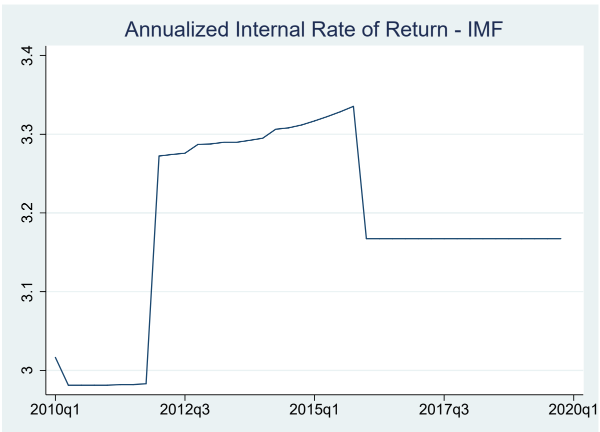


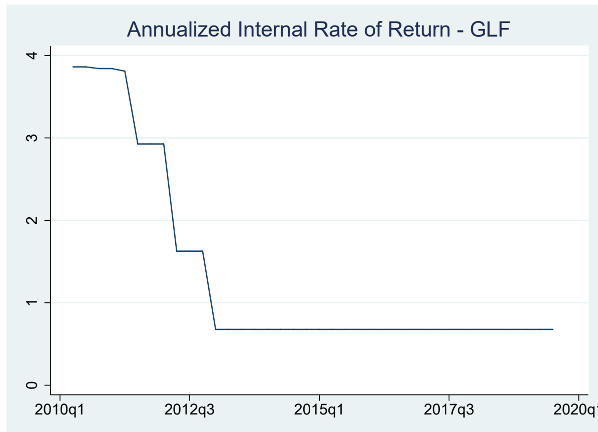
Figure 19: Basic Rate of Charge

I.5 Time-Varying NPV and IRR by Entity

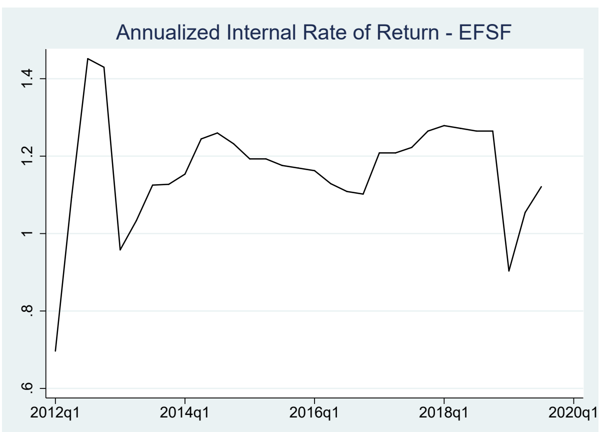
Using 1, we can calculate the size of the transfer to Greece by each entity. We first calculate net transfers for each discounting each series of net transfers, using equation H.2. We then discount this series at the IMF internal rate of return. Figure 20 shows the evolution of the internal rates of return while Figure 21 shows the size of the transfer.



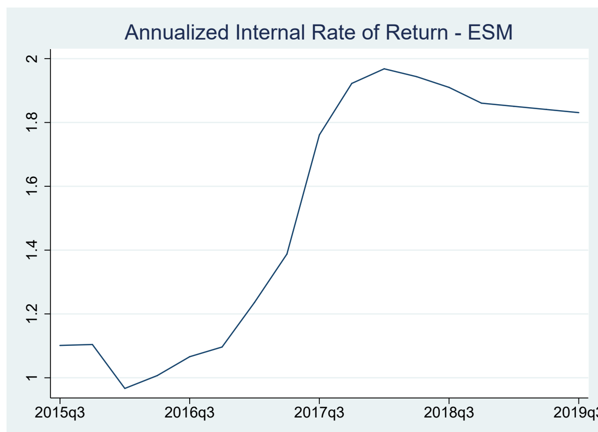
(a) IMF



(b) GLF

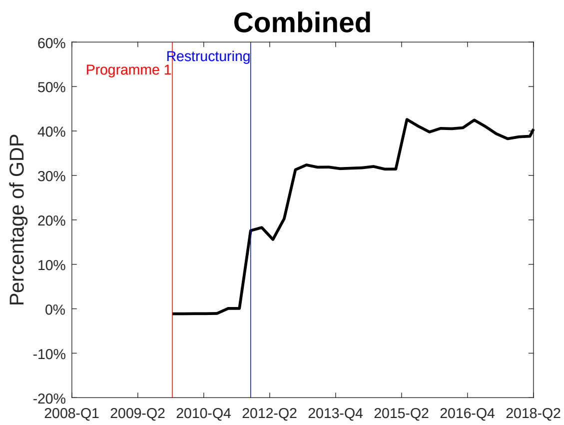


(c) EFSF

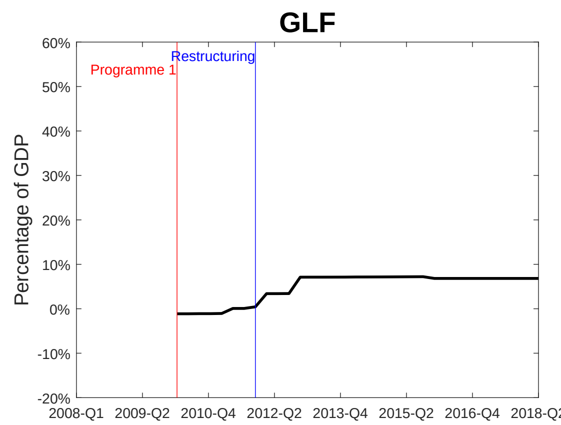


(d) ESM

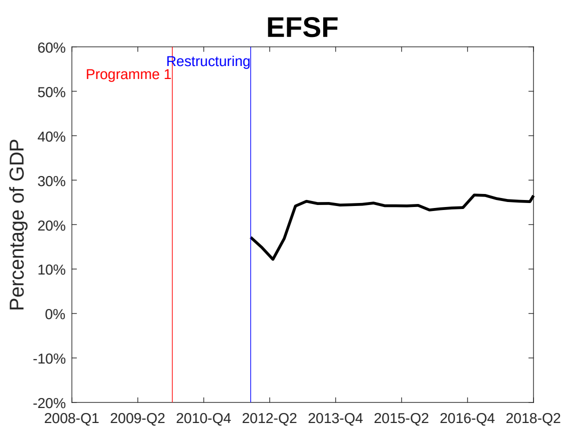
Figure 20: IRR's by Lender



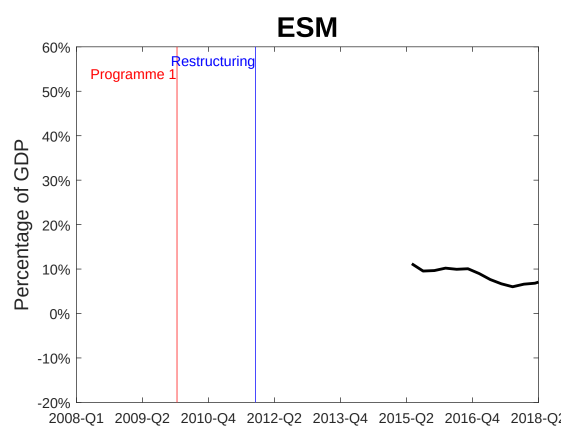
(a) NT Combined



(b) NT GLF



(c) NT EFSF



(d) NT ESM

Figure 21: Net Transfers by Lender

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