The optimal size of the European Stability Mechanism: A cost-benefit analysis
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Abstract

This study presents a core-periphery model to determine the optimal size of the European Stability Mechanism (ESM), building on Jeanne and Ranciere (2011). While the periphery is subject to a probability of losing access to external credit, the core’s incentive for setting up an ESM stems exclusively from the spillover effects present in the case of periphery default.

The model develops regional best response functions, determining a set of feasible ranges for the total ESM size, given optimal regional contributions. The model is then calibrated to the European Economic and Monetary Union.

If costs from default are reasonably high, the probability of the periphery not having access to external credit is sufficiently large, and spillover effects to the core are present, both the core and the periphery have an interest in contributing to the ESM. Calibration and sensitivity analysis suggest that the optimal ESM size is between the current and twice the size of the agreed-upon ESM.

JEL classification: G01, G17, G22, G32, C15.

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1 Introduction

The recent financial crisis has exposed major weaknesses in the design of the existing economic governance framework the Euro Area. As a response, a package including the establishment of a permanent crisis management mechanism as a safeguard against imbalances in individual countries has been adopted by the European Council of 24-25 March 2011 (ECB (2011)).

The need for existence of the European Stability Mechanism (ESM) stems from the circumstance that the European Economic and Monetary Union (EMU) is a monetary union without a full political union. This implies that national governments are responsible for the sustainability of their own public finances, the stability of their financial systems, and the competitiveness of their economies. As stated in ECB (2011), a failure to meet these conditions reduces the net benefits attained through the creation of the Euro and poses the risk of negative spillovers between EMU countries.

Since the fiscal rules agreed upon in the Stability and Growth Pact have been washed out and national debt levels have been rising over time, market confidence in some euro area countries has been diminished, and some countries have been facing unsustainably high refinancing costs. Due to the close financial and economic integration, negative spillover effects towards other EMU countries could occur.

The ESM succeeds a set of temporary solutions such as the Greek loan facility, the European Financial Stabilisation Mechanism (EFSM) and the European Financial Stability Facility (EFSF).

The mechanism is supposed to serve as a liquidity bridge until countries regain market access. This is notably desirable for the countries in financing need, but also for all other EMU countries, as spillover effects between EMU countries in the case of default of a single country are likely to be present.

In order to avoid Moral Hazard, ESM payments are subject to conditionality. Its main decision-making bodies are the Eurogroup/ESM Board of Governors and the ESM Board of Directors. To limit the liability of debtor EMU countries towards creditor countries through the ESM, total consolidated ESM lending may currently not exceed EUR 500 billion. In order to keep track of the reform progress, IMF participation is desirable.

\footnote{For details about the differences between the ESM and its predecessors, see ECB (2011).}

\footnote{Conditionality laid out in the treaty follows a long strain of economic literature, showing that conditionality limits moral hazard. The conditions under which moral hazard can...}
The primary motive for the existence of the ESM and its predecessors is to possess a liquidity bridge if access to external credit is not available, until market access can be regained. This is identical to the precautionary motive for holding foreign exchange reserves in emerging countries, facing the possibility of loss of access to external credit, known as a “Sudden Stop”. To limit the danger of Sudden Stops countries have been accumulating international exchange reserves. The basic motive, self-insurance against sudden stops, is now being addressed by the EMU countries through the ESM.

A literature has since developed to quantify costs and benefits, as well as the optimal level, thereof. As the ESM’s total subscribed capital consists partly of paid-in capital, which is stored in ECB accounts and earns interest below the costs of raising this capital, the possibility of a cost-benefit analysis arises, implying that an optimal size of the ESM does exist.

A long line of literature on reserves adequacy exists, dating back to the early 1960s and 1970s. A tractable model of precautionary reserves is presented by Carroll and Jeanne (2009), while a contracting game between international lenders and a country is brought forward by Corneli and Tarantino (2011). Maximizing the welfare criterion of a representative agent, Jeanne and Ranciere (2011) develop a closed form solution for the optimal level of international reserves.

As opposed to the auto-insurance of accumulating international reserves, the insurance mechanism in the EMU depends on contributions from countries most likely not being subject to the risk which the ESM insures against. The so called ”core” countries’ main interest in the ESM is to diminish the impact from ”periphery” countries’ financial turmoil, a feature the model presented here tries to capture.

The optimal level of precautionary reserves has also been examined by Durdu et al. (2009), Alfaro and Kanczuk (2009), and Bora Durdu et al. (2009), while the concept of insurance as laid out in Jeanne and Ranciere (2011) is comparable to that of Caballero and Panageas (2007).

For a more complete overview of the literature, see Jeanne and Ranciere (2011).

The concept of international risk sharing might also be desirable for emerging countries as suggested by Caballero (2003), who argues that more effective sudden stop insurance could be achieved by hedging risk at an international level. Studies like Caballero (2003), Cordella and Yeyati (2005a) and Cordella and Yeyati (2005b) have equally proposed...
The model draws from the framework laid out in Jeanne and Ranciere (2011). It features a core-periphery set-up with two representative consumer economies, where the periphery may lose access to external credit and consequently experiences output losses. The periphery consumer can smooth domestic consumption in the case of loss of external credit by entering an insurance contract with the ESM, financed with contingent debt. The core is willing to contribute to the ESM, even though it does not face the danger of diminished access to external financing itself, since it faces spillover costs in the case of the periphery defaulting on its debt.

The model yields an optimal size of the ESM for an interval of cooperative equilibria and suggests feasible ranges of ESM size, where core and periphery set their contributions to the ESM subject to the contribution of the other party. The desirability and optimal size of the resulting ESM depend on the probability of a sudden stop towards the periphery, the opportunity costs of the paid-in capital, the spillover effects from the periphery towards the core, and the consumer’s risk aversion.

The calibration exercise suggests that if opportunity costs of the paid-in capital in the ESM are high and output losses from default to the periphery are sufficiently low, setting up an ESM is not desirable. If output costs from defaulting are high or the periphery is not able to roll over a sufficiently large share of its short-term debt or the probability of not having access to external credit is large, the periphery has an interest in an insurance scheme. If spillover effects to the core are sizeable, both the core and the periphery have an interest in setting up an ESM. The benchmark calibration adopted yields an optimal size of the ESM of EUR 680 billion, which is substantially larger than the current ESM size. Since the core is considerably larger than the periphery, it is willing to cover a greater share of the costs of the ESM, while an auto-insurance of the periphery without core’s contribution would lead to an ESM of EUR 610 billion.

The structure of this paper is as follows: The model is introduced in the next section. Since the size of the ESM depends on each regions’ optimal payment towards the ESM, given the other region’s contribution, cooperative solutions exist. Optimal response functions are developed, allowing inference of the optimal size of the ESM given the insurers’ participation constraint. Section 3 presents calibration results and section 4 concludes.
2 A Core-Periphery Model

In the following, the assumptions of the basic model will be laid out. This part is analogous to Jeanne and Ranciere (2011). The subsequent subsections will then describe the behavior of the periphery, the core, and the insurance.

2.1 Assumptions

Both the periphery and the core are considered to be a small open economies in discrete infinite time \( t = 0, 1, 2, \ldots \). A single good exists, which is consumed domestically and abroad. Both economies follow a deterministic growth path. The periphery’s growth path may be disturbed through a loss in access to international capital markets, which in turn leads to negative spillover effects towards the core.

Both regions are assumed to have identical preferences. Each region \( i \) consists of a private sector and a government, while the private sector is composed of a continuum of atomistic and identical infinitely lived consumers with an intertemporal utility given by:

\[
U_{i,t} = E_{i,t} \left[ \sum_{j=0}^{\infty} (1 + r)^{-j} u(C_{i,t+j}) \right]
\]

where the flow of utility is characterized by a constant relative risk aversion \( \sigma \geq 0 \),

\[
u_i(C) = \frac{C_i^{1-\sigma} \sigma}{1-\sigma}, \sigma \neq 1,
\]

and \( u_i(C_i) = \log(C_i) \) for \( \sigma = 1 \). Consumers in both regions maximize welfare subject to their budget constraints

\[
C_{i,t} = Y_{i,t} + L_{i,t} - (1 + r)L_{i,t-1} + Z_{i,t},
\]

where \( Y_{i,t} \) represents regional domestic output, \( L_{i,t} \) is regional external debt and \( Z_{i,t} \) is a transfer from the respective government, while \( r \) represents the risk free interest rate, which is constant, and the representative consumer does not default on her external debt.
As common in the literature, a maximum amount of pledgable output of the domestic private sectors to foreign creditors exists. The debt is thus only fully repaid in period \( t + 1 \) if

\[
(1 + r)L_{i,t} \leq \alpha_t Y_{i,t+1}^n, \tag{4}
\]

with \( Y_{i,t+1}^n \) being trend output for region \( i \) in period \( t + 1 \) and \( \alpha_t \) being a time-varying parameter as used e.g. in Ranciere et al. (2008), implying the pledgeability of domestic output to foreign creditors. I follow the original model assuming that \( \alpha_t \), as well as \( Y_{i,t+1}^n \) are known in period \( t \), which implies that debt issued in period \( t \) is default-free if condition (4) is satisfied. The private sectors’ external borrowing constraint can change over time, which in turn introduces the possibility for sudden stops\(^6\). In this model, \( \alpha \) is supposed to be exogenous.

In the subsequent calculations, the subscript \( p \) indicates the peripheral region, while the subscript \( c \) indicates the core region.

### 2.2 The Periphery

The periphery behaves identical to the emerging market country in Jeanne and Ranciere (2011), and can be in two states: the normal state, denoted by the superscript \( n \), or in a crisis state, where access to external credit is not available, denoted by the superscript \( s \). During normal times, output grows at a constant rate \( g \) and the private sector pledges a constant fraction of output\(^7\), implying that

\[
Y_{p,t}^n = (1 + g)^t Y_{p,0}, \tag{5}
\]

and

\[
\alpha_{p,t}^n = \alpha. \tag{6}
\]

In the case of non-access to international capital markets, the periphery’s output falls by a fraction \( \gamma \) below its trend and pledgable output falls to zero:

\(^6\)See Jeanne and Ranciere (2011) for motivations of a time varying \( \alpha_t \).

\(^7\)The deterministic growth rate is assumed to be identical across regions.
\[ Y_{p,t}^s = (1 - \gamma) Y_{p,t}^n, \quad (7) \]

and

\[ \alpha_{p,t}^s = 0. \quad (8) \]

External debt which is successfully rolled over does not increase the probability of a financing stop in this model. In order to insure that the consumer does not default on her debt during a sudden stop, the model assumes that \( \alpha + \gamma < 1 \). To keep the consumer’s intertemporal income finite, it is assumed that \( r > g \).

Since capital can take multiple periods to flow back, the economy is set up to take a number of periods \( \theta \) to return to its trend path. After a sudden stop at time \( t \), the economy returns to state \( n \) at time \( t + \theta + 1 \). The interval \([t, t + \theta]\) is thus defined as the crisis interval. In any given period \( t \), the periphery can be in one of the \( \theta + 2 \) states.

Output and external credit dynamics during a crisis episode starting at time \( t \) for the peripheral region are thus given by

\[ Y_{p,t+\tau}^s = (1 - \gamma(\tau)) Y_{p,t}^n, \quad (9) \]

and

\[ \alpha_{p,t+\tau}^s = \alpha(\tau), \quad (10) \]

with \( \gamma(.) \) and \( \alpha(.) \) being exogenous functions of \( \tau = 0, 1, ..., \theta \). Using (7) and (8), it follows that \( \gamma(0) = \gamma \) and \( \alpha(0) = 0 \). In line with the original set-up, it is further assumed that the economy returns to its trend path in a monotonic manner, with \( \gamma(\tau) \) and \( \alpha(\tau) \) being non-negative, and decreasing and increasing in \( \tau \), respectively. In addition, at the end of the crisis period the representative consumer has reached the same level of access to external credit as in the pre-crisis state\(^8\), \( \alpha(\theta) = \alpha \).

\(^8\)As shown in Jeanne and Rancière (2011), the periphery’s consumption falls sharply during a sudden stop under the combined impact of capital outflows and the fall in output, and then recovers as capital flows back into the region.
2.3 The Core

For the sake of simplicity, the core’s output grows at the rate $g$ in the normal state and the private sector pledges a constant fraction of output\n
\[ Y_{ct}^n=(1+g)^tY_{c,0}, \tag{11} \]

with\n
\[ \alpha_{ct}^n=\alpha. \tag{12} \]

As opposed to the periphery, the core does not face a risk of being excluded from external credit supply, reflecting that investors have different perceptions of credibility for the core and the periphery. In line with previous assumptions, $\alpha + \gamma < 1$ and $r > g$.

If the periphery experiences a crisis, the output loss of the core is proportional to the periphery’s consumption loss until the periphery has recovered and reached its trend output. In this case\n
\[ Y_{ct}^s=(1-\xi)Y_{ct}^n, \tag{13} \]

with\n
\[ \xi=\varphi(C_{p,t}^n-C_{p,t}^s), \tag{14} \]

and $\varphi$ being a constant, exogenous parameter $0 < \varphi < 1$, representing spillover effects from the periphery towards the core.

Since after a sudden stop at time $t$, the periphery’s economy returns to state $n$ only at time $t + \theta + 1$, the core experiences output losses over the same interval $[t, t + \theta]$.

The core’s output dynamics during the periphery’s crisis episode starting at time $t$ are consequently given by\n
\[ Y_{ct+\tau}^s=(1-\xi(\tau))Y_{ct}^n, \tag{15} \]

with $\xi(\cdot)$ being a function of $\gamma(\cdot)$, where both parameters are exogenous functions of $\tau = 0, 1, \ldots, \theta$. As for the periphery, the core’s economy returns
to its trend path in a monotonic manner, with $\xi(\tau)$ being non-negative, and decreasing in $\tau$.

As described above, the core’s output falls during the time of the periphery’s crisis, however to a lesser extent since there is no capital outflow and $\varphi(.)$ is constrained over the interval $[0, 1]$. This assumption is relaxed in the appendix, where it is assumed that the spillover effect is increasing in the periphery’s crisis severity.

The only uncertainty in the model is the risk of the periphery entering a sudden stop period. In the following, $\pi$ denotes the probability that a sudden stop occurs in the next period. Both, periphery and core go back to state $n$ at the end of the sudden stop with certainty.

### 2.4 The Insurance

The insurance is set up in order to insure the periphery’s private sector against the impact of a sudden stop, which will automatically diminish consumption losses of the core’s private sector. It is assumed that the governments insure the periphery’s private sector through entering an insurance contract with perfectly competitive foreign insurers. At time 0, all parties enter a contract, which determines the payment of a premium $X_t$ for the periphery and a premium $U_t$ for the core until the periphery is hit by a sudden stop. If a sudden stop occurs at time $t$, the insurance pays out a payment $B_t$ to the periphery. The occurrence of a sudden stop ends the insurance contract and all parties can enter a new contract at the end of the crisis period. As the probability but not the timing of a crisis is known, any insurance contract signed at $t = 0$ specifies an infinite sequence of conditional payments $(X_t, U_t, B_t)_{t=1,\ldots,\infty}$.

The periphery’s representative consumer receives a cash payment from the insurance, implying that

$$Z^n_{p,t} = -X_t ,$$

as long as the periphery is in state $n$, and

$$Z^s_{p,t} = B_t - X_t ,$$

when the crisis occurs.
The core’s representative consumer on the other hand does not receive a cash payment from the insurance, but benefits from the fact that the periphery’s consumption losses are diminished, which in turn reduces costs to the core, implying that:

\[ Z_{c,t}^n = Z_{c,t}^s = -U_t. \] (18)

It is assumed that both regions pay their premia \( X_t \) and \( U_t \) for the last time in the period of the sudden stop, implying that the net transfer from the insurance is the difference \( B_t - X_t - U_t \).

As with ”reserves insurance contracts” for emerging markets, this set-up is supposed to evaluate the costs and benefits of a permanent amount of capital laid aside during normal times in order to smooth the impact of a potential crisis. Both, the core and the periphery must sacrifice resources during normal times in order to set up the insurance before the crisis occurs.

Following Jeanne and Ranciere (2011), \( \mu_t \) denotes the pricing kernel for the insurers at time \( t \). The pricing kernel is assumed to be higher if the periphery is not able to access international capital markets, thus under tight global liquidity conditions, implying that

\[ \mu_t^s \geq \mu_t^n. \]

The costs of insurance for both economies are determined by the difference between \( \mu_t^s \) and \( \mu_t^n \), and \( p \) denotes the price of a non-crisis Euro in terms of a crisis Euro, meaning that

\[ p = \frac{\mu_t^n}{\mu_t^s} \leq 1. \]

Foreign insurers are ready to provide any insurance contract \( (X_t, U_t, B_t)_{t=1,...,\infty} \), given that the present discounted value is non-negative, implying that

\[ \sum_{t=1}^{\infty} \beta^t (1-\pi)^{t-1} \left[(1-\pi)(X_t + U_t)\mu_t^n - \pi(B_t - X_t - U_t)\mu_t^s \right] \geq 0. \] (19)

In order to determine the optimal size of the insurance in an equilibrium, it is assumed that the borrowing constraint (4) is always binding.\(^9\)

\(^9\)As for the one-country case and as shown in Jeanne and Ranciere (2011), a closed form solution cannot be obtained if the borrowing constraint is not binding.
Under the ESM, the insurance is effectively carried out by governments, who in turn have to borrow from financial markets in order to provide the insurance. Insurance costs are determined by the opportunity costs of the capital bound in the ESM.

2.5 The optimal size of the insurance

The periphery maximizes domestic welfare (1) subject to the budget constraints (3), (16), (17), the binding credit constraint (4), and the insurers’ participation constraint (19), while the core maximizes domestic welfare (1) subject to the budget constraints (3), (18), the binding credit constraint (4), and the insurers’ participation constraint (19).

If (4) is binding, both regions keep a constant ratio of short-term debt to GDP, which reads:

$$\lambda_i = \frac{L^n_i}{Y^n_i} = \frac{1 + g}{1 + r} \alpha_i . \tag{20}$$

The Lagrangians are given by

$$\mathcal{L}^i = \sum_{t=1}^{\infty} \beta^t (1 - \pi)^t \left[ (1 - \pi) u(C^n_{i,t}) + \pi u(C^s_{i,t}) \right] + \sum_{t=1}^{\infty} \beta^t (1 - \pi)^t u_i[(1 - \pi)(X_t + U_t)\mu^n_i - \pi(B_t - X_t - U_t)\mu^s_i] \tag{21}$$

with $u$ indicating the shadow costs of the insurance participation constraint.

State-dependent consumption levels for the periphery can be written as:

$$C^n_{p,t} = Y^n_{p,t} + \frac{\alpha}{1 + r} Y^n_{p,t+1} - \alpha Y^n_{p,t} - X_t \tag{22}$$

and

$$C^s_{p,t} = Y^s_{p,t} - \alpha Y^n_{p,t} + B_t - X_t \tag{23}$$
The first order condition for the periphery implies that

\[ u'(C_{p,t}^n) = p u'(C_{p,t}^s), \tag{24} \]

meaning that global investors and domestic consumers in the periphery can substitute consumption between the two states at the same rate.

The state-dependent consumption levels for the core read:

\[
C_{c,t}^n = Y_{c,t}^n + \frac{\alpha}{1+r} Y_{c,t+1}^n - \alpha Y_{c,t}^n - U_t
\]

\[ = Y_{c,t}^n (1 - \frac{r-g}{1+g} \lambda_c) - U_t \tag{25} \]

and

\[
C_{c,t}^s = Y_{c,t}^s + \frac{\alpha}{1+r} Y_{c,t+1}^n - \alpha Y_{c,t}^n - U_t
\]

\[ = Y_{c,t}^n (1 - \xi + (1 - \frac{r-g}{1+g}) \lambda_c) - U_t, \tag{26} \]

with

\[ \xi = \phi(C_{p,t}^n - C_{p,t}^s), \tag{27} \]

which can be written as

\[ \xi = \phi((\gamma + \lambda_p) Y_{p,t}^n - B_t), \tag{28} \]

and yields a state dependent consumption level of

\[
C_{c,t}^s = Y_{c,t}^s + \frac{\alpha}{1+r} Y_{c,t+1}^n - \alpha Y_{c,t}^n - U_t
\]

\[ = Y_{c,t}^n [1 - \{ \phi((\gamma + \lambda_p) Y_{p,t}^n - B_t) \} + (1 - \frac{r-g}{1+g}) \lambda_c] - U_t. \tag{29} \]

The first order condition for the core\textsuperscript{10} is given by

\[ u'(C_{p,t}^n) = p \varphi u'(C_{p,t}^s). \tag{30} \]

\textsuperscript{10}The spillover effect is normalized by \( Y_{c,t}^n \).
The core can thus only substitute consumption between the two states at the same rate as global investors if the negative spillover effects from the periphery are non-existent.

The best response functions for both regions $X_t(U_t)$ and $U_t(X_t)$ can be derived from equations (24) and (30), the state dependent consumptions levels (22), (23), (28), (29), and the binding participation constraint of the foreign insurers:

$$B_t = \frac{((1-\pi)p+\pi)}{\pi} X_t + \frac{((1-\pi)p+\pi)}{\pi} U_t.$$  

(31)

After some manipulation, the periphery’s best response function $X_t(U_t)$ can be written as:

$$X_t(U_t) = \frac{(1+g)pU_t - \pi((1+g)((1-p)(1+g)\lambda_p)Y^n_{p,1} - \pi p^{1/q}(1+g(1+\lambda_p) - r\lambda_p))Y^n_{p,1}}{(1+g)((-1+p)\pi - \pi p^{1/q})},$$

(32)

while the core’s best response function $U_t(X_t)$ is slightly more complicated and is equal to:

$$U_t(X_t) =$$

$$= \frac{Y^n_{c,1}\left\{ (1+g)\varphi p X_t + \pi \left\{ 1+g(1+\lambda_c) - \lambda_c r - (\varphi p)^{1/q}(1+g(1+\lambda_c) - \lambda_c r) \right\} \right\}}{1+Y^n_{c,1}\varphi(1+p) - (\varphi p)^{1/q}} + \frac{Y^n_{c,1}\pi \left\{ \varphi(X_t(1+g-p(1+g)) - \gamma p Y^n_{p,1}(1-g) - \lambda_p Y^n_{p,1}(1-g)) \right\}}{(1+g)(-1+p)\pi - \pi p^{1/q}.$$

(33)

The best response functions $X_t(U_t)$ and $U_t(X_t)$ specify the regions’ optimal contributions to the insurance for each fixed contribution of their opponents. Both regions’ contributions to the insurance are decreasing in the other region’s payment.

Using the insurers’ participation constraint and regional payments, the final size of the insurance fund can be derived. The range of contributions and implications for the optimal size of the insurance will be discussed in the next section.
3 Calibration

In what follows, a benchmark calibration and some sensitivity analysis are presented.

3.1 Benchmark calibration

The size of the insurance fund \( B_t \) is determined by eight parameters: The probability of a sudden stop occurring in the periphery \( \pi \), the output loss in the case of a default towards the periphery \( \gamma \), the ratios of short-term debt to GDP of both periphery and core, \( \lambda_p \) and \( \lambda_c \) respectively, the risk free market interest rate \( r \), the risk premium \( \delta \), the risk aversion parameter \( \sigma \), and the spillover effects from the periphery to the core \( \phi \).

The data used for the benchmark calibration stems from the ECB data warehouse, where short-term debt is defined by initial maturity, and is calculated as the sum out of "Currency and Deposits", "Short term securities other than shares, excluding financial derivatives", and "Short term loans", and renders a short-term debt to GDP ratio of 12.8% for 2011 across the EMU.

The peripheral region includes Portugal, Ireland, Greece, Italy, and Spain, while the core region consists out of all remaining EMU countries. For the benchmark calibration, \( \lambda_p \) is set at 13.1% and \( \lambda_c \) at 7.8%, which are the regional arithmetic means from all included nations’ 2011 short-term debt to GDP ratios\(^{11}\).

In order to estimate the probability of a sudden stop \( \pi \), occurring in a given period, two possibilities exist. In the debt crises literature, a sudden stop is often defined following Guidotti et al. (2004), who identify a sudden stop if in a given year \( t \) the ratio of capital inflows to GDP falls by more than 5% relative to the previous year. An equally often applied methodology was developed by Calvo (1998a) and Calvo et al. (2004), who identify a sudden stop if monthly year-on-year capital inflows are sufficiently far below a moving threshold. Another possibility would be to define sudden stop episodes through interest rate spreads on government bonds.

In the peripheral area of the EMU sudden stop episodes are relatively difficult to observe compared to sudden stop episodes in emerging countries. Spreads

\(^{11}\)It is not clear at the time of writing whether in the future ESM loans might be extended to cover private banks. In this case, \( \gamma \) and therefore the optimal ESM size would be underestimated in the current setting.
on government bonds have declined during the first years of EMU and remained very low until the breakout of the recent global financial crisis. Since then, spreads have moved abruptly in line with political events and decision taking rather than with a change in economic fundamentals. In addition, due to public capital flows, spreads do not allow for identification of periods of large private capital outflows or decreases in inflows. This is the case since if large private capital outflows occur, which are not met by private capital inflows, the European monetary system permits a substitution of these flows through public capital in the course of the TARGET2 (Trans-European Automated Real-time Gross settlement Express transfer) system and flows from disbursements under IMF/EU programs, as illustrated extensively in Merler and Pisani-Ferry (2012).

Following Merler and Pisani-Ferry (2012), who identify sudden stop periods in the eurozone, a sudden stop episode is classified as a sufficiently large decrease in private capital inflows. Merler and Pisani-Ferry (2012) define sudden stops according to the methodology developed in Calvo et al. (2004). As in the absence of TARGET2 and IMF/EU programs, a serious threat of incurring high rollover costs during these episodes would have existed, their identification strategy is followed. Monthly data is taken from the ECB data warehouse, and private capital flows are calculated as the financial account, as reported in the balance of payments and international investment position, net of changes in TARGET2 balances and inflows associated to disbursements under IMF/EU programs.

The result is shown graphically in Figure 1, presenting the number of EMU countries in a sudden stop episode from the year 2000 onwards. Several sudden stop periods can be observed. The first sudden stop episode occurred in Spain during the burst of the internet bubble in 2001, while three large sudden stop episodes can be observed during the onset of the financial crisis in 2008, during which Ireland and Portugal entered into financial turmoil, in 2009/10, and during the period of highly volatile refinancing costs for

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12 A sudden stop is an episode with at least one month where capital flows fall two standard deviations below the sample mean, where the start of the episode coincides with the first months in which y.o.y. changes in capital flows drop one standard deviation below the mean, and the end of a sudden stop period is the first month of capital inflows on a y.o.y. basis reverting to or above the mean, defined as at least the average minus one standard deviation.

13 Classified as Balance of Payment items: Financial account, Other investment, Liabilities, Monetary authorities, and Liabilities, General government, respectively. Following Merler and Pisani-Ferry (2012), averages and standard deviations are computed in each month over an expanding window with fixed starting date and a minimum width of 24 month, considering data up to $t - 1$. 

15
Portugal, Italy, Greece, and Spain in late 2011.

The unconditional probability\(^{14}\) for the periphery to be in a period of sudden stop is 7.2%, which is rounded to \(\pi = 7\%\) for the baseline calibration\(^{15}\) and is allowed to vary over the interval (0.02-0.1).

Due to substitution of private capital outflows through public capital inflows and the global financial crisis of 2008, output costs related to sudden stop periods are not directly observable in periphery countries. Output cost estimates are thus taken from the sudden stop literature and allowed to vary over a relatively large interval. Estimated output costs vary from 6.5% in

\(^{14}\)It is possible that the probability of financial crises, \(\pi\), is endogenous and conditional on the ESM size.

\(^{15}\)The unconditional probability is calculated as the number of months a peripheral country is in a sudden stop period divided by the total number of months for which observations are available. Ireland has thus been in a state of sudden stop for a total of 21 months, Spain for 15 months, Greece and Portugal for 9 months, and Italy for 3 months. In order to diminish the influence of volatile monthly capital flows, a sudden stop episode is registered as such if a sudden stop lasts at least 3 months. The probability might be under/overestimated in the case of private capital flows being correlated with EU/IMF program participation. The sign and size of this potential bias are ambiguous.
Jeanne and Ranciere (2011), who measure the fall in economic growth in the year following a sudden stop, to around 10% of GDP over periods of about 6 years in Caballero and Panageas (2007). Even though most empirical studies find output losses between 6% and 14% of GDP, some estimate costs to be higher. Hutchinson and Noy (2006) find costs of 13-15% of GDP over three year periods, while Becker and Mauro (2006) arrive at 16.5% of GDP. The output losses incurred by the periphery are calibrated across a large interval of 5% to 15%, with the baseline being the middle-ground of 10% of GDP.

One channel through which sudden stops and refinancing turmoil in the periphery can affect core output is through financial contagion. Kodres and Pritsker (2002) develop a multiple asset rational expectations model of asset prices in order to explain financial market contagion, focusing on contagion through cross-market rebalancing, while Polson and Scott (2011) find significant contagion effects during the major EU crisis periods of May 2011 and August 2011.

Constancio (2012) considers several contagion channels, concluding that significant sovereign-sovereign contagion did exist in late 2011. Additionally, sovereign-bank contagion has been found in some studies, resulting in decreased funding availability and increased funding costs for a number of banks exposed to the sovereign debt of peripheral countries. Eichengreen et al. (1996) show that not only the incidence of speculative attacks is temporally correlated, but also that contagion appears to spread more easily to countries which are closely tied through international trade linkages. Berkmen et al. (2009) find that for a broader set of developing countries the trade channel mattered more for transition of negative spillover effects than the financial contagion channel during the recent financial crisis. In addition, they conclude that nominal exchange-rate flexibility, absent in the EMU, clearly helped in buffering the impact of the shock.

The results of the above mentioned studies suggest that negative spillover effects in the case of default do exist and due to close trade and financial interlinkages might be larger between EMU countries than within other regions in which individual economies have experienced sudden stops. The partial elasticity of the core's output loss towards the periphery’s loss, as measured by \( \varphi \) is set at 0.6 for the baseline calibration and allowed to vary over an interval from 0.1 to 1 in the sensitivity analysis.

\[16\] The existence of this effect is however disputed by De Haan and Mink (2012). Asgharian and Nossman (2011) reason that the regional market contributions to stock market volatility within the EU are more important than contributions from non-EU countries.
Jeanne and Ranciere (2011) show how the insurance model can be interpreted in terms of opportunity costs, conditional on assumptions about the set of available assets and liabilities. The insurance is interpreted as a liability whose payoff is contingent on a sudden stop. The unitary price of the perpetuity is the expected payoff discounted using the pricing kernel of foreign investors.

Jeanne and Ranciere (2011) derive an expression for the unitary price $q$ of the perpetuity, which is equal to

$$q = \frac{1}{r + \pi + \delta},$$

with

$$\delta = \frac{1-p}{p/(\pi+1)/(1-\pi)},$$

which the country can replicate by financing a buffer stock of capital with a perpetuity that defaults contingent on a sudden stop. The pure risk premium on this perpetuity, $\delta$, is equal to the opportunity costs associated with the financing of the buffer stock of capital. The opportunity costs of financing the ESM is the pure risk in the perpetuity issued\textsuperscript{17}. The opportunity costs of maintaining an insurance is often measured as the spread between the interest rate on a country’s long-term external debt and the return on the paid-in capital held in the insurance fund (foreign exchange reserves, or in this case a stock of paid-in capital). Jeanne and Ranciere (2011) argue that the opportunity costs should thus be measured by the pure risk premium $\delta$, rather than by the full spread $\pi + \delta$.

The opportunity costs for the EMU in year $t$ of the paid-in capital to the ESM are given by

$$\delta_t = r_{EMU,t} - r_{ECB,t},$$

where $r_{EMU,t}^d$ is the interest rate EMU countries pay on long-term debt during normal times and $r_{ECB,t}^s$ is the interest earned on the paid-in capital to the ESM.

The paid-in capital to the ESM currently amounts to EUR 80 billion, while the callable capital (including the IMF contribution) is set to be EUR 620

\textsuperscript{17}See Jeanne and Ranciere (2011) for the derivation of insurance contract costs.
billion, summing to a total subscribed capital of EUR 700 billion. Euro area countries have made a commitment to ensure a minimum ratio of 15% between paid-in capital and outstanding ESM securities issuance during the period over which capital is paid in (ECB (2011)). At the moment the ratio between paid-in capital and outstanding ESM securities is equal to 16%.

The interest rate on long-term debt is calculated on the basis of a synthetic EU17 ten year bond. The development of national ten year government bond interest rates can be seen in Figure 2.

Figure 2: 10 year government bond rates

![Figure 2: 10 year government bond rates](image)

Source: Bloomberg, DNB calculations, in percentages, monthly averages

Interest rates of EMU countries converged to a relatively stable level of around 5% after the creation of the euro and have been only marginally different during the period 2000-2009. They started diverging rather abruptly with the onset of the European debt crisis from the end of 2009 onwards. Depending on the time window chosen, the synthetic ten year EU17 bond yields an interest rate of 5.02% to 5.36%. For the benchmark calibration, the synthetic EU17 ten year bond rate is set at 5.3%. Since the paid-in capital is most likely going to be stored in ECB accounts, implying a fixed rate of return of 50 basis points, the opportunity costs of the paid-in capital are around 4.8%. As stated above, the ratio between paid-in capital and outstanding ESM securities is equal to 16%, leaving total opportunity costs $\delta$ during normal times at 0.77% as a benchmark value, which is allowed to vary over a relatively wide interval from 0.25% to 4% in the sensitivity analysis. The benchmark value for $\delta$ implies a $p$ of
\[ p = 1 - \frac{\delta}{(1-\pi)(\pi+\delta)} = 0.89. \]

The risk-free short-term interest rate \( r \) is set at 3%, and the growth rate \( g \) is set at 2.5%, which is the average EMU area GDP growth rate over the period 1996-2007.

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<th>Parameter</th>
<th>Baseline</th>
<th>Range of Variation</th>
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<tr>
<td>Probability of SS for Periphery</td>
<td>( \pi )</td>
<td>7% [2%- 10%]</td>
</tr>
<tr>
<td>Spillover Periphery-Core</td>
<td>( \varphi )</td>
<td>0.6 [0.1 - 1]</td>
</tr>
<tr>
<td>Output loss Periphery</td>
<td>( \gamma )</td>
<td>10% [5%- 15%]</td>
</tr>
<tr>
<td>Short term debt to GDP Periphery</td>
<td>( \lambda_p )</td>
<td>7.8%</td>
</tr>
<tr>
<td>Short term debt to GDP Core</td>
<td>( \lambda_c )</td>
<td>13%</td>
</tr>
<tr>
<td>Potential Output Growth</td>
<td>( g )</td>
<td>2.5%</td>
</tr>
<tr>
<td>Term Premium</td>
<td>( \delta )</td>
<td>0.77% [0.25% - 4%]</td>
</tr>
<tr>
<td>Risk-free interest rate</td>
<td>( r )</td>
<td>3%</td>
</tr>
<tr>
<td>Risk aversion</td>
<td>( \sigma )</td>
<td>4 [1 - 10]</td>
</tr>
</tbody>
</table>

*Author’s calculations*

The best response functions for both regions, calibrated to the baseline parameters, are shown in Figure 3.

**Figure 3: Best response functions baseline**
As expected, both regions’ optimal contributions are decreasing in the other region’s payment towards the insurance. Both regions have an interest in the existence of the ESM, even in the absence of payments from the other party. Since the best response functions’ slopes are only marginally different, a wide range for cooperative solutions exists.

The benchmark calibration adopted yields an optimal size of the ESM of EUR 680 billion, which is EUR 180 billion larger than the current size of the ESM, and about the same size of the ESM plus the IMF contribution. Due to its larger size, the core is willing to cover a larger share of the insurance payments. In a non-cooperative game where the contribution scheme could be chosen by both players, it would always be optimal for the periphery to not contribute to the insurance at all, knowing that the core would cover all expenses, even in the absence of periphery’s payments. If the core would not contribute to the insurance, the periphery’s self-insurance fund would be considerably smaller, leading to a total ESM size of EUR 610 billion, which would still be EUR 110 billion larger than the currently agreed-upon ESM.

Given that a contribution from one region can be fixed beforehand and the other region decides on its contribution afterwards, two possible fund sizes, EUR 680 billion and EUR 610 billion, exist. If the core’s contribution is decided on first and is below EUR 610 billion, the periphery will decide on a payment in order to make the insurance equal to EUR 610 billion. If on the other hand, the periphery’s installment is fixed first, the core will always top-up the insurance to be equal to EUR 680 billion.

In practice, the contribution key agreed upon in the treaty establishing the European Stability Mechanism is fixed, with the periphery countries financing 33.9% of the paid-in capital. The periphery’s share of total payments in the cooperative space, however, varies from zero to 90%, leaving large space for adjustments in the capital contribution key.

### 3.2 Sensitivity analysis

Based on the best response functions and the insurers’ participation constraint presented above, feasible ranges of payments over parameter intervals are presented.

The optimal size of the ESM increases up to EUR 1.12 trillion if the probability of a sudden stop is increased to 10%.

The model is less sensitive to variations in the degree of output losses the
periphery experiences in the case of a sudden stop, where the periphery, as expected, adjusts its optimal contribution to varying output costs faster than the core, as shown in Figure 5. This is due to the fact that the periphery experiences the direct effect from output losses, while the spillover effect depends on periphery’s consumption losses, which are a weighted function from the stop in capital flows and the severity of the crisis itself. For output losses of 15% of GDP, a possible scenario given the current economic situation in some peripheral countries, the optimal fund size increases to above EUR 850 billion.

Figure 4: Regional contributions over $\pi$

Figure 5: Regional contributions over $\gamma$

The dynamics shown in Figure 7, with regional contributions over a range of $p$, which is decreasing in the term premium $\delta$, are more complex to analyze. While total insurance size is increasing in $p$, the core’s contributions are
not. The core takes into account that spillover costs from the periphery are decreasing in $p$ since the periphery auto-insures itself to a larger extent. In addition, the insurers’ participation constraint shows that as $p$ increases, less of the regional payments are lost for the purpose of insuring and the total size of the insurance increases for a decreasing term premium. Even though total fund size increases if the term premium decreases, the periphery still has an interest to contribute more if the price of the insurance decreases. It does so in a non-linear fashion, with the elasticity of $X(U)$ being decreasing in an increasing $p$.

While the periphery’s payments are largely increasing in rising levels of $\sigma$, the core’s contributions are less sensitive.

Figure 6: Regional contributions over $\sigma$

![Figure 6](image1.png)

Figure 7: Regional contributions over $p$

![Figure 7](image2.png)

$p$ is decreasing in the term premium $\delta$ and presented over the interval $[0.25\% - 4\%]$.

As can be seen in Figure 8, the core’s payments towards the fund, depending on the size of the spillover effect, are increasing sharply at low levels of the
spillover effect where the marginal increase tapers off afterwards. It would be reasonable to assume that the size of the spillover effect is larger if the periphery has reached some threshold of crisis severity. The possibility of loss-dependent spillover costs are therefore explored in Appendix A.1.

Figure 8: Core’s contribution over $\varphi$

The calibration exercise has shown that both regions have an interest in the existence of the ESM and that for baseline parameters, the core is willing to contribute more to the fund than the periphery. While the total size of the fund varies, it is, for reasonable parameter values, between the current and twice the size of the agree-upon ESM.

4 Conclusion

This study has introduced a core-periphery model to determine the optimal size of the European Stability mechanism (ESM), drawing from Jeanne and Ranciere (2011). The model has developed regional best response functions, determined a set of feasible ranges for the total ESM size, given optimal regional contributions, and been calibrated to the European Monetary Union.

It has been shown that the ESM can be purposeful for core countries as spillover effects between EMU countries in the case of default are likely to be present, and that the benefits might outweigh the costs associated with an ESM.

The desirability and optimal size of the resulting ESM depend on the probability of a sudden stop towards the periphery, the output loss incurred in the case of default, the opportunity costs of the paid-in capital, the spillover effects from the periphery towards the core, and the consumer’s risk aversion.
The benchmark calibration yielded an optimal size of the ESM of EUR 680 billion. Two possible optimal fund sizes exist, where in absence of fixed contribution schemes, the periphery’s dominant strategy is to let the core insure the region. Sensitivity analysis suggested that the optimal ESM size is, depending on the contribution scheme and choice of parameters, between the current and more than twice the size of the agreed-upon ESM.

A possible direction for future research could be to estimate the conditions for existence and the optimal size of the ESM through a two-period OLG model or in the game theoretical set-up of a multiple agent decision tree. In the same line, a multi-country imperfect information model could be developed in order to evaluate the question at hand.

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Appendix A  Extensions

Appendix A.1  Loss-dependent spillover costs

In April 2012, the IMF World Economic Outlook discussed the possibility of a break-up of the EMU, stating that “The potential consequences of a disorderly default and exit by a euro area member are unpredictable. If such an event occurs, it is possible that other euro area economies perceived to have similar risk characteristics would come under severe pressure as well, with full-blown panic in financial markets and depositor flight from several banking systems. Under these circumstances a break-up of the euro area could not be ruled out”, implying non-linear and increasing spillover costs in the size of a peripheral crisis.

In addition, one key feature of the sudden stop literature is the existence of multiple equilibria as modeled e.g. in Calvo (1998b), Calvo (2005), and Obstfeld (1996). Calvo (2008) states that under equilibrium multiplicity, government policy can help coordinate between equilibria. An insurance, such as the ESM or international reserves could play a key role in this coordination game since they could help to cushion destructive financial spillovers of sudden stops, but also implies that costs to other regions are more than proportionally increasing in the size of a potential sudden stop.

It is thus assumed that spillover costs to the core are increasing in the size of the periphery’s loss. In order to capture this condition, I assume that the core’s state dependent consumption level is given by

\[ C_{c,t}^s = Y_{c,t}^n + \alpha Y_{c,t+1}^n - \alpha Y_{c,t}^n - U_t \]

with

\[ \xi = \varphi \left( C_{p,t}^n - C_{p,t-1}^n \right)^\kappa, \]

with \( \kappa > 1 \), where the previous case corresponded to the special case of \( \kappa = 1 \). The spillover costs can be written as

\[ \xi = \varphi \left( (\gamma + \lambda_p) Y_{s,t}^n - B_t \right)^\kappa, \]

which yields a state dependent consumption level of
\[ C_{t}^{\text{core,s}} = Y_{c,t}^{s} + \frac{\alpha}{1+r} Y_{c,t+1}^{n} - \alpha Y_{c,t}^{n} - U_{t} \]

\[ = Y_{c,t}^{n} [1 - \{ \varphi((\gamma + \lambda_{p})Y_{s,t}^{n} - B_{t})^{\kappa} \} + (1 - \frac{\gamma + \lambda}{\gamma + g})\lambda_{c}] - U_{t}. \]

The first order condition\(^{18}\) for the core now implies that

\[ u'(C_{p,t}) = p\varphi^{\kappa} u'(C_{p,t}^{s}). \]

The core’s new best response function \( U_{t}(X_{t}) \) can be derived from this equation, the state dependent consumptions levels, and the binding participation constraint of the foreign insurers. The function is non-linear and can only be solved for specific values of \( \kappa \). The periphery’s best response function remains unchanged. As before, the optimal size of the insurance \( B_{t} \) can be derived using both regions’ reaction functions and the insurers’ binding participation constraint.

\(^{18}\text{After normalization.}\)
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