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Research Article

The existential trilemma of EMU in a model of fiscal target zone

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Abstract

Objectives: Is the Economic and Monetary Union (EMU) truly 'irreversible' as stated in the treaties? (i) From the sovereign debt crises of the 2010s, and the outbreak of the COVID-19 pandemic, we draw the lesson that when exposed to large, systemic shocks the EMU faces a trilemma among preserving its irreversibility, monetary orthodoxy and fiscal orthodoxy: irreversibility can only be saved by relaxing one of the twin orthodoxies or both. (ii) We show how central monetary/fiscal backstops to irreversibility can be designed in a consistent manner that minimises their amplitude and mitigates the moral hazard concerns. **Methods:** We present a novel fiscal target zone model of the EMU, where public debt is hit by stochastic shocks and member governments under monetary and fiscal orthodoxy are willing to abide by their commitment to debt stability only up to an upper bound of their feasible fiscal effort. Shocks large enough push the stabilisation fiscal effort beyond the feasibility constraint, in which case a government would opt for default on debt service and breakup of EMU membership—similarly to the abandonment of an exchange-rate agreement. **Results:** For the EMU to be truly irreversible, ramparts for extraordinary times are necessary beside regulations for ordinary times. The alternative to these devices is reformulating the treaties with explicit and regulated exit procedures.

Keywords: self-fulfilling speculative attacks, sovereign debt crises, fiscal target zone, EMU trilemma, EMU governance

INTRODUCTION

The conversion rate between the euro and the national currency of a country accessing the European Economic and Monetary Union (EMU) is said to be 'irrevocably fixed'. More generally, EMU membership has been conceived and is regarded *de facto*, as irreversible. ['Unlike the conditions for accession to the EU, which are addressed, even if not exhaustively, in Article 49 TEU11, neither the founding treaties (...) nor the successive amending treaties made until the ratification of the Lisbon Treaty, made any provision for a Member State's withdrawal (negotiated or unilateral) from the EU or EMU' (Athanassiou, 2009).]

And yet, is it truly so?

As a general principle, institutions should pass the test of cost–benefit analysis by members. The institutions of European integration make no exception. [See, e.g. Cohen (2000), Alesina et al. (1995, 2005), Spolaore (2013) and Andreozzi & Tamborini (2019). The cost–benefit approach to monetary unions has been playing a central role ever since the theory of optimum currency areas (Kenen, 1995). Ultimately, 'member states have to be better off inside than they would be outside' (Draghi, 2014). As Bilbie et al. (2021) put it bluntly, 'we do not think that in the long-run a eurozone can be based on anything other than self-interest' (p. 79).] After remarkably prolonged honeymoon, doubts about irreversibility have gained strength over the past decade. Three are the catalytic episodes. For the European Union (EU) as a whole, one is obviously 'Brexit', the UK's leave. The second, for the EMU in particular, is the sequence of sovereign debt crises after 2010, when movements of 'exiters' gained voice and political momentum across the EMU. The third is the outbreak of the COVID-19 pandemic, which, through the early months of 2020, triggered powerful dis-integration forces across member states.

There is now broad agreement among scholars and institutional bodies that the EMU was built 'incomplete', and it has remained incomplete despite the frantic corrections put together during the crises of the 2010s. [At the level of EU institutional bodies, one may recall the 'Five Presidents Report' (Juncker, 2015), the 'White Paper about the future of the EU' (European Commission, 2017a), the 'Reflection Paper on the Deepening of the Economic and Monetary Union' (European Commission, 2017b) and the subsequent 'Roadmap for Deepening the Economic and Monetary Union' (European Commission, 2017c).] Here, we focus on a critical dimension of incompleteness, namely that the irreversibility of EMU membership, and thus the integrity of the EMU, if it is not to remain a wishful claim in the founding treaties, needs carefully designed ramparts for extraordinary times alongside regulations for ordinary times (see

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also e.g. Brunnermeier et al., 2016, Corsetti et al., 2020, Orphanides, 2020, Lane, 2021).

To begin with, the lesson we draw from the aforementioned episodes and present in Section "The EMU trilemma" is that when exposed to large, systemic shocks the EMU faces a trilemma among its vocational *irreversibility*, the *monetary* and the *fiscal* 'twin orthodoxies' on which the EMU has been erected and rests. Monetary orthodoxy is epitomised by the single mandate to price stability and no monetization of public debts, fiscal orthodoxy by rules of budgetary discipline, no transfers across member states and the no bail-out clause. The trilemma arises as irreversibility can only be preserved by relaxing either monetary orthodoxy, or fiscal orthodoxy, or both. As a matter of fact, the crisis of the 2010s was painfully overcome only after some (much disputed) relaxation of monetary orthodoxy *vis-à-vis* tightening of fiscal orthodoxy. By contrast, it is widely agreed that, after some initial hesitation, the reaction to the pandemic shock has been stronger, faster and, most importantly, on both the monetary and fiscal side, where the 'unorthodox' innovations contained in the Next Generation EU (NGEU) programme figure prominently. It is however unclear whether this newly created backstop to EMU integrity will be institutionalised or remain a once-and-for-all expedient.

Against this background, in Section "The model", we elaborate on the EMU trilemma by means of a fiscal target zone (TZ) model with two aims: understanding its causes and consequences, as well as designing appropriate mechanisms able to shield EMU irreversibility against disruptive events.

The model grafts the sovereign choice between debt repayment and default onto the TZ modelling technique originally developed in the field of exchange-rate theory, in particular at the time of the European Monetary System (EMS). [Key references are Krugman (1991), Krugman & Rotemberg (1990, 1992), Bertola & Caballero (1992). The application of exchange-rate TZ models to the case of speculative attacks on public debt in the EMU has been proposed for the first time by Della Posta (2018, 2019).] In our model, public debt can be hit by random shocks, and EMU member governments are willing to abide by the commitment to debt stability under the twin orthodoxies only up to an upper bound of their feasible fiscal effort (measured by the ratio of the primary surplus to GDP), beyond which the costs of compliance are deemed larger than those of noncompliance. Large enough shocks push the stabilisation fiscal effort beyond the feasibility constraint, in which case a government would opt for default on debt service, that we treat as breakup of EMU membership—similarly to the abandonment of an exchange-rate agreement. Anticipation with nonzero probability of this event triggers a self-fulfilling run on debt that precipitates the breakup event—a result known in the TZ literature as 'divorce'. By contrast, anticipation that at the upper bound of the TZ there will be a stabilisation, no-breakup intervention prevents runs on debt and allows the system to absorb larger shocks—the so-called 'honeymoon' effect.

Subsequently, in Section "Relaxing the twin orthodoxies", we show how monetary as well as fiscal no-breakup interventions can be designed in a consistent manner that minimises their amplitude and mitigates the moral hazard concerns. In this perspective, our fiscal TZ approach presents some specific advantages that arise from integrating, in a single rigorous framework: (i) explicit recognition of limits to fiscal sustainability and the breakup option [for instance, in the literature about monetary vs. fiscal dominance governments are simply assumed to have a welfare function conflicting with that of the central bank (Beetsma and Giuliodori, 2010). Moral hazard issues are usually raised only in consideration of fiscal misbehaviour, not unsustainable shocks (Gros, 2014; CEPR, 2018). 'Escape clauses' from the Excessive Deficit Procedure are defined in terms of GDP not of debt sustainability.]; (ii) well-defined trade-off between hedging against moral hazard and hedging against EMU breakup (the original design of the EMU does not consider any downside of hedging against moral hazard: Brunnermeier et al., 2016); (iii) explicit solution for the no-breakup mechanisms, and how they relate to moral hazard issues, which improves over pleas to reconcile risk-sharing and risk-reduction (CEPR, 2018). We also argue that the alternative to the introduction in the EMU governance of no-breakup mechanisms is reformulating the treaties with explicit and regulated exit procedures. The final section summarises and concludes.

THE EMU TRILEMMA

The rationale for the creation of the euro was popularised by the celebrated metaphor of the 'inconsistent quartet' coined by Padoa-Schioppa (1982). As the process of European economic integration was gaining momentum, he warned that the four cardinal points of free trade, free mobility of capital, a system of fixed exchange rates and autonomous national monetary policies were incompatible. 'The circle cannot be squared: one element has to be surrendered in order to avoid any inconsistency' (p. 7). The inconsistency became blatant with the collapse of the EMS in September 1992. Somewhat paradoxically, that event accelerated the process towards the single currency, vindicating Padoa-Schioppa's (1987) earlier claim that the EMS 'was not enough' and that a complete monetary union was needed, with monetary sovereignty being 'the element to be surrendered' in order to resolve the inconsistent quartet. The events of the 2010s witness that the EMU, as it was conceived, was not enough either. [As a matter of fact, one can find some analogies between the two crises of the EMS and of the EMU. Corsetti et al. (2020) point out four of them: costly adjustments of fundamental divergences, poor policy coordination and cooperation, exposure to self-fulfilling speculative attacks and lack of a backstop to the integrity of the system. Yet, whereas this last deficiency in the case of EMS was mitigated by the escape lane of realignments, or outright exit, in the case of EMU no easy escape lane is open, which may transform the euro in a 'trap' (Sinn, 2014). Notably, Corsetti et al. (2020) also argue that the countries involved in the EMS collapse recovered more successfully and rapidly than at the time of the EMU crisis, not only thanks to currency devaluations but also because national central banks and governments found ways to support their banking systems and sovereign debt markets that have been partially precluded in the EMU.]

COVID-19 has hit the EMU still convalescent after the crises of the 2010s, with growth remaining anaemic in 2018–19, and, what is more important, with the backlog of unresolved institutional weaknesses. Born to free the European integration process from the embarrassments of the 'inconsistent quartet', the EMU has encapsulated it into the trilemma among preserving the irreversibility of the euro on one side, and monetary orthodoxy and fiscal orthodoxy on the others (Fig. 1).

In fact, the lesson of the early phase of the EMU crisis, between 2009 and 2012, is that, in the presence of a systemic shock, with several member countries falling under severe economic or financial distress, it is not possible to preserve both the twin orthodoxies and the irreversibility of the euro. One between monetary and fiscal orthodoxy, or perhaps both to some extent, should be relaxed.

People left alone in the face of huge social and economic costs do not care much about macroeconomic orthodoxies and their very long-run virtues, while at the same time they become intolerant towards limitations to the sovereignty of their freely elected governments (O'Rourke and Taylor, 2013). [A rich empirical literature has investigated the relationship between the EMU crisis and the surge of euro-sceptic or openly anti-euro movements and parties: see, e.g. Tosun et al. (2014) and Guiso et al. (2016).] Thus, well before 'Brexit', the ghost of 'Grexit', and possibly of other countries under debt attack, materialised with the 'No' in the 2015 Greek referendum on the conditionality of debt restructuring agreed by the Tsipras government with the so-called 'Troika' formed by International Monetary Fund, European Commission and European Central Bank. Some empirical research on the determinants of sovereign spreads has found evidence of nonzero breakup probability under the form of so-called 'redenomination risk'. That is to say the risk that, as a consequence of breakup, a country would redenominate its debt in the new national currency heavily depreciated against the euro thus causing a large capital account loss for foreign debt holders (Di Cesare et al., 2012; De Santis, 2015).

The move of the ECB into the unchartered territory of 'unconventional monetary policies' since 2012 can be viewed as a relaxation of monetary orthodoxy in rescue of EMU irreversibility. This move is represented by the arrow on the left-hand side of the triangle in Fig. 1. As a matter of fact, the goal was achieved almost immediately by force of President Draghi's announcement of the new stance of the ECB in July 2012 and the subsequent launch of the Outright Monetary Transactions programme, which has never been activated. Whether, and the extent to which, monetary orthodoxy was relaxed remains highly debated. No doubt, there was large and unprecedented recourse to unconventional tools including purchases of sovereign bonds on secondary markets that, though practiced by other central banks, conflicted with well-established interpretations of the ECB's mandate (see, e.g. Siekman and Vieland, 2014; Brunnermeier et al., 2016, Part III; Schnabel, 2020a).

On the other hand, there is a wide agreement that monetary relaxation was obtained *vis-à-vis* preservation of fiscal orthodoxy by means of 'austerity'. The fiscal regulatory tightening is documented by the new dispositions known as Six Pack, Two Pack and Fiscal Compact (Brunnermeier et al., 2016, Part III). Agreement also extends to the critical assessment of the ensuing euro-area policy mix consisting of accommodative monetary stance *vis-à-vis* restrictive fiscal stance. This mix is seen responsible for both the unduly prolonged EMU stagnation and the institutional overburden on the shoulders of the sole ECB (see Orphanides, 2020, for a recent overview).

After some backward-looking hesitation, the reaction of the EMU policymakers to the COVID-19 shock in the course of 2020 marked a clear U-turn with respect to the crisis management of the 2010s. As urged by a large majority of scholars (e.g. Baldwin and Weder di Mauro, 2020), the monetary and 'aggregate fiscal' stances were swiftly aligned in complementary support to the EMU-wide economy, as indicated by the arrow also on the right-hand side of the triangle in Fig. 1.

The ECB has relaunched its quantitative easing measures with a specific Pandemic Emergency Purchases Programme largely targeted to sovereign bonds. The main novelty is that also the appropriate aggregate fiscal stance for the EMU as a whole has been pursued in three ways. First, by (temporary) lifting the fiscal constraints at the country level. Second, by enhancing access to central resources available with the European Commission, the European Stability Mechanism and the European Investment Bank. Third, by creating, for the first time, a central fiscal capacity backed by a pool of common resources, a significant part of which collected on financial markets, namely the NGEU programme. The whole fiscal package opens to a significant relaxation of fiscal orthodoxy in order to share with the ECB some of the burden of the EMU irreversibility.

Whether these will be extraordinary exceptions, or the beginning of change in the EMU architecture in order to resolve the trilemma, remains to be seen, depending on the economic and political scenarios that will materialise once the pandemic will be over.

THE MODEL

As a preliminary stylised representation of public debt evolution in the EMU, Fig. 2 reproduces the band between

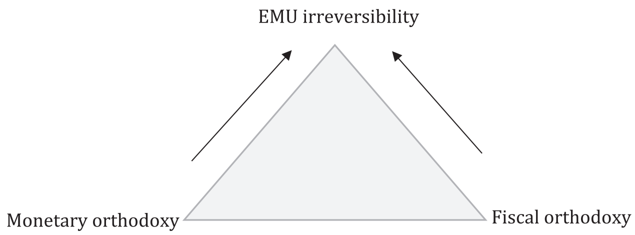


Figure 1. The EMU trilemma

the highest and the lowest level of the public debt-to-GDP ratio, centred on the ratio of the EMU as a whole, from 1999 to 2021. These data suggest that debt has gone through three phases: 1999–2008, 2009–19 and 2020–21. Each change of phase corresponds to major external shocks, the Global Financial Crisis and Great Recession in 2009, and the COVID-19 pandemic in 2020, with a 'jump' into a higher band after the shocks accompanied by a higher standard deviation (~28%, 36% and 43%, respectively). On the other hand, the (average) coefficient of variation shows only slight increase at each phase, i.e. 0.41, 0.42 and 0.43, respectively.

During each phase, however, the debt band has shown substantial stability, with the highest and lowest debt countries remaining the same, and no major changes in the standard deviation. If on the one hand high-debt countries failed to converge towards the 60% target, on the other, there was no evident upward drift, signalling some stabilisation effort by governments. This pattern is clearer if Greece is excluded as the single country that 'trespassed the band' and fell into a partial default procedure. How far can governments' stabilisation effort go, and under what conditions is this consistent with EMU irreversibility?

We model the evolution of the public debt ratio to GDP, b (henceforth public debt), as driven by a set of fundamentals and a stochastic component represented in the following continuous-time dynamic equation:

$$db_t = -\left(s_t + m_t + f_t\right) dt + \left(r_t - g_t\right) b_t dt + \sigma dz, \qquad (1)$$

where the fundamentals on right-hand side are, at any moment t, the GDP ratio of the public sector's primary balance s_t (with $s_t > 0$ denoting a surplus), the GDP ratio of the monetisation of public debt m_t (in the forms to be specified subsequently), exogenous net fiscal transfers f_t (e.g. the possibility for the government to receive fiscal support from other governments). The term $(r_t - g_t)b_t$ is the contribution to db_t resulting from the interest rate r_t, net of the rate of growth of GDP g_t, which is charged on the outstanding public debt. (For simplicity, we abstract from the inflation rate, which may be regarded as negligibly low. Hence, it is immaterial whether r and g are computed in real or nominal terms.) The term dt indicates the instantaneous time variation.

The stochastic component is given by the driftless Brownian motion process dz. [Some TZ models consider instead a Brownian motion process with drift (e.g. Krugman and Rotemberg, 1992). In this context, the drift would not add further insights, and we can therefore avoid its use here.] The parameter σ represents the instantaneous standard deviation of the Brownian motion, and the term dz is the Brownian motion variation, which is so characterised:

$$dz = \chi\sqrt{dt}, \qquad (2)$$

where χ is a random variable that is independently, identically and normally distributed, with 0 mean and variance equal to 1.

Fiscal and monetary orthodoxy

We identify EMU 'fiscal orthodoxy' as member governments' commitment to stabilising public debt (as a ratio to GDP unless otherwise stated) by their own means (i.e. to the exclusion of fiscal transfers, debt sharing or bailout, by any other member government, $f_t = 0$). Moreover, government should also aim at the Maastricht official target of 60%. For this reason, and others that will be introduced below, it is thus convenient to think of b_t as the excess of the debt level over the official debt target at any moment t.

Equation (1) also displays two important interaction channels with monetary policy represented by the monetisation rate of public debt m_t, and the interest rate r_t on public debt. Monetisation can take various forms, some of which will be treated subsequently for the time being, by this term, we mean any intervention of the central bank implying money creation that supports the debt stabilisation effort of the government. We identify EMU monetary orthodoxy by the prohibition of monetisation in any form, $m_t = 0$. The fiscal effort, s_t, then, is what remains to affect the dynamics of the public debt

As to the interest rate, it may be thought of as being composed by a riskless reference interest rate i_t, which is the policy instrument in the hands of the central bank, and by a country-specific risk premium, RP_t. We shall consider the policy rate i_t as an exogenous variable amenable to spot changes by the central bank (hence the time index will be dropped). The specification of the risk premium will be introduced below.

Consequently, the commitment to the stability of public debt, in compliance with the fiscal and monetary orthodoxies, requires that $E(db/dt) = 0$ at any point in time. [For precision, according to the Fiscal Compact undersigned in 2012, as outstanding debt rises above 60% ($b_t > 0$), the government would be required to reduce debt by 1/20th of the excess per year. Technically, this requirement would introduce a correction mechanism in the debt process, which would complexify the model with the only tangible implication of a target primary surplus greater than in (3). In order to keep the model manageable, we disregard this requirement. We may add that, as a matter of fact, it has never been enforced, and it will probably not be enforced in the near future. See also previous comments on Fig. 2.] According to (1) and (2),

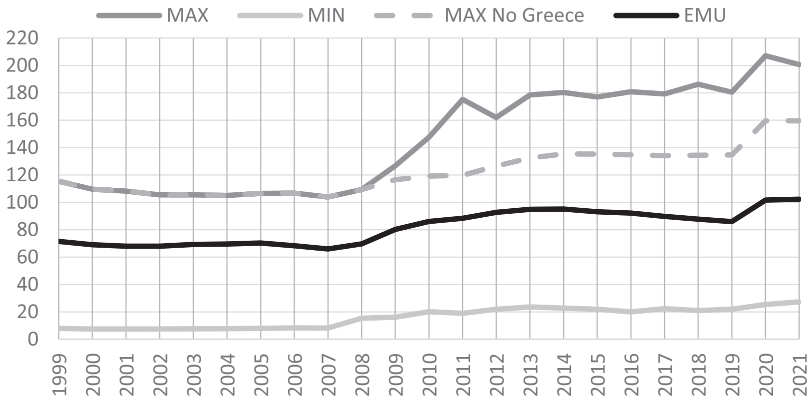


Figure 2. Band of the highest and lowest debt/GDP ratios in the EMU 1999–2021 (variable composition). *Source*: Elaborations on Eurostat database AMECO

governments should aim at the primary balance given by

$$\tilde{s}_t^* = (\bar{\imath}_t + RP_t - g_t)\, b_t \tag{3}$$

so that subsequently public debt may only be moved away by the stochastic amount:

$$db_t = \sigma dz. \tag{4}$$

Equation (3) shows that the 'fiscal effort' $\tilde{s}_t^* \geq (\bar{\imath}_t + RP_t - g_t)b_t$ is necessary to achieve debt stabilisation (Bohn, 1995).

The fiscal TZ

Is the commitment represented by (3) credible? By this term, we mean that the commitment should pass a test of government's cost–benefit assessment, of which investors are aware. An instance is provided by the strand of the literature on sovereign debt management that focuses on why 'sovereigns on the whole *choose* to service their debt or *choose* to default' (Buiter and Rahbari, 2013, p. 1).

A general feature of this literature is that governments perceive solvency or default on debt service as options, each of which bears costs and benefits. Typically, solvency bears costs given by the fiscal effort necessary to service the debt. In fact, greater fiscal effort imposes either higher taxes and/or lower expenditures with a variety of economic, social and political consequences. On the other hand, the default option also comes with economic and social costs, and further losses in terms of political reputation and access to markets.

In our setup, governments may evaluate the costs of compliance with the commitment to debt stability—their target primary surplus $\tilde{s}_t^*$—against the costs of noncompliance, which may include (partial) default on debt service. Since the latter option may lead to breakup of EMU membership (as it was foreshadowed in the Greek debt crisis), governments should also assess the costs of 'exit', including the loss of EMU benefits, which may tilt the assessment towards compliance significantly in comparison with stand-alone countries (Eichengreen, 2010; Lane, 2021).

Here, we need not go into the details of specific cost–benefit calculations, but we simply draw on the general result in this literature about the existence of an optimal threshold of the target primary surplus (3), let it be $\hat{s}$, above which the costs of compliance with debt stabilisation exceed those of noncompliance (examples are De Grauwe, 2012, Gros, 2012, Buiter and Rahbari, 2013, and Tamborini, 2015). Therefore, (3) should be complemented with the upper 'feasibility constraint':

$$\tilde{s}_t^* \leq \hat{s}. \tag{5}$$

Negative shocks to debt, or favourable conditions of the interest-growth gap, may allow the government to target primary deficits $\tilde{s}_t^* < 0$ while keeping debt stable. Nonetheless, specific to the EMU is the existence of the deficit cap of 3% of GDP. This has been further translated into a limit to the 'structural' primary balance that, according to the Medium Term Objectives in the Preventive Arm of the Stability and Growth Pact, should be in balance or in slight surplus. This objective also sets a lower 'regulatory constraint' that we can write as

$$\tilde{s}_t^* \geq 0. \tag{6}$$

At $\tilde{s}_t^* = 0$, favourable events should entirely go to debt reduction. [For precision, the structural primary balance depurates the actual primary balance from its cyclical component and transitory components. We cannot introduce this detail here; however, as will be seen, the model will accommodate the split of the growth rate of GDP in (3) between its structural and cyclical component.]

These constraints set our model within the general framework of TZ models. By controlling the primary surplus, the government intervenes to stabilise public debt after random shocks within its own TZ. (While the mathematical apparatus is the same, our fiscal TZ works in reverse with respect to the standard exchange-rate TZ, where the central bank does not intervene within the

TZ but only at margin.) Note that the upper and lower bounds of the TZ are different in nature. The lower bound is set by regulation, and each government is obliged to respect it. The upper bound is chosen by the government in violation of the unconditional commitment to debt stabilisation. When $\tilde{s}_t^*$ is at the upper bound, the government gives up its commitment to servicing debt, which amounts to breaking EMU membership, in analogy with the decision of abandoning an exchange-rate agreement. Breakup at the lower bound is due to violation of the Excess Deficit Procedure. Breakup at the upper bound is due to a sovereign debt crisis.

Key to framing debt policy within the fiscal TZ is the evolution of the target primary surplus as well as its expected evolution. According to (3), the level of $\tilde{s}_t^*$ at any moment t should match the ratio of interest payments to GDP (interest payments henceforth) so that the outstanding ratio of debt to GDP b_t remains stable. What is crucial is how the endogenous evolution of interest payments feeds back onto $\tilde{s}_t^*$.

Given b_t, interest payments depend on the interest rate—growth rate gap, which can be traced back to a structural and a transitory component. By structural, we mean the component that prevails as long as debt is stable and $\tilde{s}_t^*$ is not expected to change, whereas transitory is the component that is triggered as debt is shocked and $\tilde{s}_t^*$ is expected to change. Consequently, we also have a structural and a transitory component of interest payments and hence of $\tilde{s}_t^*$. Notice that this partition of the factors affecting the target variable is common throughout the earlier TZ literature concerning exchange-rate dynamics, and it is key to obtaining the 'self-fulfilling', or 'positive feedback' mechanism, between the target variable and its expected change that lies at the core of this class of models. [An example is Krugman (1991), where the current value of the exchange rate also depends on its expected change. Other significant applications concern the case of the inflation rate, well represented by Barro and Gordon (1983) and the use that in that article is made of the Phillips curve, where the current inflation rate also depends on the expected inflation rate for the future.]

The structural component of the interest–growth gap is due to the fundamentals-driven sovereign risk premium ρ the government should pay above the risk-free rate i, and to the potential growth rate of GDP $\overline{g}$. [For instance, Tamborini (2014) shows that in a standard model of optimal portfolio choice under risk aversion ρ is determined by the difference between the variance and covariance of the sovereign's debt with respect to the alternative benchmark weighed by the risk aversion coefficient. Alcidi & Gros (2018), Furceri & Zdzienicka (2011) and European Commission (2014) suggest that the fundamental risk premium increases when the public debt-to-GDP ratio exceeds a given threshold that is assumed to be risk free, which corresponds to our definition of $b_t > 0$. The European Commission, referring to the European countries, finds a 0.03% increase in the risk premium, the IMF (having in mind mostly emerging countries) finds a 0.04% increase, for any percentage point of the public debt-to-GDP ratio exceeding 60%.] Hence, let $\delta = (i + \rho - \overline{g})$ be the structural interest-growth gap and δb_t be the structural component of interest payments. Let instead $\widetilde{RP}_t$ and $\tilde{g}_t$ be the transitory components of the risk premium and growth, respectively. We call $\widetilde{RP}_t b_t$ the risk-premium channel and $\tilde{g}_t b_t$ the growth channel, of interest payments.

We can then express the relationship between the risk-premium channel of interest payments and the expected change in $\tilde{s}_t^*$ as follows:

$$\widetilde{RP}_t b_t = \alpha E \frac{d\left(\widetilde{s*}_t\right)}{dt} \tag{7}$$

This equation says that the expectation of a future increase in the primary surplus increases the risk-premium channel of interest payments, i.e. the extra interest payments the government should stand ready to disburse, since it signals that the process is approaching the upper bound of $\tilde{s}_t^*$ at which the government would give up the stabilisation of public debt and opt for default. A higher probability of default calls for higher risk premium. This further increases $\tilde{s}_t^*$, thereby igniting a self-fulfilling, destabilising spiral. The parameter $\alpha > 0$ weighs the impact of this process on the generation of higher $\tilde{s}_t^*$,.

Our formulation encapsulates a varieties of ways in which the role of self-fulfilling expectations on public debt sustainability emerges. The seminal paper is Calvo (1988) where he shows how default expectations increase the government's probability to default thereby becoming self-validating. Ayres et al. (2018) highlight the role of expectations on debt repayment in driving the market towards 'good' or 'bad' equilibria where the risk premium is high because the interest rate is high. Draghi (2012), De Grauwe (2012), Gros (2012), Lane (2020) and Schnabel (2020b) have elaborated on these processes with special reference to the EMU sovereign debt crises. More akin to our setup, Tamborini (2015) provides a theoretical model where the non-fundamental risk premium increases with the share of investors who believe that the primary surplus necessary to stabilise debt is at the government's upper threshold. [A whole strand of empirical studies have investigated into the non-fundamental components of euro-area sovereign spreads. See, among others, Caceres et al. (2010), Favero & Missale (2011), Gödl & Kleinert (2016). De Grauwe & Ji (2013a) and Passamani et al. (2015) show that the widening of spreads during the sovereign debt crisis in the EMU was also driven by mounting expectations of unsustainable fiscal consolidation, 'austerity' measures, creating positive correlation between larger austerity and higher interest rate (e.g. Passamani et al., 2015, Fig. 2).]

Note that indirectly, through the determination of $\tilde{s}_t^*$, the risk premium is sensitive to the institutional environment where governments operate, namely its extent of fiscal and monetary orthodoxy. This point has been raised by the well-known paper by De Grauwe (2012) comparing the higher risk premia of EMU countries relative to non-EMU countries with similar debt stocks but backed by the central bank as lender of last resort (LLR). It will also play a key role in the development of our model.

The expectations about the increase of the target primary surplus may create another critical feedback onto higher interest payments through the growth rate of GDP. Though not strictly necessary for our model's purposes, it is worth being considered as a possible reinforcing mechanism.

The impact of fiscal manoeuvres on GDP is matter of long-lived research around the so-called 'fiscal multipliers'. The implementation of austerity in the EMU has spurred a new wave of controversies. If a restrictive fiscal manoeuvre $d\tilde{s}_t^*/dt > 0$ has a 'Keynesian' effect and depresses growth, the ratio of interest payments to GDP may increase, and hence the target primary surplus should also increase further in a vicious circle, a phenomenon known as 'excess' or 'self-defeating' austerity (Nuti 2013; De Grauwe and Ji 2013c; Fatàs and Summers, 2018). However, a strand of alternative literature (Giavazzi and Pagano, 1990; Alesina and Perotti, 1997; Alesina and Ardagna, 2010) argues that if the expected fiscal restriction is well designed, e.g. cutting expenditures instead of raising taxes, the fiscal multiplier may be negligible or even change sign.

In order to take this issue into account in a tractable manner, let us relate the expected change in the fiscal stance to the transitory growth channel of interest payments as follows:

$$\tilde{g}_t b_t = -\phi E \frac{d\left(\tilde{s}_t^*\right)}{dt} \tag{8}$$

where $\phi < 0$ denotes a Keynesian effect, which depresses growth and raises the interest payments-to-GDP ratio, and hence the target primary surplus.

Therefore, using (7) and (8), the target primary surplus (3) can be rewritten:

$$\tilde{s}_t^* = \delta b_t + \beta E \frac{d\left(\tilde{s}_t^*\right)}{dt} \tag{9}$$

The parameter δ plays a critical role as long as it remains positive, which we assume as the normal condition, whereas $\beta = \alpha - \phi$ encompasses the weights of the risk-premium and growth channels of interest payments discussed above. [The case $\delta \le 0$ may stylise a scenario with zero policy rate and positive, although low (zero) nominal growth that fits the current situation in the EMU. The effect would be that the problem of stabilisation vanishes. The government may stay passive and keep the primary surplus in balance or enjoy space for deficits, for any level to where shocks may bring public debt b_t since $\delta \le 0$ ensures that debt will not grow ($\delta = 0$) or will be self-reducing over time ($\delta < 0$). In fact, Blanchard et al. (2019) argue for the reconsideration of the issue of debt sustainability when the interest-growth gap is zero or negative.] The sign of the parameter β is certainly positive in case of a negative fiscal multiplier, $\phi < 0$, so that the vicious circle of 'self-defeating austerity' enhances the risk-premium channel, accelerating the trajectory towards the upper bound of the primary surplus. A positive fiscal multiplier might instead mitigate the vicious circle or even reverse it (if $\phi > \alpha$).

It may be noted that the sole growth channel of interest payments may be sufficient to obtain (9) with $\beta > 0$, if the Keynesian case with $\phi < 0$ occurs. (We thank an anonymous referee of this journal for bringing this point to our attention.) However, we deem important to consider both channels for completeness and because in debt crisis episodes they typically operate in tandem (see for instance Berti et al., 2013, with regard to the EMU case). An additional merit of our approach is that it shows that even if the non-Keynesian, rather than Keynesian, effect on GDP growth were to materialise, the risk premium channel might well be strong enough to exceed the former, thereby providing the same 'self-defeating' effect produced by the traditional Keynesian result. [Some theoretical studies point out that it is in fact the combination of the two channels that is responsible for the final outcome of fiscal consolidations (e.g. Afonso, 2007; Beetsma et al., 2015). Fiscal consolidations may end up being successful because the reduction of the risk premium sustains growth, and this sustains the reduction of the risk premium. The empirical studies of Berti et al. (2013) and Fatàs & Summers (2018) detect in the EMU sovereign debt crisis the opposite combination, with investors translating worse growth prospects into higher risk premium.]

To summarise, our fiscal TZ model is composed by the following equations [this combination of a stochastic fundamental and an expectation component is analogous to the standard formulation of exchange-rate TZ models, such as Krugman (1991), Krugman & Rotemberg (1992) and Bertola & Caballero (1992)]:

$$\tilde{s}_t^* = \delta b_t + \beta E \frac{d\left(\tilde{s}_t^*\right)}{dt} \tag{9}$$

$$db_t = \sigma dz. \tag{4}$$

$$\tilde{s}_t^* \le \hat{s} \tag{5}$$

$$\tilde{s}_t^* \ge 0. \tag{6}$$

These equations imply a lower and upper bound of debt, too. In fact, as $\tilde{s}_t^*$ hits the bounds of the TZ, then $E\frac{d\left(\tilde{s}_t^*\right)}{dt} = 0$; therefore, at $\tilde{s}_t^* = 0$ debt should be $b_t = 0$, i.e. at the official target of 60% of GDP, whereas at $\tilde{s}_t^* = \hat{s}$ debt cannot exceed $b_t = \hat{b} = \hat{s}/\delta$. Hence, the shock-absorption capacity of the government depends positively on its upper bound to fiscal effort and negatively on the structural interest-growth gap. Consequently, public debt can

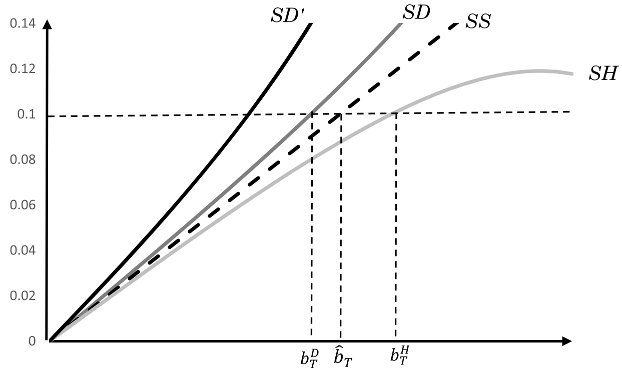


Figure 3. Divorce and honeymoon in the fiscal TZ

fluctuate within a band centred on $\hat{b}/2$, where the crucial role is played by the expectation component of $\tilde{s}_t^*$, which reacts to the extent the government is expected to be able to accommodate debt shocks or not, and impinges upon non-fundamental risk premium and growth.

The model solutions

Preliminarily, let us consider (9) when its expectation component is muted, as if the government's unconditional commitment to stabilising debt for any amount of the shock were taken at face value. As a result, $\tilde{s}_t^*$ would 'linearly' increase with the level of debt (Fig. 3, schedule SS). This will provide a useful benchmark in the subsequent analysis.

When the expectation component of the target primary surplus is active, (9) becomes a first-order differential equation, which, given (4–6), has the general solution (see the Appendix A1 for derivation):

$$\tilde{s}_t^* = \delta b_t + A_1 e^{\lambda_1 b_t} + A_2 e^{\lambda_2 b_t}$$
$$\lambda_{1,2} = \pm\sqrt{2/\beta\sigma^2} \tag{10}$$

The parameters $A_{1,2}$ are indeterminate, and in order to determine them and close the model, it is necessary to analyse the behaviour of the function as $\tilde{s}_t^*$ approaches its upper and lower bounds.

We treat the behaviour of the system at the lower bound straightforwardly, assuming that the government is always compliant with the zero primary-balance rule. Hence, for 0 to be zero at $b_t = 0$, it should hold that $A_2 = -A_1$, so that

$$\begin{cases} \tilde{s}_t^* = \delta b_t + A\left(e^{\lambda b_t} - e^{-\lambda b_t}\right) bt \geq 0 \\ 0 \text{ otherwise} \end{cases} \tag{11}$$

To study the behaviour of the system at the upper bound, we shall follow the solution method of TZ 'realignments' presented by Bertola & Caballero (1992). This is based on an arbitrage argument. The value of the target primary surplus $\tilde{s}^*(\hat{b}) = \hat{s}$ has to be equal to the expected one resulting from the probabilities of two different events that may take place when $\tilde{s}_t^*$reaches $\hat{s}$.

With probability p, public debt is allowed to jump upwards above $\hat{b}$ by say the amount ε^u. This event, therefore, is virtually equivalent to moving up to the centre of a higher debt TZ $\in [\hat{b}, 2\varepsilon^u]$ that would require a target primary surplus larger than $\hat{s}$. Yet, the government is unwilling to sustain such a larger primary surplus and will leave its debt service unsatisfied. Hence, in our context, ε^u can be interpreted as the 'haircut' that investors expect in case of breakup.

With complementary probability (1-p), debt will not be allowed to increase. The stabilising intervention—whatever it may be as will be discussed subsequently—is such that debt remains at $\hat{b}$ or moves below by say the amount ε^d to the centre of the debt TZ $\in [\hat{b}$ - $2\varepsilon^d$, $\hat{b}]$ where the government is still willing to stabilise debt.

As we show in Appendix A2, the value of A consistent with the above no-arbitrage condition is

$$A = \delta\left[p\left(\varepsilon^u + \varepsilon^d\right) - \varepsilon^d\right]\left(e^{\lambda\hat{b}/2} - e^{-\lambda\hat{b}/2}\right)^{-1} \tag{12}$$

Substituting (12) into (11) yields the explicit form of the function of the target primary surplus, used to draw Fig. 3 for hypothetical parameter values.

Divorce vs. honeymoon

Probability p can be interpreted as a measure of distrust in the commitment to unconditional debt stabilisation, and hence in the irreversibility of the EMU. It plays a crucial role in the dynamic evolution of the system by conditioning the sign of the parameter A. As can be seen from (12),

$$A \underset{<}{\overset{>}{}} 0 \text{ iff } p \underset{<}{\overset{>}{}} \frac{\varepsilon^d}{\varepsilon^u + \varepsilon^d} \equiv p*$$

We denote by $p*$ the critical level of p such that $A = 0$, yielding the linear case of the SS function in Fig. 3. This critical $p*$ in turn depends on debt behaviour expected at the upper bound of the TZ. If debt is expected to move up or down by the same amount, then $p* = 1/2$. [Bertola & Caballero (1992) assume the probability of a symmetric upward or downward jump. See also Della Posta (2018a).] The more public debt is expected to move up than down, $\varepsilon^u > \varepsilon^d$, the more $p*$ is reduced, meaning that also the chances of breakup should be lower in order to keep the system on the linear track. Yet, as long as p is independent of the other parameters, $p = p*$ may only materialise by chance.

If $p > p*$, i. e. there is high distrust in the no-breakup intervention, then $A > 0$, and the ensuing function, labelled *SD* in Fig. 3 becomes convex. The consequence is that for any level of debt, *SD* bends above and to left of the linear *SS*. The economic intuition is that as $\tilde{s}_t^*$ gets closer to the upper bound, the anticipation of the non-feasibility of the fiscal consolidation that would be necessary to guarantee stability raises the risk premium to be paid by the government, which accelerates the trajectory towards the upper bound. In other words, owing to the expectation component of the target primary surplus, the shock-absorption capacity of the government is reduced ($b_T^D < \hat{b}$ in Figure 3), and shocks lead faster to breakup. This scenario has been dubbed 'divorce' in the TZ literature.

The extent of the divorce effect depends on the curvature of the *SD* function, which increases with *A*. As a limit case, with integral EMU orthodoxy, investors know for sure ($p = 1$) that at the upper bound there will be no resources needed to revert public debt towards the centre of the band ($\varepsilon^d = 0$). Consequently,

$$A = \delta \frac{\varepsilon^u}{2} \left(e^{\lambda \hat{b}/2} - e^{-\lambda \hat{b}/2} \right)^{-1} > 0, \tag{13}$$

which generates the schedule *SD*' in Fig. 3. Note that anyway $\varepsilon^d = 0$ is sufficient for $A > 0$ for any *p*.

This outcome of the model may vindicate the criticisms about the unintended consequences of the EMU twin orthodoxies in combination with market discipline (see also the next section). Defenders maintain that the perception of the *de facto* demise of the no bail-out clause prompted fiscal laxity and market undervaluation of default risks, thus paving the way to the sovereign debt crisis. Critics argue that the clause may turn itself into a threat to the EMU stability and integrity. [As a 'field experiment' of this view, the notorious 'Deauville walk' is often cited, when, on 19 October 2010, Nicolas Sarkozy and Angela Merkel decided in a private talk the future involvement of the private sector in the debt restructuring of EMU member states applying for financial assistance. The event concurred to the sudden diffusion and acceleration of the sovereign debt crisis across the board. For detailed rendition and discussion, see, e.g. Brunnermeier et al. (2016), ch. 2.] Indeed, our model shows that if investors understand that countries do have a limit to their sustainable fiscal consolidation, and firmly believe in the no-bailout clause, then the system is less resilient to sovereign debt shocks and prone to breakup threats.

If $p < p*$, i.e. higher confidence arises in the no-breakup intervention, then $A < 0$, and the opposite scenario occurs, called 'honeymoon'. The function of the target primary surplus, labelled *SH* in Fig. 3, becomes concave and bends below and to the right of *SS*, meaning that the shock-absorption capacity of the government is increased as measured by the difference between b_T^H, the debt absorbed by the government at the moment *T* when *SH* crosses the upper bound, and $\bar{b}$. In fact, now the relative greater confidence in sufficient resources to absorb the shock within the government's upper bound reduces the risk premium and decelerates the run-up of the target primary surplus towards the upper bound.

This approach to TZ modelling has the merit of explaining transitions from 'honeymoon' to 'divorce' scenarios, and return, that may be hard to explain on the basis of simple fundamentalist models. An important driver of transitions are sentiments of trust/distrust in the irreversibility of the system captured by the probability *p*. Volatility of these sentiments may account for the sudden and abrupt transitions that we have observed in the two decades of life of the EMU sovereign debt markets, such as the 2010–11 upsurge of spreads after a decade of tranquility (both of which phenomena may be judged inconsistent with fundamentals alone), and the rapid reversion after the celebrated 'whatever-it-takes' speech by the ECB's President Mario Draghi.

On the other hand, trust and distrust may not be totally unrelated to real factors. Though we treat *p* as exogenous, our model highlights a relationship with the institutional design of the EMU, since investors figure out what the behaviour of the system may be at the upper bound of the fiscal TZ taking into account whether or not enough resources may be deployed to sustain the no-breakup of the EMU. [This point, the critical role of resources necessary to 'defend' the upper bound, is similar to the one maintained by Krugman & Rotemberg (1990) in the case of an exchange-rate TZ with limited reserves.] In the subsequent part of the paper, we shall address the issue of modifications of the EMU setup apt to sustain trust in its irreversibility.

RELAXING THE TWIN ORTHODOXIES

To sum up, the shock-absorption capacity of single governments, however strong it may be, remains limited. Unusual tail events may suddenly push towards divorce for single governments or *the collapse of the system as a whole*, as was indeed the case in the aftermath of the Global Financial Crisis and of the outbreak of the pandemic. When these events happen, the EMU trilemma materialises and the imperative of euro irreversibility is in jeopardy.

Our aim now is to show that the preservation of the EMU can be achieved by relaxing one between monetary and fiscal orthodoxy, or both. [This is in line with the conclusions reached in the literature on anti-inflationary credibility as to the opposition between rules and discretion: while the seminal deterministic models by Kydland & Prescott (1977) and Barro & Gordon (1984) concluded that rules are Pareto superior to discretion, the introduction of uncertainty, namely the possibility that the economic system is hit by stochastic shocks, led to deny such a conclusion (Lohman, 1992).] We complete the analytical solutions of the model treating the case in which the commitment to debt stabilisation is credible, in the sense that investors anticipate that shocks will be fully accommodated, and debt stabilised, within the government's feasibility constraint (namely $\tilde{s}_t^* \leq \hat{s}$). Note that credibility is assessed not against the unconditional commitment dictated by fiscal orthodoxy but against the actual stabilisation capacity of the government. The upper bound of the target primary surplus is still in place, and investors are aware of it. We shall see that this creates the condition for the honeymoon effect.

Relaxing monetary orthodoxy

Monetary policy can influence the dynamic evolution of the fiscal TZ presented above through different channels. The first one is the 'conventional' interest-rate policy, which is introduced in the model through the risk-free policy rate i in the parameter δ.

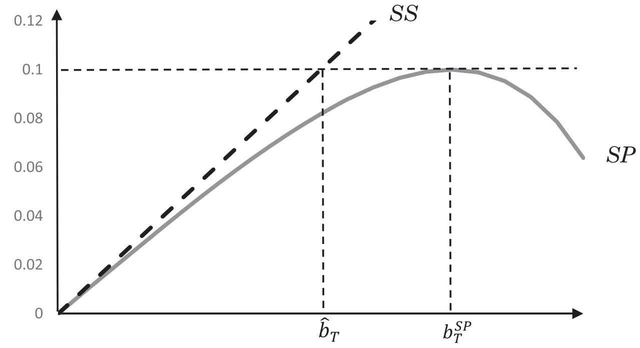
EMU monetary orthodoxy prescribes that the policy rate is exclusively targeted to price stability, which makes it fully exogenous to the problem of governments' debt control. The higher i and δ, the harder the problem. This hurdle can be lowered either because the 'divine coincidence' of below-target inflation allows the central bank to reduce the policy rate, as has been the case for the past 10 years (Lane, 2020), or because the central bank decides a cooperative policy for the debt control problem (e.g. Mason and Jayadev, 2018; Bonatti et al., 2020). In either case, the conventional policy faces the well-known zero lower bound of the policy rate (though in practice central banks have the power to achieve negative interest rates in the money market: Lane, 2020).

As long as $\delta > 0$, in alternative, or addition, to conventional interest-rate policy, a central bank in a stand-alone country has virtually an unlimited liquidity potential and it is, therefore, always able to back up the sovereign debt as LLR. As suggested by De Grauwe (2012) and De Grauwe & Ji (2013a,b), this option, beyond its actual activation, has proved able to stabilise the sovereign debt markets, and financial markets more generally, in the non-EMU countries. Analogous result has been obtained by the change of attitude towards direct financial stabilisation undertaken by the ECB since 2012 (Buiter and Rahbari, 2012). Ever since Bagehot's *Lombard Street*, it has been known that a critical aspect of the LLR is its design and conditionality in order to limit moral hazard. As we shall see, our TZ model allows for a well-defined treatment of these issues.

In terms of our model, key to preventing the system breakup is investors' expectation of the central bank to provide enough liquidity to absorb the stochastic shocks hitting public debt, complementing or substituting the fiscal effort necessary for debt stability, should it exceed the maximum level $\hat{s}$ that the country can withstand. Hence, the first important characterisation is that the LLR interventions are once-and-for-all and targeted to a specific event.

The effect can easily be seen by means of the conditions of divorce vs. honeymoon after setting $\varepsilon^u = 0$. The result is that $A < 0$, i.e. the condition for the honeymoon scenario, for any probability p assigned by investors to the alternative event of breakup.

However, as a second characterisation, it may be desirable that the LLR intervention is minimised, that is to say, necessary and sufficient to absorb just the excess debt that is not sustainable by the government ($\varepsilon^d \to 0$). The solution technique consists of the 'smooth pasting' condition that was also used to close the first generation of TZ models launched by Krugman (1991), which mathematically calls for finding the tangency condition



$\hat{s} = 0.1, \delta = 0.1, \beta = 0.5, \sigma^2 = 1, \hat{b} = 1, 1/\lambda = 0.5$

Figure 4. Honeymoon and 'smooth pasting'

between the equation of the target primary surplus (10) and the upper bound at the instant T when the latter is hit.

More specifically, LLR interventions can be done in various forms that we can accommodate in our framework: (i) creation of Treasury's monetary balances (an instance of 'helicopter money') [for the current revival of the 'helicopter money' idea, see, e.g. Galì (2020) and Cochrane (2020)]; (ii) purchases of new debt created by the shock; (iii) purchases of outstanding debt on the secondary market, as currently practiced by the ECB under the Asset Purchases Programme and the Pandemic Emergency Purchases Programme.

Let us first consider the basic case (i) mentioned above, let us name it 'pure monetisation', which has a straightforward correspondence with the variable m_t in the debt equation (1). Consequently, we can write

$$\tilde{s}_t^* = -m_t + \delta b_t + A\left(e^{\lambda b_t} - e^{-\lambda b_t}\right) \tag{14}$$

Denoting with b_T^{SP} the level of debt at the upper bound, at point in time T, the first-order condition for smooth pasting is

$$\frac{ds_T}{db_T^{SP}} = \delta + \lambda A\left(e^{\lambda b_T^{SP}} - e^{-\lambda b_T^{SP}}\right) = 0,$$

which yields the value of A

$$A = -\frac{\delta}{\lambda}\left(e^{\lambda b_T^{SP}} - e^{-\lambda b_T^{SP}}\right)^{-1} < 0 \tag{15}$$

$A < 0$ ensures the honeymoon effect. The resulting concave function $\tilde{s}^*(b_t)$ is plotted as SP in Fig. 4.

Then we can establish that the target primary surplus at the upper bound has value:

$$\tilde{s}_T^* = \hat{s} = -m_T + \delta\left(b_T^{SP} - 1/\lambda\right) \tag{16}$$

The implied LLR intervention is therefore

$$m_T = \delta\left(b_T^{SP} - 1/\lambda\right) - \hat{s} \tag{17}$$

i.e. the central bank should stand ready to monetise any debt shock in excess of the maximal shock-absorption capacity of the government, b_T^{SP}. To pin down the value of b_T^{SP}, we can recall that $\hat{s} = -m_T + \delta\hat{b}$. The result is, therefore,

$$b_T^{SP} - \hat{b} = 1/\lambda > 0, \tag{18}$$

which measures the honeymoon effect. Note that its extent is only determined by $\lambda = \sqrt{2/\beta\sigma^2}$, i.e. by the exogenous parameters that govern the process of $\tilde{s}_t^*$.

We can thus appreciate two important features that characterise this institutional setup. First, thanks to the honeymoon effect, the resilience of the system is enhanced. To the extent that investors anticipate the LLR intervention, the non-fundamental risk premium driven by expectations of breakup is curbed all along the trajectory of the target primary surplus also in case of within-the-band shocks (the *SP* curve in Fig. 4), even though *the central bank does not intervene on these shocks*. Since the LLR intervention is *erga omnes*, we may say that the honeymoon effect translates itself into a 'no-breakup premium' embodied by the sovereign debt market as a whole. [This would make the sovereign debt of EMU members more similar to that of stand-alone countries according to the distinction drawn by De Grauwe (2012).] Second, monetary and fiscal debt stabilisation are 'synergic': in the sense that the commitment to LLR, conditional on the government's full fiscal effort, increases the shock-absorption capacity of the government and reduces the potential exposure of the central bank.

We can now consider the other two types of LLR interventions, consisting of purchases of sovereign bonds either at issuance or in the secondary market. Though often regarded as equivalent to pure monetisation, they are not. For these interventions, in different ways, boil down to a debt swap from the market to the central bank. This fact has implications that should be taken into account since they modify the picture presented above.

The first issue is whether the central bank's share of public debt reduces or not the government's total exposure b_t. The answer may be affirmative in a stand-alone country, where assets and liabilities across state compartments cancel out and the central bank fully pays interests back to the government. Whether the same applies to the EMU is more controversial because of the different capital keys of member countries in the ECB's capital (De Grauwe and Ji, 2013b). Indeed, the EMU fiscal rules are targeted to the total outstanding debt regardless of the share held by the Eurosystem. The second issue concerns the determination of the interest rate and the relevant risk premium. Does the debt swap to the central bank make any difference? The presumption is that it does, otherwise there would be no point in doing the swap. [A rationale may be that the central bank has greater loss-absorption capacity than private investors and hence can contribute to reduce the risk premium paid by the government. According to some authors (e.g. De Grauwe and Ji, 2013b), the central bank has infinite loss-absorption capacity since, having no creditors, it cannot go bankrupt. The equivalence between purchases of debt and pure monetisation would occur with full cancellation of debt and interests owed to the central bank, which has been put forward recently (e.g. Becchetti and Scaramozzino, 2020).]

Since the ECB is not allowed to buy sovereign bonds at issuance, let us consider the case of purchases of outstanding debt. These, at any point in time, reduce b_t by the amount b_t^{CB} leaving the difference on the market. Let us assume that the central bank's holdings do not reduce the total debt to be targeted by the government, but with its purchases it pushes the interest rate towards the risk free policy rate i. Consider now this intervention at the upper bound by the amount b_T^{CB} that leaves $b_T^{SP} - b_T^{CB}$ on the market, weighed by $\delta = i + \rho - \bar{g}$, while b_T^{CB}, weighed by $\delta' = i - \bar{g}$, is in the hands of the central bank. As a result,

$$\tilde{s}_T^* = \hat{s} = -\rho b_T^{CB} + \delta\left(b_T^{SP} - 1/\lambda\right) \tag{19}$$

By comparing (16) and (19) it turns out that $\rho b_T^{CB} = m_T$, and, since $\rho < 1$, then $b_T^{CB} > m_T$. This result has two implications that help understanding and assessing the ECB asset purchases programmes deployed since 2015 (further discussion in the subsection "Moral hazard and EMU irreversibility"). First, the honeymoon effect is still present as in the case of monetisation. Second, the government's debt relief at the margin, however, is limited to the resulting 'discount' on the fundamental risk premium. Consequently, the required amount of debt purchases should be (much) larger than pure monetisation. It would be possible to argue that this is quite a significant toll to be paid to the prohibition of pure monetisation.

We have seen that in order for the EMU irreversibility to be fully credible, the ECB commitment as LLR ought to be unlimited. We would move therefore into a system of full insurance of investors by the central bank against governments' defection on the commitment to debt stability, since any shock beyond the absorption capacity of governments would be absorbed by the central bank. The next question is the extent to which this system is feasible, and to this we shall turn subsequently.

Relaxing fiscal orthodoxy

In the case in which monetary policy is not available (e.g. because there may be the risk of inflation or because of institutional constraints—as it might be the case for the ECB), and/or in order to reduce its extent of intervention, there is yet another possibility, namely stabilising national public debt thanks to a 'federal' fiscal support (f_t in (1)). Equation (14), then, becomes

$$\tilde{s}^*(b_t) = -m_t - f_t + \delta b_t + A\left(e^{\lambda b_t} - e^{-\lambda b_t}\right) \tag{20}$$

A prominent, and unprecedented, example is NGEU, the anti-pandemic plan elaborated by the European Commission and approved by the European Council in July 2020. The plan allocates to Member States collective resources explicitly targeted to public expenditures in view of stabilisation and recovery of the economies shattered by the pandemic. (In the case of NGEU, f_t should be considered net of the country's own share in the creation of the collective fund.) As such, the plan complements the already huge expansion of public debts generated by the emergency plans at the national level. From this point of view, NGEU acts as backstop to the governments' shock-absorption capacity analogously to the monetary interventions examined in the previous paragraph. As is clear from (20), analytically, the same results as above apply.

In particular, the analogy also regards the government's liability after the intervention. NGEU resources consist of a grant component γ and a loan component (1-γ). The grant component means that no liability is left after the intervention, which corresponds to the case of pure monetisation above, whereas the loan component entails a liability towards the EMU at a concessional rate. Let the latter be the risk-free rate i, and $\delta' = i - \overline{g}$. Therefore, the fiscal intervention at the upper bound of the TZ is

$$\tilde{s}_T^* = \hat{s} = -f_T\left(\gamma - \delta'(1-\gamma)\right) + \delta\left(b_T^{SP} - 1/\lambda\right). \qquad (21)$$

Writing f_T as the complement to the government's maximal shock absorption, and recalling from (18) that $b_T^{SP} = \hat{b}_T + 1/\lambda$, we can see that

$$f_T = \frac{\delta\left(\hat{b}_T + 1/\lambda\right) - \overline{s}}{\gamma(1+\delta') - \delta'} \qquad (22)$$

that is to say, f_T has to be larger, the smaller is the grant component γ.

Another important point highlighted by (20) is that the monetary and the fiscal interventions are synergic. Activating both reduces the extent of each. As argued in the Introduction, this is one of the key innovations of the overall anti-pandemic policy package of the EMU in comparison with the response to the crisis of the 2010s when the whole burden of the integrity of the EMU was left on the shoulders of the ECB, with heavier strain of monetary orthodoxy *vis-à-vis* the tightening of fiscal orthodoxy. (We do not consider here other specific aspects of the fiscal intervention that differentiate it from monetary interventions, such as the possibility to target the resources to growth-enhancing expenditures.)

Moral hazard and EMU irreversibility

As said above, the 'smooth pasting' solution in our model is equivalent to an insurance on investments in sovereign bonds, and any insurance scheme brings the moral hazard issue with itself. Minimisation of moral hazard has been central in the design of the rules of the EMU (e.g. Brunnermeier et al., 2016, ch. 6 and Gros, 2021), and it remains central in the debate about the reforms of the rules (e.g. Delatte et al., 2017, CEPR, 2018, European Fiscal Board, 2019). Discussion of such a complex issue is beyond our scope here. However, a few considerations are in order.

The first is that our model supports the view that the protective belt of the monetary and fiscal orthodoxies against moral hazard may bring benefits but also risks for the EMU. If the benefits come from enforcing fiscal discipline of national governments, the risks arise from the loss of resilience of the system as a whole in the face of large shocks. The credibility of the imperative of EMU irreversibility cannot be entirely left on the shoulders of governments' commitment to fiscal discipline and debt sustainability. It should be acknowledged that governments, especially those under democratic scrutiny in complex developed societies, face limits to the fiscal effort they can bear in order to keep public debt stable in the event of large shocks. These 'may happen', making fiscal effort unsustainable.

A widely shared lesson drawn from the crisis of the 2010s is that a wise institutional design should take these events into account and foresee appropriate instruments, instead of muddling through *ad hoc* arrangements afterwards. A 'Union's no-breakup mechanism' (monetary and/or fiscal) is also necessary (De Grauwe, 2012; Gros, 2014; Brunnermeier et al., 2016, chs. 6–7; Corsetti et al., 2020; Orphanides, 2020; Lane, 2021).

In the second place, in the original conception of the EMU, monetary and fiscal orthodoxy curb moral hazard in cooperation with market discipline, i.e. the alleged efficiency of financial markets in finding the 'right price' of sovereign bonds. This presumption has seriously been weakened by the events leading to, and then boosting, the sovereign debt crisis. In line with this literature, our model, too, shows that the non-fundamental component of the risk premium may ignite the acceleration towards breakup.

More on normative grounds, monetary interventions aimed at the stabilisation of the sovereign debt market have been legitimised by the necessity to curb the non-fundamental component of widening risk premia, while being beneficial to the stability of the system as a whole and not just to single countries (Schnabel, 2020a). As we have seen, this is precisely the result of the investors' anticipation of a backstop to governments' shock-absorption capacity in the honeymoon scenario. Moreover, the honeymoon effect operates as a 'no-breakup premium' all the time even in the absence of direct intervention, as in fact happened with the ECB's announcement of the Outright Monetary Transactions.

This feature is particularly relevant in consideration of moral hazard. For the no-breakup mechanism need be activated only at the margin, the upper bound of the TZ, while the stabilisation of inframarginal shocks remains full responsibility of national governments. Moreover, we have shown that, with the no-breakup mechanism in place, their shock-absorption capacity is increased, while at the margin, too, they are fully involved in the stabilisation effort by their own part.

This arrangement, where the conditionality of intervention concerns the country's (sustainable) involvement in the stabilisation, seems more effective than the more usual one where conditionality concerns debt restructuring (private sector involvement) and subsequent macroeconomic adjustment. In fact, the perspective of the private sector involvement is precisely the booster of the divorce scenario, while the perspective of heavy macroeconomic adjustment raises the costs of compliance with EMU membership and lowers the upper bound of the TZ. Much of the painstaking management of the Greek crisis was due to major mistakes on these two issues. [From this point of view, it is unclear whether the creation of the European Stability Mechanism may be regarded as an effective no-breakup mechanism of the kind considered here. In the first place, it is conceived, and endowed, as a means to dealing with single emergency cases. In the second place, the required *ex-post* macroeconomic adjustment seems to exert deterrence. This may be regarded as a positive feature in view of the moral hazard problem, but it may also produce the perverse effect of making the divorce scenario more likely. As a matter of fact, no government has so far activated the pandemic facility provided by the ESM, despite the explicit exclusion of *ex-post* adjustment programmes.]

It may be argued that the consistent application of the backstop mechanism underpinning the smooth pasting solution presupposes (i) the ability to discriminate between genuine unfavourable events and fiscal misbehaviour and (ii) the identification of the actual (sustainable) shock-absorption capacity of the government. These two points recall the 'illiquidity *vs.* insolvency' dilemma, which, most of the times, is a true dilemma that plagues the management of financial crises at the micro as well as at the macro level. Yet, this awareness should not prevent the conception of a design that balances the risk of moral hazard of national governments with the risk of EMU breakup.

In this perspective, it should be recognised in the first place that the twin monetary and fiscal orthodoxies are strongly tilted towards the minimisation of the risk of moral hazard: in doubt, presume fiscal misbehaviour and hidden adjustment capacity (Brunnermeier et al., 2016, p. 119). This attitude conditioned the early institutional response to the Europeanisation of the world crisis regarded as a collection of violations of the rules by single Member States without seeing the overall picture of existential threats to the EMU. By contrast, the response to the pandemic crisis has taken the opposite road. As argued in the previous section, the joint relaxation of the twin orthodoxies has been an efficient strategy to reduce the strain on both. It is likely that this outcome has been made possible since the pandemic shock is more easily perceived as a symmetric, involuntary catastrophic event.

Looking ahead at the post-pandemic EMU, other black swans may materialise, of more economic nature and less general involvement *ex-ante*, that have to be tackled to prevent general involvement *ex-post*. A system of preemptive controls of fiscal discipline, and debt sustainability, remains necessary (possibly better conceived than the present one: see e.g. European Fiscal Board, 2019). However,

'for extreme adverse events, excessive emphasis on individual liability is counterproductive; in such circumstances the solidarity principle should dominate. The European community thus needs a discussion of the extent to which it is willing to assume tails risks for its members. A commonly acceptable cutoff needs to be identified, agreed upon, clearly communicated, and enforced in future crises' (Brunnermeier et al., 2016, p. 117).

CONCLUDING REMARKS

The key findings of our view of the EMU as a fiscal TZ can be summarised as follows. First, debt stabilisation by means of exclusive fiscal discipline is costly, and most likely faces a feasibility constraint. This may become binding in the face of large shocks, especially of a systemic nature. Second, investors understand that governments can, at best, commit themselves to debt stabilisation within a band of fiscal sustainability. Hence, setting to governments the unconditional commitment to debt stabilisation is non-credible as it may not pass the test of the feasibility constraint. Third, as investors anticipate that the upper bound of the band is not defendable, the system becomes more fragile in that self-fulfilling run-ups to the upper bound are triggered, smaller debt shocks can be absorbed by governments, and breakup becomes more likely.

The plea for EMU completion needs to include monetary and/or fiscal emergency no-brake mechanisms as backstop to the irreversibility principle. Drawing on TZ literature, we have shown how these devices can be designed in a consistent manner that minimises their extension and mitigates the moral hazard concerns. The alternative to these devices is reformulating the treaties with explicit and regulated exit procedures.

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A1. The general solution of the model

In order to solve equation

$$\tilde{s}^*_t = \delta \mathbf{b}_t + \beta E \frac{d\left(\tilde{s}^*_t\right)}{dt} \quad (A.1)$$

let us assume a generic functional form for $\tilde{s}^*_t$. The simplest functional form that we can assume is

$$\tilde{s}^*_t = f\left(b_t\right) \quad (A.2)$$

We can now use this equation to calculate the expected variation of the target primary surplus. In order to do this, let us expand the function in a Taylor-type series, by calculating Ito’s differential:

$$d\tilde{s}^*_t = f'\left(b_t\right)\left(db_t\right) + \frac{1}{2} f''\left(b_t\right)\left(db_t\right)^2 \quad (A.3)$$

From (1–4) in the text, considering expected values, it turns out that $E(db_t) = 0$ and $E(db_t)^2 = \sigma^2 dt$. We obtain, then, Ito’s lemma:

$$\frac{E\left(d\tilde{s}^*_t\right)}{d_t} = \frac{1}{2} f''\left(b_t\right)\sigma^2 \quad (A.4)$$

By replacing (A.4) into (A.1), we have

$$\tilde{s}^*_t = f\left(b_t\right) = \delta b_t + \beta\left[\frac{1}{2} f''\left(b_t\right)\sigma^2\right] \quad (A.5)$$

This is a differential equation of the second order whose generic solution is of the class (Bertola and Caballero, 1992, p.522):

$$\tilde{s}^*_t = f(b_t) = \delta b_t + A_1 e^{\lambda_1 b_t} + A_2 e^{\lambda_2 b_t} \quad (A.6)$$

where $\lambda_{1,2} = \pm\sqrt{2/\beta\sigma^2}$ are the two roots of the characteristic equation.

A2. Honeymoon and divorce

In the text, we have established that at the lower bound of the TZ, (A.6) should be $f(0) = 0$, which requires

$A_2 = -A_1 = A$. To study the conditions at the upper bound, we apply the Bertola & Caballero (1992) methodology of TZ 'realignments'. To this end, we introduce the notation $f(b_t; c)$ where b_t refers to the current value taken by the fundamental, and c refers to the value of the centre of the band. For symmetric bands, (A.6) becomes

$$f(b_t; c) = \delta b_t + A(e^{\lambda(b_t - c)} - e^{-\lambda(b_t - c)}) \tag{A.7}$$

Recall that the current band of the target primary surplus is $\hat{s}_t^* \in [0, \hat{s}]$ to which there corresponds the debt band $b_t \in [0, \hat{b}]$, centred on $c = \hat{b}/2$. Now, let b_t hit the upper bound at time T, $b_T = \hat{b}$. Investors anticipate that with probability p, b_T will be let to jump up by the amount ε^u; with probability 1 - p, b_T will be moved down by the amount ε^d. Also, let ε^u and ε^d be the centres of two new bands of dimension, respectively, $[\hat{b}, \hat{b}+2\varepsilon^u]$ and $[\hat{b}-2\varepsilon^d, \hat{b}]$. The solution is provided by the no-arbitrage condition such that

$$p\, f\left(\hat{b} + \varepsilon^u; \hat{b} + \varepsilon^u\right) + (1 - p) f\left(\hat{b} - \varepsilon^d; \hat{b} - \varepsilon^d\right) = f\left(\hat{b}; \hat{b}/2\right) \tag{A.8}$$

By applying (A7), we obtain

$$p\delta(\hat{b} + \varepsilon^u) + (1 - p)\delta(\hat{b} - \varepsilon^d) = \delta\hat{b} + A\left(e^{\lambda\hat{b}/2} - e^{-\lambda\hat{b}/2}\right) \tag{A.9}$$

which yields the value of A in (12) in the text.