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MONETARY STABILISATION IN A Ccurrency UNION OF SMALL OPEN ECONOMIES

by Marcelo Sánchez

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by Marcelo Sánchez[2]

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Abstract

This paper studies stabilisation policies in a multi-country currency union of small open economies. It abstracts from key factors favouring currency union formation, such as reduced transaction costs and enhanced credibility, which are exogenous to the factors studied here. Demand-side shocks hamper monetary union stabilisation unless members face identical output-inflation tradeoffs and their business cycles are perfectly synchronised. Under supply shocks, welfare implications from joining a currency union are less clear cut. In particular, when these shocks are common across participating countries a tradeoff arises whereby the latter benefit if they are relatively open but are at a disadvantage in case they are of small size. Monetary-fiscal interaction leads to a free rider problem, with area-wide supply shocks eliciting higher interest rate variability. Compared with the case of real wage rigidity, increased real wage flexibility mitigates the free rider problem. Higher trade union decentralisation overall favours a currency union. The present multi-country currency union setup should not be seen as an attempt at settling the sharp differences that exist in the literature. Our model could be modified in order to derive results that are valid in more realistic environments. These include the analysis of public debt considerations in the case of fiscal policies, and both institutional and (further) macroeconomic aspects in the area of wage determination.

Keywords: Monetary union; stabilisation; welfare; small open economies; fiscal policy; wage setting

JEL classification: E52; E58; F33; F42; E63

Non-technical summary

This paper examines monetary policy stabilisation in a multi-country currency union. Member countries are modelled as small open economies that have explicit inflation targets and face supply, real demand and risk premium disturbances. We abstract from key factors favouring currency union formation, such as reduced transaction costs, increased financial and economic integration and enhanced monetary policy credibility, which are exogenous to the factors studied here. Therefore, the welfare analysis carried out in this study is partial and disregards key aspects of real world currency unions. The inflation target of the currency union is allowed to be an average of (possibly country-specific) inflation targets. This may be more general than needed in specific cases; in particular, country-specific inflation targets are not consistent with the setup of EMU. We assess the role of factors such as country size, trade openness, fiscal policies, wage setting, the preference for price stability and the cross-country distribution of shocks. First, we neglect monetary policy's interaction with fiscal policies and wage-setting institutions. The central bank of the monetary union, by reacting to area-wide indicators, propagates shocks across countries. This investigation allows disturbances to be country-specific, evaluating the monetary stabilisation properties of a currency union by means of welfare simulations. Second, we investigate monetary policy in interaction with national fiscal policies, in a context where governments have incentives to respond to domestic macroeconomic developments. Third, both fiscal policies and wage-setting trade unions are allowed to interact with the single monetary authority. We assess how wage-setting considerations affect the free rider problem and whether they enhance or hamper monetary stabilisation.

Our study of monetary stabilisation produces a number of different results. The performance of a currency union depends on the cross-country distribution of shocks, desired inflation and structural parameters. Demand shocks hamper monetary union stabilisation properties, except when participating

countries face identical output-inflation tradeoffs and their business cycles are perfectly synchronised. In the event of supply disturbances, welfare implications from joining a currency union are less clear cut. When supply shocks are country-specific, economies that are relatively small and open are adversely affected. The intuition for this result is as follows. First, small economies play a limited role in the union-wide goals pursued by the single monetary authority, the latter thus helping stabilise the domestic economy less than a national central bank. Second, higher openness makes the supply curve steeper, implying a worse output-inflation tradeoff in which case a currency union cannot handle supply disturbances as well as autonomous monetary policy. Under common supply shocks, a tradeoff arises whereby such countries benefit from being open to international trade but are at a disadvantage due to their small size. Monetary-fiscal interaction leads to a free-rider problem, with area-wide supply shocks eliciting higher interest rate variability. Given that the single monetary authority cannot discipline national fiscal authorities, each of the latter aims at countering domestic shocks. As a result, the common central bank combats the national government's actions. The coordination failure involved here raises the need for institutions that limit uncoordinated national fiscal moves. Compared with the case of real wage rigidity, increased real wage flexibility (related to trade unions which also care about output stabilisation by reducing wages in case of adverse shocks) mitigates the free rider problem and employment volatility. The extent of this beneficial influence decreases with the number of trade unions, as higher decentralisation implies that each union internalises less of the adverse effect of higher wage demand on output supply. This effect is however stronger under monetary autonomy, thereby implying that trade union decentralisation overall improves a currency union's stabilisation performance. The present multi-country currency union setup should not be seen as an attempt at settling the sharp differences between various approaches put forward in the fields of fiscal policy and wage

setting. Our model could be modified in order to derive results that are valid in more realistic environments. These include the analysis of public debt considerations in the case of fiscal policies, and both institutional and (further) macroeconomic aspects in the area of wage determination.

1 Introduction

The experience and prospects of monetary integration around the world have attracted a wide-ranging literature over the last fifty years. The arguments used to evaluate the suitability of a group of countries for monetary integration have mostly focused on two major areas. First, the traditional view, inspired by the early work on optimal currency areas (Mundell, 1961, McKinnon, 1963, and Kenen, 1969), stresses the importance that countries belonging to a monetary union be highly integrated among each other. The motivation for this is that a high degree of real and financial integration would help reduce the likelihood of asymmetric shocks and unsynchronised business cycles. Second, a more recent approach, spawned by the empirical work of Rose (2000), has emphasised the positive impact that currency unions have on international trade via the elimination of exchange rate risks. This has led some analysts to assess more positively the possibility of a country joining a currency union even before full economic integration is achieved.[1] It has however to be mentioned that not all of the considerations about currency unions lead to a support of a common currency. For example, with regard to the operation of labour markets, some studies suggest that currency unions may entail costs in this area by encouraging a wage equalisation process across countries that may fail to be backed by corresponding improvements in productivity.[2]

The aim of this paper is to assess the role of monetary stabilisation in a currency union under three different settings. In each case, welfare analysis is performed by comparing the situation under monetary autonomy with that in the currency union. First, monetary policy is addressed abstracting from its interaction with fiscal policies and wage-setting institutions. The central

[1] For a meta-analysis of a currency union's effect on international trade, see Rose and Stanley (2005).

[2] In a similar vein, Cukierman and Lippi (2001) discuss the possibility that monetary unions raise trade-unions' wage demands. Recently, there have been discussions as to whether this effect could be offset by globalisation or credibility considerations (see *e.g.* Posen and Gould, 2006).

bank of the monetary union, by reacting to union-wide economic indicators, propagates shocks from one country to the others. Among the many studies in this area of research, Lane (2000) is probably closest to our approach to welfare analysis. Following him, the present paper permits disturbances to be country-specific, assessing the monetary stabilisation properties of a currency union by means of welfare simulations (including sensitivity to changes in key structural parameters).[3] Second, we analyse monetary policy in interaction with national fiscal policies. Rather than studying many plausible issues, our analysis focuses on the free rider problem previously analysed by Chari and Kehoe (2008) and Uhlig (2002). Such problem arises in a context where national governments have incentives to respond to macroeconomic developments, creating aggregate demand pressures that end up leading to higher interest rates than in the absence of monetary-fiscal interaction.[4] Third, both fiscal policies and wage-setting trade unions are allowed to interact with the single monetary authority. The importance of labour market institutions has often been highlighted in an optimal currency area context (see *e.g.* de Grauwe, 2005). Our analysis builds on previous work by Onorante (2006). The idea is to provide some insights as to how wage-setting considerations may affect the free rider problem and whether they enhance or hamper monetary stabilisation performance.

The approach pursued here is game theoretic, which in line with a considerable fraction of the studies in the related literature.[5] We disregard the possibility that there is time inconsistency in policymaking. The number of agents

[3] We deviate in different ways from Lane's (2000) original contribution. Such departures include the adoption of a country point of view for welfare analysis (as opposed to Lane's focus on the actual monetary authority), the use of interest rate - and not a money aggregate - as the monetary policy instrument, and consideration of many economies instead of a two-country setup.

[4] One limitation of the approach used here is that it lacks an explicit incorporation of the debt dynamics, which is left for further research. Moreover, we neglect the interesting question of whether fiscal policy can help stabilise the economy in the face of country-specific shocks that cannot be dealt with by the common monetary policy.

[5] Another branch of the related literature explicitly derives its results from first principles. Models with full microfoundations certainly should provide additional insights into the problems under study.

making decisions simultaneously (be it fiscal authorities or trade unions) are assumed not to cooperate in their choices. In the resulting Nash equilibrium, agents of the same type hold the group's all other choices fixed when making decisions, as if they could each reach the best possible outcome by means of unilateral actions. Everybody in each group is doing the same, the end result being that all are worse off than by cooperating. The analysis is thus meant to capture the consequences of coordination failure and to detect factors that could lead to either aggravate or mitigate such phenomenon.

Other features of our approach are the following. The basic model employed in this paper extends the existing literature on currency unions by drawing from recent work on small open economies, as spawned by Ball (1999, 2002) and Svensson (2000). In connection with our focus on small open economies, we neglect the possibility of spillovers across countries of the type normally analysed in two-country models. We propose a setup with a broad set of shocks and a role for national inflation targets. Regarding welfare analysis, we complement our analytical results with quantitative comparisons of stabilisation performance under currency union participation relative to the alternative of autonomous monetary policy. In doing so, we permit in our simulations both disturbances and a key structural parameter (the supply slope parameter) to vary across countries.[6]

Our study of monetary stabilisation in a currency union of small open economies produces a number of different results. The performance of a currency union is found to depend on the cross-country distribution of shocks, desired inflation and structural parameters. Demand shocks hamper monetary union stabilisation properties, safe for the case when participating countries face identical output-inflation tradeoffs and their business cycles are perfectly synchronised. In the event of supply disturbances, welfare implications from

[6] Cross-country diversity in structural parameters may result from a number of different sources. For instance, countries may differ in the trade-off between output and inflation due to differences in their degree of openness (Romer, 1993) or their stage of development (Sánchez, 2006a).

joining a currency union are less clear cut. When supply shocks are country-specific, economies that are relatively small and open are adversely affected. The intuition for this result is as follows. First, small economies play a limited role in the union-wide goals pursued by the single monetary authority, the latter thus helping stabilise the domestic economy less than a national central bank. Second, higher openness contributes to making the supply curve steeper, implying a worse output-inflation tradeoff in which case a currency union cannot handle supply disturbances as well as autonomous monetary policy. Under common supply shocks, a tradeoff arises whereby such countries benefit from being open to international trade but are at a disadvantage due to their small size. Monetary-fiscal interaction leads to a free-rider problem, with the outcome that union-wide supply shocks elicit higher interest rate variability. Given that the single monetary authority cannot discipline national fiscal authorities, each of the latter aims at mitigating the economic consequences of domestic shocks. As a result, the common central bank combats the national government's actions, which leads to wider fluctuations in nominal interest rates. The coordination failure involved in this free-rider problem raises the need for institutions that limit uncoordinated national fiscal moves. Increased real wage flexibility allowing trade unions to have an output stabilisation motive is found to mitigate the free rider problem. The extent to which such increased real wage flexibility entails this beneficial influence decreases with the number of trade unions, as higher decentralisation implies that each union internalises less of the adverse effect of wage demand on the supply side of the economy. This effect induced by a larger number of trade unions is however stronger under monetary autonomy, thereby implying that trade union decentralisation overall improves a currency union's stabilisation performance.

The structure of the rest of the paper is as follows. In section 2, we review the literature on monetary stabilisation in a currency union that analyses the single monetary policy either in isolation from other policies or in its interac-

tion with national fiscal policies. In section 3 the basic model is laid out. The analysis of a currency union is preceded by a study of optimal autonomous monetary policy. Section 3 also presents quantitative results on stabilisation performance relative to monetary autonomy as well as the corresponding sensitivity analysis. In sections 4 and 5, the analysis is extended to the cases where the single monetary policy interacts with fiscal policies, and with both fiscal policies and wage-setting by trade unions, respectively. Section 6 concludes.

2 A review of the literature

Model-based analyses of welfare in a monetary union show large differences in terms of their specification. Most of them consist of two-country (or two-region) frameworks, but a number of multi-country approaches can also be found. Some models are derived explicitly from optimising behaviour, while others lack explicit microfoundations for the equations employed.[7] A number of papers concentrate on monetary stabilisation, while others analyse the interaction between the single monetary policy and the conduct of fiscal policies at the country level. Among the latter studies, there are discrepancies between those that argue in favour of flexibility for national fiscal policies and those that propose that fiscal instruments be constrained in order for monetary stabilisation to operate effectively within the currency union.[8]

[7] The non-optimising models reviewed here have game-theoretical foundations. They are rooted in the Barro and Gordon (1983) tradition, although they may deemphasise the time-inconsistency aspect of the original contribution. In the case of microfounded models, it has become standard to characterise welfare of the agents through a second-order approximation of the utility function. Such characterisation of welfare enables the analyst to model the optimal policy problem through a tractable linear quadratic approach, like in the Barro-Gordon-type approaches.

[8] The present section exclusively reviews literature concerning fiscal issues. At the beginning of section 5 the reader can find a concise discussion of some relevant studies about wage setting behaviour.

2.1 Monetary stabilisation in a currency union

Mundell (1961) is the classical reference for those studies analysing monetary stabilisation at the currency union level separately from fiscal considerations. Following this seminal contribution, it has been customary to investigate a tradeoff involved in monetary union. On the one side, there are the favourable microeconomic effects induced by the reduction in barriers to trade and capital movements with the rest of the currency union. While on the other side are the macroeconomic costs associated with the loss of the monetary policy instrument.

This remains to this day an area of quite active research. For the most part the studies in this field report stochastic simulations analysing the welfare effects of losing independent monetary policy for different configurations of parameters and shocks hitting participating countries. Among the studies conducted in the absence of explicit microfoundations, Lane's (2000) study focuses on the stabilisation performance of monetary union in a two-country framework, while postulating that some monetary aggregate is the instrument of monetary policy. It shows that the performance of a currency union relative to alternative exchange rate arrangements depends on cross-country patterns of consumption and production as well as on the relative weights placed on price stability versus employment stability in the monetary authority's objective function. A related two-country approach is given by Sánchez's (2007a, 2008b; see also 2006b) investigation of monetary union stabilisation properties under the occurrence of two supply shocks, one spreading to the entire economy ("aggregate") and the other differing across production sectors ("sectoral"). In this environment, which allows for productivity-driven real exchange rate developments (such as the classical Balassa-Samuelson effect), welfare analysis is found to depend on the specific shocks impacting member states as well as on the latter's structural characteristics.[9] Unlike these contributions of a

[9] The general message from this whole area of research carries over to the multi-country extensions in Ca' Zorzi and De Santis (2004) and Sánchez (2006a).

sectoral nature, the present paper considers the production of a single type of good.

Lane (2000) can be considered to be closely related to the monetary stabilisation analysis conducted here in section 3. With regard to differences between Lane's paper and the present one, in addition to those discussed in the Introduction, the former paper assumes that the single monetary authority's loss function is a weighted average of those of the individual countries, whereas I assume that the loss function is linear quadratic in the union's average levels of the goal variables. Recent papers have extended the literature to investigate other types of loss functions. For instance, Matsen and Røisland (2005) study, on top of the previously mentioned two types of loss functions, the cases of majority and consensus rules under committee decisions. Moreover, Botazzi and Manasse (2005) analyse a possible adverse selection problem arising from national authorities' incentives to misrepresent the shocks hitting their economies in order to influence the common policy.

Another relevant non-optimising two-country approach is that of Fuchs and Lippi (2006). In a context where time-consistency is an issue, they conclude that monetary union generates welfare gains by making surprise inflation impossible, even if this means the sacrifice of flexibility. The optimal common policy is shown to respond to a country's temptation to leave the union by tilting both current and future policy in its favour. Each country's weight in policy decisions is thus found to be time-varying and depend on its incentive to abandon the union. Interestingly, the paper also analyses conditions under which a break-up of the union would take place, in line with some historical episodes.

Alesina and Barro (2002) develop a formal model to investigate the relationship between currency unions and trade flows. They model the adoption of a common currency as a reduction of "iceberg" trading costs between two

countries. A currency union involves a tradeoff between the benefits of commitment to price stability and the loss of an independent stabilisation policy. Alesina and Barro (2002) find that, under reasonable assumptions about elasticities of substitution between goods, countries that trade more with each other benefit more from adopting the same currency.[10] The authors also investigate what is the optimal number of currencies in the world. In connection with this, they find that smaller countries should be more inclined to give up their currencies. Hence, as the number of countries increases (and their average size shrinks), the number of currencies in the world should increase less than proportionately. Alesina and Barro (2002) establish the conditions under which an even stronger result holds: as the number of countries increases, the equilibrium number of currencies decreases.

Alesina *et al.* (2002) is an empirical application of the approach described in the previous paragraph. It explores the pros and cons for different countries to adopt as an anchor the dollar, the euro, or the yen. The study reports that while there appear to be reasonably well-defined euro and dollar areas, there does not seem to be a yen area. Moreover, the analysis addresses the issue of endogeneity in currency union formation, attempting at answering the question of how trade and co-movements of outputs and prices would respond to the formation of a currency union.

Currency union theory has many points in common with the literature on international monetary policy coordination. The latter literature is normally cast in a two-country environment, with a large number of studies using fully microfounded models. In particular, most of the recent literature on international monetary policy coordination has used so-called "new open economy macroeconomic" (NOEM) models, which assume optimising households, mo-

[10] This result does not hold unambiguously. It is possible that, in contrast with the authors' most likely scenario, the marginal gain from the introduction of a currency union be greater when the existing volume of international trade is low. For instance, this could be the case of trade of intermediate inputs that is initially deterred due to substantial trading costs at volumes for which the marginal product is rather high.

nopolistic competition and nominal rigidities. This work concentrates on the strategic interaction that derives from optimal stabilisation policy. The standard conclusion is that either the allocation with coordinated policies coincides with the allocation obtained under independent policies, or the gains from coordination are small (see *e.g.* Corsetti and Pesenti, 2001, and Obstfeld and Rogoff, 2002).[11]

While the overall conclusion of these recent contributions is that international monetary policy coordination leads to modest or zero gains, there are however some studies that instead obtain clear-cut results either in favour of against the advantages of coordination. In this regard, this whole literature makes clear that domestic monetary policies induce terms of trade effects, which is at the root of the countries' strategic interaction. Cooley and Quadrini (2003) produce results in favour of policy coordination in a model where prices are perfectly flexible and production operates at the efficient level. The authors devote considerable attention to the problem of systematic inflationary biases. They find that policy coordination contributes to avoiding the effect of interest rates on terms of trade, while policy competition generates an inflationary bias with a large adverse welfare effect – one that is magnified by the lack of policy commitment. In addition, coordination achieves a lower inflation rate which compensates for the loss of flexibility involved.[12] Another study favouring international policy coordination is Canzoneri *et al.* (2005). They show that the need for policy coordination in a NOEM model arises because of asymmetries in the stochastic processes for sectoral productivity, with asymmetries in nominal inertia implying an additional need for coordination. Among the papers arguing in favour of international policy competition, Ro-

[11] However, the generality of these results has been disputed (see *e.g.* Benigno and Benigno, 2003).

[12] That this literature is more general than that on monetary unions specifically is illustrated by Cooley and Quadrini's (2003) claim that their theoretical results favouring coordination finds empirical support in the experience of falling and convergent inflation and interest rates that accompanied increasing monetary integration within the European Monetary System both pre- and post-EMU.

goff (1985a) shows that competition helps alleviate the distortion derived from domestic nominal rigidity, while coordination may lead to higher inflation and lower welfare.[13]

Finally, some microfounded general equilibrium models have focused more specifically on the implications of nominal rigidities for monetary union stabilisation. One interesting two-country paper in this area is Benigno (2001), who finds that, if the two countries share the same degree of price stickiness, the optimal policy is to target a weighted average of the national inflation rates. These weights are given by the economic size of each country. In case the two countries differ in the degree of nominal rigidity, the single monetary authority can get close to the optimal plan by attaching a larger weight to the country that exhibits the higher degree of price stickiness. Dellas and Tavlas (2005) focus on the implications of nominal wage rigidity in an EMU context. They find that countries that have a relatively similar degree of wage rigidity (such as France and Germany) would benefit from EMU participation, while for a country like the UK – possessing a more flexible wage contract structure – EMU has the potential to being destabilising. Le and Minford (2006) argue that optimising models may provide the same intuition of optimal currency area analysis as that of standard approaches in that asymmetric economic developments are detrimental to the union. With regard to Dellas and Tavlas' (2005) study, in particular, Le and Minford point out that, while differing nominal rigidities qualify as an asymmetry, the former authors' conclusion deviates from what was found in the earlier literature where the focus on the degree of asymmetry between countries joining EMU was more general. As we have mentioned, microfounded general equilibrium approaches allow for cross-country heterogeneity - be it in the nature of shocks or the characteris-

[13] Cooley and Quadrini (2003) argue that a case for policy competition would likely arise from NOEM models with discretionary policies (no commitment). Their idea is that "in a coordinated equilibrium the distortions induced by monopolistic competition create an incentive for the monetary authorities to inflate. When policies are chosen competitively, however, this incentive is mitigated by the negative impact of inflation on the terms of trade. Therefore, policy competition can lead to lower inflation and higher welfare".

tics of the transmission process - to enter the analysis in a number of different ways. One of the important differences between the microfounded literature discussed here and the approach used in the present paper is that the former is mostly cast in a two-country setup, while we employ a multi-country framework for (a finite number of) small open economies. As we shall see below, we are not explicit about the microfoundations behind the aggregate supply scheduled used (a standard Phillips curve). This schedule is often justified in terms of imperfectly competitive features concerning price formation. It is worth saying that imperfect competition is expected to lead to an inefficient level of economic activity, raising issues of time-inconsistency from the standpoint of monetary policy. Notwithstanding, we ignore the possibility of policies that involve inflation bias, thereby differentiating ourselves from Romer (1993) or Lane (1997), who analyse time-inconsistent equilibria under a monopolistic competition environment. To justify our approach, we could invoke microfounded studies that introduce a government sector that subsidises firms to prevent the equilibrium level of output to be less than the socially optimal level, while financing its activities by means of lump-sum taxes raised from households. Galí and Monacelli (2008) describe conditions under which an employment subsidy that meets the requirements above also offsets terms of trade distortions arising from the imperfect substitutability between domestic and foreign goods. The terms of trade effects involved here (relating to the study of small open economies) must however be distinguished from those that are at the root of the two-country international macroeconomic coordination literature reviewed in the current subsection.

2.2 Interaction between the single monetary policy and national fiscal policies

The literature on monetary-fiscal interaction in a currency union focuses on the problem where, instead of a single benevolent social planner deciding upon

both monetary and fiscal policy, there are different national fiscal authorities acting on their own and independently from the single monetary authority. This literature comprises studies that differ on their focus on either the need of flexibility to adjust to asymmetric shocks (which national fiscal policy can accomplish, while single monetary policy cannot) or the need to constrain fiscal deficits to enhance single monetary policy's performance.[14]

The conclusion as to whether domestic fiscal policy should remain flexible or be limited in a monetary union context does not appear to depend on whether the models used assume optimising agents or resort to an "ad-hoc" formulation instead. Indeed, either type of results has been reached using both classes of models. Moreover, a larger number of analyses are carried out in the context of a two-country framework, with some papers - such as Dixit and Lambertini (2001, 2003), Galí and Monacelli (2008) and Uhlig (2002) among the studies reviewed below - instead using a multi-country approach.

2.2.1 Is there a case for constraints on domestic fiscal policy?

Recent contributions such as Chari and Kehoe (2008) and Uhlig (2002) emphasise that the time-consistency problem of monetary policy may still arise in a monetary union if the fiscal autonomy of the individual countries is not constrained. However, this same methodological approach has the implication that the full gains from monetary unification can be obtained only if the monetary authority is able to commit to future policies. The latter implication is developed in Cooper and Kempf (2004) and Dixit and Lambertini (2001, 2003).[15] Chari and Kehoe's (2008), Dixit and Lambertini's (2001, 2003) and

[14] See Beetsma and Debrun (2004) for a comprehensive review of this literature. The main text concentrates on results relating to the technical effectiveness of fiscal policy as a countercyclical stabilisation tool. Calmfors (2003) discusses other practical considerations, including the political-economy dimension of fiscal policies.

The relevant issue of interactions also extending to national wage-setting trade institutions is not discussed here. In section 5, we undertake an analysis of such interactions inspired in Onorante (2006).

[15] While Dixit and Lambertini (2001, 2003), Chari and Kehoe (2008) and Uhlig (2002) lack explicit microfoundations, Cooper and Kempf (2004) adopt an optimising approach.

Uhlig's (2002) contributions are discussed in the present subsection, given that they point to the convenience of restrictions to national fiscal policies.

Chari and Kehoe (2008) and Uhlig (2002) provide insights into how the monetary-fiscal interaction in a currency union may lead to a free rider problem. Such a problem arises when each of the national fiscal authorities sees itself only as a small player compared to the union-wide average, thereby attaching little importance to its own effect on the union's interest rate decisions. In that case, fiscal authorities free-ride in its policy actions on the single monetary policy. In equilibrium, every country free-rides in this manner, thereby implying an overall worse policy-mix than if the countries were not to join the currency union. Chari and Kehoe (2008) show that the optimality of constraints on non-monetary policies (including fiscal policies but also banking regulation or unemployment policies) depends on whether there is a time inconsistency problem in monetary policy. The presence of the latter problem leads to free riding in the setting of non-monetary policies. The free rider problem is found to lead to higher equilibrium inflation as participating countries follow lax non-monetary policies. This problem can be alleviated by imposing constraints on the non-monetary policies, like debt or deficit limits in the case of fiscal policy. Without time consistency problem there is no free rider problem either, in which case constraints on non-monetary policies would fail to be welfare-improving. Uhlig (2002) focuses the discussion around the EMU case, showing that the free rider problem leads to a situation where, in the absence of constraints on fiscal policies, the ECB would end up responding not only to cost-push shocks but also to the fine tuning actions undertaken by domestic authorities. Uhlig also goes beyond the business cycle consequences of excessive fiscal deficits to address the potentially more severe threat of fiscal and banking crises. Overall, his policy conclusions point to the need for institutional reform, with Stability and Growth Pact deemed to require further strengthening and EMU-wide banking regulation being recommended. Given

the important role attached in the present paper to the free rider problem, the contributions discussed in this paragraph are the most relevant to us with regard to the treatment of fiscal policies.

Dixit and Lambertini (2001, 2003) also develop a case against fiscal policy discretion. They show that fiscal dominance constrains monetary policy to the point where monetary commitment does not produce any gains. This implies that constraining fiscal actions is welfare-improving as it contributes to restoring the commitment power of the union's central bank. Another result from this work is that if the single monetary authority and fiscal authorities do not share the same desired goals for output and inflation, there are welfare gains from the two sides agreeing about the targets. This "monetary-fiscal symbiosis" produces better outcomes that the "leadership" of one of the two sides. In particular, under this arrangement fiscal policy is found to be a better way to achieve the agreed level of output than surprise inflation under discretionary monetary policy.

Some optimising two-country models, such as those of Canzoneri *et al.* (2001) and Leith and Wren-Lewis (2006), examine the implications of the so-called fiscal theory of the price level for monetary union. The key idea here is that a common currency area is not viable if fiscal policy in two (or more) of the countries fails to guarantee fiscal solvency for any sequence of macro-economic developments. Canzoneri *et al.* (2001) demonstrate that monetary policy alone can control inflation under a "Ricardian regime" of fiscal solvency. Instead, in non-Ricardian regimes monetary policy cannot maintain price stability in countries where seigniorage revenues are too small. Leith and Wren-Lewis (2006) report a series of simulations showing that, when fiscal authorities are solvent, fiscal disturbances have limited impact on output and inflation. In contrast, fiscal shocks have a much greater impact on both output and inflation when monetary policy is forced to abandon its pursuit of

price stability.[16]

2.2.2 Is there a case for national fiscal stabilisation?

As mentioned above, Cooper and Kempf (2004) analyse the issue of free-riding and policy coordination failures also tackled by Chari and Kehoe (2008), Uhlig (2002) and Dixit and Lambertini (2001, 2003). The former paper differentiates itself from the latter group by concluding that there is a case for national fiscal stabilisation in a context of commitment on the part of the single monetary authority. In a two-country monetary union context, Cooper and Kempf (2004) analyse the role of fiscal policy in facilitating risk sharing between agents in event of asymmetric disturbances. They show that, when the single monetary authority has the ability to commit to policy, optimal fiscal interventions by national governments will be welfare improving for any correlation of shocks. That is, Mundell's (1961) tradeoff would not take place even if the cross-country correlation between shocks is very low.

Other results pointing to the advantages of fiscal flexibility are reported by Beetsma and Jensen (2005), Ferrero (2005) and Kirsanova *et al.* (2007). The former study investigates the optimal coordinated monetary and fiscal policies under different scenarios. For instance, when the degree of price rigidity is homogenous across the currency union, monetary policy is free from the time-consistency problem, whereas fiscal policy is affected by such a problem. In consequence, fiscal policy commitment entails welfare gains. As in Benigno (2001), with differences in price rigidity, the optimal common monetary policy puts a relatively larger weight on stabilising the inflation of the country with the higher degree of price rigidity. This implies that the other country exhibits more variable inflation and employs a more active fiscal stabilisation policy.

[16] While both studies can be seen as providing arguments for fiscal restraint, only Canzoneri *et al.* (2001) explicitly find that these arguments support the type of limits contained in the Maastricht Treaty (and continuing in the Stability and Growth Pact). Leith and Wren-Lewis (2006) instead conclude that the required extent of debt or deficit control is below that embodied in the Pact.

From a welfare point of view, the use of fiscal policy for stabilisation appears to be relevant, which is the case regardless of whether shocks are asymmetric or positively correlated. Ferrero (2005) shows that, while monetary policy focuses on maintaining price stability, fiscal policy plays a key role to smooth country-specific disturbances. Fiscal rules that respond to a measure of real activity approximate the optimal plan and lead to large welfare gains in comparison with balanced budget rules. Additionally, Kirsanova *et al.* (2007) discuss the potentially large role of fiscal policy in responding to asymmetric shocks, especially in the case where the degree of inflation persistence is high. These authors find that fiscal policy can play an important role in reacting to inflation and output, but that not much is lost if national fiscal policy is restricted to react only to national differences in inflation and output.

Finally, Galí and Monacelli (2008) present an optimising multi-country model of monetary union. They show that, in the presence of nominal price rigidities, the abandonment of autonomous monetary policy produces a stabilisation role for fiscal policy. The stabilising role for fiscal policy is found to be desirable not only from the perspective of each individual country, but – as in Beetsma and Jensen (2005) - also at the union-wide level.[17]

3 A simple model of monetary union stabilisation

In order to investigate monetary stabilisation policy in a currency union, let us consider a simple small open economy model. Four equations describe the

[17] In what is a very important concern for the present paper, Galí and Monacelli's (2008) model cannot assess the implications of size because it assumes that all countries are of the same size, and in particular infinitesimal. For an early monetary union approach in this regard (one focusing on international fiscal coordination issues), see Chari and Kehoe (1990).

behaviour of the private sector in each country $i = 1, 2, ..., n$:

$$y_i = \alpha_i (\pi_i - \pi_i^e) + \varepsilon_i \quad (1)$$

$$y_i = -\beta_i r_i - \delta_i e_i + \varsigma_i \quad (2)$$

$$r_i = \theta_i e_i + \varepsilon_i^f \quad (3)$$

$$r_i = R_i - \pi_{i,+1}^e \quad (4)$$

where all variables, with the exception of the inflation rate (π_i), are expressed in deviations from steady state values. Output (y_i) is in logarithms. Constants have been normalised to zero. All parameters are assumed to be positive. All shocks are of the zero-mean, constant variance type. They are also assumed to be uncorrelated with each other for economy i, but allowed to be correlated across countries.

Equation (1) is a simple aggregate supply schedule which states that output responds positively to surprises from the last period's expectations of the inflation level ($\pi_i - \pi_i^e$). Such a relationship can be derived from an economy where prices are determined as a mark-up over wages and wages are set one period in advance (that is, in accordance with π_i^e).[18] Expression (2) states that aggregate demand is decreasing in the (short-term) real interest rate (r_i). Output also depends negatively on the real exchange rate (e_i). Note that an increase in e_i denotes an appreciation of the real exchange rate. Equation (3) posits a positive relation between interest rates and exchange rates that can be interpreted to mean that higher interest rates encourage capital inflows,

[18] In line with common practice in simplified models, we are not too explicit about the supply-side of the model. For instance, the inclusion of π_i^e in equation (1) could as well capture firms' guesses concerning produced input costs or competitors' prices. However, in light of the results presented in section 5 (where trade unions are allowed to dislike variability in both real wage growth and output), it is best to think of the present section's results as reflecting a very high degree of real wage rigidity, and in particular a lack of response of real wages to employment developments.

For simplicity, we do not include an exchange rate pass-through term in equation (1). The latter is customarily shown to affect monetary policy in a rather simple way by modifying inflation targets with an extra term that corrects for temporary deviations from long run real exchange rate. See *e.g.* Ball (2002) and Sánchez (2008a).

which leads to an appreciation. Other determinants of exchange rates, such as investor confidence and expectations, are captured by the error ε_i^f. Finally, (4) is the Fisher equation defining the real interest rate as a difference between nominal short-term interest rate R_i (or R in the case of a currency union) and the current period's expectation of future inflation, $\pi_{i,+1}^e$. Positive values for ε_i and ς_i represent favourable supply and real demand shocks, respectively, while a positive value for ε_i^f is interpreted to reflect an adverse risk premium shock.

3.1 Autonomous monetary policy

In this case, monetary authorities choose their policy independently at the country level. The central bank minimises a loss function given by[19]

$$L_i = \frac{1}{2}\left[y_i^2 + \chi_i(\pi_i - \tilde{\pi}_i)^2\right] \tag{5}$$

This objective function penalises deviations of both output and inflation from the target, the latter being defined as $\tilde{\pi}_i$ in the case of inflation. For simplicity, we assume that $\tilde{\pi}_i$ adopts a fixed and credible value. The central bank has no incentive to surprise the private sector with inflation even in the presence of supply shocks. In consequence, there is no inflation bias. Parameter χ_i denotes the weight of inflation aversion of the central bank relative to the aim of achieving output stabilisation.

We assume that country i's public knows α_i, β_i, δ_i, θ_i, χ_i and $\tilde{\pi}_i$. In addition, the two-stage game proceeds as follows. First, the public sets its inflation expectations $\pi_{i,+1}^e$. Then, shocks ε_i, ς_i and ε_i^f are drawn. Next, the central bank sets the nominal interest rate R_i. An equilibrium is a subgame

[19] Results do not change if the central bank is modelled as minimising intertemporal objective function $E_t \sum_{s=0}^{\infty} \rho^s L_{i,s+1}$, with $\rho \in (0,1)$, where the period loss function L_i is defined as in (5). The reason is that, given our simplifying assumption that inflation targets are fixed and credible, the model is of a truly static nature. Therefore, the optimisation problem for the central bank would anyway separate into a sequence of one-period decision problems.

perfect equilibrium, except for inflation expectations, which are formed rationally as opposed to strategically. In this context, the monetary authority's state-contingent reaction function is feasible.[20]

The equilibrium can be obtained by solving the model backwards. That is, given inflation expectations, the central bank solves its optimisation problem, and one can then solve for expected inflation. However, given that the monetary policy rule is found to be linear in the shocks, we instead start by imposing the result that expected inflation equals the targeted level (also assumed to be credible), that is, $\pi_i^e = \pi_{i,+1}^e = \tilde{\pi}_i$. This result implies that, in (4), $r_i = R_i - \tilde{\pi}_i$. This eases computational burden in the derivation of the central bank's reaction function in terms of the nominal short-term interest rate.[21] Using (1), (2) and (4) with expected inflation at the targeted level, we obtain

$$R_i = \tilde{\pi}_i + \frac{1}{d_i}\left(-\frac{\chi_i}{\alpha_i^2 + \chi_i}\varepsilon_i + \varsigma_i + c_i\varepsilon_i^f\right) \tag{6}$$

where $d_i \equiv \beta_i + c_i$ and $c_i \equiv \delta_i/\theta_i$. Thus, the central bank raises interest rates above the inflation target in response to a positive excess demand shock and unfavourable supply and risk premium shocks.

Moreover, output and inflation can be expressed as follows:

$$y_i = \frac{\chi_i}{\alpha_i^2 + \chi_i}\varepsilon_i \tag{7}$$

$$\pi_i = \tilde{\pi}_i - \frac{\alpha_i}{\alpha_i^2 + \chi_i}\varepsilon_i \tag{8}$$

where deviations of output and inflation from target are shown to respond to supply shocks. The previous two equations indicate how optimal monetary policy splits the cost of the supply shock between the output gap and inflation.

Finally, replacing (7) and (8) into (5) allows us to express the loss function

[20] On the implications of introducing informational frictions in this type of models, see *e.g.* Sánchez (2007b).

[21] The simplification obtained here is rather small. But it will be considerably larger for the linear policy rules obtained in sections 4 and 5.

and its unconditional expectation as

$$L_i = \frac{1}{2}\frac{\chi_i}{\alpha_i^2+\chi_i}\varepsilon_i^2 \quad (9)$$

$$E(L_i) = \frac{1}{2}\frac{\chi_i}{\alpha_i^2+\chi_i}\sigma_{\varepsilon_i}^2 \quad (10)$$

where $\sigma_{\varepsilon_i}^2$ is the unconditional variance of ε_i. As we can see, α_i plays an important role in equilibrium output and inflation and thereby domestic loss functions. This role will carry over to the country's loss function resulting from currency union participation. For welfare simulation purposes, we shall later work with the inverse of the output-inflation tradeoff, namely, $\alpha_i' \equiv 1/\alpha_i$, which we refer to as the slope of the supply curve. Parameter α_i is likely to reflect cross-country differences in economic structure among countries. In particular, the output-inflation tradeoff can be seen as being negatively related to the degree of openness of the economy. That is, trade openness makes α_i smaller and thus the supply schedule steeper. The reason is that, for a given real exchange rate depreciation associated with output expansion, the inflationary effect is larger the more open the economy is (see *e.g.* Romer, 1993).[22] This means that the higher the degree of openness the larger the rise in overall prices as the price increase in tradable goods exceeds that in non-tradables. A steeper supply curve is known to entail monetary stabilisation costs since a supply shock makes the deviation of inflation from target larger for a given change in the output gap.[23]

[22] An illustrative (partially) microfounded model explaining the mechanism behind this result can be found in Romer's (1993) Appendix. This is a two-country model that distinguishes between sticky and flexible prices, assuming the presence of a direct cost to inflation.

[23] Some studies have found evidence of an inverse relationship between size and openness. Alesina *et al.* (2005) summarise both the evidence and arguments in favour of such inverse link. The evidence is rationalized with the notion that trade openness, by enhancing the magnitude of the market facing a given country, increases the benefits of small size. Conversely, small countries have a strong interest in maintaining access to international markets (including via multilateral and regional means). However, many studies report that there is no simple linear relationship between size and openness, with size in particular being influenced by many other determinants that have not only economic but also historical and socio-cultural roots (see *e.g.* Alesina and Spolaore, 2003). Lacking a precise estimate of the correlation between these two variables constrains us to a purely qualitative evaluation in this area.

We thus see the degree of openness as affecting the slope of the aggregate supply schedule. It is worth saying that a recent microfounded general equilibrium study by Erceg *et al.* (2007) shows that, in addition to having supply-side effects (as characterised by wealth effects on labour supply decisions), openness could also influence the demand side of the model. More specifically, higher openness is seen to increase the interest-elasticity of aggregate demand, provided that the trade price elasticity is higher than the intertemporal elasticity of substitution in consumption. The authors however conclude that openness only seems to matter for calibrations that impose an implausibly high trade price elasticity, even for a wide range of trade shares. For this reason, in what follows we will rather associate openness with its effect on α_i, leaving to the reader the freedom of also attributing to openness some of the consequences that we report from changes in β_i, our coefficient for the interest-elasticity of aggregate demand. Finally, our analysis is subject to the caveat that the output-inflation tradeoff may be affected not only by openness but also by other structural features of the economy.

3.2 The currency union

Let us examine the case in which a number n of small open economies (indexed by i) form a currency union. The union's monetary authority chooses R to minimise the following loss function:[24]

$$L_u = \frac{1}{2}\left[y_u^2 + \chi(\pi_u - \tilde{\pi}_u)^2\right] \tag{11}$$

Mirroring the analysis made at the country level, the union's central bank has no incentive to surprise the private sector with inflation, and there thus is no inflation bias. Parameter χ is the weight of inflation aversion of the

[24] In the following, we denote with subindex u all union-wide aggregates (be it parameters or variables) using $\varphi_i \in (0,1)$. For instance, $y_u \equiv \sum_i \varphi_i y_i$.

central bank relative to the aim of achieving output stabilisation. In (11), the objective function of the central bank is assumed to penalise departures of union-wide output and inflation from desired values set to zero and $\tilde{\pi}_u$, respectively. The latter is assumed to adopt a fixed and credible value, as a result of this also being the case for country-level inflation targets.

The idea that the currency union's inflation target is an average of values that are allowed to be country-specific deserves further discussion. First, the interpretation of possible country-specificities in inflation targets lies with factors other than those contained in the standard set of disturbances and propagation mechanisms. Allowing for potential differences in inflation targets appears to be the more general case, covering all possible specific situations. In particular, the models developed in the present paper can be applied to the case where inflation differentials arising from convergence considerations can be simply ignored (that is, by assuming that $\tilde{\pi}_i = \tilde{\pi}_u$ for all i). As we shall see below, this can be done without affecting any of the substantive welfare results reported here.

After this digression, let us resume the presentation of the model for the currency union case. In resemblance to the country-level analysis of the previous subsection, we assume that the union's public knows α_i, β_i, δ_i, θ_i, χ and $\tilde{\pi}_i$. The remaining informational and timing assumptions are also analogous to those made in the last section, with the single monetary authority in particular taking the place of its national counterpart at the end of the game.

Before we turn to the solution of the model, let us define different types of shocks according to their distribution across the union. This will be needed when interpreting the results and doing welfare analysis. In the case of each shock considered here (be it either a supply, demand or risk premium shock), we examine the three types of shocks, namely: (i) asymmetric; (ii) idiosyncratic; and (iii) common. Shocks are normalised to be of unit magnitude for country I, which is - without loss of generality - the focus of our comparisons

across regimes. Asymmetric shocks are defined to be shocks such that they add up to zero at the currency union level; in particular, country I of size φ_I is assumed to face a shock equal to 1, while each of the remaining countries faces a shock equal to $-\varphi_I/(1-\varphi_I)$.[25] Idiosyncratic shocks are those in which shocks to country I equal 1, and shocks to any other country equal 0. Finally, common shocks are defined to be shocks such that all countries face a shock equal to 1.

To solve the model, let us start by taking averages over (1)-(4), which yields

$$y_u = d_u R + \sum_i \varphi_i \varsigma_i + \sum_i \varphi_i c_i \varepsilon_i^f + \sum_i \varphi_i d_i \tilde{\pi}_i \quad (12)$$

$$\pi_u = -\tilde{d} R - \sum_i \varphi_i \alpha_i' \varepsilon_i + \sum_i \varphi_i \alpha_i' \varsigma_i + \sum_i \varphi_i \alpha_i' c_i \varepsilon_i^f + \sum_i \varphi_i \alpha_i' d_i \tilde{\pi}_i \quad (13)$$

where $\tilde{d} \equiv \sum \varphi_i \alpha_i' d_i$.

We next replace (12) and (13) into (11), and differentiate with respect to R to get the first-order condition. As a result, we derive an expression for the union level monetary policy reaction function:

$$R = \frac{1}{A}\left(-\chi \tilde{d} \sum_i \varphi_i \alpha_i' \varepsilon_i + \sum_i \varphi_i \zeta_i \varsigma_i + \sum_i \varphi_i \zeta_i c_i \varepsilon_i^f + \sum_i \varphi_i \zeta_i d_i \tilde{\pi}_i\right) \quad (14)$$

where $A \equiv d_u^2 + \chi \tilde{d}^2$ and $\zeta_i \equiv d_u + \chi \tilde{d} \alpha_i'$. Expression (14) captures the reaction of the nominal interest rate, which is the central bank's policy instrument, to terms aggregating over shocks and inflation targets at the country level. If the supply schedule parameter α_i shows no cross-country variation, then pure asymmetric shocks in ε_i and ς_i would have no impact on monetary authorities' decisions. If in addition the bunch of model parameters grouped as c_i shows

[25] This definition of asymmetric shocks is rather flexible. In particular, it encompasses the case when half the size of the union faces a shock of 1 and the remaining half one of -1 (in which case $\varphi_I = 0.5$).

no cross-country variation, then the same conclusion can be reached regarding pure asymmetric shocks in ε_i^f. One corollary of this is that, if parameters display sufficient parameter homogeneity across the union (in the sense just described) but shocks are asymmetric, the interest rate would be changed only in response to a rise in the average inflation target. Otherwise, R is raised in response to adverse supply and risk premium shocks, favourable demand shocks and higher desired inflation, judging from the aggregates that appear in (14). In this more general case, R could still react to disturbances depending on country-specific parameter values, even if shocks are asymmetric.[26]

We use (1)-(4) and (14) to derive expressions of output and inflation for a generic individual country I under currency union participation, denoted by y_I^u and π_I^u, respectively:

$$y_I^u = \vartheta_I + \frac{\tilde{\chi dd}_I}{A} \sum_i \varphi_i \alpha_i' \varepsilon_i - \frac{d_I}{A} \sum_i \varphi_i \zeta_i \vartheta_i \tag{15}$$

$$\pi_I^u = \tilde{\pi}_I - \alpha_I' \varepsilon_I + \alpha_I' \vartheta_I + \frac{\tilde{\chi d} \alpha_I' d_I}{A} \sum_i \varphi_i \alpha_i' \varepsilon_i - \frac{\alpha_I' d_I}{A} \sum_i \varphi_i \zeta_i \vartheta_i \tag{16}$$

where $\vartheta_i \equiv \varsigma_i + c_i \varepsilon_i^f + d_i \tilde{\pi}_i$. It is worth mentioning that the composite expression ϑ_i captures the full set of exogenous factors operating through the demand side, as opposed to ε_i which works through the supply side. In particular, it is important to realise that it is the combined forces in ϑ_i that has a direct effect on aggregate demand, and not simply ς_i which we have defined above as the "real demand" shock.

In (15) and (16), developments in each and every country i contribute to determine output and inflation in a given economy I, while also inducing monetary policy responses. The economy appears to be driven by country-level shocks and inflation targets, their impact also reflecting the relative size

[26] See the Appendix for an illustration for the simpler case with parameter homogeneity and a presentation that resembles a two-country model.

of the countries involved and the reactions in each of them as influenced by country-level structural parameters. More concretely, y_I^u and deviations of π_I^u from target are driven by both supply and demand forces. An adverse supply shock at home (that is, a smaller value of ε_I) raises domestic inflation, which is partially countered by an interest rate hike. This monetary policy offset is stronger the more the disturbance is spread across the union (see fourth term of (16)). In particular, the strength of the latter term is increasing in the magnitude of the realisations of ε_i and the associated country sizes φ_i.[27] The monetary tightening involved here leads to a reduction in domestic output (see second term of (15)). Turning to exogenous factors weighing on aggregate demand, an expansionary impulse at home (that is, an increase in ϑ_I) tends to raise both y_I^u and π_I^u, as can be seen in the first term of (15) and third term of (16), respectively. This induces a partially offsetting rise in the interest rate that intensifies the more the impulse is shared by the union's other countries (see third term of (15) and fifth term of (16)).

Expressions for y_I^u and π_I^u in (15) and (16), respectively, can be plugged into (5) to compute the value of country I's loss function under monetary union participation. That value can be denoted by $L_I^u = \left[(y_I^u)^2 + \chi(\pi_I^u - \tilde{\pi}_I)^2\right]/2$. A welfare comparison can be carried out by relating that value to L_I, which is the loss under monetary autonomy in expression (9). More precisely, we shall below look at the ratio $C_{uI} = L_I^u/L_I$ in order to study the sensitivity of relative stabilisation performance of a currency union to changes in parameter values. In particular, a decrease in C_{uI} means that country I enjoys a lower loss, and thus higher welfare, from participating in a currency union. It is worth reiterating that, from a very general point of view, the cross-country distribution of shocks and the values of inflation targets affect the monetary union's stabilisation performance in a way that depends on specific parameter values. In particular, the common central bank reacts to country-specific

[27] The effect is also influenced by the values of structural parameters featuring in ζ_i, and in particular each economy i's country-specific responsiveness of inflation to output, α_i'.

macroeconomic developments in a way that is influenced by the strength of the impulses, the size of the countries affected and the values of relevant structural parameters. Additionally, in a currency union shocks to any given country in general propagate to the rest of the union via the induced interest rate response.

In equations (15) and (16), macroeconomic developments in country I (as given by y_I^u and π_I^u) are affected not only by idiosyncratic supply shocks - as was the case under monetary autonomy - but also by supply shocks to other countries and unexpected factors (captured by ϑ_i) possibly hitting the demand side of every participating economy. In light of the linear quadratic form of country I's loss function, this means that the latter type of shocks weighing on aggregate demand can be considered to lead on balance to a welfare loss from currency union membership relative to monetary autonomy. That is, realisations of ϑ_i imply that relative welfare measure C_{uI} is at least 1 over the range of all possible values. In particular, C_{uI} can be found to equal exactly 1 in case countries exhibit parameter homogeneity and movements in ϑ_i are of the common type.[28] However, as long as either structural parameters or realisations of ϑ_i display cross-country variation, then a welfare loss will be incurred by participating countries - a loss that would fail to occur under autonomy. The reason is that the single monetary policy cannot handle a country's specificity like a national central bank. The cases in which structural parameters and/or exogenous demand factors are country-specific make the difference, with monetary autonomy thus outperforming the currency union for demand-driven economies.[29]

[28] For details in the case of parameter uniformity, see the Appendix.

[29] The common monetary authority may fail to fully offset demand shocks that are country-specific and/or that arise in the context of parameter heterogeneity. In these cases, countries are to a variable extent left to adjust on their own, experiencing larger macroeconomic variability than under the alternative of monetary autonomy. The implied welfare loss can be found to be larger the smaller the country under study and the lower the correlation of its shocks with the rest of the union. See the Appendix for a related analysis in the simpler case of uniform structural parameters.

Turning to the welfare implications of supply shocks, they are found to be more complex given that they are able to affect macroeconomic developments, and thus welfare, both under monetary autonomy and currency union membership. Therefore, rather than constraining ourselves to the qualitative remarks for the case of demand-side exogenous factors - as contained in the last paragraph - we proceed to a more detailed quantitative investigation in the next subsection.

3.3 Relative performance

The analytical results found in the previous section are qualitative, and as such do not indicate the size of the performance differences between regimes, nor how sensitive they are to variations in key parameter values. This section turns to the quantitative analysis of welfare in a currency union relative to that obtained under autonomous monetary policy. We concentrate entirely on shocks to aggregate supply because the latter enter the loss functions for the two scenarios studied here, namely, monetary autonomy and the currency union.

In making relative welfare comparisons, we consider the three types of shocks defined in the previous subsection, namely: (i) asymmetric; (ii) idiosyncratic; and (iii) common. We examine the sensitivity of relative stabilisation performance to changes in key parameters of the model from benchmark values.

The parameter values used here follow calibrations from previous work on small open economies. Our analytical results from last subsection have shown that supply schedule parameter α_i' affects - via composite coefficient ζ_i - the single monetary policy response to forces driving macroeconomic developments and thus welfare. We allow α_i' to display cross-country variation. The central value for α_i' is set to 0.4, again as in Ball (1999). The values of α_i' will hover around that central value. In the benchmark case we allow for two values for

α_i', a high value $\bar{\alpha}' = 0.45$ and a low value $\underline{\alpha}' = 0.35$.[30] In contrast, we do not allow for cross-country variation in $d_i \equiv \beta_i + \delta_i/\theta_i$. More specifically, we set $\beta_i = 0.6$, $\delta_i = 0.2$ and $\theta_i = 0.5$, for all i, as in Ball (1999). This implies that $d_i = 1$ for all i. Our benchmark value for φ_I is 0.1. Finally, we assume one same value for χ_i and χ. In the absence of existing calibrations for χ for small open economies, we use a benchmark value of 2.5, which is very close to Broadbent and Barro's (1997) estimate using US data.

Depending on the values for α_i' among the currency union's member states, we distinguish between three types of reference country I. First, in Case A, we do not allow for cross-country variation in supply slope parameter α_i', in which case the reference country I displays the *average* value $\alpha_I' = \alpha'$ for this parameter. Second, in Case H, the reference country possesses a *high* supply slope parameter, that is, it is type $\bar{\alpha}'$. Third, in Case L, the reference country exhibits a *low* supply slope parameter, that is, it is type $\underline{\alpha}'$.

Using the assumption (maintained in the rest of this subsection) that coefficient d_i exhibits no cross-country variation (that is, it equals d for each country i), and ignoring shocks other than supply disturbances, we can rewrite (15) and (16) as

$$y_I^u = \frac{\chi \alpha_u'}{1 + \chi (\alpha_u')^2} \sum_i \varphi_i \alpha_i' \varepsilon_i \tag{17}$$

$$\pi_I^u = \tilde{\pi}_I - \alpha_I' \left[1 - \frac{\chi \alpha_u' \alpha_I'}{1 + \chi (\alpha_u')^2}\right] \varepsilon_I - \frac{\chi \alpha_u' \alpha_I'}{1 + \chi (\alpha_u')^2} \left(\alpha_I' \varepsilon_I - \sum_i \varphi_i \alpha_i' \varepsilon_i\right) \tag{18}$$

As mentioned in the previous subsection, in order to study the stabilisation performance of a currency union we look at the ratio $C_{uI} = L_I^u / L_I$. This ratio expresses the value of the loss function (11) associated with the reference country's participation in the currency union relative to the loss function obtained under autonomous monetary policy. One key parameter is the slope of

[30] In what follows, whenever we allow α_i' to vary across countries, we assume the following distribution of this parameter within the union: country I can be any type, half the size of the remaining part of the union is type $\bar{\alpha}'$ and the rest is type $\underline{\alpha}'$.

the supply curve, α_i', whose cross-country variation plays a major role in the present model. In this regard, we carry out sensitivity analysis with respect to the central value for this parameter, α', and the difference between high and low alternative values for the latter, which we call simply $spread \equiv \bar{\alpha}' - \underline{\alpha}'$. In addition, we examine the effects of varying two other parameters, namely, the size of the reference country, φ_I, and the relative weight placed by the monetary authority on inflation stability in its loss function, χ. We consider the three scenarios of common, idiosyncratic and asymmetric supply shocks, allowing for either uniform or country-specific supply slope parameters.

In subsection 3.2, we have argued that the current modelling strategy can be used both if inflation targets are country-specific and uniform. Inflation targets are allowed to vary across countries, but they can as well be set to a common value without affecting the substantive results of the present paper. In the case of welfare analysis, the robustness of our analysis can be gauged by comparing equations (17) for output and (18) for inflation under the reference country's participation in a currency union with the corresponding expressions (7) and (8) obtained under autonomous monetary policy. First, output equations - be it (17) or (7) - are not affected by inflation targets. Second, the two expressions for inflation show that this variable reacts one to one with the domestic inflation target, with deviations of inflation from target thus being independent from $\tilde{\pi}_I$. Given that loss functions involve output and deviations of inflation from target as objectives, welfare comparisons are unaffected by whether inflation targets are country-specific or uniform. Having said this, inspection of equations (12) through (14) indicate that other (intermediate) results such as the union-wide levels of output, inflation and interest rates are affected by a number of country-specific parameters, including inflation targets.[31] Again, this does not prevent the model from being general, allowing

[31] Structural inflation differentials affect other intermediate results below, such as fiscal and wage reaction functions. The corresponding terms can however easily be switched off if one prefers to abstract from this complication. The general results reported below reassure the reader that the main results of the paper do not depend on the cross-country distribution of inflation targets.

for parameters to be set to a uniform value (as we do in sections 4 and 5 for the case of slope coefficients).

Figures 1 through 4 show the relative welfare loss under aggregate supply shocks as measured by the ratio C_{uI} for different types of reference countries, cross-country distribution of shocks and parameter values.

In Figure 1, we consider the effects on relative stabilisation performance of varying α', the central value for the supply slope parameter, over the range [0.2-0.6]. An increase in α' indicates a higher responsiveness of inflation to the output gap, that is, a steeper supply schedule. There is a difference between the results for the case of common shocks, on the one hand, and idiosyncratic and asymmetric shocks, on the other. This difference is mostly related to the existence of two different forces driving inflation volatility in different directions when α' increases. First, the second term of (18) captures the same idea as inflation fluctuations when monetary policy is run autonomously (see equation (8)). The intuition for this term is that the relevant monetary policymaker setting interest rates - be it the national central bank or the single monetary authority - splits the damage from supply shocks between output and inflation. Both under monetary autonomy and in the currency union, when α' rises (that is, the supply curve is steeper) inflation fluctuates by more in reaction to a given supply shock. This first channel operates rather similarly under common and country-specific shocks. Second, the third term of (18) indicates that α' affects both the expression in parenthesis and the factor premultiplying it. The expression in parenthesis captures deviations between the inflationary impact of the own supply shock and that for the union as a whole. This expression should be rather small under common shocks (and even zero in Case A when supply curve slopes are also homogeneous), but it tends to be larger, on top of increasing in α', when shocks are country-specific. The fraction premultiplying the expression in parenthesis, which measures how

much of the country-specific shock to inflation is not offset by an interest rate change, is also increasing in α'.

Let us use the results in the previous paragraph to analyse the welfare implications of changes in α' in the face of different types of shocks. For common shocks, the second term of (18) is mostly responsible for the outcome. In Case A, where there are no cross-country differences in supply slopes either, changes in α' have no effect on welfare as monetary policy is as effective in a currency union as it is when it is conducted autonomously. When countries differ in their output-inflation tradeoff, participation in a currency union implies some stabilisation costs, but these are declining in α'. The reason is that, for a given value of *spread*, an increase in the central value for supply slope coefficients implies an increasingly homogenising effect that makes monetary union a less disadvantageous option. The relative improvement (compared to baseline parameter values) is larger for Case L. This stems from the initial condition that in this case an autonomous country would enjoy a more favourable tradeoff, which becomes eroded at a faster pace as the supply curve becomes steeper.

Turning to country-specific shocks (of either the idiosyncratic or asymmetric type), an increase in α' is bad for currency union participation irrespective of the initial supply curve of country I. Here it is the third term of (18), which captures the inflationary effect of country-specific shocks, that is the key for the result. As we have seen, an increase in α' magnifies the effect of such shocks by both making the inflationary gap in parenthesis larger and by increasing the fraction of such impulse that is not offset by the single monetary authority. This effect is present in the currency union only, and highlights the difficulty involved in employing the single monetary policy to stabilise supply shocks of a country-specific nature.

Figure 2 reports sensitivity analysis for *spread* over the range [0.05-0.35]. Under common supply shocks, the differences between participating countries are constrained to their sizes and the values of α_i'. For both Cases H and L,

an increase in *spread* induces a deterioration in monetary union performance. The deterioration is larger for Case L as in this case the country enjoys under autonomy an increasingly favourable output-inflation tradeoff as $\underline{\alpha}'$ (country I's supply slope) goes down. The same mechanism, working in reverse, instead contributes to improve a currency union's stabilisation properties in Case H, when the reference country's supply slope ($\underline{\alpha}'$) goes up as *spread* rises. However, this result is overturned by the increasing role of the third term of (18) in driving inflation volatility up. This is driven by an increasing value of $\underline{\alpha}'$ compared to α'_u driving the expression in parenthesis up, coupled with a larger coefficient premultiplying that expression. That is, in Case H the extra inflationary effect stemming from the increasingly steep supply curve (relative to the union's average) has on balance an adverse impact on monetary union's performance.[32] Turning to country-specific shocks, as with the increase in α', a higher *spread* triggers an increasing role of the third term of (18). In Case H, the implied higher supply slope makes the overall inflationary impact from the shock larger. In Case L, the inflationary effect instead becomes smaller. That is, a higher *spread* is favourable (adverse) for a currency union's stabilisation performance when the reference country has a flatter (steeper) supply schedule.

In Figure 3, we vary φ_I over the range [0.05-0.5]. An increase in φ_I affects welfare only in the currency union. The increase in a country's own size tends to induce a favourable effect from currency union participation. In terms of the inflationary effect of a supply shock, the reason behind this is that a higher φ_I implies a reduction in the intensity of both the second and third terms of (18), as the single monetary policy puts a larger weight on the country's macroeconomic variables when determining its interest rate decision. Therefore, this decision gets closer to what would be done under monetary autonomy. Simi-

[32] In Case L, instead, the third term of (18) becomes positive due to an increasingly lower $\underline{\alpha}'$. However, the stabilising effect on inflation from this channel is damped down by a reduction in the coefficient premultiplying the expression in parenthesis.

larly, output fluctuations in (17) approach those under monetary autonomy as φ_I becomes larger. The exceptions to the favourable consequences of size for currency union membership are given by: *i)* no effect at all for Case A in the face of common and asymmetric shocks (the former explained by the relative lack of cross-country variation and the latter by the definition of asymmetric shocks); and *ii)* the only adverse effect of size for monetary union performance is Case L under asymmetric shocks (due to the smaller monetary policy offset in light of the lower α'_u caused in turn by the higher weight attached to a flat supply country – see coefficient in third term of (18)).

Figure 4 reports sensitivity analysis for the central bank's preference parameter χ over the range [0.5-5].[33] The increase in χ tends to have an adverse influence on a currency union's stabilisation properties. The exception to this is Case A under the occurrence of common shocks, in which situation there is no difference between the two regimes as highlighted by the similarity in the interest rate response between monetary autonomy and the currency union. In all other cases, a higher weight on price stability raises the stabilisation costs associated with the single monetary policy in the face of cross-country heterogeneity (as given by country-specific shocks and/or heterogeneous supply schedules).

Let us end this subsection with a summary, including a further discussion in a couple of instances. In the face of supply shocks both a change in the central value and the cross-country variation of supply curve slopes have welfare implications that depend on the distribution of shocks within the union. For common shocks, an across-the-board steeper supply curve improves the stabilisation performance of a currency union, while a wider intra-union dispersion of supply slopes generates the opposite outcome. For country-specific shocks (of either idiosyncratic or asymmetric nature), a steeper supply schedule is a

[33] Parameter χ is of central importance in models of monetary policy. For instance, Rogoff (1985b) favours the appointment of a central banker with χ higher than its social value in order to achieve lower equilibrium inflation rates. It is worth saying that this result does not carry over to our model since we do not allow for inflation bias.

challenge for the single monetary policy which offsets a smaller fraction of a country's inflationary pressures. These types of disturbances are also more favourable to currency union participation in countries with flatter than supply curves than in those with steeper ones - the latter countries facing a more disadvantageous output-inflation tradeoff. For the remaining two parameters analysed (preference for inflation stability and country size), the results are more clear cut. A higher preference for inflation stability on balance hampers a currency union's stabilisation, given that inflation volatility - which is harder to control than when the monetary authority operates autonomously - is now penalised more harshly. It is worth stressing however that the analysis abstracts from favourable effects that could stem from a stronger commitment to price stability, with credibility effects being often cited as one consideration for some countries to adopt a (more established) foreign currency. A larger country size tends to favour monetary union participation, with only one case where the opposite is true (a country with a relatively flat supply curve whose larger size would contribute to a smaller anti-inflationary monetary policy offset). These results for country size and different supply slopes can be used to assess welfare implications for small open economies. For this, we use the above-mentioned positive relationship between trade openness and steepness of the supply curve. For country-specific supply shocks, relatively small open economies are more adversely affected by monetary union participation. In the event of common shocks, there is instead a tradeoff between the (favourable) effect of openness and the (adverse) one resulting from a smaller size. This highlights the relevance – also for small open economies - of the discussion about whether currency unions have implications for the likelihood of common as opposed to country-specific disturbances. As discussed by Frankel and Rose (1998), some important economic developments may be endogenous to monetary union.[34] One such development is the enlargement-induced rise in

[34] For simplicity, our analysis has made the impact of changing structural parameters conditional on the occurrence of various types of shocks (see also Lane, 2000). In other

overall trade. The safest assessment of the current debate is that stronger trade integration has no very clear implications for the distribution of shocks within the union. It could make business cycles more synchronised - as we are tempted to believe - but it might as well lead to specialisation and thus increase the likelihood of country-specific shocks (Kalemli-Ozcan *et al.*, 2001).

4 Monetary-fiscal interaction

As discussed in section 2, the literature on the interplay between monetary and fiscal policies in a currency union focuses on the problem where there are different national fiscal authorities acting on their own and independently from the single monetary authority. This section attempts to shed some light on the consequences of this type of monetary-fiscal interaction in a monetary union context, in particular concentrating on the free rider problem involved. This problem arises in a context where, from each national government's perspective, there are incentives to respond to disturbances hitting the individual country and to shocks to other participating countries that are transmitted across the borders via the common monetary policy reaction. By responding under these circumstances, fiscal authorities' responses lead to an overall worse outcome for all countries in the union.[35] The model used here is the natural extension to fiscal policy of that used in section 3. It is also closely related to Uhlig (2002), with the main contribution here lying on the welfare analysis which borrows from that carried out in the previous section. This analysis can also be seen as facilitating the understanding of the more complex issue - also involving an interaction with wage-setting institutions - presented in section 5.

words, we treat the size and asymmetry of disturbances as exogenous, disregarding the possibility that the distribution of shocks and parameter values might both well depend on the intensity of regional integration (which is different across monetary policy regimes).

[35] By focusing on the free rider problem, the present analysis neglects another issue concerning fiscal policy addressed in the literature, namely, the need for flexibility on the fiscal side to respond to certain shocks when necessary.

Let us first look at the case of monetary autonomy, then studying the economy as it joins the currency union. The main goal is to compare welfare under these two scenarios. The economy in each country i (with $i = 1, 2, ..., n$) resembles that presented in section 3, with the addition of a public deficit term g_i (that is, the difference between spending and taxes):[36]

$$y_i = \alpha_i (\pi_i - \pi_i^e) + \varepsilon_i \tag{19}$$

$$y_i = -\beta_i r_i - \delta_i e_i + g_i + \varsigma_i \tag{20}$$

$$r_i = \theta_i e_i + \varepsilon_i^f \tag{21}$$

$$r_i = R_i - \pi_{i,+1}^e \tag{22}$$

All parameters in the expressions above are positive.

In the monetary autonomy case, the central bank has the same objective function in the previous section:

$$L_i = \frac{1}{2}\left[y_i^2 + \chi_i(\pi_i - \tilde{\pi}_i)^2\right] \tag{23}$$

which is still considered to represent society's preferences.

The objective function that the fiscal authority is assumed to minimise is given by

$$L_{gi} = \frac{1}{2}\left[y_i^2 + \gamma_i(g_i - \varepsilon_{gi})^2\right] \tag{24}$$

that is, the fiscal authority dislikes both deviations of output from potential and deviations of g_i from random term ε_{gi}. This shock reflects changes in the deficit that may arise randomly, as resulting from spending needs or available revenues differing from their projected values. Objective function (24) reflects the government's preference for both output stability and a balanced budget. Parameter γ_i is the weight the fiscal authority puts on a balanced budget relative to stable economic activity.

[36] We do not distinguish between the macroeconomic effects of a changes in g_i resulting from a change in spending as opposed to one in taxes.

The three-stage game has the following sequence. First, the public sets its inflation expectations $\pi^e_{i,+1}$. Then, disturbances ε_i, ς_i, ε^f_i and ε_{gi} are drawn. Second, the fiscal authority chooses the deficit g_i. Third (and finally), the central bank sets the nominal interest rate R_i. The timing used here implicitly assumes that central bank actions have no way to influence fiscal policy choices. This can be justified by the real-world feature that fiscal policy tends to depend on exogenous factors (not least political ones such as elections and compromises between parties). Moreover, it makes sense to portray monetary policy as reacting more timely to economic developments, including changes in the fiscal stance of participating countries. In contrast, fiscal policy is largely the result of a long process of negotiation which is not very likely to factor in the latest interest rate decision.

As in section 3, we solve for the equilibrium by proceeding backwards. Given inflation expectations and fiscal deficit levels, the national central bank solves its optimisation problem, which leads to monetary policy reaction function

$$R_i = \tilde{\pi}_i + \frac{1}{d_i}\left(-\frac{\chi_i}{\alpha_i^2+\chi_i}\varepsilon_i + g_i + \varsigma_i + c_i\varepsilon_i^f\right) \tag{25}$$

Interest rates are raised above the inflation target in response to positive excess demand developments (be it driven by "private sector shocks" in ς_i or fiscal deficits) and unfavourable supply and risk premium shocks.

The fiscal authority of country i knows the interest rate rule (25). It solves its optimisation problem by choosing g_i to minimise (24) subject to the constraint given by (25). The solution is simply given by $g_i = \varepsilon_{gi}$. Under monetary autonomy, the optimal fiscal choice is to adjust deficits only in response to the fiscal shock ε_{gi}, but not to the shocks to supply, private demand and the risk premium. The nominal interest rate, inflation rate, output gap and real exchange rate are then independent of the preferences of the fiscal authority. The reason is that the national fiscal authority recognises that its reaction to the disturbances other than ε_{gi} would be fully compensated for by the monetary

authority moving subsequently: there thus is no point in reacting to them.

Again, as in section 3, output and inflation can be expressed as follows:

$$y_i = \frac{\chi_i}{\alpha_i^2 + \chi_i}\varepsilon_i \tag{26}$$

$$\pi_i = \tilde{\pi}_i - \frac{\alpha_i}{\alpha_i^2 + \chi_i}\varepsilon_i \tag{27}$$

Only the supply shock influences output and inflation in equilibrium. The demand pressures generated by fiscal shock ε_{gi} fail to affect output and inflation, being instead fully offset by higher interest rates, as can be seen in (25).

By plugging (26) and (27) into (23), we obtain the following value for the loss function:

$$L_i = \frac{1}{2}\frac{\chi_i}{\alpha_i^2 + \chi_i}\varepsilon_i^2 \tag{28}$$

When every country i (with $i = 1, 2, ..., n$) participates in a monetary union, the problem is changed from the previous one by having the union's central bank minimise:

$$L_u = \frac{1}{2}\left[y_u^2 + \chi_i(\pi_u - \tilde{\pi}_u)^2\right] \tag{29}$$

The informational assumptions are analogous to those made for the monetary autonomy case in this section. The definitions for types of shocks according to their distribution across the union are the same as in section 3, while being extended to the fiscal shock as well. Concerning the timing of events, the one-period game has the following sequence. First, the public sets its inflation expectations $\pi_{i,+1}^e$. Then, shocks ε_i, ς_i, ε_i^f and ε_{gi}, for each country i, are drawn. Next, the fiscal authority in each country i sets the deficit g_i. Finally, the single monetary authority sets the nominal interest rate R.

The common central bank's reaction function is the same as in section 3,

except for the addition of aggregates of g_i :

$$R = \frac{1}{A}\left(-\chi\tilde{d}\sum_i \varphi_i \alpha_i' \varepsilon_i + \sum_i \varphi_i \zeta_i g_i + \sum_i \varphi_i \zeta_i \varsigma_i + \sum_i \varphi_i \zeta_i c_i \varepsilon_i^f + \sum_i \varphi_i \zeta_i d_i \tilde{\pi}_i\right) \tag{30}$$

Equation (30) indicates how the nominal interest rate responds to expressions aggregating over shocks and inflation targets at the country level. R reacts as long as underlying country developments do not happen to offset each other at the currency union level. In the absence of such offset, monetary policy is tightened in response to adverse supply and risk premium shocks, favourable demand developments and higher desired inflation. In contrast, if parameters α_i, c_i and d_i show no cross-country variation, then pure asymmetric shocks in ε_i, ς_i and ε_i^f can be shown not to contribute to changes in R (which now carries over to asymmetric fluctuations in g_i). Under such homogeneity conditions, the nominal interest rate would still reflect union-wide inflation as captured in $\tilde{\pi}_u$.[37]

To proceed, let us assume that parameters α_i, c_i, d_i, χ_i and γ_i are homogeneous across the union's countries, that is, $\alpha_i = \alpha$, $\alpha_i' = \alpha'$, $c_i = c$, $d_i = d$, $\chi_i = \chi$ and $\gamma_i = \gamma$. Let us also assume that φ_i shows no cross-country variation either, that is, each country i has the same size $\varphi_i = 1/n$. In this case, we can rewrite (30) as

$$R = H + \frac{1}{d}\left(\frac{g_I}{n} + \frac{n-1}{n}\bar{g}_I\right) \tag{31}$$

where $H \equiv \tilde{\pi}_u - (a\varepsilon_u - \vartheta_u)/d$ and $\bar{g}_I \equiv \sum_{i \neq I} \varphi_i g_i$ is the weighted average of deficits in countries other than I.

The fiscal authority in a given country I knows the interest rate rule (31). It solves its optimisation problem by choosing g_I to minimise (24) subject to

[37] These results for homogeneous parameters can be obtained using the same logic that was followed in the Appendix in the absence of fiscal authorities.

the constraint given by (31). The first order condition can be written as

$$g_I = \frac{\gamma n^2}{\gamma n^2 + (n-1)^2}\nu_I + \frac{n(n-1)}{\gamma n^2 + (n-1)^2}dH + \frac{(n-1)^2}{\gamma n^2 + (n-1)^2}\overline{g}_I \qquad (32)$$

where $\nu_i \equiv \varepsilon_{gi} - [(n-1)/(\gamma n)]\vartheta_i$ for all i. Composite shock ν_I can be interpreted as fiscal shock ε_{gI} net of the fraction - given by $(n-1)/n$ - of the exogenous factors affecting demand in ϑ_I that is not offset by the single monetary policy. This fraction is in turn appropriately rescaled by fiscal policy preference parameter γ.

In order to compute the individual country government deficit, replace $\overline{g}_I$ with $(ng_u - g_I)/(n-1)$ in equation (32). We solve by aggregating for g_u to find

$$g_u = \frac{\nu_u}{\gamma} + \frac{n-1}{\gamma n}dH \qquad (33)$$

The interest rate reaction function (31) can thus be written as

$$R = \frac{1}{d}\left[\varepsilon_{gu} + \vartheta_u - \frac{\gamma n + n - 1}{\gamma n}a\varepsilon_u\right] \qquad (34)$$

where $a \equiv \chi/(\alpha^2 + \chi)$. Equation (34) shows that, in responding to union-wide shocks, the monetary policy reaction varies inversely with d, which is the interest-rate sensitivity of output.

The individual country government deficit can be expressed as

$$g_I = \frac{\gamma n}{\gamma n + n - 1}\nu_I + \frac{n-1}{\gamma n + n - 1}dR \qquad (35)$$

Here g_I appears to be equal to a weighted average of the country-specific "net fiscal shock" ν_I and the foreseen nominal interest rate R, rescaled by the latter's effect on the output gap (as given by d). That is, the fiscal stance is eased to alleviate the real effects of the imminent monetary tightening. For concreteness, with adverse supply shocks, each national fiscal authority

rationally anticipates an interest rate hike, thereby deciding to generate a larger deficit in order to mitigate the macroeconomic impact at home. But that in turn means that the single monetary authority will tighten in order to maintain its desired combination of inflation and output.[38]

To better assess the role of fiscal policy in monetary stabilisation, let us compare (34) with the equivalent expression in the absence of fiscal policy considerations. Such equation is given by (A.1) from the Appendix, which obtains when we impose parameter homogeneity on the more general expression (14). The comparison indicates that the interest rate rise following an adverse supply shock is higher when allowing for fiscal policies. This can be seen in the fact that the factor $(\gamma n + n - 1)/\gamma n$ affecting the response of R to supply shocks in (34) - and that is lacking in (A.1) - is larger than 1.[39] Moreover, this factor is increasing in the number of fiscal authorities, n, and decreasing in the weight put by them on the fiscal objective, γ. In this model, however, the damage from monetary union enlargement (that is, a rise in n) is limited: the factor $(\gamma n + n - 1)/\gamma n$ amplifying the effect of supply shocks on R tends in the limit to $(1 + \gamma)/\gamma$. When this bound is attained, no fiscal authority internalises any of the effects of its action, making its decision while simply ignoring its implications for the single monetary policy. With regard to the role of γ, a higher weight on the fiscal objective reduces the free rider problem, in the limit even eliminating it altogether as $(\gamma n + n - 1)/\gamma n$ approaches 1. The intuition for this is that, by focusing more on the budget as opposed to fine tuning the economy, fiscal authorities create less of a need for interest rates to offset the incipient business cycle fluctuation.

[38] Consideration of a - say - rise in exogenous demand factors in ϑ_u is more complex as it involves the implications of both a higher interest rate and, in case a change to ϑ_I is involved, a smaller value for the country-specific "net fiscal shock" ν_I. The latter effect should however be relatively small.

[39] For instance, under our baseline value for $n = 10$ (in light of $\varphi_I = 0.1$) and setting γ to 0.5 (as in Herz *et al.*, 2004), the factor $(\gamma n + n - 1)/\gamma n$ equals 2.8.

It is worth mentioning that the free rider problem discussed here is robust to whether inflation targets are assumed to be country-specific or uniform.

The implications of monetary-fiscal interaction can also be gauged by replacing (34) into (35) to get

$$g_I = \varepsilon_{gI} - \frac{n-1}{\gamma n + n - 1}\left[(\varepsilon_{gI} - \varepsilon_{gu}) + (\vartheta_I - \vartheta_u)\right] - \frac{n-1}{\gamma n} a\varepsilon_u \qquad (36)$$

The fiscal stance is eased (by an increase in deficit g_I) in response to a positive fiscal shock ε_{gI}, which is partially offset by an interest rate hike if the own fiscal shock exceeds the union average - as captured by the $\varepsilon_{gI} - \varepsilon_{gu}$ term. Moreover, the individual country deficit is raised in the event of country-specific contractionary demand pressures ($\vartheta_I - \vartheta_u$ term) and adverse union-wide supply shocks in ε_u. The presence of terms other than ε_{gI} in (36) reflects the notion that, in some plausible scenarios, the currency union's central bank does not discipline fiscal actions, contrary to what was the case in the monetary autonomy case. Suppose that a given fiscal authority has a reason (as given by - say - an adverse union-wide supply shock) to increase its deficit in order to mitigate the worsening economic conditions at home. Given that each fiscal authority only has an effect proportional to $1/n$ of the union's economy, it looks as if it could pursue unilateral actions (holding all other choices fixed) and still attain the best possible outcome. Nonetheless, all other national fiscal authorities are embarking in similar actions, the end result simply being an increase in the nominal interest rate beyond what would have otherwise taken place.[40] The reason for this is that the common central bank combats the expansionary pressure stemming from higher government deficits. The previous result is indicative of a typical coordination failure as given by the problem of free-riding in a currency union.

All fiscal authorities would be better off in a cooperative equilibrium, in which they agree to a common fiscal policy of balanced budgets, thereby achieving the same outcome as under monetary autonomy (in the absence

[40] Again, see (34) and the interpretation of this expression in light of factor $(\gamma n + n - 1)/\gamma n$ being bounded above by 1.

of fiscal shocks). In contrast, in the decentralised equilibrium the deficit is different from zero, depending on exogenous factors. One way out of the co-ordination failure involved is the type of constraints is given by a ceiling on national deficits g_i's being interpreted as a tool to help all member states reap gains from cooperation.

We use (19)-(22), (34) and (35) to find the output gap and inflation rate for a generic individual country I under union participation, denoted by y_I^u and π_I^u, respectively:

$$y_I^u = a\varepsilon_u + \frac{\gamma n}{\gamma n + n - 1}\left[(\varepsilon_{gI} - \varepsilon_{gu}) + (\vartheta_I - \vartheta_u)\right] \tag{37}$$

$$\pi_I^u = \tilde{\pi}_I - \frac{1-a}{\alpha}\varepsilon_I - \frac{a}{\alpha}(\varepsilon_I - \varepsilon_u) + \frac{1}{\alpha}\left(\frac{\gamma n}{\gamma n + n - 1}\right)\left[(\varepsilon_{gI} - \varepsilon_{gu}) + (\vartheta_I - \vartheta_u)\right] \tag{38}$$

The single monetary policy may miss output and inflation targets not only in the face of idiosyncratic supply shocks - as was the case for monetary autonomy - but also under some other country-specific scenarios for supply shocks and exogenous factors affecting aggregate demand. In the event of common shocks, favourable supply disturbances raise output and lower inflation at the individual country level, while factors lifting aggregate demand (either those in fiscal shocks ε_{gi}'s or "private demand shocks" ϑ_i's) fail to have an effect on π_I^u and y_I^u. Compared to common disturbances, country-specific supply shocks have a smaller impact on output, while the inflationary effect is larger since the offset from monetary policy is scaled down by the country's size. Country-specific exogenous factors raising demand have expansionary and inflationary consequences, contrary to the lack of any effect detected in the pure symmetric case. For instance, in case $\varepsilon_{gI} > \varepsilon_{gu}$ both output and inflation increase at home as monetary policy fails to offset the entire impulse. However, a redistribution of monetary tightening effects is taking place here, which once more generates a scope for cooperation by setting limits to cross-country devi-

ations in the fiscal stance. Naturally, the magnitude of the spillovers involved is constrained by the size of the deviating union members.[41]

By plugging (37) and (38) into (23), the value L_I for the loss function can be computed in terms of the deviations of individual country output and inflation from their targets. Taking into account the linear-quadratic form of the loss function, the results for y_I^u and π_I^u discussed in the previous paragraph have the following welfare implications. Similarly to what was concluded in section 3, shocks affecting the demand side of the economy are found to reduce participating countries' welfare in light of the larger output and inflation volatility compared to the monetary autonomy case. Given that demand-side disturbances fail to impact the monetary policy tradeoff of a country operating autonomously, they can be seen as leading to a deterioration in monetary union stabilisation properties. Instead, supply shocks happen to affect welfare both when a country follows autonomous monetary actions and when it joins a currency union.

Qualitatively speaking, the main conclusions from section 3 concerning welfare analysis thus still hold true. The only new parameter arising from the monetary-fiscal interaction studied in the present section is γ, the fiscal authorities' weight on fiscal instrument stability. This parameter only affects the volatility of output and inflation, and thus welfare, in the event of demand-side shocks (see the last composite terms of both (37) and (38)). The latter shocks are unambiguously welfare-reducing from the point of view of a country joining the currency union. Moreover, it is worth recalling that a higher value of γ is found to reduce the free rider problem: by focusing more on strict budget considerations the fiscal authorities avoid the temptation to fine tune the economy, thereby contributing to a smoother interest rate path. While parameter n - which is an inverse measure of the relative size of a country -

[41] Uhlig (2002) compares the cross-country (output and inflation) adjustments taking place in this example with the real forces involved by the Balassa-Samuelson-type effects that affect the new EU member states. Of these, Slovenia adopted the euro on 1 January 2007, while Cyprus and Malta followed on 1 January 2008.

has already been studied in section 3, it adopts a new connotation here by representing the number of national fiscal authorities in the currency union. In this regard, a higher value of n is found to aggravate the free rider problem as each fiscal authority internalises less of the interest rate implications of changes in national budget.

In sum, some results from section 3 are seen to carry over to the analysis of monetary-fiscal interaction. In particular, demand-side exogenous factors (now also including random elements impacting the fiscal budget process) have welfare implications only under currency union participation, making the latter a less preferable arrangement compared to monetary autonomy. Adverse supply disturbances instead worsen the tradeoff facing the monetary authority both under currency union and autonomous policy.[42] The most important new finding concerns the emergence of a free rider problem. While monetary autonomy does not impede fiscal discipline, national fiscal authorities are found to free-ride on a currency union's common central bank who cannot fully tackle country-specific shocks. The existence of such free rider problem raises the question as to how to improve over the coordination failure arising in the decentralised equilibrium. To avoid this free rider problem, institutions should be designed that make fiscal authorities focus on budget considerations as opposed to reacting to cyclical fluctuations. For instance, putting a cap on national deficits constrains the temptation in each country to seek an improvement in their situation at the expense of all other monetary union participants.

[42] Rather than reporting simulations for the model extension presented in this section, we postpone a deeper discussion of the free rider problem and other issues arising from the analysis of monetary-fiscal interaction to the next section. There the discussion of both qualitative and detailed quantitative results will take place in the more general context of interactions also extending to wage-setting institutions.

5 Monetary-fiscal-wage interaction

This section revisits the interplay between monetary and fiscal policies presented in section 4 in a context where trade unions set wage demands independently. Here we allow for more real wage flexibility by modelling trade unions as disliking variability in both real wage growth and output - the latter capturing a concern for employment stability. One key question addressed is that of whether trade union decentralisation can be seen as amplifying the free rider problem arising from monetary-fiscal interaction. The analysis is reminiscent of Onorante (2006), who investigates the convenience of fiscal constraints in an environment where the output of participating countries is hit by disturbances. In his analysis, fiscal activism is related with both entry in monetary union and with structural differences in the national labour markets. He concludes that fiscal constraints on government deficits appear essential in a monetary union when one takes wage setting into account. In this section, we analyse the role of a number of shocks affecting all endogenous variables of the model, while also carrying out an explicit welfare analysis along the lines of section 3.

In addition to real wage flexibility considerations, we allow trade unions to react to output developments, which can be regarded as an attempt at implicitly capturing employment developments. Our approach in part relates to the macro variety of studies about trade union behaviour. Cukierman and Lippi (1999, 2001) and Iversen and Soskice (1998, 2000) are arguably the most representative analyses in this area.[43] They draw from Calmfors and Driffill's (1988) seminal paper, which supports the view of a hump-shaped relationship between wage bargaining centralisation and economic performance, with both centralised and decentralised levels of wage bargaining contributing to lower inflation and unemployment. In particular, at a higher degree of centralisation the union internalises the cost of inflation induced by wage pressures to a larger extent, thereby increasing the chances of wage restraint. In Cukierman

[43] See Calmfors (2001) and Cukierman (2004) for partial surveys of the related literature.

and Lippi's (1999, 2001) two-country model, a coordination problem between wage-setting institutions and the single monetary authority of a currency union occupies centre stage. After currency union formation, trade unions correctly perceive that their size is reduced relative to the total (area-wide) labour force. In consequence, they engage in more aggressive wage demands, knowing that this will have a smaller impact on - and thus be offset to a lesser extent by - the single monetary policy than in the case of policies conducted by a national central bank.

The studies mentioned in the previous paragraph propose a non-linear link between wage bargaining centralisation and economic performance. This contrasts with Bruno and Sachs (1985), who derive a linear relationship between trade union centralisation and economic outcomes - the best economic outcomes being reached when wages are set at a centralised level. Soskice (1990) challenges Calmfors and Driffill's (1988) approach by claiming that it is actual rather than formal wage bargaining institutions that determine economic outcomes, with some formally decentralised experiences turning out to in practice imply a comparable degree of coordination as formally centralised cases. More recently, a different result from the models in the previous paragraph has become under scrutiny, namely, the prediction that monetary union leads to more aggressive wage demands on the part of trade unions. This has been questioned by Posen and Gould (2006), who reviews other approaches that point to the opposite conclusion (see two paragraphs below) while also better aligning with the empirical evidence.

Unlike the studies mentioned two paragraphs above, in our modelling of trade union behaviour we neglect some potentially important macro factors such as a concern for inflation and – in light of not modelling labour market explicitly - the roles of unemployment and the substitutability of labour across trade unions (see *e.g.* Cukierman and Lippi, 1999 and 2001, on these aspects). Moreover, while we assess the role of trade union (de)centralisation

in an environment of lack of coordination, a large number of wage bargaining institutional features are considered beyond the scope of the present paper. These include, for instance, union membership, union coverage, the precise level at which wages are negotiated, the length of collective bargaining agreements, and the roles of productivity and indexation mechanisms.[44]

Further to the previous models having a relatively strong macro emphasis, four other approaches have been put forward to explain the link between wage bargaining and labour market behaviour, and in particular to account for the wage restraint phenomenon (most often characterised as real wage growth below productivity growth).[45] First, some analyses relate to the degree of international competition in product markets (Danthine and Hunt, 1994). In this view, wage-setting institutions have incentives to moderate wage demands because they believe that this helps home firms' competitiveness, thereby favouring domestic employment. Second, a different approach looking at international forces behind wage restraint emphasises the role played by global competition in inducing a decline in union density. The latter decline is a process triggered by the rise in the global labour supply among emerging markets, which competes with workers located in advanced economies (Dumont *et al.*, 2006). Third, drawing on the political science tradition, Garrett (1998) and Hibbs (1987) emphasise the differences between the preferences of central banks and trade union negotiators, with the former being the type of agent that attaches a larger weight to inflation *vis-à-vis* economic activity indicators. According to this view, wage-setting institutions characterised by lower union density and lower centralisation would be more likely to back wage moderation, while the central bank would then tend to follow its preferences

[44] See *e.g.* Du Caju *et al.* (2008) for the role of all these factors among OECD economies. The OECD maintains, for some of its member countries, a comprehensive dataset for union density, the ratio of minimum to median wage, and indexes of union coverage, coordination and corporatism. See Freeman (2007) for a recent survey of the literature on the role of the different institutional factors weighing on collective wage negotiations.

[45] See Posen and Gould (2006) for a more in-depth discussion of these additional approaches.

for low inflation more closely. Fourth and lastly, currency union formation is sometimes seen as creating conditions for wage restraint indirectly, through the promotion of positive structural effects. Wage-setting institutions would feel more inclined to wage restraint in an environment of contained and predictable inflation, with a common central bank more credibly seen (compared to at least some pre-existing national central banks) as standing ready to move in case too aggressive wage settlements were to threaten price stability.

Interestingly, all previously mentioned approaches are still to be supported by robust empirical results. Indeed, a wide-ranging empirical literature reports difficulties in uncovering a convincing relationship between different theoretical predictions and labour market results. Concerning the predictions of the literature with a stronger macro orientation, there has been a failure to uncover a clear connection between wage bargaining centralisation and economic outcomes (see *e.g.* Aidt and Tzannatos, 2005; and Flanagan, 1999).[46] OECD (2004, ch. 3) strikes a similar negative note more generally regarding the link between any of the institutional features for which indicators can be constructed (see footnote 43), on the one hand, and both wage and non-wage outcomes, on the other.[47]

As mentioned earlier, the present paper extends the existing literature by modelling a multi-country currency union of small open economies and performing welfare comparisons with respect to the autonomous monetary policy arrangement. What we do not attempt to do here is to settle the sharp differences between different approaches proposed in the fields of either fiscal policy or wage setting. Instead, we propose a simple setup which could

[46] On the prediction that restrictive monetary policy rules that are internalised by wage setters can lead to favourable equilibrium outcomes for output and unemployment, Franzese (2001) finds that disagreement remains over the precise nature of these interactive effects (also see Acocella *et al.*, 2008).

[47] Posen and Gould (2006) find in cross-sectional investigations that wage restraint either is unchanged or has increased in the vast majority of countries. This finding contradicts the predictions of the first brand of macro-models reviewed here that deal with the coordination of labour market bargaining. The authors however report some time-series evidence in favour of wage restraint as a result of credibility gains for the case of Italy.

in the future be modified in order to derive results that are valid in other environments of interest. These include the analysis of dynamical public debt considerations in the case of fiscal policies, as well as both institutional and (further) macroeconomic features in the area of wage determination.

5.1 The monetary autonomy case

Once more, we start by studying the economy under monetary autonomy, then looking at the currency union case. The main goal is to compare welfare under these two scenarios. To proceed, let us assume that parameters α_i (and thus its reciprocal α_i'), c_i and d_i are homogeneous across the union's countries, that is, $\alpha_i = \alpha$, $\alpha_i' = \alpha'$, $c_i = c$ and $d_i = d$. Let us also assume that φ_i shows no cross-country variation either, that is, that each country i has the same size $\varphi_i = \varphi = 1/n$.

The economy in each country i (with $i = 1, 2, ..., n$) is basically the same that was studied in section 4, safe for the addition of a supply-side role for deviations in wage growth from expected inflation $(\pi_i^w - \pi_i^e)$ in aggregate supply:

$$y_i = \alpha\left(\pi_i - \pi_i^e\right) - \lambda\left(\pi_i^w - \pi_i^e\right) + \varepsilon_i \tag{39}$$

$$y_i = -\beta r_i - \delta e_i + g_i + \varsigma_i \tag{40}$$

$$r_i = \theta e_i + \varepsilon_i^f \tag{41}$$

$$r_i = R_i - \pi_{i,+1}^e \tag{42}$$

As in the previous two sections, all parameters are positive.

Under monetary autonomy, the central bank once more minimises

$$L_i = \frac{1}{2}\left[y_i^2 + \chi(\pi_i - \tilde{\pi}_i)^2\right] \tag{43}$$

which is still considered to represent society's preferences.

As in section 4, the fiscal authority has the following objective function is assumed to minimise is given by

$$L_{gi} = \frac{1}{2}\left[y_i^2 + \gamma(g_i - \varepsilon_{gi})^2\right] \tag{44}$$

In the model extension used here, each trade union j (with $j = 1, 2, ..., m$) in the country under study minimises

$$L_{wi} = \frac{1}{2}\left[y_i^2 + \kappa(\pi_{ij}^w - \tilde{\pi}_i)^2\right] \tag{45}$$

that is, trade unions like neither deviations of output from steady state nor deviations of wage growth from targeted inflation. The objective function above reflects the desire of trade unions to enjoy stability in both the economy and real wage growth. Parameter κ is the weight each trade union puts on real wage growth stability relative to output stability.

The following sequence is assumed for the one-period game. First, the public sets its inflation expectations $\pi_{i,+1}^e$. Then, the disturbances ε_i, ς_i, ε_i^f and ε_{gi} are drawn. Next, each trade union j sets π_{ij}^w. Then, the fiscal authority sets the deficit g_i. Finally, the autonomous monetary authority chooses the nominal interest rate R_i. In addition for the reasons behind the timing order for monetary and fiscal moves discussed in section 4, the analysis in the present section assumes that wage-setting institutions behave independently from both fiscal and monetary decisions.[48]

Once more, we solve the model by proceeding backwards. Given inflation expectations, fiscal deficit levels and wage demands, the national central bank solves its optimisation problem, which leads to monetary policy reaction

[48] Onorante (2006) justifies this by arguing that the normal situation is one where there is a large number of trade unions in a given country, with their reactions being harder to anticipate than those of the fiscal authorities. In addition, wages tend to be set for many years and the contracting process is much more dispersed and slower than that characterising fiscal decisions.

function

$$R_i = \frac{1}{d}\left[-a\varepsilon_i + g_i + \vartheta_i + \lambda a\left(\pi_i^w - \tilde{\pi}_i\right)\right] \tag{46}$$

As before, the interest rate responds to business cycle fluctuations arising from both the demand and supply sides - in the latter case now including the reaction to real wage growth. The central bank raises the interest rate above the inflation target in response to factors raising demand (be it driven by private-sector shocks, fiscal deficits or higher inflation targets) and unfavourable supply shocks.

The fiscal authority knows the interest rate rule (46). It solves its optimisation problem by choosing g_i to minimise (44) subject to the constraint given by (46). Once more, the solution is given by $g_i = \varepsilon_{gi}$, which means that monetary discretion is consistent with fiscal discipline. Taking into account this, together with (46), output can be expressed as

$$y_i = a\varepsilon_i - \lambda a\left(\pi_i^w - \tilde{\pi}_i\right) \tag{47}$$

Trade union J chooses its wage growth demand, π_{iJ}^w, to minimise (45) subject to (47). In doing so, it takes into consideration the role of π_{iJ}^w in overall wage growth, π_i^w. The latter relationship obeys

$$\pi_i^w - \tilde{\pi}_i = \frac{\pi_{iJ}^w - \tilde{\pi}_I}{m} + \frac{m-1}{m}\left(\overline{\pi}_{iJ}^w - \tilde{\pi}_i\right) \tag{48}$$

where $\overline{\pi}_{iJ}^w$ is the weighted average of wage growth for unions other than J. Aggregating over individual trade union's choices can be found to yield

$$\pi_i^w = \tilde{\pi}_i + \frac{\lambda a^2}{(\lambda a)^2 + m\kappa}\varepsilon_i \tag{49}$$

National wage inflation π_i^w deviates in equilibrium from target inflation by a term affected by supply shocks. The result that the latter shocks instead fail to affect fiscal policy highlights the central bank's difficulties in offsetting

supply-side factors (including wage developments) in contrast to its ability to control demand factors such as the fiscal impulse.

Taking into account the interaction between the three parties involved (namely, the central bank, the fiscal authority and the group of trade unions), the following monetary policy reaction function can be derived:

$$R_i = \tilde{\pi}_i + \frac{1}{d}\left[-\frac{m\kappa}{(\lambda a)^2 + m\kappa} a\varepsilon_i + \varepsilon_{gi} + \varsigma_i + c\varepsilon_i^f\right] \tag{50}$$

Moreover, output and inflation can be expressed as follows:

$$y_i = \frac{m\kappa}{(\lambda a)^2 + m\kappa} a\varepsilon_i \tag{51}$$

$$\pi_i = \tilde{\pi}_i - \left(\frac{1-a}{\alpha}\right)\frac{m\kappa}{(\lambda a)^2 + m\kappa}\varepsilon_i \tag{52}$$

where output and deviation of inflation from target are shown to respond to supply shocks. The previous two equations indicate how optimal monetary policy splits the cost of the supply shock across the output gap and inflation. Interestingly, the fact that $m\kappa/\left[(\lambda a)^2 + m\kappa\right]$ is a fraction bounded above by 1 indicates that increased real wage flexibility is a stabilising factor in the response of both y_i and π_i to supply shocks. This stabilising property however appears to fade away as trade unions become more decentralised (larger m). Finally, replacing (51) and (52) into (43) allows us to compute a value for the loss function L_i.

5.2 Monetary union stabilisation

When every country i (with $i = 1, 2, ..., n$) participates in a monetary union, the problem changes from the previous one by having the currency union's (as opposed to the national) central bank minimise:

$$L_u = \frac{1}{2}\left[y_u^2 + \chi_i(\pi_u - \tilde{\pi}_u)^2\right] \tag{53}$$

Individual country loss function (43) is still considered to represent society's preferences in any country i. The informational assumptions are also analogous to those made earlier in this section, with the single monetary authority taking the place of its national counterpart at the end of the game. The definitions for types of shocks according to their distribution across the union still hold. With regard to timing, the one-period game has the following sequence. First, the public sets its inflation expectations $\pi^e_{i,+1}$. Then, the disturbances ε_i, ς_i, ε^f_i and ε_{gi}, for country i, are drawn. Next, each trade union j sets π^w_{ij} in each country i. Then, the fiscal authority in each country i sets the deficit g_i. Finally, the single monetary authority sets the nominal interest rate R.

The single monetary policy reaction function is the same as in section 4, except for the addition of aggregates of a real wage term:

$$R = \frac{1}{d}\left[-a\varepsilon_u + \vartheta_u + g_u + \lambda a\left(\pi^w_u - \tilde{\pi}_u\right)\right] \tag{54}$$

Expression (54) formulates the reaction function of the currency union's central bank. Interest rates are raised in the face of adverse supply shocks, favourable exogenous demand factors (involving both the private sector and the governments) and positive deviations of wage growth from expected inflation. Notwithstanding, pure asymmetric shocks in ε_i, ς_i and ε^f_i would not contribute to movements in R, which is also true for asymmetric fluctuations in deficits and deviations of wage growth from targeted inflation.

The fiscal authority of a given country I knows the interest rate rule (54). It solves its optimisation problem by choosing g_I to minimise (44) subject to the constraint given by (54). The solution is given by

$$g_I = \frac{\gamma n^2}{\gamma n^2 + (n-1)^2}\nu_I + \frac{n(n-1)}{\gamma n^2 + (n-1)^2}d\tilde{H} + \frac{(n-1)^2}{\gamma n^2 + (n-1)^2}\bar{g}_I \tag{55}$$

where $\tilde{H} \equiv \tilde{\pi}_u - \left[a\varepsilon_u - \vartheta_u - \lambda a\left(\pi^w_u - \tilde{\pi}_u\right)\right]/d$. Here the deficit appears to

be raised in the event of shocks ν_I at home, union-wide developments in $\tilde{H}$ (including wage inflation pressures) and deficits $\bar{g}_I$ incurred elsewhere in the monetary union.

Monetary-fiscal interaction can also be gauged by replacing (54) into (55) to get

$$g_I = \varepsilon_{gI} - \frac{n-1}{\gamma n + n - 1}\left[(\varepsilon_{gI} - \varepsilon_{gu}) + (\vartheta_I - \vartheta_u)\right] + \frac{n-1}{\gamma n} a \left[-\varepsilon_u + \lambda\left(\pi_u^w - \tilde{\pi}_u\right)\right] \tag{56}$$

Optimal fiscal policy is seen to increase the deficit g_I in response to a positive fiscal shock ε_{gI}, which is partially offset by an interest rate hike if the own fiscal shock exceeds the union average - as captured by the expression $\varepsilon_{gI} - \varepsilon_{gu}$. In addition, the fiscal stance is eased if demand shocks in ϑ_i's are more contractionary at home than in the rest of the union ($\vartheta_I < \vartheta_u$). The second (composite) term carries in front the factor $(n-1)/(\gamma n + n - 1)$, which lies between 0 and 1. The less-than-full impact implied by this factor for idiosyncratic demand-side developments (that is, cases where $\varepsilon_{gI} \neq \varepsilon_{gu}$ and/or $\vartheta_I \neq \vartheta_u$) reflects the following result: The higher the interest of the government in the fiscal outcome target (that is, the higher γ, and thus the lower factor $(n-1)/(\gamma n + n - 1)$), the lower the fiscal authority's interest in offsetting fluctuations in targeted output as arising from country-specific developments in aggregate demand. Finally, fiscal policy is also relaxed in the face of adverse union-wide supply developments affecting the last composite term of (56). Within this last composite term, we see that the shock to aggregate supply and the wage inflation term have different signs. We shall see below that the former term prevails, as wage inflation is itself driven by the supply shock but reacts to it less than one to one in light of wage-setting institutions' sensitivity to output developments.

Following the same steps as in section 4, the interest rate reaction function

(54) can be written as

$$R = \tilde{\pi}_u + \frac{\varepsilon_{gu} + \vartheta_u}{d} + \frac{a}{d}\left(\frac{\gamma n + n - 1}{\gamma n}\right)\left[-\varepsilon_u + \lambda\left(\pi_u^w - \tilde{\pi}_u\right)\right] \quad (57)$$

The interest rate reflects the union-wide inflation target and is raised in response to aggregate demand pressures (see $\varepsilon_{gu} + \vartheta_u$ term) and adverse supply developments grouped in the last composite term in (57).

The individual country output can be expressed as

$$y_I = \frac{\gamma n}{\gamma n + n - 1}\left(\varepsilon_{gI} + \vartheta_I - dR\right) \quad (58)$$

A given trade union J in country I minimises (45) subject to (58). This requires use of the information on the interest rate contained in (57) as well as on the link between wage growth decided by the trade union (π_{IJ}^w) and union-wide wage growth (π_u^w):

$$\pi_u^w - \tilde{\pi}_u = \frac{1}{n}\left[\frac{\pi_{IJ}^w - \tilde{\pi}_I}{m} + \frac{m-1}{m}\left(\bar{\pi}_{IJ}^w - \tilde{\pi}_I\right)\right] + \frac{n-1}{n}\left(\bar{\pi}_I^w - \bar{\tilde{\pi}}_I\right) \quad (59)$$

where $\bar{\pi}_I^w$ and $\bar{\tilde{\pi}}_I$ are the weighted averages of wage growth and targeted inflation in countries other than I, respectively.

Aggregating over trade unions decisions (in a way similar to that used for fiscal policies in the previous section) allows us to obtain wage growth for country I and at the currency union level, respectively, as:

$$\pi_I^w = \tilde{\pi}_I + \frac{\lambda a^2}{(\lambda a)^2 + nm\kappa}\varepsilon_u + \frac{\gamma n}{\gamma n + n - 1}\left[(\vartheta_I - \vartheta_u) + (\varepsilon_{gI} - \varepsilon_{gu})\right] \quad (60)$$

$$\pi_u^w = \tilde{\pi}_u + \frac{\lambda a^2}{(\lambda a)^2 + nm\kappa}\varepsilon_u \quad (61)$$

Expression (60) indicates that domestic wage growth rises in response to favourable realisations of either union-wide supply shocks or demand-side

domestic pressures in excess of those existing at the currency union level. Equation (61) shows that only the former source of changes in π_I^w (that is, union-wide supply shocks in ε_u) carries over to overall wage inflation π_u^w.

Using (61), the monetary and fiscal policy feedback rules can be rewritten as

$$R = \tilde{\pi}_u + \frac{\varepsilon_{gu} + \vartheta_u}{d} - \frac{a}{d}\left(\frac{\gamma n + n - 1}{\gamma n}\right)\frac{nm\kappa}{(\lambda a)^2 + nm\kappa}\varepsilon_u \tag{62}$$

$$g_I = \varepsilon_{gI} - \frac{n-1}{\gamma n + n - 1}\left[(\varepsilon_{gI} - \varepsilon_{gu}) + (\vartheta_I - \vartheta_u)\right] - \frac{n-1}{\gamma n}\frac{nm\kappa}{(\lambda a)^2 + nm\kappa}a\varepsilon_u \tag{63}$$

In (62), the interest rate rises above the inflation target to counter union-wide forces given by favourable demand shocks (second term) and adverse supply shocks (third term). The response of R to the latter disturbances reflects two factors: i) the free rider problem discussed in section 4, which continues to show in ratio $(\gamma n + n - 1) / \gamma n$; and ii) a new, stabilising element that is introduced by increased real wage flexibility and appears in fraction $nm\kappa / \left[(\lambda a)^2 + nm\kappa\right]$, which is bounded above by 1. The reason for this dampening effect is the following. In the presence of adverse supply shocks, trade unions have an incentive to lower wage demands. By doing so, they partially offset the shocks' inflationary and contractionary consequences, thereby indirectly eliciting a smaller interest rate reaction due to free-rider-problem considerations. As anticipated earlier, the same stabilising force influences the fiscal decision in (63): union-wide adverse supply shocks demand less of an increase in the individual country deficit now that part of the disturbance is offset by wage moderation. In any case, the dampening role of increased real wage flexibility in monetary and fiscal stabilisation is increasing in its degree of centralisation. Indeed, more decentralised trade unions, as captured by an increase in m, turns out to increase the fraction $nm\kappa / \left[(\lambda a)^2 + nm\kappa\right]$, and thus reduce the stabilising role of wage formation.

As discussed in the previous paragraph, the free rider problem is mitigated due to wage moderation in the face of disturbances impinging on aggregate supply. The framework developed in section 3 was there described as being consistent with wage inflation being set in accordance with expected inflation (in particular implying $\pi_u^w = \tilde{\pi}_u$ at the union level). This means that the economy faces an extremely high degree of real wage rigidity in the face of shocks. Compared with that, loss function (45) is associated with enhanced real wage flexibility due to trade unions' sensitivity to output effects induced by aggregate supply disturbances. It is worth mentioning, however, that this modelling strategy entails a higher degree of real wage rigidity than would be observed under perfectly competitive labour markets. The "stabilising" role of trade union behaviour referred to above should only be interpreted relative to the extremely rigid real wage determination in the basic model of section 3. In particular, the force in question is not "fully" stabilising, but exerts only a partial offset to some of the impacts of supply disturbances (as in the case of the free rider problem).[49]

Finally, we use (39) (with $\pi_I^e = \tilde{\pi}_I$), (55), (57) and (58) to find the output gap and inflation rate for individual member state I, denoted by y_I^u and π_I^u, respectively:

$$y_I^u = \left[\frac{nm\kappa}{(\lambda a)^2 + nm\kappa}\right] a\varepsilon_u + \frac{\gamma n}{\gamma n + n - 1}\left[(\varepsilon_{gI} - \varepsilon_{gu}) + (\vartheta_I - \vartheta_u)\right] \tag{64}$$

$$\begin{aligned}\pi_I^u &= \tilde{\pi}_I - \frac{(1-a)}{\alpha}\left[\frac{nm\kappa}{(\lambda a)^2 + nm\kappa}\right]\varepsilon_I - \left[\frac{\lambda^2 a + nm\kappa}{(\lambda a)^2 + nm\kappa}\right]\frac{a}{\alpha}(\varepsilon_I - \varepsilon_u) \\ &\quad + \frac{1}{\alpha}\left(\frac{\gamma n}{\gamma n + n - 1}\right)\left[(\varepsilon_{gI} - \varepsilon_{gu}) + (\vartheta_I - \vartheta_u)\right]\end{aligned} \tag{65}$$

[49] Our baseline calibration will put a neutral weight between wage-setting institutions' two objectives, that is, output stability and real wage stability. From expressions (64) and (65) below, however, we can see that - in the limit - a neglect for the latter objective would fully insulate output and inflation developments from supply shocks.

Once more, output and inflation are driven not just by idiosyncratic supply shocks - as was the case under monetary autonomy - but also by supply shocks elsewhere in the union and exogenous factors weighing on aggregate demand. Two aspects of equations (64) and (65) are worth emphasising. First, country-specific shocks cause both output and inflation to increase at home as monetary policy fails to offset the full effect. A redistribution of monetary tightening effects is taking place here, as other countries (even those not hit by own shocks themselves) will be indirectly affected by the interest rate response. In the specific case of ε_{gI}, this can be seen to create a scope for cooperation by setting limits to cross-country deviations in the fiscal stance. Naturally, the magnitude of the spillovers involved is constrained by the size of the deviating union members. Second, the presence of increased real wage flexibility introduces a dampening effect into monetary and fiscal stabilisation rules. Compared to the pure monetary-fiscal interaction in section 4, smaller changes in interest rates are needed in the presence of wage formation. In this context, output fluctuations are reduced. Indeed, as can be seen in the first term of (64), the usual impact from union-wide supply shocks is now pre-multiplied by fraction $nm\kappa/\left[(\lambda a)^2 + nm\kappa\right]$ which cannot exceed 1. The wage mechanism involved also contributes to dampen inflation volatility, as given by the second term of (65). Closer inspection indicates that increased real wage flexibility brings about an additional contribution which is not necessarily stabilising. In the third term of (65), country-specific supply shocks (that is, when ε_I deviates from ε_u) are seen to now entail a generally larger impact than before, given that $\left[\lambda^2 a + nm\kappa\right] / \left[(\lambda a)^2 + nm\kappa\right]$ is bounded below by 1. For this reason, it is convenient that we proceed to complement these qualitative analytical results with a quantitative simulation study. The latter is intended to shed light on the economic relevance of the mechanisms at play.

5.3 Welfare implications

Let us now turn to the welfare implications which we draw on the basis of sensitivity analysis. As in section 3, we focus exclusively on aggregate supply disturbances since this is the only type of shock that influences the loss function of the national central bank operating autonomously. This contrasts with the currency union regime, in which national welfare is affected by all types of disturbances. In consequence, sensitivity analysis is particularly relevant in the case of aggregate supply shocks, as in all other cases the occurrence of disturbances leads to higher stabilisation costs in case potential participating countries relinquish their monetary sovereignty.

With regard to calibration, many of the parameter values employed here are the same as those used in section 3, while some modifications to the parameter set now mirror those introduced into the model specification. First, we only consider the case of an homogenous supply slope, that is, $\alpha_i' = \alpha'$ for all i - the case that we had labelled Case A in section 3. In consequence, we do not allow *spread* to play a role in welfare comparisons any longer. Second, we must calibrate wage-related parameters, lacking any guidance from previous studies, we set $\lambda = 0.2$, $\varphi_m \equiv 1/m = 0.1$ and $\kappa = 1$.[50] Our sensitivity study will allow these three new parameters to vary over the ranges $[0.05, 0.5]$ for λ, $[0.05, 0.5]$ for φ_m, and $[0.5, 5]$ for κ. With regard to fiscal authorities' weight on instrument stabilisation, γ, there is no need to calibrate it for the present analysis since this parameter does not influence supply shocks' impact on macroeconomic developments (see (64) and (65) as well as their monetary autonomy counterparts).[51]

Once more, in order to study the stabilisation performance of a currency union we look at the ratio $C_{uI} = L_I^u / L_I$, which relates the value of the loss

[50] Parameter φ_m simply measures the size of any given trade union in each and every country.

[51] As we have seen, this parameter does instead play a role in the face of demand shocks, while also weighing on the magnitude of the free rider problem.

function of the monetary authority under a currency union to that obtained under autonomous monetary policy. Figures 5 through 10 show the relative welfare loss under aggregate supply shocks as measured by the ratio C_{uI} for different types of reference countries, cross-country distribution of supply shocks and parameter values.

There is a difference between the results for the case of common shocks, on the one hand, and country-specific shocks (that is, idiosyncratic and asymmetric shocks), on the other. Compared with section 3, the differences worth highlighting here are naturally related to the interaction of monetary policy with fiscal authorities and trade unions. This includes possibly modified sensitivity results for previously existing parameters and the insights provided by the study of the new coefficients, namely, φ_m and λ. In the case of the former type of parameters, changes with respect to section 3 are related to a comparison between fractions $nm\kappa/\left[(\lambda a)^2 + nm\kappa\right]$ and $m\kappa/\left[(\lambda a)^2 + m\kappa\right]$, which feature in expressions (64) and (65) for output and inflation, respectively. Given that both fractions lie between 0 and 1, they capture a partial stabilisation of the effect of aggregate supply shocks on macroeconomic developments (both output and inflation, as can be seen in (64) and (65)) under currency union participation and monetary autonomy, respectively. The intuition behind these (partially) stabilising influences have to do with the assumption that both governments and wage-setting institutions care about output stability; taking these concerns into account, the monetary authority in question simply decides how to split the damage caused by the disturbance (but partly offset by the two former types of agents) into changes in output and inflation. Under supply shocks of the common type, the welfare ratio C_{uI} is affected by the values of the two afore-mentioned fractions in relation with each other. In particular, it is important to compare the evolution of the part of common shocks that fails to be offset by interest rate changes under each alternative monetary arrangement. For all parameter values, it is worth

noting that such fraction is smaller under autonomous monetary policy than in a multi-country currency union (for which $n > 1$).

Overall, under common shocks the stabilisation costs raised by a currency union do not appear to be much different from those arising under autonomous monetary policies. This general result is in line with what was found in section 3. This is hardly surprising, in light of the implied similarities between the problems facing the monetary authority in each regime. After all, this was the case under the basic setup and the afore-mentioned fractions governing changes with respect to section 3 do not appear to have a very large impact, tending to imply that relative welfare C_{uI} is rather insensitive to parameter values.[52] Only two parameters exhibit perceptible welfare implications thanks to also having a larger effect on the previously mentioned fractions (and more precisely, on either of them in relation to the other). These two parameters correspond to the class of "new" parameters not yet defined in section 3, namely, φ_m and λ (see panels (a) of Figures 8 and 10, respectively). Both happen to be wage-related. An increase in λ is found to hamper a currency union's stabilisation performance as it reduces the fraction of inflation variability that is not offset by monetary policy by more than when the latter is run autonomously. Helping explain this result, an enhanced sensitivity of economic activity to wage developments entails a worsening of the output-inflation tradeoff facing the single monetary authority (also relative to monetary autonomy). Concerning φ_m, the increase in the size of trade unions (and thus a reduction in their number per country) allows interest rate decisions to dampen a larger fraction of supply-driven inflation variability in a currency union (even compared with monetary autonomy). The task of the common central bank is facilitated by the result that fewer trade unions each of them internalises a larger fraction of the impact of their wage setting on output stability. However, the correspond-

[52] This is related to the fact that - for the range of parameter values considered here - both fractions are rather large, thereby tending to be little affected in the context of our sensitivity analysis.

ing (partially) stabilising contribution is stronger under monetary autonomy, thereby implying that a higher φ_m has a relatively detrimental impact on the single monetary policy. Put it differently, trade union decentralisation overall favours monetary union relative to the case where interest rates are set autonomously.

Regarding the welfare analysis under country-specific shocks (see panels (b) and (c) of Figures 5 through 10), the performance of monetary autonomy relative to a currency union is now also affected by the way the latter arrangement is able to cope with the supply shock gap $\varepsilon_I - \varepsilon_u$ featuring in the third term of (65). The latter term captures the impact of spillover effects on a given country's domestic inflation from other countries' reactions to the supply shock differential. Such spillover involves the reaction of the interest rate to a country-specific disturbance, taking into consideration the propagation response through the rest of the union. Once more, the comparison of results with those obtained in section 3 involve the interaction of monetary policy with fiscal authorities and trade unions. And when compared with the case of common shocks, the presence of country-specific shocks activates the third term of (65), which is affected by the ratio $\left[\lambda^2 a + nm\kappa\right] / \left[(\lambda a)^2 + nm\kappa\right]$ appearing in front. As in the case of common disturbances, this allows parameters to exert an additional influence relative to that described for the basic model in section 3. The effect in question refers to inflation developments.

For those parameters that already existed in section 3, most of the sensitivity results under country-specific disturbances appear to carry over to the case where the monetary authority interacts with fiscal authorities and trade unions. For instance, an increase in the supply slope, α', here also has an adverse influence on monetary union's relative stabilisation properties (see Figure 5), even if the mechanism is somewhat more complex. As already detected in section 3, this parameter change makes the relative stabilisation costs under a currency union larger through the worsening of the output-

inflation tradeoff. Further to this, a steeper supply curve now raises ratio $\left[\lambda^2 a + nm\kappa\right] / \left[(\lambda a)^2 + nm\kappa\right]$ in the third term of (65), thereby aggravating the deterioration in a currency union's stabilisation performance via higher inflation volatility. The intuition for the latter mechanism is that the interest rate rise induced by a – say – adverse supply shock at home entails reactions of governments and trade unions in the rest of the union aimed at mitigating the impact on foreign output stability. As a result, the increase in the interest rate is moderated, thereby leading to higher inflation variability in country I. The interest rate hike would be larger in the absence of spillovers, and in particular under monetary autonomy.

A more conservative central bank (as given by a higher weight on price stability, χ) also hampers a currency union's stabilisation performance (see Figure 6). The effect of χ on welfare ratio C_{uI} can be decomposed into two components. First, as in section 3 an increased preference for price stability deteriorates the single monetary policy's performance by penalising domestic inflation volatility – harder to control in a currency union - more harshly. Second, the latter reaction is reinforced by the same type of spillover effect as described for a steeper supply curve. The analogy between this parameter change and a higher χ is intuitive, since both entail a rise in the share of a supply disturbance's impact on inflation relative to output that is intended to be offset by monetary policy. A new result compared with section 3 is that a greater preference for price stability now includes a propagation mechanism operating via the foreign reactions of fiscal authorities and wage-setting institutions.

Turning to an increase in country size (that is, a higher φ), this parameter change is found to have a favourable effect on monetary union stabilisation performance (see Figure 7). As in section 3, a larger size allows a given country to have a larger influence on the interest rate decision, helping contain stabilisation costs arising from losing monetary autonomy. Further to this,

in the context of monetary-fiscal-wage interactions a larger country size also implies that there is a smaller number of fiscal authorities and - given φ_m - a smaller number of trade unions. This involves an additional effect operating via the third term of (65), which reinforces the previous one. When a - say - adverse country-specific supply shock hits country I, the single monetary authority raises the interest rate, eliciting reactions on the part of foreign governments and trade unions aimed at limiting output losses. This damps down the interest rate hike. In particular, the latter ends up being smaller than under an autonomous monetary policy, which explains the larger rise in inflation at home.[53]

The results for new parameters in the event of country-specific shocks are the following. As in the case of common shocks, changes in the trade unions' weight on real wage growth stability, κ, fail to have any noticeable impact on relative welfare C_{uI}. The welfare implications of the remaining wage-related parameters, namely φ_m and λ, are both qualitatively and quantitatively comparable to those reported for common shocks. That is, higher values for either λ or φ_m induce a currency union to exhibit a worse stabilisation performance compared to monetary autonomy (see Figures 8 and 10, respectively). These parameter changes lead to this outcome in light of the relative intensity with which they shrink the fraction of inflation variability that fails to be offset by the single monetary policy (as described in more detail for the case of common disturbances), but also owing to the monetary-fiscal-wage interactions influencing the third term of (65). To see the latter, note that ratio $\left[\lambda^2 a + nm\kappa\right] / \left[(\lambda a)^2 + nm\kappa\right]$ is decreasing in m (and thus increasing in φ_m), as well as increasing in λ. Intuitively, a higher φ_m (as given by a smaller number of a given country's trade unions) lead the latter to each of them internalise less of the effect that their wage demands exert on the supply side of the economy, thereby deteriorating a currency union's relative stabilisation properties

[53] In the case of idiosyncratic shocks, the gap $\varepsilon_I - \varepsilon_u$ will became smaller as country I grows larger, thereby contributing to contain the magnitude of this second effect.

in line with what was discussed for the case of a larger φ. In turn, an increase in λ also favours monetary autonomy relative to its alternative by making the output-inflation tradeoff worse, resembling the mechanism discussed for a steeper supply schedule.

In sum, our welfare analysis of monetary union points to the need to distinguish between exogenous factors impacting the demand and supply sides of participating states. In countries that are driven by shocks hitting the demand side of their economies, a currency union's monetary stabilisation is adversely affected. This outcome obtains unless both structural parameters and exogenous demand factors are uniform across member states, in which case monetary autonomy and a currency union yield the same outcome. Turning to the case of supply shocks, modifications to both supply schedule slopes and the preference for price stability have welfare implications that depend on the distribution of shocks within the union. For common shocks, neither of these two parameter changes has any effect on the stabilisation performance of a currency union. For country-specific disturbances (of either idiosyncratic or asymmetric nature), both a steeper supply curve and a higher preference for price stability make the single monetary policy less effective compared with that conducted autonomously. It must be borne in mind that, although a higher preference for price stability is found to favour monetary autonomy, this result obtains while abstracting from any favourable credibility impact that this structural feature might have on a currency union's new entrants. These types of disturbances overall favour monetary union membership of countries with larger size. All of these results are consistent with those found in section 3.[54]

The results for the new, wage-related parameters are found to hold regardless of whether disturbances are common or country-specific. A larger

[54] The results in section 3 (that is, in the absence of monetary policy interactions with fiscal authorities and trade unions) also assess the case in which supply slopes differ across countries.

sensitivity of output to wages and a rise in the size of trade unions are both found to induce a deterioration in a currency union's stabilisation properties compared with autonomous monetary policies. Quantitatively, these welfare implications appear however to be rather small. Even more so in the case of changes in the trade unions' weight on real wage growth stability, which fail to have any noticeable welfare implications. A further discussion of the result concerning the number of trade unions is in order here. As we have said before, the approach pursued here indicates that increased real wage flexibility produces a (partially) stabilising contribution to macroeconomic developments in comparison with a pure monetary-fiscal game. In addition, more decentralised trade unions, as captured by a reduction in the size of trade unions, turns out to partially counter this favourable result, given that each union internalises less of the damaging effect of wage inflation on the tradeoff between output and inflation. This effect of trade union decentralisation is however stronger under monetary autonomy, thereby being consistent with the summary result that a larger (smaller) trade union size overall hampers (improves) a currency union's stabilisation performance.[55]

6 Conclusions

Our study of monetary stabilisation in a currency union of small open economies abstracts from a number of key factors which favour participation in a monetary union provided the preconditions are fulfilled. It also disregards certain institutional features of EMU. It thus cannot be regarded as an overall assessment of welfare implications of EMU participation. The paper shows that the main results regarding stabilisation policies depend on the distribution of shocks across the union, as well as on key structural parameters. First, we have seen that a currency union's optimal monetary policy responds to dif-

[55] The discussion here focuses on conjunctural stabilisation matters. It is thus separate from the longer-run considerations favouring trade union decentralisation for its flexibility-enhancing implications (see *e.g.* OECD, 2007).

ferent factors. When structural parameters are not uniform across the union, the interest rate is raised in response to broad-based developments amounting to adverse supply and risk premium shocks, favourable demand shocks and higher desired inflation. However, when we allow parameter values to be country-specific the monetary policy response also depends on this additional structural source of heterogeneity within the currency union.

We analyse monetary union stabilisation using three different frameworks. The results are broadly comparable across the different frameworks, which progressively complicate the analysis in terms of further interactions among relevant players. First, monetary policy is addressed abstracting from its interaction with fiscal policies and wage-setting institutions. The central bank of the monetary union, by reacting to union-wide economic indicators, propagates shocks from one country to the others. This investigation allows disturbances (as well as two structural parameters, namely, country size and supply slopes) to be country-specific, assessing the monetary stabilisation properties of a currency union by means of welfare simulations. Second, we investigate monetary policy in interaction with national fiscal policies, focusing on the existence of a free rider problem. Such problem arises in a context where national governments have incentives to respond to macroeconomic developments as induced by aggregate supply shocks, creating aggregate demand pressures that end up leading to wider interest rate fluctuations than in the absence of monetary-fiscal interaction. Third, both fiscal policies and wage-setting institutions are allowed to interact with the policymaker setting the interest rate - be it the national central bank or the single monetary authority. The idea here is to provide some insights as to how wage-setting considerations may affect the free rider problem and whether they enhance or hamper monetary stabilisation performance.

The interplay between monetary policies and uncoordinated fiscal actions gives rise to a free rider problem. This problem arises in a context in which

the overall fiscal framework fails to discipline national fiscal authorities in the event of - say, adverse - union-wide supply shocks. Each of the governments aims at mitigating the economic consequences of the domestic disturbance. All other fiscal authorities are embarking in similar actions, the end result simply being a more pronounced increase in the nominal interest rate as the common central bank combats the expansionary pressure from higher government deficits. The presence of such coordination failure raises the need for institutions to be designed that make fiscal authorities focus on budget considerations as opposed to reacting to cyclical fluctuations. For instance, putting a cap on national deficits constrains the temptation in each country to seek an improvement in their situation at the expense of all other monetary union participants. The free rider problem is found to carry over to the situation where monetary and fiscal authorities interact with wage-setting institutions. The latter are modelled as caring about real wage stability and output stability; this abstracts for tractability more realistic wage-setting frameworks, such as that in Cukierman and Lippi (2001) who also allow for inflation stability considerations. The increased real wage flexibility studied in the present paper is found to damp down to some extent the intensity with which uncoordinated national fiscal policies lead to higher interest rate volatility. The extent to which the free rider problem is mitigated decreases with the number of trade unions, as higher decentralisation implies that each union internalises less of the adverse effect of wage demands on the supply side of the whole economy. This effect induced by a larger number of trade unions is however stronger under monetary autonomy, thereby implying that decentralised trade unions overall improve a currency union's stabilisation performance.

The welfare analysis of monetary union stabilisation needs to distinguish between exogenous factors impacting the demand and supply sides of participating states. In countries that are driven by demand-side shocks a currency union's monetary stabilisation is adversely affected. This outcome obtains

unless strong cross-country homogeneity assumptions hold for structural parameters and exogenous demand factors. Turning to the case of supply shocks, modifications to both supply schedule slopes and the preference for price stability are found to have welfare implications that depend on the distribution of shocks within the union. For common shocks, neither of these two parameter changes has any effect on the stabilisation performance of a currency union if structural parameters are homogeneous across the union. For country-specific disturbances (of either idiosyncratic or asymmetric nature), both a steeper supply curve and a higher preference for price stability on balance make the single monetary policy less effective compared with that conducted autonomously. The former parameter change is known to worsen the output-inflation tradeoff, while the latter penalises inflation deviations from target more strongly (as elicited by country-specific supply disturbances). In consequence, both parameter changes deteriorate a currency union's stabilisation performance, which is not as effective in dealing with those disturbances as an autonomous monetary regime. Moreover, country-specific supply shocks overall favour monetary union membership of countries with larger size. These results appear to be robust to the presence of monetary policy interaction with fiscal authorities and trade unions, once we take into account that such interaction is analysed only in the absence of cross-country variation in supply slopes.

The results for wage-related parameters are found to hold regardless of whether disturbances are common or country-specific. Both a larger sensitivity of output to wages and a rise in the size of trade unions are found to hamper a currency union's stabilisation properties relative to monetary autonomy. Quantitatively, these welfare implications appear however to be rather small. Even more so in the case of changes in the trade unions' weight on real wage growth stability, which fail to have any noticeable welfare implications. It is worth saying that increased real wage flexibility as modelled

here produces a (partially) stabilising effect on macroeconomic developments in comparison with a pure monetary-fiscal game. In addition, more decentralised trade unions, as captured by a reduction in the size of trade unions, turns out to dampen this favourable result, given that each union internalises less of the damaging effect of wage inflation on the tradeoff between output and inflation. This effect of trade union decentralisation is however stronger under monetary autonomy, thereby being consistent with the summary result that a larger (smaller) trade union size overall hampers (improves) a currency union's stabilisation performance.

There are two other issues worth examining. First, a higher preference for price stability is found to favour monetary autonomy. This notwithstanding, it must be borne in mind that this result obtains abstracting from any favourable credibility impact that this structural feature might have on a currency union's new entrants. Second, it is possible to derive welfare implications specifically suited for small open economies. This arises from our findings regarding country size and supply slopes, coupled with the link between the latter and the degree of trade openness. In the face of country-specific supply shocks, relatively small open economies are found to be more adversely affected by currency union membership. This result is intuitive in the face of country-specific disturbances. First, a small economy receives little attention from the single monetary authority, who pursues union-wide objectives. Second, a relatively open economy faces a rather unfavourable output-inflation tradeoff, thereby benefiting from tailor-made policies implemented by a national central bank. Under common supply disturbances, no effect is discernible in the case when supply slopes are uniform across the union's countries. In the setup in which we consider cross-country variation in supply slopes (which is the case when we abstract from interactions of monetary policy with fiscal authorities and wage-setting institutions), common supply shocks give rise to a tradeoff between the (favourable) effect of openness and the (adverse) one resulting from a smaller

size.[56] This highlights the relevance - also for small open economies - of the discussion about whether currency unions have implications for the likelihood of common as opposed to country-specific disturbances. In this regard, a monetary union is expected to foster the intensity of international trade among participating countries (see Rose, 2000). While this enhances welfare, it is fair to say that it is not clear whether such stronger trade integration would make disturbances more or less correlated across member states. Intensified trade interactions are intuitively believed to turn business cycles more synchronised, but they might as well lead to specialisation and thus increase the likelihood of country-specific shocks (Kalemli-Ozcan *et al.*, 2001). In any case, it is worth emphasising that, despite the focus on stabilisation costs in this paper, regime choice involves comparison of such costs with potential benefits arising from factors such as the oft-mentioned trade- and credibility-enhancing effects of monetary union.

There are a number of interesting extensions to the present study that are worth exploring, including the addition of microfoundations, informational frictions and dynamical considerations. With regard to the latter, for instance, the free rider problem could be examined in a context where debt dynamics is also allowed to play a role. Finally, the treatment of wage setting could be improved by looking at relevant institutional features of the labour market, as well as further macro aspects addressed in the literature such as trade unions' concern for inflation or the roles played by unemployment and the substitutability of labour.

[56] The joint analysis of country-specific parameters and monetary-fiscal-wage interactions is left for further research.

Appendix

This Appendix simplifies the presentation of monetary stabilisation contained in section 3. There monetary stabilisation is studied in the absence of interactions with either fiscal policy or both fiscal policy and wage-setting. The simplification made here consists of assuming parameter homogeneity and splitting the currency union in two parts (namely, the country of interest and the rest). The latter gives the presentation here a two-country flavour, although the reader should bear in mind that the part of the union grouped in the "rest" could well comprise many countries.

Concerning parameter homogeneity , here we assume that α_i, c_i, d_i, χ_i and γ_i are uniform across the union's countries, that is, $\alpha_i = \alpha$, $\alpha_i' = \alpha'$, $c_i = c$, $d_i = d$ and $\chi_i = \chi$. We however allow country size and inflation targets (that is, φ_i and $\tilde{\pi}_i$) to exhibit cross-country variation. Under these assumptions, the union level monetary policy reaction function (14) can be expressed as

$$R = \tilde{\pi}_u + \frac{1}{d}\left(-a\varepsilon_u + \varsigma_u + c\varepsilon_u^f\right) \tag{A.1}$$

where $a \equiv \chi/(\alpha^2 + \chi)$. Expression (A.1) shows that the interest rate, which is the central bank's policy instrument, reflects the union-wide inflation target and reacts to terms aggregating over disturbances. More concretely, R is raised in the event of adverse supply shocks and favourable real demand and risk premium shocks. In light of parameter homogeneity, pure asymmetric shocks in ε_i, ς_i and ε_i^f have no impact whatsoever on the single monetary authority' decisions. In this case, the interest rate would be changed only in response to a rise in the average inflation target.

Expressions (15) and (16) in the main text give output y_I^u and inflation π_I^u for a generic individual country I under union participation, respectively. Under the maintained parameter homogeneity assumptions, those expressions

simplify to

$$y_I^u = a\varepsilon_u + (\vartheta_I - \vartheta_u) \tag{A.2}$$

$$\pi_I^u = \tilde{\pi}_I - \frac{1-a}{\alpha}\varepsilon_I - \frac{a}{\alpha}(\varepsilon_I - \varepsilon_u) - \frac{1}{\alpha}(\vartheta_I - \vartheta_u) \tag{A.3}$$

where $\vartheta_i \equiv \varsigma_i + c_i\varepsilon_i^f + d_i\tilde{\pi}_i$ captures the effect of exogenous factors on output through the demand side. Composite expression ϑ_i shows the overall exogenous factors operating through the demand side, as opposed to ε_i which works through the supply side.

Country I's expected loss from participating the currency union, $E(L_I^u)$, can be derived by taking unconditional expectations on the loss function (5) in section 3. This gives

$$E(L_I^u) = \frac{(1-\varphi_I)^2}{1-a}\left(\frac{\sigma_{\vartheta_I}^2 + \sigma_{\bar{\vartheta}_I}^2}{2} - \sigma_{\vartheta_I\bar{\vartheta}_I}\right) + B\sigma_{\varepsilon_I}^2 + C\sigma_{\bar{\varepsilon}_I}^2 - D\sigma_{\varepsilon_I\bar{\varepsilon}_I} + F\sigma_{\varepsilon_I\bar{\vartheta}_I} + G\sigma_{\vartheta_I\bar{\varepsilon}_I} \tag{A.4}$$

where $B \equiv (1/2)\left[\chi(1-a)^2 + \varphi_I^2 a^2 + \chi(1-\varphi_I)^2(a/\alpha)^2\right]$, $C \equiv (1/2)\chi a(1-\varphi_I)^2/\alpha^2$, $D \equiv (1-\varphi_I)(\chi a/a)\left\{1 - [1-(1-\varphi_I)/\alpha]\, a\right\} - \varphi_I(1-\varphi_I)a^2$, $F \equiv (1-\varphi_I)\left[\chi(1-a) + a/\alpha - \varphi_I\chi/\alpha\right]/\alpha$ and $G \equiv (1-\varphi_I)^2\chi/\alpha^2$. We denote the unconditional variance of any disturbance x by σ_x^2, and the unconditional covariance between any pair (x, z) by σ_{xz}. Moreover, we denote with an upper bar the average shock hitting countries other than I in the currency union.[57] All of these constants (B, C, D, F and G) are positive under the range of parameters considered in this paper. Own-covariances between shocks are set to zero in light of the structural interpretation attached to disturbances.

There is a relationship between covariances in (A.4) and the classification of disturbances (according to their distribution across the currency union) made in section 3. An asymmetric shock implies a negative covariance between country I and the rest of the union, an idiosyncratic shock amounts to a zero

[57] For instance, $\bar{\varepsilon}_I \equiv \sum_{i \neq I} \varphi_i \varepsilon_i$ is the weighted average of supply shocks in countries other than I.

covariance between country I and the rest of the union, and a common shock means that the covariance between country I and the rest of the union is 1.

Judging from the unconditional cross-country covariances in (A.4), country I's currency union membership is facilitated by lower variances (both at home and abroad) of shocks to supply and demand. Supply and demand shocks of the common type (as captured by cross-country covariances $\sigma_{\varepsilon_I \bar{\varepsilon}_I}$ and $\sigma_{\vartheta_I \bar{\vartheta}_I}$, respectively, being equal to 1) also favour monetary union participation. Idiosyncratic such shocks implying zero covariances would be welfare-neutral, while asymmetric disturbances would correspond to negative covariances and thus hamper monetary union performance.[58] Finally, larger cross-covariances between supply and demand shocks within the union (as given by higher values of $\sigma_{\varepsilon_I \bar{\vartheta}_I}$ and $\sigma_{\vartheta_I \bar{\varepsilon}_I}$) hamper a currency union's monetary stabilisation performance. The reason is that, although both shocks are expansionary they have opposite effects on inflation. Such contrasting forces point to some extent to more muted interest rates responses at the union level, contrary to the action needed in each specific national circumstance.

[58] Common shocks impacting either demand or supply elicit an interest rate reaction of the type involved under monetary autonomy. At the other extreme, asymmetric such shocks entail no response of the single monetary authority at all, while the interest rate reaction to idiosyncratic disturbances is proportional to the size of the country in question.

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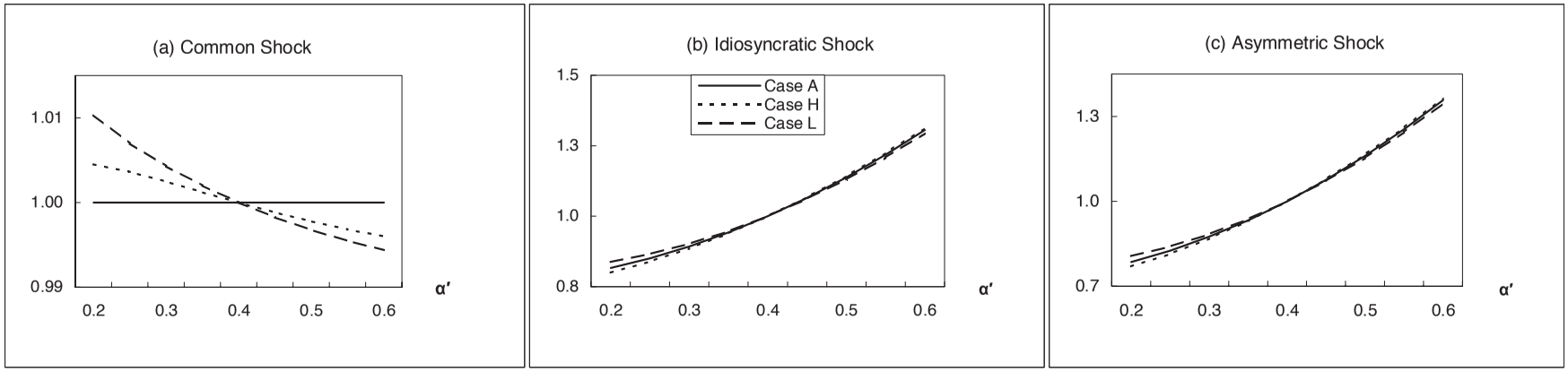
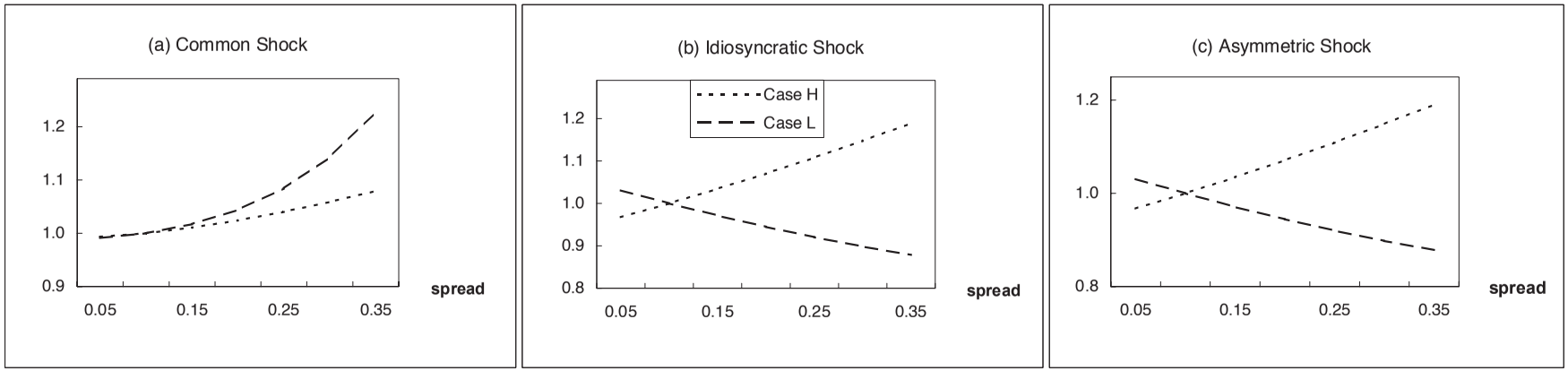


Fig. 1. Relative welfare: Sensitivity to *α′*



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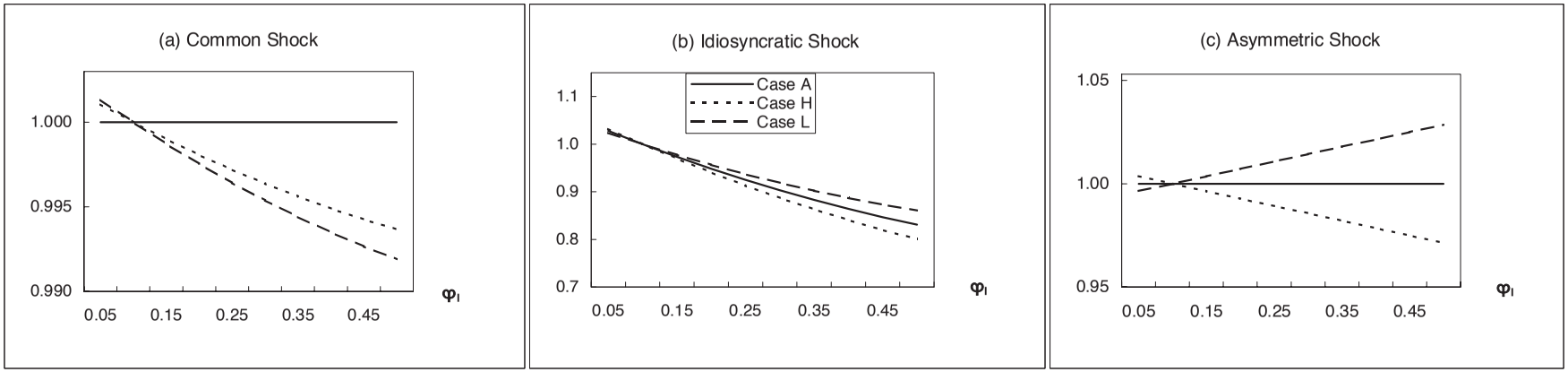


Fig. 3. Relative welfare: Sensitivity to φ_I

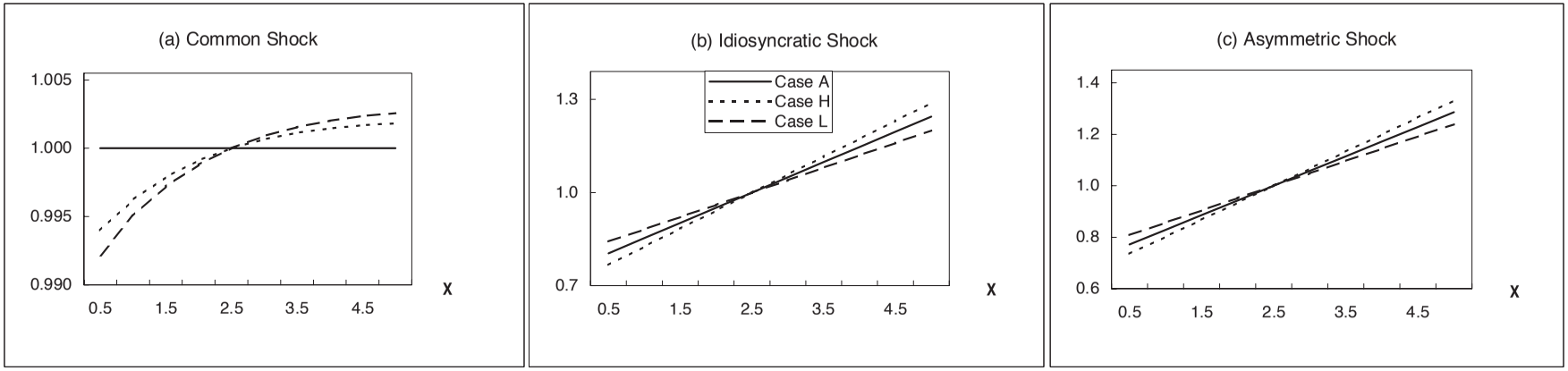


Fig. 4. Relative welfare: Sensitivity to χ

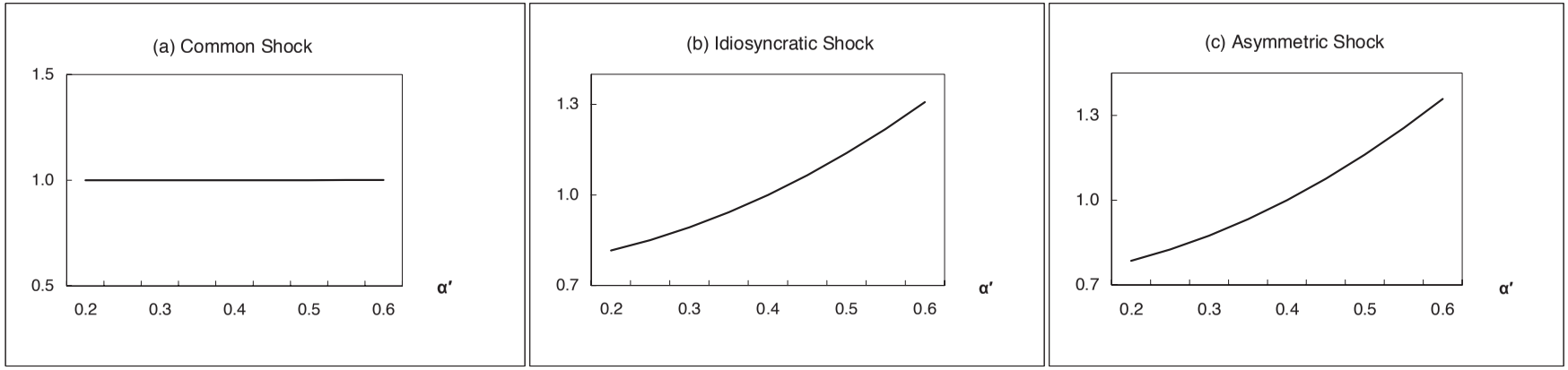
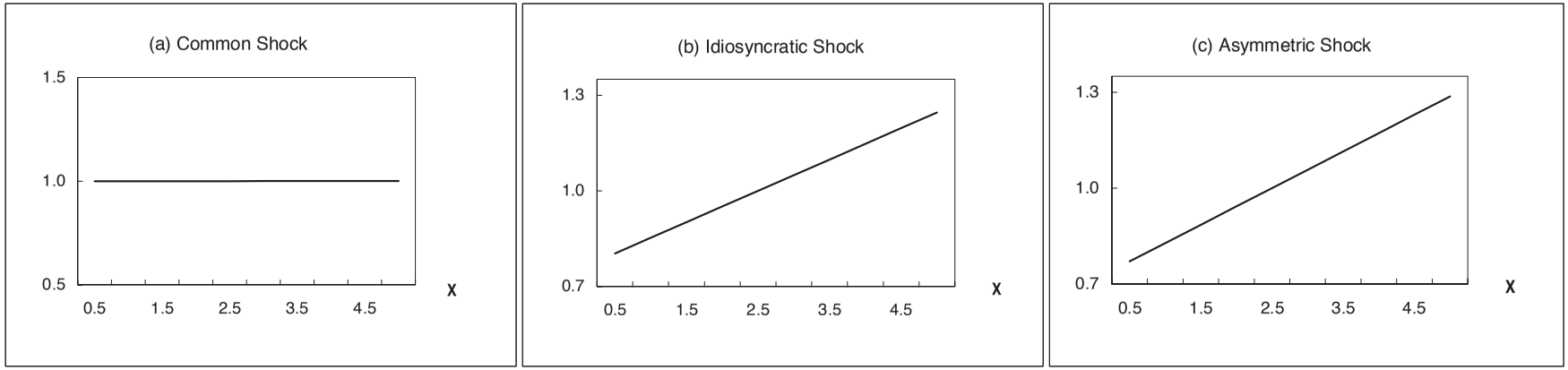


Fig. 5. Relative welfare under monetary-fiscal-wage interaction: Sensitivity to α'



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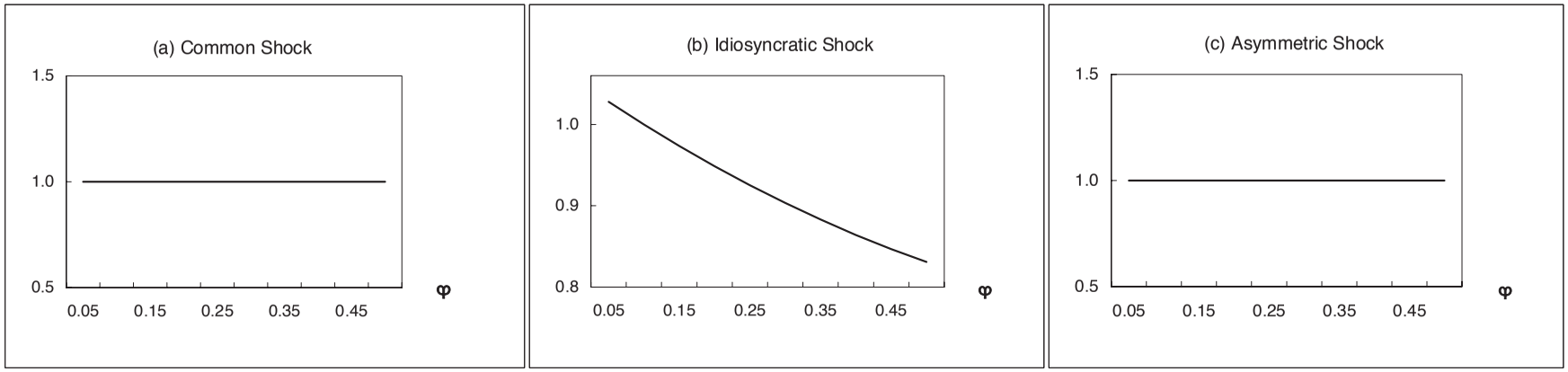


Fig. 7. Relative welfare under monetary-fiscal-wage interaction: Sensitivity to φ

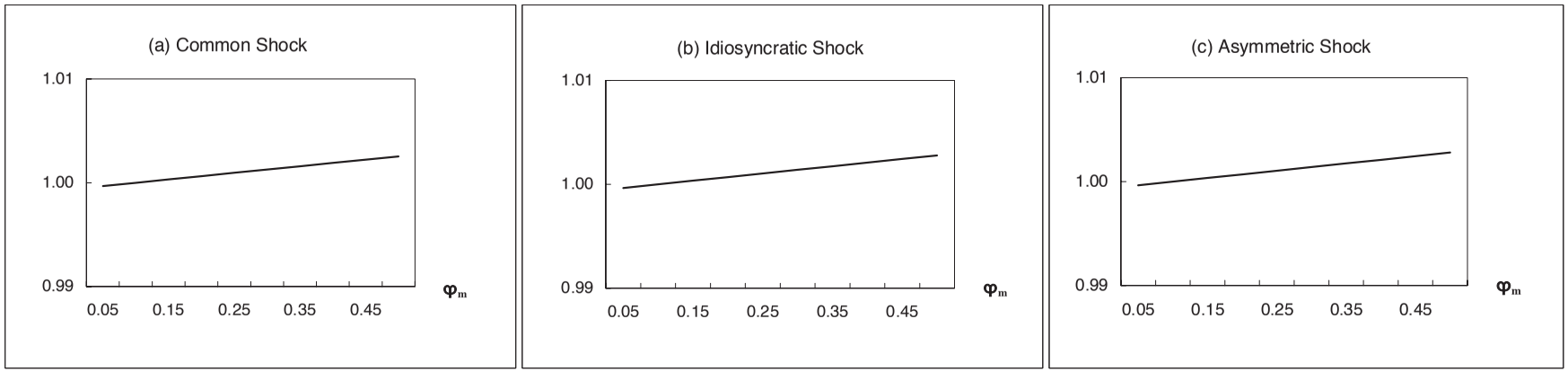


Fig. 8. Relative welfare under monetary-fiscal-wage interaction: Sensitivity to φ_m

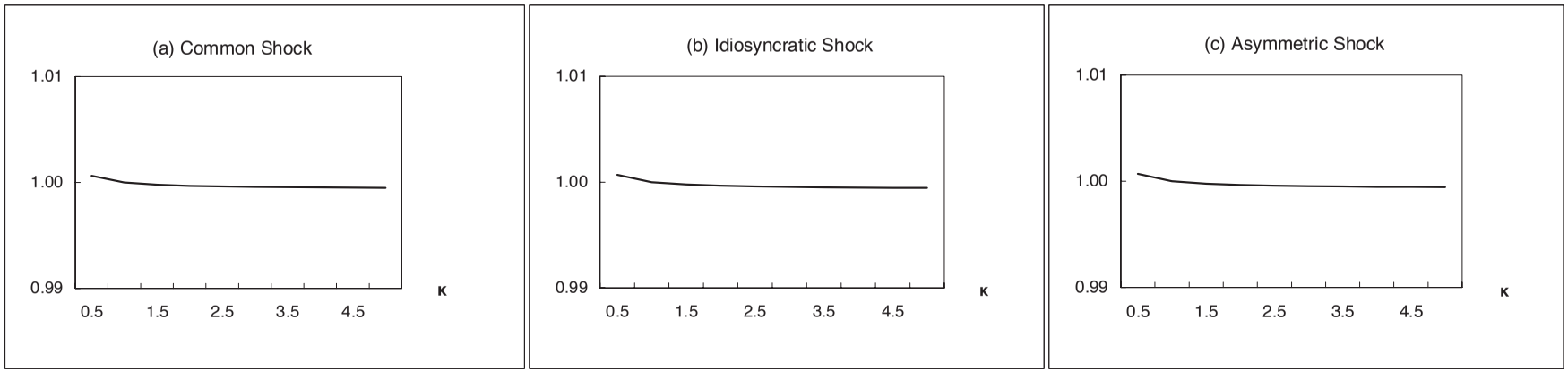
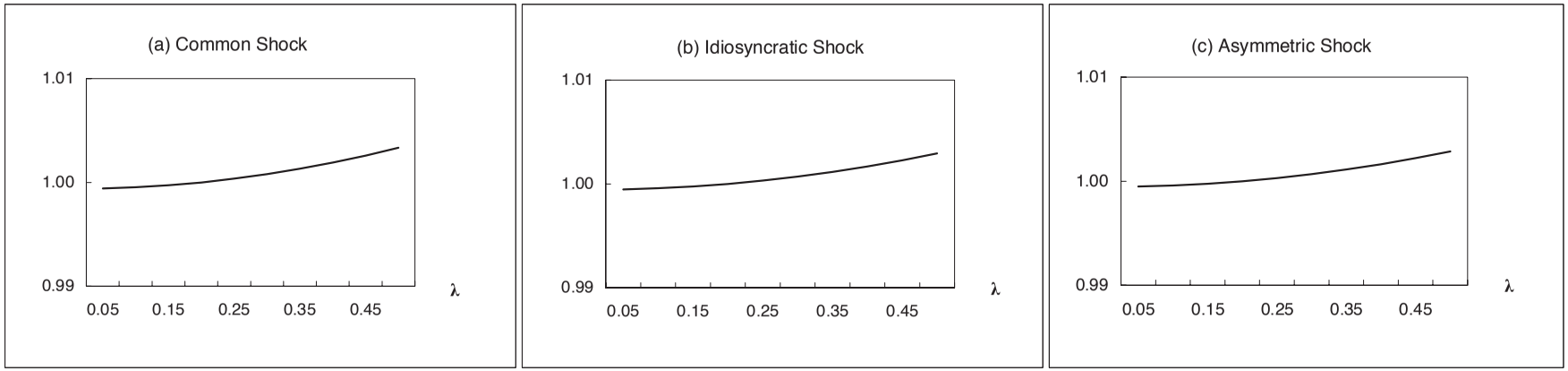


Fig. 9. Relative welfare under monetary-fiscal-wage interaction: Sensitivity to κ.



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