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Cross-Country Long-Run Spillover Effects and Coordination of Fiscal Policy: a Quantitative Exploration for Europe

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Authors:
Thomas Davoine, IHS
Matthias Molnar, IHS
Michael Reiter, IHS

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Thomas Davoine† Matthias Molnar‡ Michael Reiter§

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JEL-Classification: C68, E62, F21, F42

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†`davoine@ihs.ac.at` Institute for Advanced Studies (IHS) Vienna, Josefstädter Straße 39, AT-1080, Vienna. Corresponding Author

‡`molnar@ihs.ac.at` Institute for Advanced Studies (IHS) Vienna, Josefstädter Straße 39, AT-1080 Vienna.

§`michael.reiter@ihs.ac.at` Institute for Advanced Studies (IHS) Vienna, Josefstädter Straße 39, AT-1080 Vienna.

Case	*Crisis Countries*	*Impact* ΔGDP_a	ΔGDP_p	*Spillover (%)*
Tax reform	0	+0.43%	+0.008%	1.8%
Crisis and reform	1	−0.59%	−0.14%	24.4%

Legend: ΔGDP_a = change in per capita GDP in active country (where reform is triggered or crisis takes place); ΔGDP_p = maximal change in per capita GDP in other, passive, countries; spillover = $\Delta GDP_p/\Delta GDP_a$.
Key assumptions: only consumer goods and investments can move across countries (workers and firms are immobile); constant exchange rates; capital flows from rich to poor European countries until marginal products of capital are equalized. Other assumptions and details on simulations: see text.

Table 1: Summary maximum spillover effects in simulations sample

Executive summary[1]

For a number of reasons, interest in fiscal policy coordination has been growing in the policy debate. Some see it as a condition to generate additional government revenue and repay the public debt accumulated after the 2007 financial crisis. Globalization trends continuing, others want to influence the international competitive environment and protect against so-called social dumping practices. Or, some consider that increased fiscal policy harmonization is a natural, if not necessary, next step for countries with a unified monetary policy and basic public debt management rules, such as countries of the Eurozone.

It is however empirically difficult to isolate the factors behind the cross-border influence of domestic fiscal policy. Lacking concrete examples, it is even more difficult to estimate empirically the gains from policy coordination. In this study, we develop a detailed macroeconomic model which can be used to simulate and quantify long-run fiscal policy spillover effects and gains from fiscal policy coordination. The multi-country model that we develop is an extension of a single-country model which is used on a regular basis for public policy analysis at a domestic level, and covers 14 European Union countries assuming an integrated capital market (but separated and isolated labor markets). We then apply the model to investigate spillover effects in some scenarios as well as some examples of fiscal policy coordination, without investigating all possible forms of coordination.

Table 1 provides results of some simulations which quantify spillover effects. The results show that spillover effects can be significant in case of crisis and provide a rationale for policy coordination.

Two cases are reported in the table. In the first case, one country performs a fiscal policy reform to stimulate its own economic activity (concretely, a drop in

[1]This part can be read independently from the rest of the document. Conversely, readers interested in details can skip this part (all information contained in this part is contained in the rest of the document).

labor income taxes financed by an increase in consumption taxes in Germany, so that public debt is constant). In the second case, one country is hit by a unique and large negative shock which generates a crisis and warrants a temporary increase in public spending (financed by an increase in labor income taxes, so that public debt is constant) for relief purposes. In both cases, other countries perform no reform except adjusting their fiscal policy to keep their public debt constant, if needed.

The table shows contrasting outcomes. When there is a labor tax policy reform and no crisis (first case), there are spillover effects but they are small (1.8%). When there is a crisis and associated reforms (second case), spillovers can be large (more than 24%).

In the first case indeed, the country which performs the reform generates a long-term 0.43% improvement of its per capita gross domestic product (GDP). Other countries also benefit from the reform, but to a small extent: among the 13 other countries, the largest per capita GDP increase is 0.008%, about 1.8% of the gain in the reform country. The intuition for the spillover, due to exports, tax adjustments and improved labor supply incentives, is the following. In the reform country, the labor tax cut stimulates labor supply. Domestic consumption also increases but to a lower extent, as consumption taxes are set higher. Production thus increases more than consumption, so the reform country exports more. Non-reform countries thus import more, allowing for higher consumption, which increases the consumption tax base. Targeting a constant public debt allows these countries to lower the tax rate, which stimulates their own labor supply. Production thus also increases in non-reform countries.

In the second case, spillover effects are significantly larger. Following a crisis, per capita GDP decreases on average 0.59% per year over the next 25 years in the country hit by the shock. The maximum loss in the other, shock-free, countries amounts to a yearly average of 0.14%, close to 25% of the loss in the country suffering from the crisis. The intuition for the outcome is the following. The country hit by the shock provides relief to domestic households and firms, increasing government expenditures, which draws resources from the goods and capital market and increases the interest rate. Because the capital market is integrated, the interest rate increases for all firms, reducing investment in all countries. Furthermore, the resulting decrease of the capital stock and capital-labor ratio pushes wages down, reducing incentives for labor supply in all countries. Spillovers are large because the relief efforts make an immediate and large draw on the capital market, which the increase in the domestic saving rate is unable to compensate. Foreign investors then shift part of their investments to the country with the highest returns on capital, namely the country hit by the shock.

Table 2 provides the impact of different examples of fiscal policy coordination.

Three cases are reported. For each case, we consider two examples of coordination rules and compare their respective benefits. The table shows that the choice of coordination rules has an influence on economic outcomes. Depending on the rule, gains from coordination in reforms can be higher or larger. In the

Case	*Crisis Countries*	*Coordination Rule*	*Impact* ΔGDP_a	*Relative Coordination Gain (%)*
Tax reform	0	Reforms in all countries	+0.91%	
		Reform in one country	+0.93%	2.9%
Crisis and reform	1	No public debt increase	−0.59%	
		Temporary public debt increase	−0.54%	8.3%
Crisis and reform	All	No public debt increase	−0.94%	
		Temporary public debt increase	−0.85%	9.7%

Legend: ΔGDP_a = change in per capita GDP in the same active country (Germany; where reform is triggered or crisis takes place), over the long run (tax reform case) or yearly average over next 25 years (crisis and reform case); temporary public debt increase = public debt can increase 12.5% but needs to be back to pre-crisis level within 25 years.
Key assumptions: interest rate spread between public and private debt: 4% points. See also table 1. Other assumptions and details on simulations: see text.

Table 2: Summary coordination gains in simulations sample

examples considered here however, coordination gains are never large.

In the first case, countries perform a fiscal policy reform to stimulate economic activity, specifically financing a labor income tax cut with a reduction in unconditional subsidies to households. Either all countries perform the reform at the same time (first line) or only one country performs it (second line). The second coordination option delivers benefits to the country always performing the reform, GDP gains being almost 3% larger. The reform stimulates labor supply. To keep the capital-labor ratio in production optimal, firms invest to increase the capital stock. When only one country implements the reform, the increase in demand in the integrated capital market is limited. When all countries do the reform, the increase in demand is large, pushing up the price of capital and reducing investments in all countries. The capital stock increases less, so does GDP. Because spillover effects are small when there is no crisis (see discussion of table 1), gains in the best of the two coordination options are small.

In the second case, one country is hit by a shock and increases public spending to provide relief, financed by an increase in labor income taxes (same as in table 1). We consider fictitious examples where international coordination rules either impose the country to keep its public debt constant (third line) or allow a temporary increase in public debt after the shock, to be brought back to its initial level within a given time frame (fourth line). The second coordination option is beneficial, as GDP losses are 8.3% lower in the country hit by the shock. When debt stays constant, taxes need to be increased much, as long as government spending is increased. When debt can be temporarily increased, the

increase in taxes lasts longer but it is moderate. Because the disruptive effects of taxation increase over-proportionally with the level of taxation, allowing for a temporary increase in public debt reduces the overall tax distortion and delivers benefits: the GDP loss is 8.3% smaller (yearly average loss of 0.54% instead of 0.59%), because the reduction in labor supply is smaller. The size of the benefit depends on the interest rate spread between (safe) public and (risky) private debt, as well as the elasticity of labor supply. With a moderate spread (4%) and conservative elasticity values (0.2 for participation, 0.1 for hours), gains are limited.

The third case is the same as the second case, except all countries are hit by a shock and increase public spending to provide the same amount of relief, financed by higher labor taxes. Again, our examples of international coordination either impose public debt to remain constant (fifth line) or allow for a temporary increase (sixth line). As in the second case and for the same reasons, the second coordination option delivers gains: the GDP loss is reduced. The novelty in the third case is that gains are larger. When all countries are hit by a shock, allowing for a temporary debt increase reduces the GDP losses by 9.7%; when only one country is hit by the shock, the temporary debt increase reduces the GDP losses by 8.3%. The intuition for this new finding is the following. When only one country is hit by a shock and can temporarily increase public debt, the shock can be smoothed across countries and across time. When all countries are hit by the shock, it can only smooth out the shock across time. When debt cannot increase and one country is hit by a shock, smoothing across countries remain. Smoothing options disappear when all countries are hit by a shock and debt can not increase. Smoothing across time takes place with a temporary increase in public debt. Smoothing across countries (if a shock is limited to one country) takes place because the capital market is integrated and foreign investors help smooth the shock (see spillover discussion below table 1).

Summarizing and deriving policy implications, our simulations find sizable spillover effects in some cases of large unexpected shocks: per capita gross domestic product losses in shock-free countries can amount to a quarter of the losses in countries hit by a shock, because of spillovers. Spillovers are small in case of standard labor tax policy reforms, when no shocks take place. When large one-time shocks take place, negative economic consequences can be reduced if public debt is allowed to increase temporarily and come back to its initial level at a later point. The benefits from this policy option are larger when more than one countries are hit by the shock. Under our conservative assumptions for the interest spread and labor elasticities, gains in the examples that we consider are however limited, the gross domestic product losses being reduced by 10% or less when public debt is allowed a temporary increase.

For many countries of the European Union, such temporary increases in public debt would however not be compatible with the current coordination rules, which impose an upper limit on fiscal deficits and public debts. Countries which have not been able to respect these rules in the past are usually in a weaker economic position, and less likely to have the room for a temporary increase in public debt if they are hit again by an adverse shock. Over time,

countries with bad luck or unsound public finance management or both may find themselves in growingly weaker economic position because of coordination rules, rather than their own economic policy (vicious circle). The European Union fiscal rules may thus benefit from an adjustment, seeking to differentiate cases of unsound public finance management from other cases.

1 Introduction

Since the last financial crisis and subsequent sovereign debt crisis, policy makers have renewed their interest in policy coordination in the European Union (EU). Calling for reinforcement of economic policy coordination for instance, the European Commission recommended the creation of a "European Semester" to better synchronize the assessment of fiscal and structural policies of EU member states (European Commission, 2010). For many, increased fiscal policy harmonization should be the next step for countries with a unified monetary policy and basic public debt management rules, such as countries of the Eurozone.

According to Alesina and Wacziarg (1999), the optimal degree of fiscal policy coordination represents a trade-off. Heterogeneous preferences across nations and country-specific constraints are in conflict with the capability for managing policy spillovers. National policy makers have to decide to which extent country specific policy opportunities should be sacrificed for building a framework which counterbalances policy spillovers.

The current framework of European economic governance implements coordination mainly as a set of rules whose purpose is to prevent or at least mitigate the risk of fiscal shocks and ensure long-term sustainability of public finances (e.g. SGP[2]). The current governance system proceeds from the hypothesis that spillovers are the result of a response to an idiosyncratic shock (e.g. demand or supply shock). The aim of the response is to stabilize the economy, or the shock itself. The response itself is implemented as a fiscal policy decision. This is the variable under control of the policy maker.

Thus the main questions which we want to consider in this paper are the following: Are cross-country spillovers large enough to justify coordination? Is the advantage in coordinating fiscal policies always visible?

The literature on spillovers and policy coordination provides ambiguous findings. There is a large theoretical literature on the advantages and disadvantages of fiscal policy coordination in a monetary union, focusing mainly on strategic issues of the distinct agents[3].

In comparison, the concrete quantification of spillovers received relatively little attention in the literature. Nevertheless there are a few studies using econometric approaches as well as modelling approaches to quantify spillovers from fiscal

[2]The Stability and Growth Pact (SGP) is an agreement between the member states of the EU whose aim is to ensure fiscal stability in the EU. For instance countries are committed to respect a government budget deficit limit (maximum 3% of GDP) and a public debt limit (maximum 60% of GDP) in fiscal policy implementation.

[3]For examples see Jensen (1996), Beetsma and Bovenberg (1998), Beetsma et al. (2001), Beetsma and Bovenberg (2001) and Uhlig (2002).

policy actions.

Beetsma et al. (2006) find with their panel vector auto-regression model that spillovers are economically relevant and that the magnitude of the spillovers depends on the size of the originating country and the distance of the trade partner. Auerbach and Gorodnichenko (2013) consider spillovers transmitted through trade linkages. They find that spillovers on output are stronger during recessions than during expansions. However the estimated multipliers are not significant if the economy is in a state of expansion. Hebous and Zimmermann (2013) likewise argue in favor of fiscal policy coordination based on qualitative arguments. They find that the positive effects on output are larger for the case of an area-wide fiscal shock compared to a domestic shock of similar size[4].

Besides these econometric approaches, model simulation approaches also exist in the literature. Gros and Hobza (2001) condense the results of four different established macroeconomic models[5] used for policy analysis. They argue that spillovers tend to be quantitatively small and the sign of the impact is not clear. Given the minor importance of spillovers, fiscal policy coordination is not favorable.

Corsetti et al. (2010) find that a combination of a tax increase and a spending decrease can reinforce spillovers, but overall spillovers tend to be moderate in size. Cwik and Wieland (2011) use the model by Taylor (1993) to quantify spillover effects of a fiscal stimulus in one country and conclude that spillovers are small. More recent literature has emerged, taking effects of monetary policy developments into account. Benes et al. (2013) find larger spillovers than previous studies on conventional monetary policy, once they take the zero lower bound on the interest rate into account, and conclude that fiscal policy coordination could be useful. Boersch-Supan et al. (2006) quantify spillovers due to differences in the speed of population ageing and conclude that *"closed-economy models of pension reform miss quantitatively important effects of international capital mobility*" (p. 625).

To evaluate long-run spillovers and to compare different forms of fiscal policy coordination between representative countries of the EU we develop a multi-country overlapping generations model with an integrated capital market. Compared to the existing general equilibrium studies, our approach has various benefits. Consistent with empirical evidence, we include capital-skill complementarities in the production function. Because spillovers are channeled through the integrated capital market and education levels differ across countries, spillovers will then have different impacts across countries. Further, we model the labor market in detail (including involuntary unemployment, intensive and extensive margins and a pension system), as labor supply varies with fiscal policy and thus

[4]However the costs of the shock are important in this context. The costs are lower in the area-wide scenario as the respective country bears only a fraction of the total costs of the shock. Hence if the shock is same in size, then naturally the coordinated scenario is advantageous.

[5]QUEST II (European Commission), Marmotte (CEPII), NiGEM (National Institute of Economic and Social Research) and MULTIMOD Mark III (IMF). We limit the discussion to the results from QUEST II and Marmotte as we focus here on GE-models.

plays a role in cross-country transmission of fiscal policy shocks. Our modelling approach therefore incorporates heterogeneous spillover impacts and allows for asymmetric coordination effects. Because our interest is long-run effects, we neglect business cycle fluctuations and focus on permanent changes or large shocks occurring at low frequency, such as policy reforms or crises. The first contribution of this study is thus a multi-country framework allowing quantitative assessments of long-run cross-country spillovers effects which are enabled by the integration of capital markets in Europe.

The second contribution is an exploration of long-run spillover effects and coordination of fiscal policy across countries in Europe. More specifically, we perform simulations on a representative set of fourteen EU countries to quantify spillovers from labor and consumption tax reforms, large one-time exogenous shocks typical of crises, and combinations of both. Furthermore, we compare selected forms of fiscal policy coordination, with and without exogenous shocks, without considering all possible forms of coordination.

In the policy reforms and exogenous shocks cases that we consider, we find that spillovers emerging from fiscal policy actions in a single country are negligibly small (e.g. when Germany cuts its labor income tax by a fifth, the largest spillover on GDP of other countries is less than 2% of the effect in Germany). In scenarios where economies are not hit by a large shock, simultaneous implementation of a labor income tax cut, one example of coordination, does not provide any economic advantage. In case of large exogenous shocks, spillovers are moderate in size and larger than spillovers from sole policy reforms (e.g. when Germany is hit by a shock destroying a fifth of its capital stock, the largest spillover on GDP of other countries is more than 10% of the effect in Germany). Area-wide shocks generate larger effects for the respective country than shocks to the country alone. The form of fiscal policy response to a shock matters. An appropriate policy response can improve domestic economic circumstances and reduce negative spillovers to other countries. The gains are larger in case of an area-wide shock, but only to a small extent. Furthermore, we show that a temporary violation of public debt rules can be beneficial for all countries.

The remainder of this paper is organized as follows: Section 2 outlines the specifics of our modelling approach while section 3 describes the model in detail. Section 4 explains the calibration approach. Section 5 presents the results of our quantitative explorations and section 6 concludes. Appendix A provides a detailed discussion of the related literature.

2 Approach specifics

In comparison with the existing quantitative general equilibrium analysis of fiscal spillovers and fiscal policy coordination (QUEST II and Marmotte in Gros and Hobza (2001), Benes et al. (2013), Boersch-Supan et al. (2006), Corsetti et al. (2010) and Cwik and Wieland (2011)) our modelling approach differs along several dimensions. One key difference with some, but not all, existing analyses is that we calibrate the model at European country levels, rather than

taking Europe as a region, which is necessary for investigating cross-country spillovers within the European Union.
In the following we highlight the main differences in our approach with all existing analyses, skill differences and capital-skill complementarity, which allow for heterogeneous spillover effects and heterogeneous coordination impacts across countries[6].
Our model distinguishes households into three different skill classes, reflecting different levels of education. Across the EU there are large differences in the percentage of people having reached higher education levels (e.g. in Great Britain 31% of adults completed tertiary education while in Austria 13% of adults did). Higher levels of education are, among others, associated with higher relative earnings. The EU countries often rely on a progressive income tax system. Thus there are large differences in the structure of tax revenue. It is therefore likely that different countries in the EU react differently when applying the same tax reform. This leads to the conjecture that different spillovers could arise from this distinct behaviour.
Productivity differs by skill classes. The representative firm thus produces a single composite good using capital and three different types of labor which correspond to the three skill classes. We assume imperfect substitution between the various types of labor. High-skilled labor is assumed to be more complementary to capital than middle-skilled labor, itself more complementary to capital than low-skilled labor. This feature is consistent with empirical evidence and generates endogenous wage differentials between the skill classes. This is an important feature of our model as the channel for spillover effects is the integrated capital market. The same capital stock variation, due to a shock in another country, will lead to larger GDP variations in countries with a large proportion of highly skilled workers than countries with a small proportion, because of capital-skill complementarity. For instance, a shock on the capital stock of a country where the agricultural sector is predominant generates different effects than a shock to a country where the service sector is predominant. Existing general equilibrium models of fiscal spillovers are lacking this feature.

3 Model

To quantify long-run cross-country spillover effects and potential gains from fiscal policy coordination, we develop a multi-country computable general equilibrium model with an integrated capital market. We assume that only capital is freely mobile, while labor is immobile[7].

Spillover effects may be due to policy reforms, demographic changes or large one-time economic shocks which take place in times of crisis, such as the 2007 subprime crisis or the 2010 European sovereign debt crisis. Short-run spillover effects due to business cycle fluctuations are not considered.

[6] Other specifics of our modelling approach are presented in appendix B.

[7] Clemens (2011) wonders why migration flows are so small, given the large welfare gains that model simulations exhibit.

Concretely, we start from an existing single-country overlapping-generations model routinely used for policy evaluation[8] and extend it to a multi-country model following the Buiter (1981) procedure[9]. The single-country model, of the Auerbach and Kotlikoff (1987) tradition, builds on Jaag, Keuschnigg, and Keuschnigg (2010), which features endogenous labor supply decisions along intensive and extensive margins as well as imperfect labor markets, and adds a separation in three skill levels following Jaag (2009). Because business cycle fluctuations are out of the scope of the analysis and we assume a single composite good, the model does not have money, price rigidities or any of the typical features of Real Business Cycle models.

We present details of the multi-country extension and the main features of the single-country model[10].

3.1 Single-country setting

Demographics: Households go through several stages $a \in \{1, \ldots, 8\}$ in their life. A stage a lasts several time periods. After birth, households educate, then enter the labor market and retire. Several stages a cover labor market activity, reflecting different productivity levels (typically hump-shaped). Households face a constant, age-dependent probability of dying $1-\gamma^a$. They differ in skills, birth date and death date[11]. After they are born, they are randomly assigned one of three skill levels, low, medium or high, $i \in \{l, m, h\}$. Medium and high skills are acquired through further education, which has no cost but delays access to the labor market. Education for medium skills takes place in stage $a = 1$, for high skills in stages $a \in \{1, 2\}$. Retirement is defined exogenously and happens some time during stage $a^R = 5$. Stages $a \in \{6, 7, 8\}$ are full retirement stages but with different probabilities of dying $1-\gamma^a$, to better replicate the empirical age structure of the population. As in Blanchard (1985), a reverse life insurance allocates assets at death[12].

Labor market: After education, households can enter the labor market. They choose whether to participate or not (at a rate $\delta^{a,i} \in [0, 1]$, which represents the

[8] See for instance Berger et al. (2009) or CPB et al. (2013).

[9] The extension has been used in a number of studies, including Frenkel and Razin (1986) and Boersch-Supan et al. (2006).

[10] Details on the single-country model are contained for instance in the technical appendix of Berger et al. (2016).

[11] In the implementation, households also differ in the the speed at which they go through the stages of the life cycle, which reflects differences in appetite for effort, luck or other unobserved attributes, a generalization of Gertler (1999) used in Jaag, Keuschnigg, and Keuschnigg (2010). For ease of presentation, we ignore this model feature. The complexity arises in numerical simulations. Aggregation results, presented in the on-line appendix of Berger et al. (2016), help to deal with it.

[12] We use an implementation where the average durations of stay in each life-cycle stage correspond to ages 15-19, 20-24, 25-39, 40-54, 55-69, 70-79, 80-84 and 85+. We later use the words "*life-cycle stage*" and "*age group*" interchangeably.

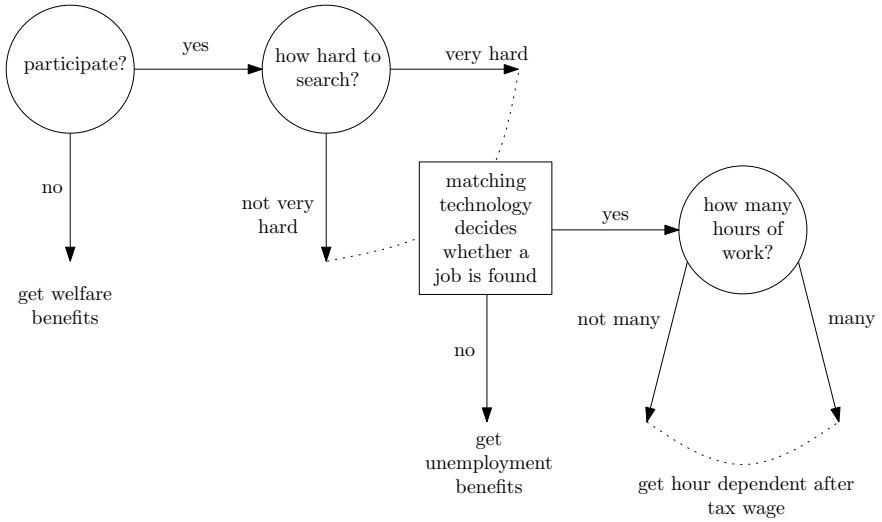


Figure 1: Sequence of households decisions related to the labor market

number of time periods of the life-cycle stage with participation[13]). The labor market is imperfect, leading to unemployment. Households who join the labor market start unemployed. Further, households who have a job may be hit by idiosyncratic unemployment shocks with probability $1-\varepsilon^{a,i}$ in each time period. Depending on search efforts, a job may or may not be found. If unemployed, households choose job search efforts ($s^{a,i} \geq 0$). If they have a job, they decide how many hours to work ($l^{a,i} \geq 0$). Being spared the unemployment shock leads to rents, which are bargained with firms to define the wage, building on the static search and matching setting of Boone and Bovenberg (2002). As in Jaag, Keuschnigg, and Keuschnigg (2010), non-participation in life-cycle a^R is interpreted as retirement. The sequence of households decisions is summarized in figure 1.

Conditional on labor market participation and employment, gross labor income equals

$$y_{lab}^{a,i} = l^{a,i} \cdot \theta^{a,i} \cdot w^i,$$

where $\theta^{a,i}$ is an exogenous age-productivity profile calibrated with micro-data and w^i is the bargained wage per efficiency unit, assuming separate labor markets for each skill class.

Household maximization: Households make labor decisions $\left(\delta^{a,i}, s^{a,i}, l^{a,i}\right)$ and consumption decisions $C^{a,i}$ to maximize their expected life-time utility $V_t^{0,i}$, where $V_t^{a,i}$ is the expected remaining life-time utility of a household in life-cycle

[13]To be more specific, the decision also depends on the time period t and the life history α of the household, which includes the birth date. One should thus write $\delta_{\alpha,t}^{a,i} \in [0,1]$. For ease of notation, we do not write indices α, t when there is no risk of confusion.

stage a with skill level i at time t. Preferences are expressed in recursive fashion and restrict households to being risk neutral with respect to variations in income but allow for an arbitrary intertemporal elasticity of substitution:

$$V_t^{a,i} = \max\left[\left(Q_t^{a,i}\right)^{\rho} + \gamma^a \beta \left(GV_{t+1}^{a,i}\right)^{\rho}\right]^{1/\rho},$$

where ρ defines the elasticity of intertemporal substitution $1/(1-\rho)$, β is a time discounting factor, $Q_t^{a,i}$ is effort-adjusted consumption, $G = 1 + g$ is the gross factor of growth by which the model is detrended.

Labor market activity generates disutility. Effort-adjusted consumption $Q^{a,i}$ captures the utility cost of labor market activity expressed in goods equivalent terms, with

$$Q^{a,i} \quad = \quad C^{a,i} - \bar{\varphi}^{a,i}\left(\delta^{a,i}, s^{a,i}, l^{a,i}\right),$$

and $\bar{\varphi}^{a,i}$ a convex increasing function in all its arguments. Specifically,

$$\begin{aligned}\bar{\varphi}^{a,i} \quad = \quad & \delta^{a,i}\left[\left(1-u^{a,i}\right)\varphi^{L,i}\left(l^{a,i}\right) + \left(1-\varepsilon^{a,i}\right)\varphi^{S,i}\left(s^{a,i}\right)\right] \; + \\ & \varphi^{P,i}\left(\delta^{a,i}\right) \; - \; \left(1-\delta^{a,i}+\delta^{a,i}u^{a,i}\right)h^{a,i},\end{aligned}$$

where $u^{a,i} \in [0,1]$ represents the fraction of time in unemployment, $h^{a,i}$ is the value of home production if the household is not working, $\varphi^{L,i}$ captures the disutility of working, $\varphi^{P,i}$ the disutility of participation and $\varphi^{S,i}$ the disutility of job search efforts.

Given the Blanchard (1985) insurance, the budget constraint of households is:

$$G\gamma^{a,i}A_{t+1}^{a,i} = R_{t+1}\left(A_t^{a,i} + y_t^{a,i} - C_t^{a,i}\right),$$

where $A^{a,i}$ represent assets, $y^{a,i}$ net income flows and $R = 1 + r$ the gross interest rate.

Social security: Before retirement, non-participants receive (net) welfare benefits y_{nonpar}^{a} while unemployed workers receive (gross) unemployment benefits $b^{a,i} = b^i \cdot y_{lab}^{a,i}$, where b^i is the skill-dependent replacement rate. After retirement, households receive (net) pension benefits $y_{pens}^{a,i} = \nu^a P^{a,i} + P_0^a$, where P_0^a is a flat part, $P^{a,i}$ represents acquired pension rights and ν^a is a conversion factor between pension rights and pension payments. Pension rights accumulate with labor earnings, following $P_{t+1}^{a,i} = \delta_t^{a,i}\left(1-u_t^{a,i}\right)y_{lab,t}^{a,i} + P_t^{a,i}$.

Taking labor income taxes and social security contributions $\tau_t^{a,i}$ into account and assuming that each labor market state (i.e. non-participation, unemployment and employment) is visited in each time period[14], net household income amounts to:

$$y^{a,i} = \begin{cases} \left(1-\tau^{a,i}\right)\delta^{a,i}\left[\left(1-u^{a,i}\right)y_{lab}^{a,i} + u^{a,i}b^{a,i}\right] + \left(1-\delta^{a,i}\right)y_{nonpar}^{a} & \text{if } a < a^R, \\ \left(1-\tau^{a,i}\right)\delta^{a,i}\left[\left(1-u^{a,i}\right)y_{lab}^{a,i} + u^{a,i}b^{a,i}\right] + \left(1-\delta^{a,i}\right)y_{pens}^{a,i} & \text{if } a = a^R, \\ y_{pens}^{a,i} & \text{if } a > a^R. \end{cases}$$

[14]The assumption follows Jaag, Keuschnigg, and Keuschnigg (2010).

Production: Production is made by a competitive representative firm taking input prices as given, namely wage rates, the interest rate and the price of the output good, which serves as numeraire. Changes in the production process are costly variations in the capital stock, and are subject to convex capital adjustment costs, following Hayashi (1982).

The production function is linear homogenous:

$$Y_t = F^Y\left(K_t, L_t^{D,i=1}, L_t^{D,i=2}, L_t^{D,i=3}\right).$$

The labor inputs $L_t^{D,i}$ from different skill classes are not perfect substitutes. Consistent with empirical evidence (Griliches, 1969), we assume that high skill labor and capital are more complementary than low skill labor and capital and use a nested CES-specification F^Y from Jaag (2009).

Firms make investment I_t and hiring decisions to maximize the flow of dividends they can generate. Formally, the firm maximizes its end of period value W, which equals the stream of discounted dividend payments χ:

$$\begin{aligned} W_t = W(K_t) &= \max_{I_t, L_t^{D,i}} \left[\chi_t + \frac{GV(K_{t+1})}{R_{t+1}}\right], \\ s.t. \qquad & \chi_t = Y_t - I_t - J(I_t, K_t) - \sum_i (1+\tau^{F,a}) w_t^i L_t^{D,i}, \\ & GK_{t+1} = \left(1-\delta^K\right) K_t + I_t, \end{aligned}$$

where $J(\cdot)$ denotes the adjustment costs and $\tau^{F,a}$ the firms social security contribution rate. Labor demands are pinned down by the marginal products and the labor costs, which consist of wage and contribution rates, i.e. $Y_{L^{D,i}} = (1+\tau^{F,a})w^i$. Given an interest rate, investment is defined so that the return on financial investments (the interest rate) equals the marginal cost of investment (Tobin's q), which depends on the marginal product of capital, net of capital adjustment costs and depreciation[15].

Government: Government provides welfare benefits, unemployment insurance, pay-as-you-go pensions and investment subsidies. State expenditures also include public consumption, long-term care and health expenditures, all defined exogenously in per capita terms and generating no utility.

To finance expenditures, the government collects consumption taxes, labor and capital income taxes, profit taxes, firm and worker social security contributions. The government can borrow on the capital market (with or without premium on the interest rate) to finance public debt, to meet some exogenously defined target (most of the time kept constant in simulations).

[15] In steady-state, the capital stock is stable so that they are no capital adjustment costs. In this case, investment satisfies the standard condition where the interest rate equals the marginal product of capital net of depreciation, $r = F_K^Y - \delta^K$.

Single-country equilibrium: In a single-country setting, we assume that the gross interest rate $R_{t+1} = 1 + r_{t+1}$ is exogenously defined, as for small open economies. Savings can be invested in firms, government debt and foreign assets. Assuming no arbitrage, the net returns on these three types of assets are the same and equal to the interest rate r_{t+1}. The goods market then clears because of trade with the rest of the world:

$$Y_t = C_t + I_t + G_t + TB_t,$$

where C_t is the aggregate private consumption[16], G_t is government expenditure and TB_t is the trade balance. Holding of foreign assets by domestic households evolves with changes in the trade balance:

$$D^F_{t+1} = R_{t+1}\left(D^F_t + TB_t\right).$$

Private household assets A_t are invested in the domestic representative firm W_t, government debt D^G_t and foreign assets D^F_t, so that the asset market clearing condition is satisfied:

$$A_t = W_t + D^G_t + D^F_t.$$

3.2 Extension to a multi-country setting

We follow Boersch-Supan et al. (2006), an extension of the two-country Buiter (1981) procedure to any number of countries and capital adjustment costs. We assume that labor is immobile, that capital is perfectly mobile and that all countries produce the same composite good. The interest rate is no longer exogenous, but endogenous.

Equilibrium: Under these assumptions, the equilibrium interest rate must be the same in all countries. The intuition is as follows. Assume there is an arbitrage opportunity. Investors in the low interest rate country start to invest in the high interest rate country. The capital stock in the first country declines, increasing the marginal product of capital and thus the interest rate in that country. The opposite happens in the second country. This continues until an equilibrium is reached where the two interest rates are identical.

As a whole, the set of countries is a closed economy, where the interest rate adjusts so that the goods market clear. The resulting equilibrium interest rate is thus the unique value such that the goods market clear over all countries. Formally, consider M countries indexed by $j \in \{1, ..., M\}$. Assume that terms of change are fixed and that each variables are normalized so that the numeraire value, after currency-exchange corrections, is the same in all countries. The interest rate is then the unique value such that

$$\sum_{j \in \{1,\ldots,M\}} TB_{j,t} = 0.$$

[16] So, $C_t = \sum_i \sum_a N^{a,i}_t C^{a,i}_t$ where $N^{a,i}_t$ is the number of households alive at time t, member of age group a and skill group i. Other households-related aggregate variables are defined in a similar fashion, including aggregate financial assets A_t.

Rest of the world: We do not consider all countries in the world but restrict policy analysis to a smaller subset[17], too small to be isolated from the world capital markets. Consistent with empirical evidence, the goods market, as a whole, will not clear over this subset. We thus consider a large synthetic *Rest-of-the-world* country (or a small group of Rest-of-the-world countries), which will account for trade with the rest of the world. The goods market will clear over all countries which are either part of the subset, or one of the Rest-of-the-world countries. Compared to a case without a Rest-of-the-world country, the adjustment of the equilibrium interest rate is dampened. This reflects access of all countries in the subset to the world capital market.

4 Calibration

We use a calibration approach which is standard in the literature. Compared to other overlapping generations models, labor market and institutions are modeled in detail. The model incorporates extensive and intensive labor supply margins, different taxes, social security contributions and a pay-as-you-go pension system. Where available, we take consensual empirical estimates from the literature. Production function specifications are adopted from Jaag (2009). Labor market parameters are derived from Immervoll et al. (2007) and Mincer wage regressions on EU-SILC microdata. Microlevel calibration targets, such as participation rate, working hours or social security benefits are estimated using LFS and EU-SILC datasets. Parameters for institutions are derived using the MISSOC database (European Commission, 2009) and OECD's Tax-Benefit model (from OECD 2007, 2008). Intervivo transfer parameters are calculated to generate life-cycle consumption profiles in line with empirical evidence.
The multi-country setup requires the inclusion and subsequent calibration of a stylized rest of the world. To be able to reflect large economic differences between countries at least to some extent, we model and calibrate a "North Rest of the World" country (NROW) and a "South Rest of the World" country (SROW). The aim is to capture a sufficient part of the real rest of the world economy while not including many single countries in our stylized rest of the world countries. The scope of this paper is indeed not to model impacts outside the EU but to capture the impact of forces coming from outside of the EU. Hence our stylized NROW consists of Canada, Japan and USA and SROW consists of Brazil, China and India[18]. For calibration we need both macrolevel and microlevel data. Macrolevel data is available for the selected countries. We use the online available databases from: World Bank, OECD, WIOD Socio Economic Accounts, UNESCO, Penn World Table, UNO, ILO and IMF.
Most of the microlevel data was not available for the selected countries. Thus

[17] In the implementation, the subset contains 14 countries member of the European Union, namely Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, The Netherlands, Poland, Slovakia, Spain, Sweden and the UK.

[18] With this approach we are capturing 58.5% of actual real world GDP and five of the eleven most important trade partners of the EU reflecting 41.5% of total trade of the EU (in terms of trade in million EURO).

we developed an approach which we label "twin country approach" in order to generate the missing microlevel data inputs for our model. The idea of twinning is the following: we create a table of various important economic and demographic indicators for each country. Then we look for a country in the scope (one of the 14 countries for which the model is already calibrated) which is the closest to the NROW (respectively SROW) region, selecting key economic, policy and demographic criterion to compare countries. We then take the calibrated value from the closest (twin) country to the NROW (respectively SROW) country. This approximation was typically necessary for data stemming from microlevel datasets, such as income and labor market data which allows to calibrate average tax rates for each age and skill class. One exception is applied: we use stylized approximation when there is a documented difference between the ROW countries and the designated twin country. For instance, if there is a documented lack of pensions, we manually adjust the respective parameter for the ROW country such that the difference is matched. Our approach results in approximating missing inputs for NROW by inputs from the already calibrated UK and missing inputs for SROW by a combination of inputs for the Czech Republic, the Slovak Republic and Poland and correct for documented differences concerning the social security systems. The appendix C contains details on calibration of the Rest-of-the-world countries.

5 Results

This section provides the quantitative and qualitative results of our experiments. For our exploration of long-run spillover effects and coordination of fiscal policy across countries in Europe, a number of simulations were needed. Specifically, we performed simulations to quantify spillovers from labor and consumption tax reforms, large one-time exogenous shocks typical of crises, and combinations of both. Furthermore, we compared selected forms of fiscal policy coordination, with and without exogenous shocks, without considering all possible forms of coordination. We confine ourselves to presenting the most important results.
Table 3 provides an overview of the simulations we report, which include policy reforms alone, exogenous shocks alone or a combination of both. Details of the simulations will be provided when each result is discussed. Appendix D provides results for additional simulations, including other forms of policy coordination, which do not change the overall conclusion from the analysis.

Description	Magnitude	Financing	Country	Subsection
Simple policy reforms				
Single country labor tax cut	-20%	LS Tax	GER	5.1
Single country labor tax cut	-20%	Cons Tax	GER	5.2
Simultaneous labor tax cuts	-20%	LS Tax	All	5.3
Exogenous shocks				
Shock to the capital stock	-20%	LS Tax	GER	5.4
Shocks to the capital stock	-20%	LS Tax	All	5.5
Shocks and policy responses				
Spending shock with response	+25%	Lab Tax	GER	5.6
Spending shocks with response	+25%	Lab Tax	All	5.7

Legend: *LS Tax* = Lump-sum tax; *Cons Tax* = consumption tax; *Lab Tax* = Labor income taxes.

Table 3: Simulation Overview

Throughout the analysis, we take gross domestic product as the main indicator of economic activity and focus our discussion of spillovers on this indicator. In the discussion we use the terms *goods market* and *capital market* interchangeably. We also characterize cross-country spillovers either in terms of variations in the trade balance or variations in the integrated capital market. These equivalences hold because the model features only a composite good which can either be consumed or invested without any further transformation, after being produced.

5.1 Labor tax cut in a single country financed by lump-sum taxes

We calculate the spillovers on 13 other European countries when one country implements a 20% labor tax cut. The country which implements the reform finances the tax reduction by raising lump-sum taxes (equivalently, reducing unconditional subsidies to households). We discuss the results for Germany, where the largest spillovers take place.

We find overall spillovers from a tax reform to be negative and quantitatively small. Table 4 displays the domestic impacts of the labor tax cut for Germany and the spillovers to Spain. We present the results for Spain because the spillovers are quantitatively the largest. For Germany the reform generates a long-term 0.93% improvement of GDP. The long-term spillovers on Spain's GDP are negative and about 1.7% of the effect for Germany: GDP decreases 0.016% in Spain.

First, we explain why a tax reform in Germany has negative spillovers on other countries. Then we continue to explain why spillovers are small.

In Germany labor taxes are lowered. This immediately creates incentives on the

labor market. Thus effective employment increases. This has a positive effect on GDP, investment, consumption and the capital stock. An increase in GDP and consumption triggers a decrease in the trade balance over the short run. The reason why consumption grows more than GDP in the short run, which decreases the trade balance, is the following: the capital stock does not increase as fast as labor supply because of capital adjustment costs. Households are forward looking and anticipate future higher output. Consumption increases more immediately because households smooth consumption intertemporally. Germany imports more to cover the increased demand over the short run.
This has the following effect on other countries. First, their trade balance increases. Other countries export more to Germany, where demand is increased. Hence consumption and investment will decrease[19]. This leads to a decrease in the capital stock and GDP. As capital declines, the marginal product of labor declines. Hence wages are declining. This leads to reduced labor supply, contributing to the decline in GDP.
We now explain why spillovers are small. The only channel through which spillovers are transmitted is the trade channel. A reform in one country triggers a change in trade, leading to more exports or imports of goods and services. Goods and services are relatively mobile, but the net trade volumes remain small. For instance, the current account position of Germany, one of the largest in Europe, stands at about 7% of GDP. Hence changes in the trade balance, which affect other countries, are small compared to the changes in the entire economic activity of Germany. Moreover the total effects transmitted are distributed across all trade partners. Migration within the European Union would lead to bigger spillovers (see e.g. Clemens, 2011) but comes with societal challenges (see e.g. Borjas, 2015), and is not considered in this project.
We now discuss a second scenario where a single country implements a fiscal policy reform. The following subsection will deal with the effects of a fiscal devaluation policy.

5.2 Labor tax cut in a single country financed by consumption taxes

We repeat the simulation presented in section 5.1 with one difference. Instead of lump-sum taxes, we use changes in consumption taxes to finance the labor tax cut, a so-called fiscal devaluation policy. Again, we display results for Germany, as the resulting spillovers are quantitatively the largest.
Table 5 shows the domestic effects for Germany and the spillovers for Spain. The long-term effect for Germany is an 0.43% increase in GDP. For Spain there is a positive long-term effect on GDP of 1.8% of the effect for Germany: GDP increases less than 0.01% in Spain.
The propagation mechanism for Germany is the same as for the case of lump-

[19] Another consistent angle is the following: as labor supply increases faster than the capital stock in Germany (due to capital adjustment costs), the increase in marginal product of capital in Germany increases returns for foreign investors, who shift some of their investments from their country to Germany.

	GER		ESP		Spillover %	
	1	FSS	1	FSS	1	FSS
Macroeconomics						
GDP (%)	0.612	0.934	-0.006	-0.016	0.980	1.713
Investment (%)	1.924	0.978	-0.077	-0.032	4.002	3.272
Capital Stock (%)	-0.001	0.978	-0.001	-0.032	100.000	3.272
Consumption (%)	1.170	0.991	-0.046	0.027	3.932	2.725
Assets (%)	1.998	0.821	-0.063	0.039	3.153	4.750
Trade Balance (%)	-0.429	0.168	0.040	-0.021	9.324	12.500
Interest Rate (%)	0.002	0.066	0.002	0.066	-	-
Public Finance						
Tax Ratio (pp)	-0.014	-0.015	0.000	0.000	0.000	0.000
Transfers to HH (pp)	-1.135	-1.118	-0.005	0.003	0.441	0.268
Labor Market						
Participation (pp)	0.173	0.204	-0.001	-0.003	0.578	1.471
Hours Worked (%)	0.196	0.233	-0.001	-0.002	0.510	0.858
Unemployment (pp)	-0.302	-0.357	0.001	0.004	0.331	1.120
Gross Wage Rate (%)	-0.848	-0.398	0.003	-0.020	0.354	5.025
Net Wage Rate (%)	2.839	3.298	0.003	-0.019	0.106	0.576
Taxes						
Consumption Tax (pp)	-	-	-	-	-	-
Worker Income Tax (pp)	-0.024	-0.024	-	-	-	-

Legend: 1 = year of impact, *FSS* = Final Steady State, (%) = changes in percentage from initial steady state, (pp) = changes in percentage points from initial steady state, *Tax Ratio* = government revenue over GDP, *Taxes* are average taxes over all age groups, *Spillover %*= percentage change in GDP (%) in ESP compared to change in GDP (%) in GER. This table shows the domestic effects and strongest spillover effects (in this case for Spain) for the case that Germany conducts a 20% labor tax cut, financed by lump-sum taxes.

Table 4: Spillovers from a labor tax cut in Germany financed by lump-sum taxes

sum tax closing, with one difference. As the consumption tax is increased to finance the labor tax cut, consumption is decreasing. The increase in GDP in combination with a decrease in consumption lead to an increase in trade balance, as Germany is exporting more. Overall, the domestic effects are weaker compared to 5.1. Consumption tax is a distortive tax. This means that households change their behavior as reaction to changes in consumption taxes. In particular the increase in consumption taxes reduces the incentive to increase labor supply that the labor tax cut generates. Hence the labor supply increases more in 5.1 than in 5.2.

For other countries the trade balance is decreasing in response, as they are importing more. Hence consumption rises and in turn the government is able to lower consumption tax. This creates incentives on the labor market. There is

more effective employment. Hence there is an increase in GDP and investment. It should again be pointed out that overall the quantitative spillover effects are negligibly small (for explanation, see 5.1).

	GER		ESP		Spillover %	
	1	FSS	1	FSS	1	FSS
Macroeconomics						
GDP (%)	0.126	0.431	0.003	0.008	2.381	1.856
Investment (%)	0.869	0.494	0.007	0.016	0.806	3.239
Capital Stock (%)	0.000	0.494	0.000	0.016	100	3.239
Consumption (%)	-0.271	0.720	0.024	-0.015	8.856	2.083
Assets (%)	1.333	2.218	0.025	-0.019	1.875	0.857
Trade Balance (%)	0.134	-0.088	-0.011	0.011	8.209	12.500
Interest Rate (%)	0.000	-0.035	0.000	-0.035	-	-
Public Finance						
Tax Ratio (pp)	0.001	0.000	0.000	0.000	0.000	100
Transfers to HH (pp)	0.000	0.000	0.000	0.000	100	100
Labor Market						
Participation (pp)	0.002	0.039	0.001	0.001	50.000	2.564
Hours Worked (%)	0.034	0.073	0.001	0.001	2.941	1.370
Unemployment (pp)	-0.141	-0.189	-0.001	-0.002	0.709	1.058
Gross Wage Rate (%)	-0.398	-0.227	-0.003	0.011	0.754	4.846
Net Wage Rate (%)	3.297	3.472	-0.003	0.010	0.091	0.288
Taxes						
Consumption Tax (pp)	0.027	0.024	-0.000	0.000	0.000	0.000
Worker Income Tax (pp)	-0.024	-0.024	-	-	-	-

Legend: see legend table 4. This table shows the domestic effects and strongest spillover effects (in this case for Spain) for the case that Germany conducts a 20% labor tax cut, financed by increasing consumption taxes.

Table 5: Spillovers from a labor tax cut in Germany financed by consumption taxes

5.3 Simultaneous labor tax cuts

In this scenario we study the effects when all countries in our scope implement simultaneously a 20% labor tax cut which is financed by lump-sum taxes, one possible form of policy coordination. Taking spillovers into account, we want to compare outcomes with the single country scenario. The results indicate that simultaneous labor tax cuts are not beneficial: the increase in GDP is lower for Germany if the labor tax cut is performed in all countries than if only Germany implements the tax cut, as in section 5.1. This effect is slightly stronger over the short run. Table 6 displays the effects on GDP for Germany. In case of an area-wide simultaneous labor tax cut, German GDP is increasing 3.66% less in the short run and 3.03% less in the long run.

The main driver is the integrated capital market. The tax cut is an incentive to provide more labor, in both cases, which increases household income and consumption. When only one country performs a tax cut, the increase in consumption is supported by an increase in imports (see 5.1), which all other countries can cover with an increase in exports. When all countries perform the tax cut, they all would like to increase imports. Only the rest of the world is in position to supply additional goods. On the goods market, there is thus a higher pressure when all countries perform the tax cut. Firms want to increase the capital stock in both cases, to keep a good capital-labor ratio, as labor supply increases. When all countries perform the tax cut, the pressure on the goods market is higher, so it is more expensive to increase the capital stock (which can be seen by a more than 4 times larger increase of the interest rate). As capital stock, a production factor, increases less with coordinated tax cuts, GDP increases less with coordinated tax cuts.
In absolute terms, the difference between the single country case and the coordinated case is small (in the single country case Germany has a 0.934% increase in GDP, in the coordinated case a 0.907% increase). The fact that this form of coordination has quantitatively a small impact follows from the fact that spillover effects (without coordination) are small: if a reform in one country has small impact on other countries, then it does not really matter if other countries also do the same reform, quantitatively.
Hence we conclude that simultaneous implementation of a simple fiscal policy reform, namely a labor tax cut, is not beneficial. Nevertheless, a simultaneous implementation, where every participating country implements the policy reform at the same time, is not the only possible form of coordination. Precisely because of the quantitatively small spillover effects, other forms of fiscal policy coordination can be beneficial.

	GER tax reform		EU tax reform		Difference in %	
	1	FSS	1	FSS	1	FSS
GDP (%)	0.612	0.934	0.591	0.907	3.66	3.03
Interest Rate (%)	0.002	0.066	0.009	0.299		

Legend: 1 = year of impact, *FSS* = Final Steady State, (%) = changes in percentage from initial steady state. This table shows the effects on GDP for Germany if only Germany implements a tax cut (GER tax reform) and if all countries implement simultaneously the same tax cut (EU tax reform).

Table 6: Area-wide simultaneous labor tax cut, selected outcomes for Germany

5.4 Asymmetric shock to the capital stock

The scenarios discussed above have in common that the reforms are implemented in economically stable times. We now discuss scenarios where one or more economies are hit by a shock and such economically unstable times (crises) may require policy responses.

Let us consider the case where Germany is hit by an exogenous shock which destroys 20% of the capital stock, for instance an earthquake. Germany does not respond (yet) to the shock, as we want to investigate the spillover effects stemming from the shock alone. The government budget in Germany is balanced by lump-sum taxes, which are non distortive. Again, we take Germany as our benchmark scenario, as the spillovers are quantitatively the largest.

We find that spillovers from shocks are quantitatively larger than from simple policy reforms. As example, we provide details for the spillovers on Spain, where spillovers are quantitatively the largest. Table 7 summarizes our findings. After 10 periods, there is a 0.35% decrease in GDP for Spain. In Germany GDP decreases by 3.38% after 10 periods. Hence the spillovers in Spain amount to 10.3% of the effect in Germany. To compare, in the case of the labor tax reform in Germany considered in section 5.1, GDP decreases in Spain by 0.018% after 10 periods and increases by 0.84% in Germany[20]. So spillovers in Spain amount to 2.1%. Hence the decrease in GDP is nearly 5 times stronger in case of a shock in Germany compared to a simple tax policy reform after 10 periods.

We first explain why there are spillovers. As a consequence of the negative shock the capital-labor ratio decreases in Germany, which reduces wages. This creates negative incentives on the labor market and effective employment drops. Because both production factors (capital and labor) drop, GDP also drops. The drop in capital-labor ratio also increases the marginal product of capital (and ultimately the interest rate), so investment increases. As production is reduced and investment is increased, there is an increase in imports (for consumption and investment) and a simultaneous decrease in exports. Hence trade balance is decreasing.

The trade balance increases for other countries as there are more exports. Domestic consumption and investment decrease in turn, while investments increase in Germany. The marginal product of capital in Germany is indeed much higher, so foreign investors prefer to invest in Germany and not domestically. The capital stock thus also decreases in other countries. As the capital stock decreases, the marginal product of labor decreases and wages decrease as well. This has a negative effect on the labor supply and effective employment. As labor supply and capital decrease, GDP is likewise decreasing.

We next explain why spillovers are larger. The shock on the capital stock induces a strong reaction on the labor market (compared to the simple tax reform in section 5.1). Net wages decrease as adjustment to the change in marginal factor products, following the capital-labor ratio decrease. Then labor supply is reduced, as wages decrease. In case of a capital shock gross wages and hence net wages decrease by 0.37% after 10 periods, compared to a decrease by 0.016% after 10 periods in case 5.1. Effective employment decreases by 0.17% after 10 periods in case of a shock and by 0.009% in case 5.1. So labor market effects are significantly larger than in case of a policy reform. Furthermore the increase in the interest rate (2.3% compared to 0.1% in 5.1) reduces incentives for firms

[20]In the interest of space, we have not reported in table 7 the impact of the labor tax cut in Germany in Germany itself. Values for period 1 can be found in table 4. Values for period 10 are not reported in any table. Key values for this period are reported in the text.

to invest in Spain. Part of the investment is crowded out in Spain and shifted to Germany (trade balance improves nearly 3 times more compared to 5.1). In combination, these effects induce a stronger decrease in the capital stock in Spain (0.58% compared to 0.026% in 5.1). Thus economic aggregates are more affected (e.g. GDP decreases by 0.35% after 10 periods compared to 0.018% in 5.1).

	K-shock to GER				Tax Cut in GER	
	GER		ESP		ESP	
	1	10	1	10	1	10
GDP (%)	-9.152	-3.384	-0.075	-0.350	-0.006	-0.018
Capital Stock (%)	-19.996	-7.540	0.006	-0.578	-0.001	-0.026
Eff. Employment (%)	-3.291	-1.124	-0.075	-0.174	-0.004	-0.009
Gross Wage (%)	-10.065	-3.587	0.084	-0.372	0.003	-0.016
Net Wage (%)	-9.843	-3.505	0.080	-0.350	0.003	-0.015
Trade Balance (%)	-7.008	-0.642	0.723	0.028	0.040	0.011
Interest Rate (%)	-0.013	2.305	-0.013	2.305	0.002	0.096

GDP Spillover %			
K-Shock to GER		Tax Cut in GER	
%ESP/GER		%ESP/GER	
1	10	1	10
0.8	10.3	0.9	2.1

Legend: 1 = year of impact, *10* = 10 years after impact, (%) = changes in percentage from initial steady state. *GDP Spillover %* = change of GDP in Spain over change of GDP in Germany. This table shows the domestic effects of a shock to the capital stock in Germany (K-shock to GER, GER), spillover effects to Spain (K-shock to GER, ESP) and spillover effects to Spain from a tax cut in Germany (Tax Cut in GER, ESP)

Table 7: Spillover effects from a shock on the German capital stock

5.5 Symmetric shock to the capital stock

Next, we consider the case of a symmetric shock to all countries in our scope, which destroys 20% of the capital stock in each country. Budgets are again balanced by lump-sum taxes. We compare outcomes of this symmetric shock with the asymmetric shock in section 5.4.

For the respective countries, the negative effects of a symmetric shock are stronger than the effects of an asymmetric shock to one country. Table 8 shows that for Germany the negative impact on GDP is 22.6% larger in case of a symmetric shock to all countries after 10 periods.

In the asymmetric case all countries which are not hit by a shock can cover the increased demand for imports in Germany with more exports. This is does not hold for the symmetric case. Only the rest of the world is in position to increase

exports. As the capital stock declines more in the symmetric case, the marginal product of labor declines more in this case. Hence wages are declining and labor supply is reduced more in the symmetric case. Hence the decrease in GDP is larger in case of a symmetric shock, as both labor supply and capital are lower.

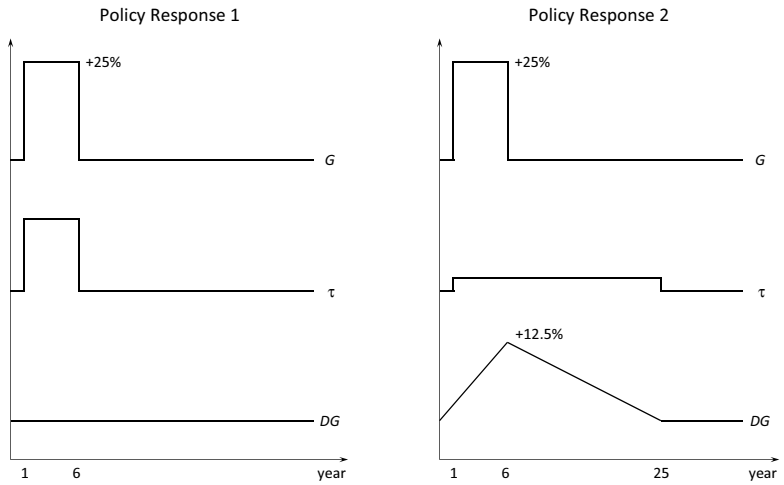
	GER K-shock		EU K-shock		Difference in %	
	1	10	1	10	1	10
GDP (%)	-9.15	-3.38	-9.25	-4.15	1.12	22.63

Legend: 1 = year of impact, 10 = ten years after impact, (%) = changes in percentage from initial steady state. This table shows the effects on GDP for Germany if only Germany is hit by a shock to capital stock (GER K-shock) and if all countries are hit by the same shock to the capital stock (EU K-shock).

Table 8: Effects of an area-wide shock to the capital stock on German GDP

5.6 Asymmetric shock to a single country with policy response

We continue our analysis with the simulation of large one-time exogenous shocks and consider different policy responses to the shock. We assume that Germany is hit by an exogenous shock which requires an increase in public spending (by 25%) to provide relief to households and firms. We implement two different policies as reaction to the shock. The first policy option, which we label response 1, consists of an increase in public consumption over five years financed by an increase of labor income taxes to keep public debt constant. The second option, which we label response 2, consists of an increase in public consumption over 5 years, but the government is allowed to increase public debt over 12 years by 12.5%. Public debt then has to return to its initial level after 25 years. Budget balance in this case is achieved by a moderate increase in labor income taxes. Figure 5.6 provides a stylized representation of the two responses, displaying variations in government consumption, average labor income taxes and public debt. Coordination rules may prescribe implementation of response 1, of response 2 or leave the country hit by the shock free to choose.
We quantify spillovers from the interaction of the shock and the policy response and compare the outcomes of the two different policy responses.
Table 9 summarizes the results. We report the results for Germany (hit by a shock), for Spain (were spillovers are largest) and Poland (where spillovers are smallest). We find that the total loss in GDP due to the shock is smaller with response 2 for Germany. Average yearly GDP loss (over 25 years) is 0.54% with response 2 and 0.59% with response 1. Spillover effects on GDP can be large, certainly larger than from a simple fiscal policy reform. The negative effects on Spain amount to 24.4% of the effects in Germany. However the size of the spillovers differ by country (24.4% for Spain, 10.0% for Poland). Furthermore



Legend: G = public spending, τ = labor income tax, DG = public debt

Figure 2: Policy Responses R1 and R2

negative spillovers on GDP of other countries is smaller with response 2. The average yearly GDP loss for Spain is 0.14% with response 1 and 0.12% with response 2.

First we explain why response 2 dominates response 1 and why the spillover effects are larger with response 1 than with response 2. With response 1 labor taxes are increasing. Consequently effective employment is decreasing in Germany. Since labor supply declines and firms keep their capital-labor ratio optimal, they reduce their capital stock (with reduced investment). This leads to a decrease in the capital stock and GDP. With lower production inputs (capital and labor), GDP declines. This simultaneous increase in public consumption and decrease in GDP induces Germany to increase imports. Thus the trade balance is decreasing.

The trade balance increases for other countries. More exports lead to a decrease in consumption and investment. This has a negative effect on the capital stock. As capital declines, the marginal product of labor declines. Hence wages are declining. This negatively affects labor supply, which together with the drop in capital affects GDP.

With response 2, the government can increase public debt. There is no need to raise labor income taxes as much as in response 1. Because disutility of labor increases in a convex fashion, tax increases generate over-proportional reactions in the labor market, so the decrease in labor supply is weaker with response 2. The decrease in GDP is smaller with response 2.

Next we explain why spillovers are small to moderate and overall larger than in the case of a simple policy reform (as in section 5.1). The largest impact is for Spain (average yearly GDP loss of 0.14% when Germany is hit by a shock

and uses response 1). As the German government increases public consumption to counterbalance the exogenous shock, the demand on the capital market is increased (crowding out of capital markets). The increase in demand is immediate and strong, following the shock in government consumption (2.8%-points of GDP). The strong initial drop in the trade balance of Germany illustrates this (-2%-points of GDP). By contrast, the increase in demand in the capital market in case of a fiscal reform is gradual, even if it is of the same magnitude (the capital stock increases close to 3.5%-points of GDP over the long run, but only 1%-point of GDP after the first 5 years). The increase in savings from German households is almost sufficient to respond to the increase in capital demand. The assistance of foreign investors is barely needed, as can bee seen with the small variation in trade balance in Germany (never more than -0.3%-points of GDP). In case of a shock, the increase in demand on the capital market has a stronger effect on the interest rate (e.g. +0.4% after 7 periods in case of a shock with response 1, compared to +0.1% in case 5.1). This reduces incentives for firms to invest in Spain. Also, the crowding out effect means that part of the production from Spain is exported Germany, which further reduces capital stock replacement. The capital stock in Spain declines (10 times larger decrease after 7 periods in this case, compared to case 5.1). As the interest rate increases and the capital stock declines, the marginal product of labor decreases (gross wage rate maximum decline of 0.16% in Spain in this case compared to 0.02% in case 5.1). This puts pressure on the wage. To maintain finances, the Spanish government increases labor taxes, hence net wages are decreasing (stronger than in case of a policy reform: 0.4% in this case instead of 0.015% in case 5.1). As a result labor supply drops (effective employment as much as 0.15% in this case compared to almost nothing in case of 5.1). Thus GDP is more affected than in case of a simple tax reform (maximum loss of 0.2% in this case for Spain, given labor supply decline of 0.15% and capital stock drop).

5.7 Symmetric shock to all countries with policy response

This scenario is very similar to the case presented in 5.6, except that all countries are hit by the same exogenous shock and all provide relief to households and firms, increasing public spending by 25%. We investigate the difference when all countries implement response 1 and when they implement response 2. We find that response 2 is better than response 1 for all countries in our scope. Coordination rules may impose response 1 or response 2 to all countries. Our simulations show that rules which prevent response 2 would be detrimental. As example we report results for Germany, contained in table 10. The average loss in GDP amounts to 0.85% with response 2 and to 0.94% with response 1 over the medium run (25 years). A symmetric shock generates larger negative effects for the respective country than a shock to the country alone. For Germany the average loss in GDP in case of a symmetric shock and response 2 is 0.85% and 0.54% in case of an asymmetric shock to Germany.

First we explain why the symmetric shock is worse than a shock to the country alone. The main driver is the capital market. The reason capital drops more

	GER		ESP		PL	
	R1	R2	R1	R2	R1	R2
	Period 7		Period 7		Period 7	
Macroeconomics						
GDP (%)	-0.447	-0.579	-0.198	-0.161	-0.090	-0.074
Capital Stock (%)	-0.523	-0.461	-0.315	-0.247	-0.195	-0.155
Trade Balance (%)	0.667	0.412	-0.106	-0.067	-0.058	-0.038
Interest Rate (%)	0.426	0.301	0.426	0.301	0.426	0.301
Labor Market						
Gross Wage Rate (%)	-0.071	0.245	-0.159	-0.118	-0.101	-0.079
Net Wage Rate (%)	-0.859	-1.892	-0.338	-0.278	-0.156	-0.127
Eff. Employment (%)	-0.247	-0.527	-0.123	-0.101	-0.055	-0.045
Yearly AVG Change						
GDP (%)	-0.591	-0.543	-0.144	-0.120	-0.059	-0.050

GDP Spillover %			
%ESP/GER		%PL/GER	
R1	R2	R1	R2
24.4	22.1	10.0	9.2

Legend: (%) = changes in percentage from initial steady state, *Yearly AVG Change* = yearly average changes over the medium run (25 years after impact), *GDP Spillover %* = yearly average change of GDP in Spain (resp. Poland) over yearly average change of GDP in Germany . This table shows effects of a shock to Germany where Germany reacts by increasing public spending, as well as spillovers to Spain and Poland.

Table 9: Effects of a spending shock to Germany and spillovers to other countries

with a symmetric shock is a stronger crowding out effect in the capital (goods) market. The crowding out effect happens in all cases: as government increases its investment (consumption), it draws more from the goods market, making it harder for firms to draw from this market. Firms therefore reduce investment. When the shock only happens in one country, the pressure on the integrated capital market is lower, so the reduction in firm investment (and hence capital stock) is smaller. In this case, there is only one country which increases government investment and puts pressure on the capital market. As the capital stock is decreasing more in case of a symmetric shock, the optimal capital labor ratio and the marginal product of labor are more affected. Furthermore labor income taxes increase less in case of an asymmetric shock to Germany, because production, and thus the wage basis, are dropping less. So in that case, the negative incentives on the labor market are weaker. This amplifies the described effect. Next we explain why a simultaneous response of all countries using response 2 is economically superior to a simultaneous response of all countries using response 1. The mechanism is the same as in section 5.6. Keeping constant public debt

as target and simultaneously increasing public consumption to counterbalance a shock lead to a strong increases in labor income taxes. Hence the negative reaction on the labor market is stronger. This has a stronger effect on macroeconomic aggregates, e.g. GDP and capital stock. In case the governments increase public debt, the effects are similar but as labor income taxes are not increased dramatically, the reactions are smaller.
We also note that the gains from implementing response 2 are larger if all countries are hit by a shock, than if only one country is hit by a shock, to a limited extent. There is a 10.7% gain in case of a symmetric shock compared to a 8.8% gain in case of an asymmetric shock (see Table 10).
The explanation is the following: With a symmetric shock, the crowding out effect is larger, because all countries are hit and little help from foreign investors takes place. When public debt cannot (temporarily) increase, labor income taxes need to be increased more, which reduces labor supply incentives. This increases the capital-labor ratio, decreases the marginal product of capital and thus exacerbates the crowding out effect (investment in firms becomes even less interesting). The symmetric shock with response 1 combines both negative effects: little help from foreign investors (because in the symmetric case, all countries are hit) and no help from intertemporal smoothing (because public debt is not allowed to increase). While response 2 is more advantageous with an asymmetric shock compared to response 1 (see section 5.6), it becomes even more advantageous with a symmetric shock.

	Shock to GER			Shock to EU		
	R1	R2	%	R1	R2	%
GDP (%)	-0.591	-0.543	8.84	-0.935	-0.845	10.65

Legend: R1 = response 1, R2 = response 2, % = Gain from response 2 in percentage, (%) = changes in percentage from initial steady state, *GDP* = average yearly change in GDP over the medium run (25 years). This table shows the yearly average loss in GDP for Germany for two cases: *Shock to GER* = Germany is hit by shock and increases public spending (see 5.6). *Shock to EU* = all countries are hit by a shock and increase public spending (see 5.7).

Table 10: Effects of different spending shocks on the GDP of Germany

6 Conclusions

We develop a rich OLG-model which is calibrated for a representative sample of the EU28 countries and two stylized Rest-of-the-World countries in a multi-country setting. We use the model to investigate standard tax policy reforms, exogenous shocks and combinations of shocks and policy reforms, quantifying spillovers within the EU. Specifically, we consider labor and consumption tax reforms as well as large one-time shocks to the capital stock or to government

spending, representative of crises. We also compare some examples of fiscal policy coordination, without considering all possible forms of coordination.
We find that spillovers are small in case of standard labor and consumption tax policy reforms, when no exogenous shocks take place, and that a simultaneous area-wide implementation of such fiscal policy reforms is not beneficial.
However spillovers are bigger in case of large, one-time unexpected shocks, as GDP losses in shock-free countries can amount to 24% of the losses in countries hit by a shock. Such sizable spillovers provide a rationale for policy coordination. When these shocks take place, negative economic consequences can be reduced if public debt is allowed to increase temporarily and come back to its initial level at a later point. The benefits from this policy option are larger when more than one countries are hit by a shock. Under the conservative assumption on interest spread and labor elasticities that we consider gains are however limited, the GDP losses being reduced by 10% or less when public debt is allowed a temporary increase.
For many countries of the European Union, such temporary increases in public debt would however not be compatible with the current coordination rules, which impose an upper limit on fiscal deficits and public debts. Countries which have not been able to respect these rules in the past are usually in a weaker economic position, and less likely to have the room for a temporary increase in public debt if they are hit again by an adverse shock. Over time, countries with bad luck or unsound fiscal public finance management or both may find themselves in growingly weaker economic position because of coordination rules, rather than their own economic policy (vicious circle). The European Union fiscal rules may thus benefit from an adjustment, seeking to differentiate cases of unsound public finance management from other cases.
The study provides a modelling framework and uses it to explore spillovers and different forms of policy coordination. Altogether, for the cases that we considered, our exploration exhibited visible spillovers but only small gains of coordination. Future research can further make use of the framework to investigate other spillover sources and alternative forms of policy coordination. In particular, policy coordination gains may be larger with more sophisticated coordination rules.

References

Alesina, A. and R. Wacziarg (1999): "Is Europe going too far?" *Carnegie-Rochester Conference Series on Public Policy*, 51, 1–42.

Auerbach, A. and Y. Gorodnichenko (2013): "Output Spillovers from Fiscal Policy," *The American Economic Review: Papers and Proceedings*, 103, 141–146.

Auerbach, A. J. and L. J. Kotlikoff (1987): *Dynamic Fiscal Policy*, Cambridge University Press.

Beetsma, R. and L. Bovenberg (1998): "Monetary union without fiscal coordination may discipline policymakers," *Journal of International Economics*, 45, 239–258.

——— (2001): "The Optimality of a Monetary Union without a Fiscal Union," *Journal of Money, Credit and Banking*, 33, 179–204.

Beetsma, R., X. Debrun, and F. Klaassen (2001): "Is fiscal policy coordination in EMU desirable?" *Swedish Economic Policy Review*, 8, 57–98.

Beetsma, R., M. Giuliodori, and F. Klaassen (2006): "Trade Spill-Overs of Fiscal Policy in the European Union: A Panel Analysis," *Economic Policy*, 21, 639+641–687.

Benes, J., M. Kumhof, D. Laxton, D. Muir, and S. Mursula (2013): "The Benefits of International Policy Coordination Revisited," *IMF Working Paper*, WP/13/262, 1–52.

Berger, J., T. Davoine, P. Schuster, and L. Strohner (2016): "Cross-country differences in the contribution of future migration to old-age financing," *International Tax and Public Finance*, forthcoming, 1–25.

Berger, J., C. Keuschnigg, M. Keuschnigg, M. Miess, L. Strohner, and R. Winter-Ebmer (2009): "Modelling of Labour Markets in the European Union," Final Report for DG EMPL of the European Commission.

Blanchard, O. J. (1985): "Debt, Deficits, and Finite Horizons," *Journal of Political Economy*, 93, 223–47.

Boersch-Supan, A., A. Ludwig, and J. Winter (2006): "Ageing, Pension Reform and Capital Flows: A Multi-Country Simulation Model," *Economica*, 73, 625–658.

Boone, J. and L. Bovenberg (2002): "Optimal labour taxation and search," *Journal of Public Economics*, 85, 53–97.

Borjas, G. J. (2015): "Immigration and Globalization: A Review Essay," *Journal of Economic Literature*, 53, 961–74.

Buiter, W. H. (1981): "Time Preference and International Lending and Borrowing in an Overlapping-Generations Model," *Journal of Political Economy*, 89, 769–97.

Clemens, M. A. (2011): "Economics and Emigration: Trillion-Dollar Bills on the Sidewalk?" *Journal of Economic Perspectives*, 25, 83–106.

Corsetti, G., A. Meier, and G. J. Mï¿œller (2010): "Cross-Border Spillovers from Fiscal Stimulus," *International Journal of Central Banking*, 6, 5–37.

CPB, CAPP, CEPII, ETLA, IHS, and IEF (2013): "Study on the Impacts of Fiscal Devaluation," Taxation Papers 36, Directorate General Taxation and Customs Union, European Commission.

Cwik, T. and V. Wieland (2011): "Keynesian Government Spending Multipliers and Spillovers in the Euro Area," *Economic Policy*, 26, 493–549.

European Commission (2009): "Mutual Information System on Social Protection (MISSOC database)," .

——— (2010): "Reinforcing economic policy coordination," COM(2010) 250 final, Brussels.

Frenkel, J. A. and A. Razin (1986): "Fiscal Policies in the World Economy," *Journal of Political Economy*, 94, 564–94.

Gertler, M. (1999): "Government debt and social security in a life-cycle economy," *Carnegie-Rochester Conference Series on Public Policy*, 50, 61–110.

Griliches, Z. (1969): "Capital-Skill Complementarity," *The Review of Economics and Statistics*, 51, 465–68.

Gros, D. and A. Hobza (2001): "Fiscal Policy Spillovers in the Euro Area: Where are they?" *CEPS Working Paper*, No.176, 1–29.

Hayashi, F. (1982): "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, 50, 213–24.

Hebous, S. and T. Zimmermann (2013): "Estimating the effects of coordinated fiscal actions in the euro area," *European Economic Review*, 58, 110–121.

Immervoll, H., H. J. Kleven, C. T. Kreiner, and E. Saez (2007): "Welfare reform in European countries: a microsimulation analysis," *Economic Journal*, 117, 1–44.

Jaag, C. (2009): "Education, demographics, and the economy," *Journal of Pension Economics and Finance*, 8, 189–223.

Jaag, C., C. Keuschnigg, and M. Keuschnigg (2010): "Pension reform, retirement, and life-cycle unemployment," *International Tax and Public Finance*, 17, 556–585.

Jensen, H. (1996): "The advantage of international fiscal cooperation under alternative monetary regimes," *European Journal of Political Economy*, 12, 485–504.

Taylor, J. B. (1993): *Macroeconomic Policy in a World Economy: From Econometric Design to Practical Operation*, W.W. Norton & Company, New York.

Uhlig, H. (2002): "One money, but many fiscal policies in Europe: What are the consequences?" Tech. rep., CentER Discussion Paper; Vol. 2002-32; Tillburg: Macroeconomics.

Wieland, V. (2006): "Comment on 'Trade Spill-Overs of Fiscal Policy in the European Union: A Panel Analysis'," *Economic Policy*, 48, 680–684.

A Appendix: related literature

This sections provides a detailed discussion of the relevant literature.
Beetsma et al. (2006) use a panel vector auto-regression model in combination with a trade panel model and estimate the impact of fiscal policy shocks on trade in the EU. They find that spillovers are economically relevant and the size of the spillovers depends on the size of the originating country and the distance of the trade partner. On average over two years upon impact, an increase in public consumption of 1% of GDP in Germany leads to an increase of 2.2% of the annual level of foreign exports. Furthermore foreign GDP is increased by 0.15%. The effects are similar, but weaker for a net tax cut. On average over two years upon impact, a decrease in net taxes of 1% of GDP in Germany leads to an increase of 0.8% of the annual level of foreign exports and an increase of 0.05% of foreign GDP. In comparison, the results are weaker by approximately a factor of 10 when Greece performs the same fiscal policy actions. The focus is on spillovers on trade and output. Spillovers stemming from changes in the interest rate are not part of their considerations[21].
Auerbach and Gorodnichenko (2013) use a variation of a vector auto-regression model and forecast data from the OECD Statistics and Projections database to estimate the effect of fiscal policy shocks on output. The spillovers are transmitted through trade linkages. They find that spillovers are significant and vary with the state of the economy. During recessions spillovers have stronger effects on output and employment than during expansions. However the estimated multipliers are not significant if the economy is in the state of expansion.
Hebous and Zimmermann (2013) likewise argue in favor of fiscal policy coordination based on qualitative arguments. They use global vector auto-regression to estimate the effects of a shock to the budget balance on output of other countries for a set of Euro-area member countries. They compare results for two different scenarios: a domestic shock and an area-wide shock of similar size. They find that the positive effects on output are larger for the case of an area-wide fiscal shock. The costs of the shock are important in this context. The costs are lower in the area-wide scenario as the respective country bears only a fraction of the total costs of the shock. Hence if the shock is same in size, then naturally the coordinated scenario is advantageous.
Besides the mentioned econometric approaches, model simulation approaches also exist in the literature. Gros and Hobza (2001) condense the results of four different established macroeconomic models[22]. They analyze the impact of fiscal policy shocks on GDP and the magnitude of spillovers from these shocks. The

[21] Wieland (2006) comments on the results of Beetsma et al. (2006). He argues that in their study, Beetsma et al. (2006) use data from 1965 up to 2004. During that time period, there have been several changes in the monetary regime as well as in the exchange rate regime in Europe. These changes are not taken into account, which may bias the results. Cwik and Wieland (2011) find in their own setting that allowing for flexible exchange rates has a positive effect on the size of the spillovers, which confirms the comment of Wieland (2006).

[22] QUEST II (European Commission), Marmotte (CEPII), NiGEM (National Institute of Economic and Social Research) and MULTIMOD Mark III (IMF). We limit the discussion to the results from QUEST II and Marmotte as we focus here on GE-models.

focus is on a scenario where Germany conducts fiscal expansion. An increase in government spending of 1% of GDP in Germany leads to average spillovers to the Euro zone between -0.03% and 0.04% of GDP, dependent on the specific model used. The results are quantitatively and qualitatively similar if more countries undertake the same fiscal expansion. Hence they argue that spillovers tend to be quantitatively small and the sign of the impact is not clear. This is due to the fact that effects which are transmitted via trade linkages are canceled out by effects which are transmitted via capital market linkages. It is not obvious which effects dominates. Given the minor importance of spillovers, fiscal policy coordination is not favorable.

Corsetti et al. (2010) apply a stylized, two-country business cycle model to study the cross-border spillovers of an increase in government spending. Their model includes sticky prices and wages as well as frictions on the financial markets. Besides the impact of trade elasticities and the openness of the economies, they especially emphasize the role of financing the fiscal stimulus. They consider the case where an increase in government spending is debt-financed and balanced by raising future taxation or by decreasing future spending. They find that financing the fiscal stimulus by combining an increase in future taxation with a decrease in future spending reinforces both the effects on the domestic economy and spillovers to other countries. However their findings suggest that overall spillovers tend to be moderate. An increase in government spending of 1% of GDP leads to an increase in foreign GDP of 0.15%.

Cwik and Wieland (2011) compare several established macroeconomic models to analyze the impact of fiscal stimulus on GDP and assess the Keynesian multiplier effect. In their comparison, they use the model by Taylor (1993) to quantify spillover effects of a fiscal stimulus in one country. This model contains price and wage rigidities, forward-looking agents and is calibrated for the G7 countries to fit Euro area data. Cwik and Wieland (2011) consider an increase in government spending in Germany and quantify the spillovers in France and Italy. They find that an increase in spending in Germany, which triggers an increase in GDP of 0.7% for Germany, induces an increase in GDP of at most 0.037% in France and 0.014% in Italy over four years. Hence they conclude that spillovers are small, as the positive demand effects are canceled out by negative effects of a subsequent currency appreciation.

More recent literature has emerged, taking effects of monetary policy developments into account. In particular there are contributions considering a zero lower bound on the interest rate in a model-based setup. Benes et al. (2013) use an overlapping-generations model in a multi-country setting considering five large regions with trade linkage. They find that taking the zero lower bound on the interest into account actually has an effect on spillovers. Spillovers are larger than in previous studies on conventional monetary policy. The difference in spillovers emerges through the financial markets channel, not the goods market channel. They conclude that fiscal policy coordination could be useful.

Boersch-Supan et al. (2006) develop a computational multi-country overlapping generations model to quantify spillovers due to changes in the speed of population ageing. Considering countries aggregated into 5 regions, they conclude that

"closed-economy models of pension reform miss quantitatively important effects of international capital mobility" (p. 625).

B Appendix: additional details on model specifics

This section summarizes additional specific features of the model, provides a rationale for their inclusion and compares our model with these features with existing general equilibrium analysis of fiscal spillovers and fiscal policy coordination[23].

Involuntary unemployment: Households can be hit by an exogenous unemployment shock and we include a matching process in the labor market. These two channels generate involuntary unemployment in our model. EU unemployment rates differ significantly across countries (e.g. Germany: 5,0% and France: 10,3%). Thus social security expenditures for unemployed people form different shares in the public spending structure of European countries (e.g. Great Britain: 0.4% of GDP and France: 1,6% of GDP). When hit by an exogenous shock or by applying a policy reform countries may therefore react differently. This may have an effect on the resulting spillovers. The studies of Benes et al. (2013), Boersch-Supan et al. (2006) and Corsetti et al. (2010) do not take unemployment into account. Only models QUEST II and Marmotte, presented in Gros and Hobza (2001), include unemployment.

Intensive and extensive margins: We model intensive and extensive margins on the household side of the labor market, considering in particular endogenous labor market participation and working hours decisions. Endogenous participation decisions delivers a more realistic welfare benefit cost model. For instance, higher unemployment benefits increase participation but not work hours. Berger et al. (2016) quantifies the bias generated with exogenous and constant participation in a population ageing context and argue that inflating intensive margin elasticities does not always help. There is no endogenous participation margin in the above mentioned studies.

Earnings-related pension system: The determination of life-time consumption decisions of ageing households is one of the main benefits using OLG models. Life-time income of the households therefore plays a key role in this decision. Considering only flat pension payments, independent of previous earnings, generates large income redistribution and affects household decisions. Without considering earning-related pension income this redistribution will be overestimated. Furthermore, for some countries the share of flat pension payments in total pension payments is significantly larger than for other countries (e.g.

[23] QUEST II and Marmotte in Gros and Hobza (2001), Benes et al. (2013), Boersch-Supan et al. (2006), Corsetti et al. (2010) and Cwik and Wieland (2011).

Beveridge system in Great Britain compared to Bismarck system in Continental Europe). Our model is able to capture this difference between countries. Spillover effects depend on household behaviour which depend on the balance between flat and earning-related part of the pension system in each country. Except for Boersch-Supan et al. (2006), existing general equilibrium models of fiscal spillovers do not take pensions into account.

Coverage of the European Union: Our model is explicitly calibrated for a representative sample of the EU28 countries. Hence we are able to measure spillovers within the European Union. Benes et al. (2013), Boersch-Supan et al. (2006) and Corsetti et al. (2010) include only aggregated regions in their models. Hence these approaches cannot quantify spillover effects within the EU.

C Appendix: calibration details

This section provides additional details on the calibration process for the two stylized Rest-of-the-world countries, NROW and SROW. First, we give an overview of different data inputs which are calculated based on available data. Next we provide a table of economic indicators which is used to determine the twin country for the stylized Rest-of-the-world countries, as described in section 4. Then we present the outcome of the calibration process and matching accuracy compared to actual data.

Data inputs

We summarize the variables, corresponding indicators and databases and the calculation procedure. Recall that NROW is a composite of Canada, Japan and the USA, while SROW is a composite of Brazil, China and India.

Capital Stock

Database: World Input-Output Database
Indicator: VA (gross value added at current basic prices in million lcu), VA_P (price levels of gross value added, 1995=100), K_GFCF (real fixed capital stock, 1995 prices).
For each country we take VA/(VA_P/100) for value added in volumes and K_GFCF for capital stock in volumes. We calculate these values for the years 2005-2009 (latest available) and build the average. The country averages are summed up over each respective Rest-of-the-world region and the ratio gross value added in volumes over capital stock in volumes is built.

Depreciation Rate of Capital

Database: Penn World Table
Indicator: Average depreciation rate of the capital stock, delta

We use 2011 values as the latest available values. We calculate a weighted average for the respective countries. The weights are derived from GDP/Capita.

GDP

Database: Worldbank
Indicator: GDP at market prices (current USD), NY.GDP.MKTP.CD
We convert all currency values into EURO, the calibration currency.

Trade Balance

Database: Worldbank
Indicator: Current Account Balance (as % GDP), BN.CAB.XOKA.GD.ZS
We take the 2010-2014 average value of the current account balance and aggregate over each respective country. Then we compute the ratio GDP/GVA and correct the weighted average current account balance by this ratio. Gross value added is taken from the World Input-Output database and GDP from the Worldbank database.

Gross Government Debt

Database: OECD
Indicator: Gross General Government Debt as % of GDP
Government Debt is calculated using the Government Debt in % of GDP and GDP in current USD from the Worldbank database. The values of the respective countries are summed up and divided by total GDP for the respective Rest-of-the-world countries.

Public Health Expenditures

Databank: Worldbank
Indicator: Health Expenditures, Public (% of GDP), SH.XPD.PUBL.ZS
We use Worldbank data on public health expenditures in % GDP and Worldbank data on GDP and calculate the sum of total expenditures. Then we divide the sum by the aggregated GDP for the respective Rest-of-the-world countries.

Survival Probabilities

Database: UN Population Division (World Population Prospects: The 2015 Revision)
Indicators: total population, both sexes combined, by five-year age group (thousands), year 2013
We match the empirical age distribution, using age classes of 5 years from the data source, aggregating values over the three countries for each Rest-of-the-world region.

Skill Distribution

Database:OECD
Indicator: Highest adult education level attained. Categories: below upper secondary, upper secondary and tertiary
We calculate the number of people in the different skill group with the help of data on total population from OECD. Then we divide the number of people in a certain skill group by the total population for the respective countries.

Tax Shares

Database: OECD
Indicator: National Accounts / Annual National Accounts / Non-Financial Accounts by Sectors and National Accounts / Annual National Accounts / General Government Accounts / Taxes and Social Contribution Receipts and Government Expenditures by Function
We calculate the 2010-2014 average total government revenues for different tax categories and express the values as percentage of gross value added.

Public Pension Expenditures

Database: Worldbank
Indicator: Total Public Pension Spending
We use the indicator to calculate the total government spending and divide the sum by the aggregated GDP for the respective Rest-of-the-world country. We use the latest available values, 2009 respectively 2010 (except for China: 2006).

Economic indicators for the "twin country approach"

Tables 11 and 12 present the economic indicators which are used for determining the twin countries for each stylized Rest-of-the-world countries, as explained in section 4.
We eliminate the eastern European countries as potential twin country candidate for the North Rest-of-the-world (NROW) region as these countries have a lower economic development (GDP/Capita). Furthermore we eliminate Spain from the potential candidates because of large differences in unemployment rate. From the remaining countries the UK displays the closest values across all indicators. Hence Canada, Japan and the USA (forming the NROW) take UK as a twin country for calibration purposes.
The eastern European countries in our scope are the closest in terms of GDP/Capita, dependency ratio, share of people with tertiary education and overall indicators for the social security system. Thus the twin country for Brazil, China and India (forming the South Rest-of-the-world region, SROW) is an equally weighted combination of Czech Republic, Poland and Slovak Republic.

Indicator	AT	BE	CZ	DEN	FIN	FRA	GER	ITA	NL	PL
GDP	383	463	306	247	217	2484	3516	2126	783	888
GDP/C	45.4	41.9	29.1	44.2	40.1	37.9	43.7	35.2	46.8	23.1
Growth	1.2	1.2	0.9	0.5	0.5	1.0	2.1	-0.5	0.5	3.0
Consumption	54	52	49	48	54	56	55	61	45	61
Population	8.4	11.0	10.5	5.6	5.4	63.2	81.0	59.7	16.7	38.4
Labor Force	67.0	65.0	68.0	64.0	64.0	63.0	66.0	64.0	66.0	70.0
Old-Age Dep.	27.7	27.7	25.9	28.7	31.0	29.7	31.9	34.3	27.0	21.4
SG2	62.9	36.6	74.1	42.8	44.9	42.0	58.6	40.9	40.7	65.6
SG3	19.7	34.8	18.1	33.9	39.0	30.1	27.4	15.2	32.7	23.4
Participation	76.0	67.7	73.3	78.2	75.8	71.0	77.4	64.2	79.5	67.3
Unemployment	5.0	8.5	6.2	6.6	8.6	9.9	5.0	12.5	6.9	9.2
Work Hours	35.5	33.8	39.9	31.5	36.0	37.1	39.1	35.7	29.9	39.8
Ret. Age M	65	60	63	65	65	61	65	63	65	65
Ret. Age W	60	60	61	65	65	61	65	62	65	60
Gini on Income	30	29	26	28	28	32	32	34	29	34
Tax Ratio	48	49	39	55	53	50	44	46	46	39
Public Debt	86	106	41	40	63	96	72	133	67	51
Pension Exp.	11.8	9.8	9.2	5.8	9.1	13.3	10.6	14.9	5.0	11.9
Health Exp.	8.4	8.2	6.2	9.3	6.8	9.0	8.7	7.2	9.9	4.8
Education Exp.	5.5	6.3	4.0	8.2	6.4	5.6	4.7	4.3	5.4	5.0
UI Exp.	1.30	3.71	0.28	4.38	3.55	0.00	2.94	0.31	2.60	1.99
UI Rep. Rate	0.31	0.40	0.06	0.57	0.36	0.39	0.27	0.24	0.50	0.11

Legend: *GDP* = GDP in Billion USD, *GDP/C* = GDP per capita divided by 1.000, *Growth* = GDP growth in %, *Consumption* = Consumption in % GDP, *Population* = population in million persons, *Labor Force* = % of population aged 15-64, *Old-Age Dep* = Old-Age dependency ratio, *SG2* = % of labor force with upper secondary education, *SG3* = % of labor force with tertiary education, *Participation* = participation rate in % of labor force, *Unemployment* = unemployment rate in % of labor force, *Work Hours* = average weakly work hours, *Ret Age M (W)* = statutory retirement age for men (women), *Gini on Income* = Gini coefficient on labor income measuring wage inequality in %, *Tax Ratio* = tax and social security contribution revenues in % GDP, *Public Debt* = debt in % GDP, *Pension Exp* = expenditures in % GDP, *Health Exp.* = expenditures in % GDP, *Education Exp* = expenditures in % GDP, *UI Exp* = expenditures on unemployment insurance in % GDP, *UI Rep. Rate* = unemployment insurance replacement rate

Table 11: Economic Indicators for the twin country approach (start)

Indicator	SVK	ESP	SWE	UK	USA	CAN	JPN	CHN	BRA	IND
GDP	142	1526	420	2413	16130	1482	4517	15177	2661	4069
GDP/C	26.3	32.7	44.1	37.9	51.3	42.6	35.4	11.2	13.7	3.6
Growth	2.7	-0.8	2.4	2.0	2.1	2.5	1.5	8.6	3.2	7.2
Consumption	57	58	46	65	68	56	60	37	60	58
Population	5.4	46.6	9.5	62.4	319	35.5	127	1364	206	1295
Labor Force	71.0	67.0	63.0	65.0	67.0	68.0	61.0	74.0	69.0	65.0
Old-Age Dep.	18.8	27.7	31.0	27.0	21.6	23.0	41.9	12.5	11.0	8.4
SG2	73.2	22.1	52.0	37.1	46.7	37.2	54.2	18.7	31.5	38.9
SG3	18.1	31.8	35.0	39.5	42.5	51.4	45.8	3.6	12.3	12.6
Participation	70.2	74.4	81.3	76.4	71.8	78.2	75.1	77.6	75.0	56.5
Unemployment	13.3	24.7	8.0	6.3	6.2	6.9	3.7	4.7	6.8	3.6
Work Hours	34.7	35.1	36.3	39.5	33.8	30.9	42.4	46.5	41.8	47.0
Ret. Age M	62	65	65	65	66	65	65	60	55	58
Ret. Age W	62	65	65	63	66	65	65	60	55	58
Gini on Income	27	35	27	34	41	34	32	42	54	34
Tax Ratio	35	37	53	40	32	39	31	20	36	20
Public Debt	52	101	44	89	103	87	229	41	66	66
Pension Exp.	8.4	8.2	8.2	5.0	6.8	4.5	10.1	2.5	6.1	1.0
Health Exp.	5.7	6.8	7.8	7.7	8.1	7.7	8.3	2.9	4.4	1.2
Education Exp.	3.9	4.6	6.5	5.5	5.3	5.0	3.7	3.3	5.7	3.6
UI Exp.	1.02	3.64	2.91	0.28	0.42	2.23	0.41	0.02	2.03	0.01
UI Rep. Rate	0.11	0.35	0.32	0.17	0.13	0.16	0.12	0.02	*	0.06

Legend: see table 11.

Table 12: Economic Indicators for the twin country approach (end)

Calibration outcomes

We present selected results of the calibration process for the stylized Rest-of-the-world countries. Table 13 shows the outcome of the model calibration in comparison to real data.

	NROW		SROW	
	Calibration	Data	Calibration	Data
Macroeconomics				
Capital/Output	2.81	2.82	3.17	3.18
Consumption/Output	0.57	0.66	0.42	0.44
Investment/Output	0.24	0.21	0.42	0.39
Participation Rate	69.9	73.10	68.26	68.50
Unemployment Rate	5.65	5.64	4.39	4.39
Government				
Public Debt	117.64	127.64	43.23	48.82
Tax Ratio	30.91	32.38	21.25	22.23
Pension Expenditures	7.32	7.32	3.32	2.66
Health Expenditures	7.47	8.08	2.73	2.79
Unemployment Expenditures	0.50	0.54	0.02	0.03*
Demographics				
Dependency Ratio	27.2	26.71	12.34	10.65
Education				
Low-Skilled	7.96	8.02	63.17	62.95
Medium-Skilled	48.04	47.99	28.62	28.77
High-Skilled	44.00	43.99	8.21	8.28

Legend: *Capital/Output* = capital stock in % GDP, *Consumption/Output* = consumption share in % GDP, *Investment/Output* = investment ratio in % GDP, *Participation Rate* = participation in % of labor force, *Unemployment Rate* = unemployment in % of labor force, *Public Debt* = debt in % GDP, *Tax Ratio* = tax and social security contribution revenues in % GDP, *Pension Expenditures* = expenditures in % GDP, *Health Expenditures* = expenditures in % GDP, *Unemployment Expenditures* = expenditures in % GDP, for SROW Brazilian data is lacking, *Dependency Ratio* = old-age dependency ratio, *Low-Skilled* = % of population with education lower than upper secondary education, *Medium-Skilled* = % of population with upper secondary education, *High-Skilled* = % of population with tertiary education

Table 13: Calibration Results for the stylized ROW countries

D Appendix: additional results

This section provides results and explanations of additional simulations.

Timing and Response Asymmetries: We consider a scenario where all countries are hit by an exogenous shock, which requires the increase in public consumption. But we take into account that different countries can respond differently and shocks need not happen at the same time. To this effect, we

divide the countries in our scope into two groups[24]. The first group is hit by an exogenous shock in the first period, while the second group is hit by the same shock in the sixth period. The countries initially hit by a shock respond by implementing response 1, the latter countries by implementing response 2. We compare outcomes to reversed implementation of the responses, where countries initially hit by a shock respond by implementing response 2 and the other countries by implementing response 1.
Table 14 contains our results. For ease of discussion, we reproduce the results from table 10. Overall, the policy option response 2 dominates the policy option response 1. For Germany the yearly average loss in GDP (over 25 years) is 0.68% with response 1 and 0.65% with response 2. The advantage of response 2 amounts to 5.11%. The reasons have already been outlined in sections 5.6 and 5.7. If governments can increase public debt to finance public consumption there is no need to raise labor taxes as much. Negative effects on labor supply are hence reduced. The average yearly loss in GDP of 0.65% with response 2 is quantitatively between the loss of 0.54% in case of an asymmetric shock to one country (see 5.6) and the loss of 0.85% in case of a symmetric shock to all countries (see 5.7). The crowding out effect (see 5.7) is not as strong as in case of a symmetric shock, but still there is crowding out, as about half of Europe is simultaneously hit by a shock.

	Shock to GER			Shock to EU					
				Symmetric			Asymmetric		
	R1	R2	%	R1	R2	%	R1	R2	%
GDP (%)	-0.591	-0.543	8.8	-0.935	-0.845	10.7	-0.679	-0.646	5.1

Legend: R1 = response 1, R2 = response 2, % = Gain from response 2 in percentage, (%) = changes in percentage from initial steady state, *GDP* = average yearly change in GDP over the medium run (25 years). This table shows the yearly average loss in GDP for Germany for three cases: *Shock to GER* = Germany is hit by shock and increases public spending (see 5.6). *Shock to EU, Symmetric* = all countries are hit by a shock and increase public spending (see 5.7). *Shock to EU, Asymmetric* = all countries are hit by a shock and respond by increasing public spending, but timing and response differences are taken into account (see text for details).

Table 14: Effects of different spending shocks on the GDP of Germany

[24] All 14 countries in the scope are distributed into two groups so that each group represents about half of the total population. In each group, we take some countries which are new member states (CZ, SK, PL), some big old member states with big welfare states (DE, ESP, FRA, ITA, NL) and some small old member states with big welfare states (AT, BE, DK, FIN, SWE). The only old member state country in the scope with a small welfare state (UK) is arbitrarily allocated to one group.