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Private and public risk sharing in the euro area

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Private and public risk sharing in the euro area

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Abstract

This paper investigates the contribution of private and public channels for consumption risk sharing in the EMU over the period 1999-2015. In particular, we explore the role of financial integration versus international financial assistance for private consumption smoothing in this set of countries. In addition, we present a time-varying test which allows estimating how risk sharing has evolved since the start of the EMU, and in particular during the recent crisis. Our results suggest that, whereas in the early years of the EMU only about 40% of country-specific output shocks were smoothed, in the aftermath of the euro zone's sovereign debt crisis about 65% of these shocks were absorbed, therefore reducing consumption growth differentials across countries. This progressive improvement of the shock-absorption capacity is due to a higher financial integration, but also to the activation of the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM) channelling official loans to distressed euro zone economies. We also show that cross-border holdings of equities and debt seem to be more effective than cross-border bank loans in isolating households from country-specific shocks, therefore contributing to consumption smoothing.

JEL codes: C23, E62, G11, G15.

Keywords: risk sharing, time-variation, financial integration, international financial assistance.

Non-technical summary

The "Five President Report"[**] has highlighted that euro area countries have to take steps, both individually and collectively, to compensate for the national adjustment tools they gave up by entering the EMU. In particular, they may enhance their shock-absorption capacity through risk sharing within the EMU. Such risk sharing mechanisms would allow consumption smoothing, decoupling consumption growth fluctuations from output growth fluctuations, thus resulting in welfare gains and a better functioning of the EMU.

Against this background, this paper presents several contributions. First, based on a sample of 11 euro area countries for the period 1999-2015, we explore the role of financial and credit market integration as well as international financial assistance to distressed euro zone countries, i.e., official loans via the EFSF-ESM, for consumption risk sharing. Indeed, risk sharing can be achieved through integrated financial and capital markets, which is generally referred to as "private risk sharing". On the one hand, internationally diversified investment portfolios can generate income flows that are unrelated to fluctuations in the domestic economy. On the other hand, integrated credit markets could contribute to reinforce risk sharing: the supply of credit to the economy should be less affected by country-specific shocks when international banks operate in that economy. At the same time, more integration in the banking sector and financial markets may also amplify aggregate and idiosyncratic shocks, if the effects of such shocks would spill over more rapidly in an interconnected economic environment. In addition to these channels, risk sharing can also be supported via public channels at the EMU level. While a fully-fledged fiscal stabilisation mechanism for the euro area as a whole has been recently discussed, but not yet introduced, the EMU architecture has in recent years benefitted from the introduction of the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM). These facilities provide official financial assistance to EMU countries under stress, which in turn is expected to help shock absorption in these countries.

As a second contribution of this paper, we propose a time-varying framework which allows estimating how risk sharing - and the relative importance of the individual private and public risk sharing channels - has evolved in the euro zone throughout this period, which includes the European sovereign debt crisis and its aftermath.

Third, we propose an empirical analysis based on a still largely unexplored dataset of bilateral cross-border bank loans from the Bank for International Settlements and of bilateral cross-border holdings of portfolio investment securities from the International Monetary Fund.

[**] See https://ec.europa.eu/priorities/sites/beta-political/files/5-presidents-report_en.pdf.

Our results suggest that, first, in the early years of the EMU only about 40% of output shocks were smoothed. However, in the aftermath of the euro zone sovereign debt crisis, about 65% of output shocks were absorbed, therefore contributing to decrease consumption differentials across countries. The progressive improvement of the shock-absorption capacity is due to higher financial integration, but also to the activation of the EFSF-ESM loans for Greece and other euro zone economies in 2010. In addition, as regards private channels of risk sharing, cross-border holdings of equity and debt seem to be the most effective in smoothing consumption. This latter finding is particularly strong when we focus on the links between "Core" and "Periphery" EMU countries: holdings of debt and equity issued by "Core" countries and included in the portfolio of agents in the "Periphery" (and viceversa) turn out to be effective in absorbing output shocks, thus allowing to better smooth consumption. However, our results indicate that cross-border bank loans tend to generate shock amplification rather than shock absorption.

The finding that risk sharing has improved over time in the euro zone, also during the recent crisis, is to some extent surprising. Yet, this finding does not imply that the severity of the crisis would have not been attenuated even further by a fully-fledged centralized fiscal capacity at the euro zone level.

1. Introduction

The architecture and the functioning of the European Economic and Monetary Union (EMU) have been severely challenged in the context of the recent global financial crisis and in particular during the 2010-2012 euro zone's sovereign debt crisis. Many commentators have argued that the lack of appropriate risk sharing mechanisms at the euro area level may have contributed to aggravate the severity of the economic downturn in the euro zone periphery and may have delayed the recovery in the aftermath of the crisis (see, e.g., Allard, 2011). Against this background, the Five President Report[1] has highlighted that euro area countries have to take steps, both individually and collectively, to compensate for the national adjustment tools they gave up on entry in the EMU. First, when economic shocks occur, each country has to be able to respond effectively at the domestic level. Second, countries may also smooth the impact of output shocks through risk sharing within the EMU. Such risk sharing mechanisms would facilitate consumption smoothing, thus decoupling consumption growth fluctuations from output growth fluctuations.[2]

Risk sharing can be achieved through integrated financial and capital markets, which is generally referred to as "private risk sharing". In addition, public policies at the supra-national level may also contribute to risk sharing across countries (see, e.g., Farhi and Werning, 2017). We refer to the latter as "public risk sharing". Private risk sharing operates through two main channels. First, internationally diversified investment portfolios can generate income flows that are unrelated to fluctuations in the domestic economy. If the return on foreign assets is highly correlated with output growth in the issuer economy and weakly correlated with output growth in the domestic (holder) economy, cross-border portfolio investments contribute to consumption smoothing. Second, integrated credit markets could reinforce risk sharing: the supply of credit to the economy is expected to be less affected by country-specific shocks when international banks – which are in principle less exposed to the same shocks - operate in that economy. At the same time, more integration in the banking sector and financial markets may also amplify aggregate and idiosyncratic shocks, if the effects of such shocks would spill over more rapidly in an interconnected economic environment.

Risk sharing can also be supported via public channels at the EMU level. While a fully-fledged fiscal stabilisation mechanism for the euro area as a whole has been recently discussed, but not yet introduced, the EMU architecture has in recent years benefitted from the introduction of the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM), which provide

[1] See https://ec.europa.eu/priorities/sites/beta-political/files/5-presidents-report_en.pdf.
[2] In general, perfect or full income risk sharing – through both private and public channels - characterizes a situation where consumption growth rates are equalized across all countries (Mace, 1991).

official financial assistance to EMU countries under stress. Therefore, such mechanisms might have also contributed to enhancing risk sharing within the EMU. The underlying intuition is that official assistance to distressed countries helped national governments in these countries to maintain a certain level of public expenditure. For example, official assistance may have contributed to finance public salaries and pensions, which otherwise would have been cut even more severely (e.g., in case of a sovereign default). This could have contributed to sustain private consumption as well. Therefore, our testable hypothesis is that public official assistance via the EFSF-ESM may have helped consumption smoothing in the euro zone periphery, on top of private channels.

This paper presents several contributions. First, based on a sample of 11 euro area countries for the period 1999-2015, we explore the role of financial integration and international financial assistance to distressed euro zone countries, i.e., official bilateral assistance via the EFSF-ESM, for consumption risk sharing. Second, we propose a time-varying framework which allows estimating how risk sharing and the relative importance of the individual private and public risk sharing channels have evolved in the euro zone throughout this period, which includes the European sovereign debt crisis and its aftermath. Third, we analyse the degree and evolution of risk sharing by focussing on the link between "Core" and "Periphery" euro area countries.

Our paper also contributes to the existing literature by making use of a unique dataset of cross-border bank loans from the Bank for International Settlements (BIS). The confidential version of the BIS International Locational Banking Statistics (ILBS) reports the outstanding bilateral positions of banking sectors for 12 out of 19 euro zone countries against residents of the countries where they are located.[3] We augment this information with data from the Coordinated Portfolio Investment Survey (CPIS) of the International Monetary Fund (IMF), recording bilateral cross-border holdings of portfolio investment securities, as well as their breakdown into debt and equity assets. We exploit the cross-sectional variation in bilateral exposures as well as the growing time coverage of the dataset. This is to our knowledge the first use of the CPIS database in a time series framework for the analysis of cross-country risk sharing.[4]

We focus on the deviation of personal consumption growth with respect to output growth across EMU countries, as suggested by the reference literature in this field (see Asdrubali *et al.*, 1996; Sørensen and Yosha, 1998). More specifically, we follow Fratzscher and Imbs (2009) and, based on this still largely unexplored dataset of bilateral financial holdings and bilateral fiscal assistance, we estimate bilateral risk sharing specifications which allow us to take full advantage of the time-series and cross-country information among euro area countries.

[3] Cyprus began reporting in 2008 and it thus not included in our sample.

[4] While previous studies have mainly focused on specific waves of the CPIS survey due to data availability (Fratszcher and Imbs, 2009), our analysis builds on all existing waves of this dataset. This expands considerably the number of observations used in the econometric analysis.

Our results suggest that, first, in the early years of the EMU only about 40% of country-specific (i.e., idiosyncratic) output shocks were smoothed. However, in the aftermath of the euro zone sovereign debt crisis, about 65% of these shocks were absorbed, therefore contributing to decrease consumption growth differentials across countries. The progressive improvement of the shock-absorption capacity is due to higher financial integration, but also to the activation of the EFSF-ESM loans for Greece and other euro zone economies in 2010. In addition, as regards private channels of risk sharing, cross-border holdings of equity and debt seem to be the most effective in smoothing consumption. This latter finding is particularly strong when we focus on the links between "Core" and "Periphery" EMU countries: holdings of debt and equity issued by Core countries and included in the portfolio of agents in the "Periphery" (and vice versa) turn out to be effective in absorbing output shocks, thus allowing to better smooth consumption. However, our results indicate that cross-border bank loans tend to generate some shock amplification rather than shock absorption. This is likely to be explained by pro-cyclical borrowing and lending: countries have often borrowed from abroad in economic good times and repaid these loans in economic bad times, adding volatility to consumption in a pro-cyclical way.

The remainder of the paper is organised as follows. Section 2 presents a short review of the related literature on risk sharing. Section 3 describes the methodology and the dataset used in the empirical analysis. Section 4 comments on the results and presents a number of robustness checks. Finally, Section 5 concludes.

2. Related literature

The literature on income and consumption risk sharing has expanded considerably in the last three decades, reflecting stronger interest in the economic profession and among policymakers on how countries (or states within a federation) may better isolate from idiosyncratic shocks hitting their economies (for a survey, see Ioannou and Schäfer, 2017).

Empirical studies of cross-country consumption risk sharing are motivated by a testable prediction of the international real business cycle model with complete markets. In a world with a single internationally-traded contingent bond, the Euler equations for the asset holdings indicate that the marginal rates of substitution between current and state-contingent future consumption should be equal across countries at each point in time. Consequently, consumption growth in any given country is only affected by global (and thus uninsurable) shocks. At the same time, in an equilibrium

characterized by perfect risk sharing, countries exhibit the same growth rate of consumption at each point in time irrespective of their output shocks (Mace, 1991; Canova and Ravn, 1996).[5]

The hypothesis of full international risk sharing has been largely rejected in the empirical literature. Contrary to the prediction of the model with complete markets, cross-country correlations in consumption growth are smaller in the data than correlations in income growth (Backus *et al.*, 1992). Lewis (1996) investigates the role of financial markets and shows that capital market restrictions partly account for the lack of observed cross-country consumption risk sharing, indicating that financial market liberalization would improve consumption insurance. As mentioned in Canova and Ravn (1996), better consumption risk sharing can also result from the presence of institutions that improve insurance by means of transfer schemes, i.e. taxes and transfers, aid or lending agreements. Therefore, we should observe higher levels of risk sharing in settings characterized by (supra)national transfer schemes, even in presence of unhampered financial markets.

One of the earlier and most influential contributions testing of the joint role of financial markets and transfer schemes for risk sharing is Asdrubali *et al.* (1996). The authors propose a framework based on a cross-sectional variance decomposition of shocks to GDP and quantify the amount of risk sharing among states in the United States over the period 1963-1990. They find that 39% of shocks to gross state product were smoothed by capital markets, 13% were smoothed by the federal government (via taxes, transfers, and grants to states), 23% were smoothed by credit markets while the remaining 25% were unsmoothed.[6] Delrio *et al*. (2018) follow the Asdrubali *et al.* (1996)'s approach and explore the role of the current account, and in particular TARGET balances via the ECB, in influencing risk sharing in the EMU. Their findings point to a reduction of risk sharing during and after the crisis and identify the current-account channel as the main driver of this reduction (see, also, ECB 2017). Milano (2017) revisits the Asdrubali *et al.* (1996)'s approach to explore the role of European institutions for risk sharing in the euro area. She finds that shock absorption in the euro zone somewhat increased from 23% in the period 1999-2006, up to 31% in the period 2007-2014. Mélitz and Zumer (2002) examine the United States, France and the United Kingdom, and find that approximately 20% of regional income is stabilized through the central government budget, while Hepp and Von Hagen (2013) suggest that this effect is only 10% for Germany in the post-unification period (1995-2006). One recent paper exploring the role of fiscal transfers for cross-country consumption insurance within the euro area is Furceri and Zdzienicka (2015). On the basis of a

[5] Farhi and Werning (2017) show that – even in presence of complete markets – some degree of public intervention allowing insurance against idiosyncratic shocks is welfare improving. In fact, private agents do not fully internalise the benefits from public risk sharing channels when forming their decisions. Therefore, the authors make a strong theoretical case for fiscal insurance as a necessary complement to private risk sharing.

[6] These results have been challenged by del Negro (2002) who shows that – once measurement error in income and consumption is taken into account - the actual amount of risk sharing across U.S. states may be significantly lower than what suggested by Asdrubali *et al*. (1996).

counterfactual experiment introducing a fictitious supranational redistribution mechanism, the authors suggest there may be considerable insurance gains from setting up a fiscal stabilization mechanism in the euro area. All in all, what emerges from these studies it that a federal transfer scheme across regions seems to be able to smooth around 20% (or less) of local shocks.

More recently, a number of empirical studies have focused on financial variables and documented that greater financial globalization tends to increase risk sharing, at least among industrial countries. The underlying intuition is that more internationally diversified investment portfolios generate income changes that are unrelated to fluctuations in domestic income, therefore better isolating agents from idiosyncratic shocks that hit their economies (see Kose *et al*., 2007, Demyanyk, *et al*., 2008, Pierucci and Ventura, 2010, Rangvid *et al.*, 2016). Nevertheless, differences in regulation and accounting standards across countries may generate home bias, resulting in sub-optimal shares of foreign assets in domestic portfolios and lower than optimal international risk sharing. Indeed, Sørensen *et al*. (2007) show that international home bias in debt and equity holdings declined during the period 1993-2003 and this decline was accompanied by an increase in international risk sharing.

However, these findings generally refer to periods of financial upturn, while the effects of more financial market integration may be reversed during financial market downturns. In addition, if globalization leads to stronger co-movements between international stock markets, the benefits of cross-border holdings of financial assets might be limited (see, e.g., Beine *et al*., 2010). This is sometimes referred to as the "knife-edge" property of the financial markets: financial interconnections work as a shock absorber (i.e., leading to risk sharing) in certain states of the world. In others, interconnections tend to generate shock amplification, i.e., risk-spreading (see Tasca and Battiston, 2011, Balli *et al*., 2013).

Our paper connects, in particular, with Fratzscher and Imbs (2009) who extend the conventional tests of international consumption risk sharing introduced by Lewis (1996). By using bilateral asset holdings for 23 lending economies and 54 borrowing economies over the period 1961-2003, the authors explore the implications of transaction costs in influencing the degree of risk sharing via financial markets. Instead, we analyse the role of both public and private risk sharing channels in the euro zone, with a focus on the recent the European sovereign debt crisis and its aftermath. Moreover, we estimate bilateral consumption risk sharing specifications which allow us to take full advantage not only of the cross-sectional dimension as in Fratzscher and Imbs (2009), but also of time-series information on bilateral holdings of financial assets among euro area countries. Within our empirical framework we are also able to gauge the relative contribution of the different financial and credit market (loans, equity and debt holdings) and the official lending (EFSF/ESM) channels to the *variation* of consumption risk sharing from the early years of the EMU to the aftermath of the euro zone's sovereign debt crisis.

3. Methodology and data

3.1 Baseline empirical setup

Most tests of consumption risk sharing are based on the difference between *per capita* consumption growth in a country and the aggregate per capita consumption growth observed in the same currency area, federation or in the rest of the world (depending on the relative importance of links between countries in a certain area).[7] Such tests are based on the following simple model,

$$(\Delta \log C_{i,t} - \Delta \log C_t) = \alpha + \beta(\Delta \log Y_{i,t} - \Delta \log Y_t) + \varepsilon_{i,t}$$

where the log-growth of variable X is denoted as $\Delta log X_{i,t}$, $C_{i,t}$ denotes real *per capita* household consumption and $Y_{i,t}$ stands for real *per capita* output in country i at time t. C_t and Y_t denote aggregate consumption and output in a certain reference area (e.g. the EMU).

Under the null hypothesis of perfect risk sharing, differences between the country-specific consumption growth and the aggregate consumption growth (i.e., the country-specific or idiosyncratic consumption growth), should be decoupled from the differences in output growth (i.e., idiosyncratic output growth), thus yielding a risk sharing coefficient β equal to zero. Under the alternative hypothesis, a coefficient β statistically different from zero indicates imperfect risk sharing, and its magnitude reflects the extent of the deviation from the theoretical benchmark.

We take this approach as a starting point but, contrary to most models in this literature, we fully exploit the information which is available in a three-dimensional panel of consumption growth and income growth differentials observed across *country pairs* over time, i.e., we test the relationship between consumption growth and output growth differentials between country *i* and country *j* at time *t*. In this bilateral setting, we define as 'country-specific' or 'idiosyncratic' a shock hitting country *i* but not country *j*. It can be shown analytically that this corresponds to estimating the coefficient β in the equation above. However, our setup allows us to exploit a much bigger dataset and therefore to increase enormously the efficiency of our estimate. In our three-dimensional panel, the basic risk sharing test then becomes:

$$(\Delta \log C_{i,t} - \Delta \log C_{j,t}) = \alpha + \beta(\Delta \log Y_{i,t} - \Delta \log Y_{j,t}) + \gamma Z_{ij,t-1} + \eta_t + \mu_{ij} + \varepsilon_{ij,t} \qquad (1)$$

The richest specification includes time-fixed effects η_t to control for aggregate common shocks, country-pair fixed effects μ_{ij} to account for time-invariant bilateral characteristics and a set of control variables $Z_{ij,t}$ that vary across pairs (ij) and over time t. In particular, the Z matrix of controls includes the difference in the growth rate of statutory value added taxes ($\Delta VAT_{ij,t}$) and the difference

[7] See, e.g., Kose *et al*. (2007).

in personal income taxes on distributed profit between countries i and j ($\Delta PIT_{ij,t}$). Indeed, Epstein *et al.* (2016), make a convincing case for the inclusion of tax measures in measurements of international risk sharing.[8] In addition to the tax-rate differentials, Z also includes the inflation differential ($\Delta INFL_{ij,t}$), the 10-year sovereign bond yield differential ($\Delta YIELD_{ij,t}$) and the real domestic credit growth differential ($\Delta DCREDIT_{ij,t-1}$), defined as the real total credit by domestic banks to the private non-financial sector (see Appendix for a description of data and sources). The inclusion of the inflation differentials is theoretically justified by the link between the relative growth rates of consumption and the dynamics of the real exchange rate (Backus and Smith, 1993; Galí and Monacelli, 2005). EMU countries are obviously characterized by invariant nominal exchange rates *vis-à-vis* other euro zone countries, therefore we account for real exchange rate differentials by including the relative dynamics of prices across countries. From a theoretical perspective, in a New Keynesian framework cross-country inflation differentials impact relative consumption growth rates (see, for example, Galí and Monacelli, 2005). We also include differentials in 10-years sovereign bond yields given that, for a large part of the sample period considered, the interest rate spreads in Europe were strongly affected by sovereign default risk. Based on a New Keynesian model featuring a 'sovereign risk channel', Corsetti *et al*. (2013) show that a larger default risk premium would translate into higher relative borrowing costs, thus exerting downward pressure on the relative growth rate of consumption. Finally, we also control for credit by domestic banks, given that this is a main source of financing for the domestic private sector, and therefore can substantially affect private consumption growth. We argue that controlling for domestic credit availability is of paramount importance for the period we analyse, given the documented increase in home bias during the sovereign debt crisis (Saka, 2016 and Ongena *et al.*, 2016) and the unconventional monetary policy and liquidity provision measures taken by the European Central Bank in order to stimulate bank lending (asset purchase programmes, targeted longer-term refinancing operations).

In light of these considerations, we condition the test of cross-country risk sharing on the chosen set of controls. In order to mitigate potential concerns about reverse causality in annual data, we use lagged values of all the covariates.[9]

[8] Epstein *et al.* (2016) account for the risk sharing wedge generated by international differences in taxation. The authors augment a business cycle model with distortionary taxes and find that an increase in the relative consumption tax or capital income tax growth leads to lower relative consumption growth. They find that across country pairs, accounting for the distortionary effect of the capital tax wedge on the relative consumption growth rates contributes to revealing a positive link between insurance and financial integration.

[9] Consistently with their theoretical model, Epstein *et al.* (2016) introduce contemporaneous tax rates, rather than their lag. Whereas our estimates are robust to the use of contemporaneous tax measures (results are available upon request), we prefer to report the results which in our opinion are less subject to potential endogeneity problems. In fact, it is conceivable that the government sets the VAT and personal income tax rates also on the basis of the current state of the business cycle which is driven by private consumption.

3.2 Introducing financial and fiscal integration

3.2.1 Construction of integration indices

In order to explore the role of financial integration and international official assistance as sources of time-varying heterogeneity in risk sharing within the EMU, we use interaction terms to model the dependence of the risk sharing coefficient on measures of integration. Given our focus on how risk sharing has changed since the inception of the EMU, we enrich the Fratzscher and Imbs (2009) model by allowing the interacting variables to vary not only across pairs, but also over time. Moreover, we extend their analysis accounting also for the risk sharing channel operating through the EFSF-ESM financial assistance among the euro area countries.

To this end, we construct time-varying bilateral measures of financial integration and bilateral assistance through the EFSF-ESM. The financial integration measure is computed following Epstein *et al.* (2016) as the sum of claims of country i over country j and claims of country j over country i, scaled by the sum of nominal GDP in country i and country j:

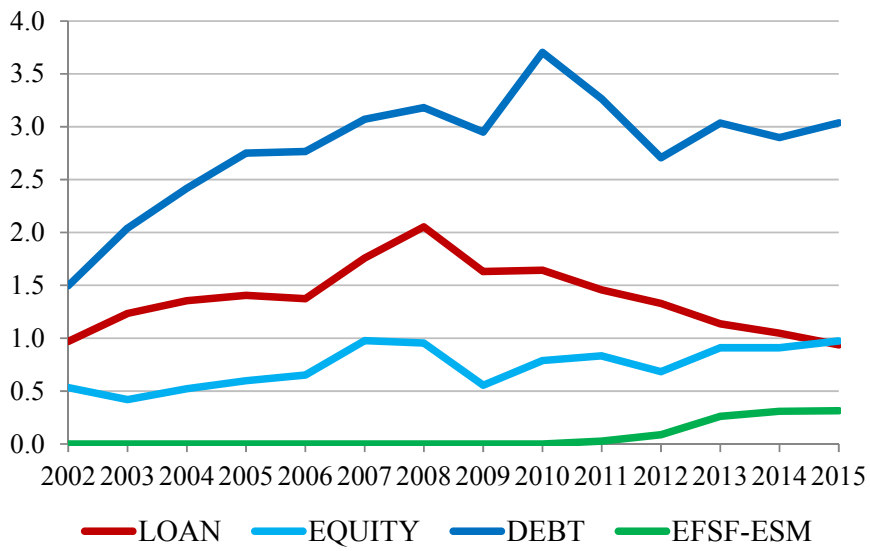
$$INT_{ij,t} = \frac{A_{i\to j,t} + A_{j\to i,t}}{Y_{i,t} + Y_{j,t}}. \qquad (2)$$

First, we compute a measure of 'overall' financial integration where $A_{i\to j,t}$ is the sum of cross-border bilateral loans and cross-border portfolio investment ($FIN_{ij,t}$). Then, we create two separate measures of integration for each of the two asset categories, namely $LOAN_{ij,t}$ and $PORT_{ij,t}$. Lastly, we further differentiate between debt and equity within the category of portfolio investment, and compute measures of integration for the corresponding assets (labelled respectively as $DEBT_{ij,t}$ and $EQUITY_{ij,t}$). We further use formula (2) to compute a measure of EFSF-ESM bilateral assistance, which we label $EFSF_{ij,t}$ (for simplicity in the notation, we label this variable only as *EFSF*, although it includes also *ESM* loans). In this case $A_{i\to j,t}$ represents the financial assistance provided by country i to country j and channelled via the EFSF-ESM loans at a given point in time.[10] Figure 1 shows the extent of time variation exhibited by these integration measures, averaged across all country pairs. We notice that the cross-border bilateral debt holdings constitute the largest component. Cross-border bilateral loans and in particular equity holdings are quantitatively less than half of their debt counterpart. Cross-border holdings of debt instruments and cross-border loans show an upward trend up to the beginning of the financial crisis (loans) and the European sovereign debt crisis (debt), followed by a reduction which was particularly marked in the loan market. At the same time, cross-border holdings of equity are substantially stable over this period. The EFSF-ESM financial assistance variable is, by construction, zero up to 2009 given that the EFSF was activated only in 2010. As of

[10] While all countries in our sample are contributors to the EFSF-ESM, we have only 4 recipient countries within our sample: Greece, Portugal, Spain and Ireland.

2010, it starts increasing, although it remains quantitatively smaller than the financial integration indices.

Figure 1: Financial integration and EFSF-ESM assistance in the euro area



Notes: Annual country-pair averages in percentage points of GDP. "LOAN", "EQUITY", "DEBT" and "EFSF-ESM" are defined as the sum of the relevant bilateral exposure of country *i* in country *j* and the bilateral exposure of country *j* in country *i* over the sum of the GDP of countries *i* and *j*. "LOAN" refers to data on cross-border bank lending from the Bank of International Settlements, "EQUITY" and "DEBT" mark the corresponding components of the IMF Coordinated Portfolio Investment Survey, and "EFSF-ESM" is official financial assistance through bilateral loans, as well as EFSF and ESM funds.

This approach also allows to compute integration indices at the country level, i.e., capturing the interlinkages of a single country vis-à-vis all other countries in the sample. Figure A1 in the Appendix shows these country-specific integration indices, where country *i* is fixed (e.g., Austria), and the integration index is constructed by averaging the bi-lateral measure across the ten remaining *j* countries. First, we notice that Ireland and the Netherlands exhibit the highest levels of financial integration, driven in particular by their foreign debt holdings. On average, the least financially integrated countries appear to be Finland, Greece and Portugal. The majority of countries exhibit a higher level of integration through debt instruments than through equity. As expected, integration indices built on debt and equity holdings fall around the financial crisis of 2008-2009. Integration through equity markets recovers rather swiftly in the year(s) following the crisis, and in most cases exhibits an ascending trend after 2010. However, between 2009-2011, debt integration drops in Ireland, Spain, Greece, Portugal (and to a lesser extent Italy). The sharp dynamics in the case of Greece reflect the moves in government debt markets during the sovereign debt crisis.[11] We observe evidence of pro-cyclicality in financial integration through cross-border loans. Nearly all figures

[11] Among the reasons for the sharp rise in the debt integration index between 2012 and 2013, there seems to be a sizeable increase of Italian and Spanish debt securities held by Greece.

exhibit a hump-shaped pattern, with a peak in the business cyclical upturn preceding the crisis (strongly visible, for instance, in the case of Belgium). Finally, the EFSF-ESM integration variable remains relatively small compared to the rest of the indicators. It reaches higher values for recipients of assistance, and a maximum of above one percent of GDP in the case of Greece.

3.2.2 Regression based on extended model including integration indices

Allowing for the risk sharing coefficient to be a linear function of the financial and fiscal integration measures, the full model takes the following form:

$$
\begin{aligned}
&(\Delta \log C_{i,t} - \Delta \log C_{j,t}) \\
&\quad = \alpha + \beta_0(\Delta\log Y_{i,t} - \Delta\log Y_{j,t}) + \beta_1(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})LOAN_{ij,t-1} \\
&\quad + \beta_2(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EQUITY_{ij,t-1} + \beta_3(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})DEBT_{ij,t-1} \\
&\quad + \beta_4(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EFSF_{ij,t-1} + \gamma Z_{ij,t-1} + \eta_t + \mu_{ij} + \varepsilon_{ij,t} \quad (3)
\end{aligned}
$$

Formally, the coefficient capturing risk sharing between country *i* and *j* will be equal to the sum of the income growth differential coefficient (β_0) and the component that captures how risk sharing is related to *K* measures of financial/fiscal integration ($\beta_1, \beta_2, \beta_3, \beta_4$):

$$\beta_t = \beta_0 + \sum_{k=1}^{K} \beta_k \, INT_{ij,t-1}^{k} \quad (4)$$

This measure of risk sharing is time-varying to the extent that the underlying measures of financial/fiscal integration (*INT*) change over time. In this model, the null hypothesis of perfect risk sharing amounts to testing whether the β_t coefficient in equation (4) is not statistically different from zero. For positive values of β_0 and positive financial and fiscal integration indices, negative (positive) coefficients of β_k indicate that higher values of integration improve (worsen) cross-country consumption risk sharing.[12]

It is worth mentioning that correct econometric inference requires us to address the symmetry generated by constructing all variables as growth differentials. To avoid double counting we only keep one observation per country pair and thus for a sample of *N* countries and *T* time periods we use a total of *TN(N-1)/2* observations. Moreover, the bilateral structure of our panel dataset induces a pattern of dyadic correlation in the errors: all pairs that have one country in common will be cross-sectionally correlated. According to Cameron and Miller (2014), the inclusion of country-pair fixed

[12] In the robustness section we extend equation (3) by including the level of the financial and fiscal assistance integration measures. Results show that the latter are generally statistically insignificant. Most importantly, our main estimates on the interaction terms remain almost identical both in size and statistical significance.

effects in panel models with paired data is insufficient to address the error-correlation structure and in general leads to underestimated standard errors. Therefore, we use the standard error correction proposed by Cameron and Miller (2014), which is specifically designed to address the particular correlation pattern of paired data.[13]

3.3 Data

Given the focus of our analysis, we restrict attention to a sample of 11 euro zone member countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. Our dataset is collected at a yearly frequency and covers the period 1999-2015. Although our analysis initially comprised the 12 euro zone countries for which cross-border bank loans from the Bank for International Settlements (BIS) are available, we exclude Luxembourg from our sample given its status as a financial hub and the observed cross-border exposures which indicate that this country is a clear outlier.

For our country and time sample, we construct a rich dataset combining information from multiple sources. The Appendix contains a full description of data and sources. As a first building block we use the confidential BIS International Locational Banking Statistics, which reports bilateral positions of the banking sector in country i against each counterparty country j. The data is recorded using the residence principle, thus accurately reflecting cross-country exposures. To minimize the overlap with portfolio investment data, we restrict our attention to cross-border loans provided by a creditor banking system to the economy of a given debtor country. We combine the BIS information with bilateral data on portfolio investment from the IMF Coordinated Portfolio Investment Survey (CPIS). The CPIS consists of data on cross-border holdings of equity and debt securities, collected from holders by means of a survey and classified according to the residence of the issuer. In line with Lane and Milesi-Ferretti (2007), we use asset stocks as opposed to flows because they provide a better proxy for wealth.

Data on bilateral assistance provided by the EFSF and the ESM is retrieved from ECB sources and represents the stock amount from each contributor to each recipient country in the euro area and channelled through the stability fund according to key capital contribution rates.[14] The EFSF was an institutional entity created in 2010 with the purpose of providing financial assistance to distressed euro zone member states. Its activity was complemented by the bilateral loans channelled via the European Financial Stabilisation Mechanism (EFSM). In the period 2010-2013, the two facilities

[13] We find that our resulting errors are not significantly auto-correlated after applying the cross-sectional dyadic error correction, and thus do not necessitate further correction.

[14] For comparability with the financial data, we transform the EFSF and ESM assistance data to current U.S. dollars.

provided aid to Ireland, Portugal and Greece. In September 2012, their activity was taken on by the European Stability Mechanism (ESM), a similar institutional arrangement that provided assistance also to Cyprus and Spain.

In addition to financial and fiscal variables, we use standard macroeconomic variables available from Eurostat, namely final household consumption and gross domestic product at market prices. We deflate the series using by the harmonized index of consumer prices with reference year 2010. Finally, we divide them by total population. Therefore, consumption and output data are in real per capita terms.

Following Epstein, *et al.* (2016), we account for the role of relative tax differentials by including these as control variables in our estimation. We favour the use of statutory tax rates as opposed to measures of effective taxation derived from national accounts in order to alleviate the concerns about endogeneity to the dynamics of consumption and income, given that the effective consumption tax is a function of underlying household final consumption expenditure and the capital tax rate depends on production and imports. The tax differentials are constructed from data on tax rates. We use the statutory standard VAT rate and the overall (corporate plus personal) statutory tax rate on distributed profit, both available at annual frequency from the OECD Tax Database. As in Epstein *et al.* (2016), the consumption tax rate is used in differences and the capital tax rate is used in levels, following the structural equations of their model.

In order to capture bilateral differences in real interest rates, we further augment the set of control variables with the 10-year sovereign bond yield and consumer price index differentials from the OECD Main Economic Indicators.[15] Finally, changes in country-level lending conditions by using data from the BIS total credit statistics. These data reflect the amount of credit supplied by domestic banks to private non-financial sectors.

4. Empirical results

4.1 Simple risk sharing regression

In Table 1 we report the results of the simple bilateral risk sharing regression as in equation (1), linking consumption growth differentials to output growth differentials (and a set of controls). In this first regression, we do not include measures of financial integration and official assistance. A coefficient on the output differential term $\left(\Delta\log Y_{i,t} - \Delta\log Y_{j,t}\right)$ equal to zero would signal perfect risk sharing, given that output growth differentials would not be reflected in consumption growth differentials. A coefficient equal to one would indicate no risk sharing. Table 1 shows the results from

[15] More information on the sources, construction and coverage of the variables is reported in the Data Appendix.

different specifications of the OLS estimation with standard errors clustered for dyadic data. In particular, column (1) shows the results with no controls added to the simple consumption-output regression, and with no fixed effects. Column (2) adds country-pair fixed effects, column (3) year fixed effects, and column (4) both types of fixed effects. The following part of the table shows the results when we include our set of controls, namely $\Delta VAT_{ij,t-1}$ and $\Delta PIT_{ij,t-1}$ (column 5), the domestic credit growth differential $\Delta DCREDIT_{ij,t-1}$ (column 6), the inflation differential $\Delta INFL_{ij,t-1}$ and the 10-year sovereign bond yield differential $\Delta YIELD_{ij,t-1}$ (column 7). Finally, column (8) reports the regression results with all controls included.

Table 1: Simple risk sharing regression model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta\log Y_{i,t} - \Delta\log Y_{j,t}$	0.521***	0.537***	0.500***	0.515***	0.476***	0.469***	0.445***	0.452***
	(0.114)	(0.118)	(0.128)	(0.127)	(0.130)	(0.0796)	(0.102)	(0.0703)
$\Delta VAT_{ij,t-1}$					-0.240*			-0.0670
					(0.138)			(0.160)
$\Delta PIT_{ij,t-1}$					-0.0919*			-0.0204
					(0.0534)			(0.0367)
$\Delta DCREDIT_{ij,t-1}$						0.143***		0.134***
						(0.0281)		(0.0309)
$\Delta INFL_{ij,t-1}$							0.131	-0.00501
							(0.243)	(0.167)
$\Delta YIELD_{ij,t-1}$							-0.225***	-0.0573
							(0.0371)	(0.0534)
Constant	-0.150	-0.174***	0.587**	0.538*	0.681**	-0.343	0.0665	0.450
	(0.139)	(0.0098)	(0.266)	(0.309)	(0.341)	(0.355)	(0.274)	(0.282)
# of observations	870	870	870	870	760	815	815	760
# of country pairs	55	55	55	55	55	55	55	55
# of countries	11	11	11	11	11	11	11	11
Country pair FE	NO	YES	NO	YES	YES	YES	YES	YES
Year FE	NO	NO	YES	YES	YES	YES	YES	YES

Notes: OLS estimation with clustered standard errors for dyadic data (in parenthesis) of equation (1). ***, ** and * refer to the 1%, 5% and 10% statistical significance.

Table 1 indicates that, across all specifications, the coefficient on the output differential is rather stable and in the interval 0.45-0.55. This indicates that, on average over the full sample, about 50% of idiosyncratic output shocks are smoothed in the euro zone, while the remaining 50% are unsmoothed.

This risk sharing coefficient appears to be larger than other estimates in the literature. For example, using the Asdrubali *et al.* (1996) approach in a sample of EA11 countries, Alcidi *et al.* (2017) obtain risk sharing estimates of 42% between 1998 and 2007, 55% between 2008 and 2009 and 16% between 2010-2013. With the same methodology, Milano (2017) places the estimate around 23% for the period 1999-2006 and 31% for the period 2007-2014. The difference between our result and those

obtained in other studies stems mainly from the definition of the consumption aggregate used in the estimation: while we opt for household final consumption expenditure (including the consumption of non-profit institutions serving households), other risk sharing regressions rely on aggregate consumption data that also includes government final consumption expenditure (see, e.g., Asdrubali *et al.*, 1996). The VAT and PIT rate differentials show a negative coefficient. Indeed, an increase in these tax rates in country *i* is expected to lead to a decrease in consumption in that country relative to country *j*, which is reflected in a negative sign of the related coefficients. As regards the other controls, the coefficient on the bond yield differentials is negative indicating a depressive effect of this variable on consumption, whereas domestic credit growth differentials are associated with diverging relative consumption growth rates. In other words, an increase in domestic credit growth in country *i* relative to the domestic credit growth in country *j* is associated with an increase in consumption of country *i* relative to country *j*. Once we include all controls at once the tax differentials remain negative but lose statistical significance. Given that we want to use the most general specification, in the remainder we will use as baseline model the one with all controls (column 8).

4.2 The effects of financial and fiscal integration on risk sharing

Table 2 reports the results from a richer specification, in which several interaction terms have been added to the baseline specification of Table 1 (column 8). In particular, as in equation (2), we interact the output growth differential with (i) international financial assistance, as represented by EFSF loans between any two euro zone countries as well as funds channelled through the ESM, and (ii) the terms representing financial integration (i.e., sum of bilateral bank loans and bilateral portfolio holdings).
The underlying intuition behind this interacted variable regression is that, in this framework, idiosyncratic output shocks may affect consumption depending on the level of the interacted variables. For example, output shocks may have smaller (bigger) effects on consumption if financial integration is higher (weaker).

In addition to the interacted terms, we deem appropriate to always include country-pair fixed effects and year fixed effects to account for unobserved country pair characteristics (such as distance, or similarity in language or institutional and legal arrangements), as well as common euro area-wide factors (e.g., the European sovereign debt crisis, which started in 2010).

In column (1) we augment the simple specification of equation (1) only with the interaction term based on the international financial assistance ($EFSF_{ij,t-1}$). The results show that the coefficient on the EFSF-ESM loans is large, negative and highly significant, thus contributing to push the coefficient on output growth differentials towards zero. This indicates that since 2010 (when the EFSF loans

were activated), financial assistance has contributed in a statistically significant way to risk sharing in the euro zone. In column (2), we only include the interaction term based on the overall financial integration index $FIN_{ij,t-1}$. The regression results suggest a statistically insignificant effect of financial integration in reducing consumption growth differentials across countries. This finding is also present when controlling simultaneously for the EFSF-ESM assistance (column (3)). Given that the true effects of financial integration might differ across the different financial instruments, we then add separately the interaction terms for bilateral bank loans in column (4), for bilateral portfolio holdings in column (5), and include loans and portfolio holdings jointly in column (6). Finally, in column (7) we account for differential effects of capital and credit markets by breaking the portfolio term into its equity and debt components and simultaneously add all three financial integration terms together with the EFSF-ESM fiscal assistance measure.

The results show that bilateral bank loans are either insignificant or tend to decrease consumption risk sharing, as reflected by the positive interaction coefficient in columns (6) and (7). This result may appear counter-intuitive, but it is consistent with a pro-cyclical behaviour of cross-border lending. More specifically, if a country pair is hit by asymmetric output shocks leading to an increase in the output growth differential, a high degree of integrated banks distributing cross-country lending in a pro-cyclical way will result in increase in the consumption growth differential.[16] The latter effect is reflected in a higher β_t or lower consumption risk sharing. Table 2 also suggests that portfolio holdings have the expected negative sign, which would indicate their role in bringing about more risk sharing. This result is mostly driven by equity holdings. Our finding corroborates other studies in the literature that indicate the positive role of cross-border equity holdings in reducing consumption growth differentials (see, for example, Schmitz, 2007, Fratzscher and Imbs, 2009). The coefficients of the other control variables tend to preserve the sign shown in Table 1: PIT rate differentials and differentials in VAT changes are always negative (although the coefficient remains statistically insignificant). The contribution of bond yield differentials is also negative. If the sovereign risk premium (as captured by the yield differential) increases in country *i* relative to country *j*, then compared to country *j* in country *i* the cost of borrowing will increase. *Ceteris paribus*, this will exert downward pressure on the growth of consumption in country *i* relative to *j*. At the same time, the differentials in domestic credit growth rates still enter the regression with a positive sign, indicating that consumption will grow faster in country *i* relative to country *j* when domestic credit in the former economy expands faster than in the latter.

We also evaluate the degree of *shock absorption* at specific values for the financial and fiscal integration indices. The latter is defined as $(1-\beta_t)$ where β_t is the overall risk sharing coefficient included in equation (4) and based on the estimates in column (7) of Table 2. A value of one

[16] See Albertazzi and Bottero (2014) on the pro-cyclicality of lending from foreign banks.

corresponds to full risk sharing (perfect shock absorption) while a value of zero indicates no shock absorption.[17] Indeed, an important main value added of our analysis is that it allows deriving a time-varying estimate for the degree of risk sharing (or shock absorption) in the EMU. The figure indicates that the degree of shock absorption increased from around 40% (of country-specific output shocks) in the early 2000s, to around 65% the end of the sample. This reveals - perhaps surprisingly - that risk sharing has progressively improved in the EMU, and also during the recent crisis period.

Our framework also allows to pin down the relative contribution of each factor in explaining the time *variation* in the degree of shock absorption. Indeed, Figure 3 reports the individual contribution of cross-border bank loans, cross-border holdings of equity and debt (i.e., portfolio) and official EFSF-ESM assistance to the time evolution of $(1-\beta_t)$. It turns out that portfolio integration has been increasingly important as a shock absorber, until 2008. In 2009, at the beginning of the crisis, the coefficient on portfolio slightly increases, thus revealing a less positive contribution to risk sharing in that year. This might be possibly due to the fact that the 2009 recessionary shock hit all countries (and financial markets) simultaneously in the euro zone, therefore cross-border holdings of financial assets did not benefit households and consumers as the scope for risk sharing was reduced. Since 2010, the contribution of international portfolio holdings has been broadly stable. Financial assistance channelled through European institutions has been a very important shock-absorber mechanism since 2010, when such loans were activated. Indeed, the EFSF and ESM assistance is the largest component, amounting in the last part of the sample to around 0.18 p.p. of the total change in shock absorption (around 0.25 p.p.). Finally, cross-border loans have contributed negatively, and in a rather stable way, to risk sharing. However, the impact of this factor seems to be rather small over the full sample (less than 5 p.p.) and has become less powerful since 2008, as reflected in progressive decline of the loan integration measure shown in Figure 1.

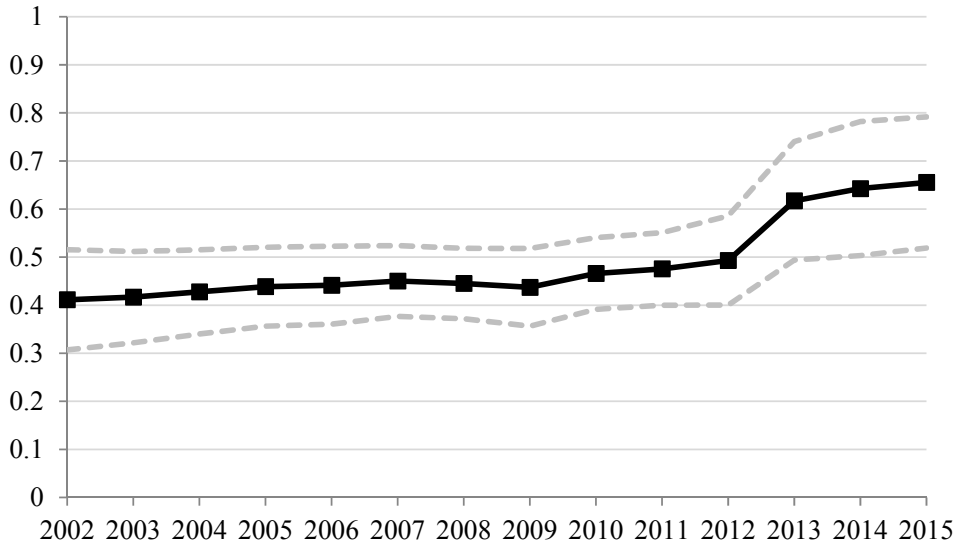
[17] The interaction terms are evaluated at their annual country-pair *averages* (see Figure 1).

Table 2: Risk sharing in the euro area: the role of financial integration and EFSF-ESM assistance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta\log Y_{i,t} - \Delta\log Y_{j,t}$	0.491***	0.557***	0.581***	0.478***	0.641***	0.635***	0.623***
	(0.0540)	(0.119)	(0.0948)	(0.0740)	(0.0752)	(0.0844)	(0.0873)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EFSF_{ij,t-1}$	-0.575***		-0.577***	-0.607***	-0.489**	-0.508***	-0.587***
	(0.192)		(0.220)	(0.192)	(0.203)	(0.180)	(0.211)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})FIN_{ij,t-1}$		-0.0138	-0.0120				
		(0.0107)	(0.00937)				
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})LOAN_{ij,t-1}$				0.00273		0.0264**	0.0262**
				(0.0166)		(0.0104)	(0.0108)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})PORT_{ij,t-1}$					-0.0251**	-0.0317***	
					(0.0111)	(0.0122)	
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})DEBT_{ij,t-1}$							-0.0292
							(0.0218)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EQUITY_{ij,t-1}$							-0.0310**
							(0.0137)
$\Delta VAT_{ij,t-1}$	-0.0437	-0.0697	-0.0566	-0.0603	-0.0410	-0.0550	-0.0219
	(0.168)	(0.159)	(0.165)	(0.169)	(0.162)	(0.163)	(0.156)
$\Delta PIT_{ij,t-1}$	-0.0158	-0.0235	-0.0188	-0.0178	-0.0180	-0.0165	-0.0118
	(0.0314)	(0.0335)	(0.0291)	(0.0310)	(0.0292)	(0.0280)	(0.0246)
$\Delta INFL_{ij,t-1}$	0.00900	0.0468	0.0563	0.0434	0.0357	0.0648	0.0672
	(0.158)	(0.127)	(0.120)	(0.135)	(0.138)	(0.121)	(0.118)
$\Delta YIELD_{ij,t-1}$	-0.212***	-0.00384	-0.164***	-0.210***	-0.129**	-0.134**	-0.179***
	(0.0575)	(0.0589)	(0.0561)	(0.0492)	(0.0638)	(0.0585)	(0.0448)
$\Delta DCREDIT_{ij,t-1}$	0.120***	0.118***	0.105***	0.111***	0.106***	0.0976***	0.0964***
	(0.0295)	(0.0321)	(0.0298)	(0.0289)	(0.0287)	(0.0279)	(0.0253)
Constant	0.369	0.366*	0.276	0.337	0.261	0.215	0.202
	(0.314)	(0.214)	(0.242)	(0.235)	(0.296)	(0.247)	(0.254)
# of observations	760	731	731	733	758	731	715
# of unique country pairs	55	55	55	55	55	55	55
# countries	11	11	11	11	11	11	11

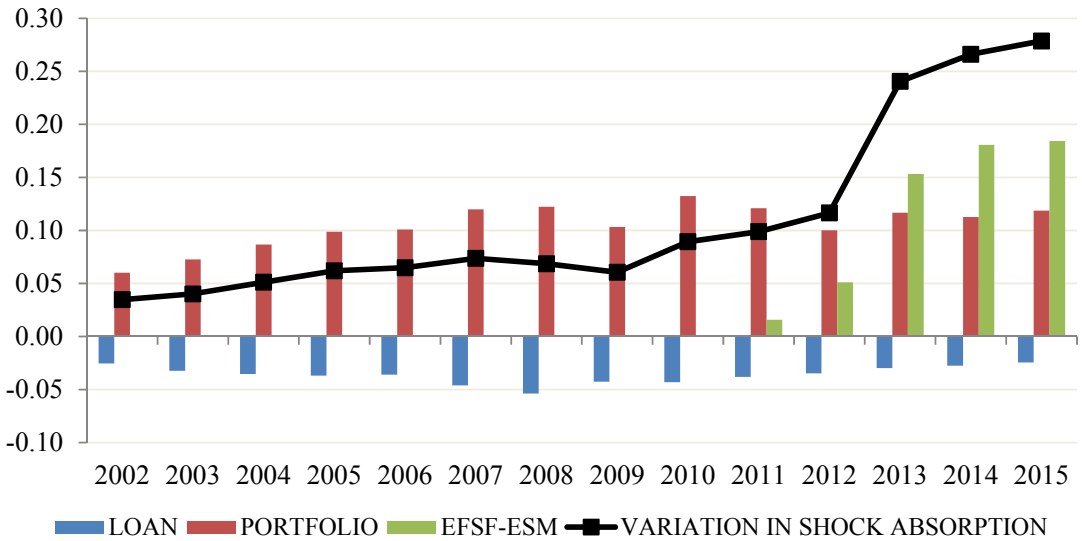
Notes: OLS estimation with robust standard errors for dyadic data (in parenthesis) of equation (3). ***, ** and * refer to the 1%, 5% and 10% statistical significance. All regressions include country–pair and year fixed effects.

Figure 2: Degree of shock absorption in the EMU.



Notes: The figure plots the degree of shock absorption defined as $(1-\beta_t)$, where β_t is the overall risk sharing coefficient defined in equation (4) and based on the estimates in column (7) of Table 2. A value of one corresponds to full risk sharing (full shock absorption of idiosyncratic output shocks), a value of zero indicates no shock absorption. The interaction terms are evaluated at their annual country-pair means (see Figure 1). Confidence bands correspond to the 90% level of statistical significance and are constructed using cluster-robust standard errors accounting for dyadic data.

Figure 3: Contributions to changes in the degree of shock absorption.



Notes: The figure plots the contributions to the variation in shock absorption of the cross-border loans (LOAN), cross-border portfolio holdings (PORTFOLIO) and ESFS-ESM assistance (EFSF-ESM). These contributions are based on the estimates reported in column (7) of Table 2. "LOAN" is calculated as $-\beta_1 * LOAN_{t-1}$; "PORTFOLIO" is calculated as $-\beta_2 * EQUITY_{t-1} - \beta_3 * DEBT_{t-1}$; "EFSF-ESM" is calculated as $-\beta_4 * EFSF_{t-1}$. The interaction terms are evaluated at their annual country-pair means (see Figure 1).

4.3 Risk sharing links between "Core" and "Periphery"

In this section, we zoom in on the risk sharing links between "Periphery" and "Core" countries within the EMU. The first group includes the euro zone "vulnerable" countries, i.e., the one most hit by the recent crisis: Greece, Portugal, Ireland, Spain and Italy. The second group includes Austria, Belgium, Germany, Finland, France and the Netherlands. In fact, financial assistance has been mainly directed from the 'Core' to the 'Periphery', therefore exploring the links between these two groups of countries is interesting. Column (2) of Table 3 presents the results for a panel model in which country pairs consist of one core and one periphery country. As a further robustness check, in column (3) we report the results in which Italy is assigned to the group of core countries instead of the peripheral countries. In both columns the coefficient of EFSF-ESM financial assistance remains negative and significant, although smaller in size relative to the baseline. The coefficient on bank loans integration maintains a positive and significant sign, while equity holdings contribute more significantly to risk sharing as compared to the all sample. Interestingly, the coefficient on debt holdings is now negative and statistically significant, suggesting that cross-border holding of debt may have led to stronger shock absorption that in the full sample, which includes country pairs of similar countries (i.e, Core-Core and Periphery-Periphery).

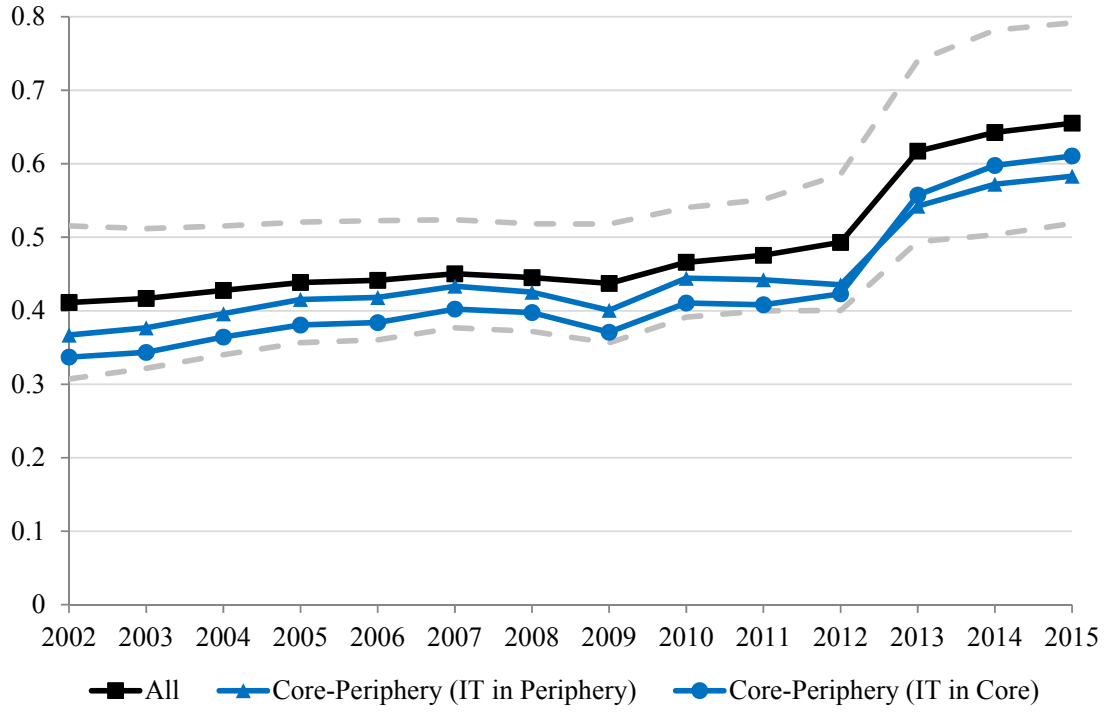
The differences in the coefficients are better reflected by the full effect estimated in the two country groups we consider, with the result presented in Figure 4. The shock-absorption indicator $(1-\beta_t)$ based on the full sample lies above the coefficient for the core-periphery group, indicating a lower elasticity of relative consumption growth to relative income growth in more homogeneous country pairs. This indicates that, overall, risk sharing seems to have been more effective between similar group of countries (which are included in the full sample estimate), than between Core and Periphery countries. These differences in the degree of risk sharing are however minor, given that $(1-\beta_t)$ is always included in the confidence bands of the full sample estimate.

Table 3: Risk sharing between "Core" and "Periphery"

	(1) All	(2) Core-Periphery	(3) Core-Periphery (IT in Core)
$\Delta\log Y_{i,t} - \Delta\log Y_{j,t}$	0.623***	0.687***	0.696***
	(0.0873)	(0.0833)	(0.0798)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EFSF_{ij,t-1}$	-0.587***	-0.383***	-0.376***
	(0.211)	(0.123)	(0.122)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})LOAN_{ij,t-1}$	0.0262**	0.0364**	0.0324**
	(0.0108)	(0.0156)	(0.0151)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})DEBT_{ij,t-1}$	-0.0292	-0.0479***	-0.0389*
	(0.0218)	(0.0172)	(0.0220)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EQUITY_{ij,t-1}$	-0.0310**	-0.0434***	-0.0516***
	(0.0137)	(0.0122)	(0.0160)
$\Delta VAT_{ij,t-1}$	-0.0219	-0.0320	-0.0316
	(0.156)	(0.138)	(0.135)
$\Delta PIT_{ij,t-1}$	-0.0118	-0.0183	-0.0173
	(0.0246)	(0.0292)	(0.0342)
$\Delta INFL_{ij,t-1}$	0.0672	0.0481	0.0945
	(0.118)	(0.116)	(0.120)
$\Delta YIELD_{ij,t-1}$	-0.179***	-0.114*	-0.0759
	(0.0448)	(0.0621)	(0.0802)
$\Delta DCREDIT_{ij,t-1}$	0.0964***	0.101***	0.105***
	(0.0253)	(0.0314)	(0.0330)
# of observations	715	394	361
# of unique country pairs	55	30	28
# countries	11	11	11

Notes: OLS estimation with robust standard errors for dyadic data (in parenthesis) of equation (3). ***, ** and * refer to the 1%, 5% and 10% statistical significance. "All" refers to all pairs across EMU countries and "Core-Periphery" refers to all unique country pairs consisting of "Core" and "Periphery" countries. "Periphery" refers to vulnerable countries in the euro area (Greece, Spain, Italy, Portugal and Ireland) and "Core" refers to resilient countries in the euro area (Germany, the Netherlands, Belgium, Austria and Finland. In column (3) Italy is moved from the "Periphery" to the "Core" group. All regressions include country-pair and year fixed effects.

Figure 4: Evolution of risk sharing between "Core" and "Periphery"



Notes: See *Notes* of Figure 2. We evaluate the non-linear effect in each subsample by using the relevant column of Table 3 and fixing the interacting variables to equal the annual averages of bilateral financial and fiscal integration computed in the corresponding sub-sample of country pairs.

5. Robustness

To test if alternative estimation methods would affect significantly these results, in Table A1 of the Appendix we replicate the last column of Table 2, with standard OLS with fixed effects (column (2)), OLS with Driscoll-Kraay standard errors (column (3)) and feasible GLS with panel-specific AR(1) autocorrelation in the error term (column (4)). The Driscoll and Kraay (1998) standard error correction accounts for general forms of both cross-sectional and time correlation, whereas the feasible GLS estimation allows for panel-specific autocorrelation of order one in the errors. The results are consistent with the baseline estimates we find in Table 2 (replicated in column (1) of Table A1 to ease comparison) in both sign and magnitude.

Columns (5) to (8) of Table A1 also show the results when we expand the non-linear model with the level of the financial and fiscal assistance integration proxies. Results show that the latter are generally statistically insignificant. Most importantly, our main estimates on the interaction terms remain almost identical both in size and statistical significance.

In Figure A2 of the Appendix we show the overall shock-absorption indicator $(1-\beta_t)$ when we exclude from the estimation one country at the time. Interestingly, we observe that although the exclusion of Greece does not induce a statistically significant shift in the relative elasticity estimate, it does lead to a flatter time path of the estimated coefficient across the full period. We can therefore claim that the presence of Greece in the euro area resulted in a slightly lower level of consumption insurance in the early years of the monetary union, and a higher one after 2011. This may be related to the low level of financial integration observed in Greece throughout the period, which in part offset the positive effect through the participation of Greece in the EFSF-ESM assistance program.

We also observe that the exclusion of Ireland results in a lower shock absorption since the start of the financial crisis, although the effect is still within the confidence bands of the full-sample estimate (see Figure A1 in the Appendix). Although Ireland was a net receiver of EFSF and ESM loans, its positive impact on the aggregate risk sharing coefficient seems to be mainly driven by the fact that this country was highly financially integrated with the rest of euro zone countries, in particular through equity holdings.

6. Conclusions

Many commentators have argued that the effects of the financial crisis and the European sovereign debt crisis have been aggravated by the absence of appropriate risk sharing mechanisms within the EMU. In this paper, we propose a novel approach aimed at gauging the extent of consumption risk sharing, and its main drivers, among member countries since the start of the EMU. In particular, based on a sample of 11 euro zone countries for the period 1999-2015, we explore the role of private channels (i.e., cross-border loans and holdings of financial assets) *versus* public channels (i.e., official financial assistance to distressed euro area countries) for consumption risk sharing.

Our results suggest that the shock-absorption capacity generated by international (private and public) channels has increased since the start of the EMU: in the early years of the EMU only about 40% of idiosyncratic output shocks were smoothed, while in the aftermath of the euro zone's sovereign debt crisis around 65% of idiosyncratic output shocks were absorbed. Both financial integration and international official assistance play an important role in explaining this improvement. At the same time, our results show that while banking integration (via cross-border loans) tends to be ineffective or even to somewhat exacerbate country differences in consumption growth, cross-border holdings of equities and debt are powerful channels in isolating households from country-specific shocks. This latter finding is particularly strong when we focus on the links between "Core" and "Periphery" EMU countries: holdings of debt and equity issued by Core countries and in the portfolio of agents in the

"Periphery" (and viceversa) turn out to be effective in absorbing output shocks, thus allowing to better smooth consumption.

The finding that risk sharing has improved over time in the euro zone, also during the recent crisis, is to some extent surprising. Yet, this result does not imply that the severity of the crisis would have not been attenuated even further by a fully-fledged centralized fiscal capacity at the euro zone level.

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Appendix

Data sources and description

Variable	Source	Definition	Sample
Bilateral loan stocks	International Locational Banking Statistics - Bank for International Settlements (BIS)	Aggregate assets (in the form of loans) of banks in reporting countries *vis-à-vis* host country economies (banking and non-banking sectors) in US dollars. Quarterly, aggregated to annual (as averages).	1999-2015
Bilateral portfolio equity and debt stocks	Coordinated Portfolio Survey (CPIS) – International Monetary Fund (IMF)	Cross-border holdings of equities and debt securities self-reported by holder economies and classified by the economy of residence of the issuer, in in US dollars.	2001-2015
Bilateral EFSF and ESM	European Stability Mechanism (ESM) and European Central Bank (ECB)	EFSF and ESM loan disbursements and country contribution keys, in US dollars. To construct the bilateral flows, we multiply the amount withdrawn by each country with the capital keys of all contributors. When the year of payment into the fund is different from the year of withdrawal, we record the bilateral flow at the time when a given recipient (GR, ES) withdraws some funds. For the period before 2010 we set all values to zero.	1999-2015
Household consumption	Eurostat	Final consumption of households. Current prices, million euro, not seasonally adjusted. Quarterly, aggregated to annual (as averages).	1999-2015 Aggregate final consumption is not available for Ireland.
Household consumption	ECB Statistical Data Warehouse (SDW)	Final consumption expenditure of households and non-profit institutions serving households. Current prices, million euro.	1999-2015 Used only for Ireland.
Gross domestic product	Eurostat	Gross domestic product at market prices. Current prices, million euro, not seasonally adjusted. Quarterly, aggregated to annual (as averages).	1999-2015
Population	Eurostat	Total population national concept, Thousand persons, Seasonally and calendar adjusted data. Quarterly, aggregated to annual (as averages).	1999-2015
Value added tax	OECD Tax Database Table 2.A2.1	Standard Value Added Tax rate (General Sales Tax) - Annual.	2000-2015
Statutory tax on dividend income (PIT)	OECD Tax Database Table II.4.	Overall statutory tax rate on dividend income (Sum of the rate on distributed profit and the rate on grossed-up dividend). Annual.	2000-2015
Domestic credit	Bank for International Settlements (Long series on total credit to the non-financial sectors)	Total credit by domestic banks to the private non-financial sector. The original series are market value, billion US Dollar, unadjusted (quarterly, aggregated to annual as averages).	1999– 2015
Long-term (10Y) sovereign bond yield	OECD MEI (Main Economic Indicators)	Long-term (10Y) sovereign bond yield, not seasonally adjusted (quarterly, aggregated to annual as averages).	1999 – 2015

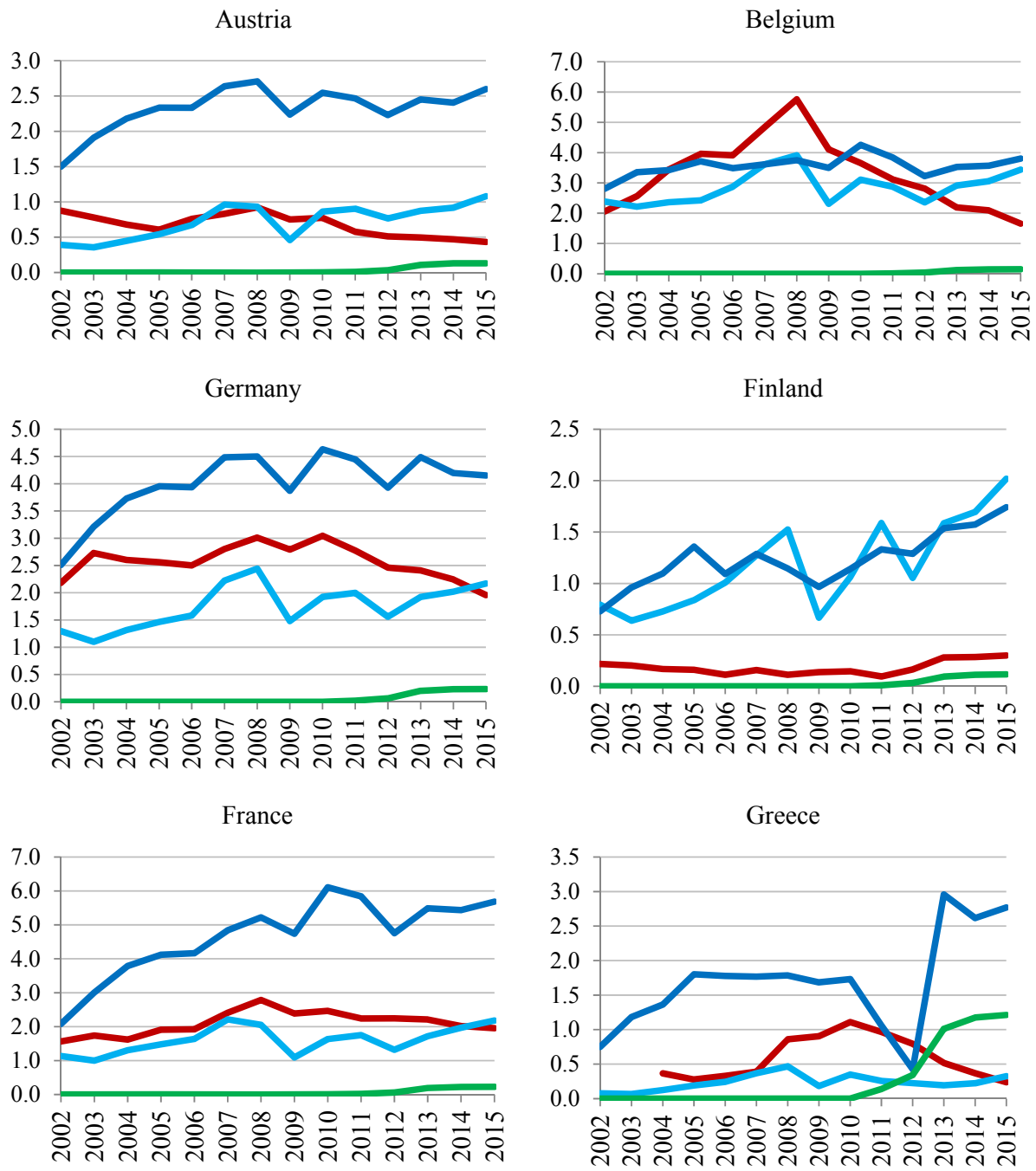
Consumer Price Index	OECD MEI (Main Economic Indicators)	Consumer Price Index, All items (Index 2010=100). Quarterly, aggregated to annual (as averages). We calculate inflation as the growth rate in the Consumer Price Index.	1999 – 2015
US/EUR exchange rate	ECB Statistical Data Warehouse (SDW)	ECB reference exchange rate, USD/EUR. Monthly, aggregated to annual (as averages). We use it to multiply GDP (in EUR) in order to match the currency of financial data (USD).	1999 – 2015

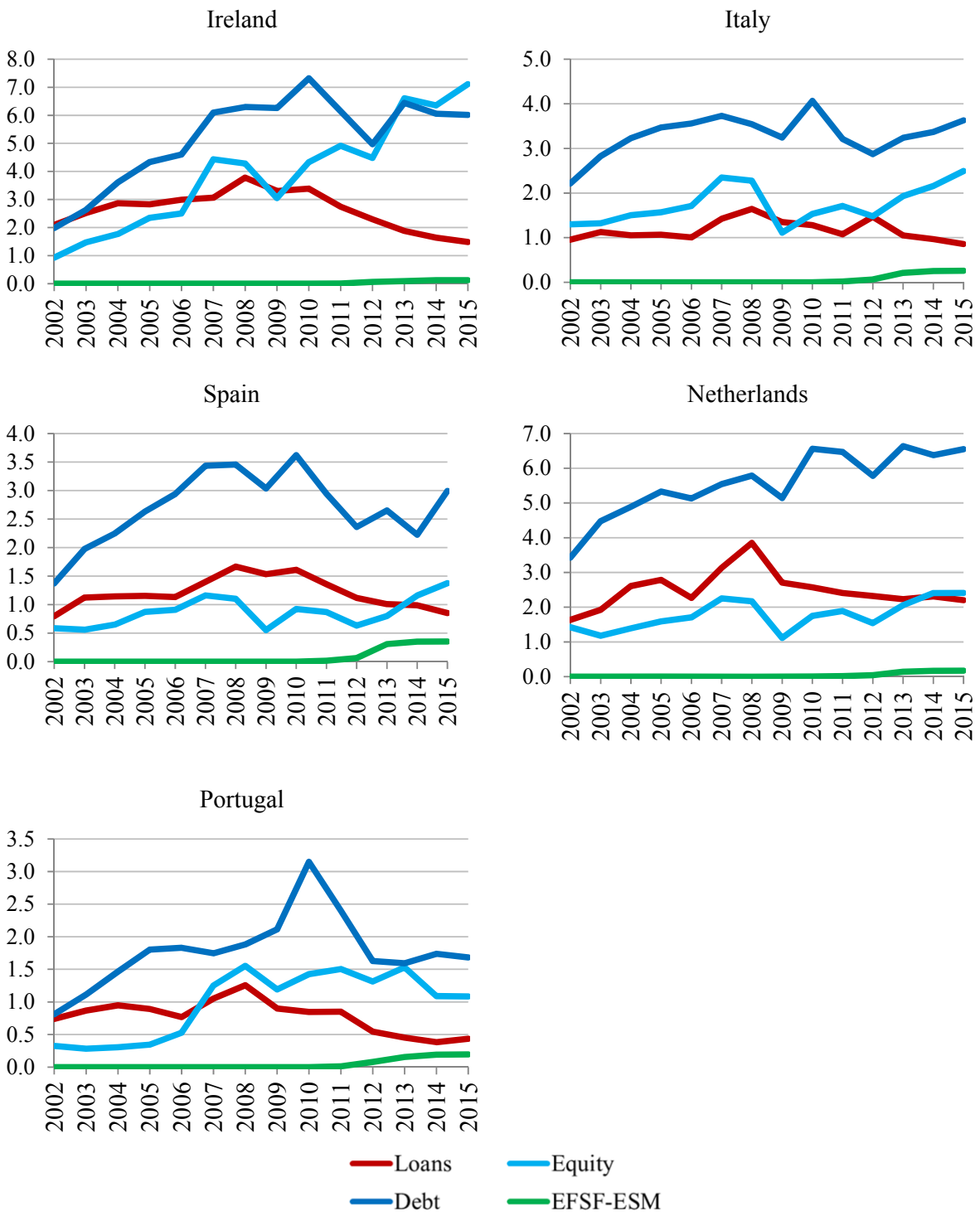
Table A1: Results with different estimation methods and including levels of interacted variables

	(7)	(7)	(7)	(7)	(8)	(8)	(8)	(8)
	Dyadic	OLS	DK	GLS	Dyadic	OLS	DK	GLS
$\Delta\log Y_{i,t} - \Delta\log Y_{j,t}$	0.623***	0.628***	0.642***	0.614***	0.625***	0.631***	0.647***	0.620***
	(0.0873)	(0.0592)	(0.0757)	(0.0308)	(0.0894)	(0.0617)	(0.0768)	(0.0309)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EFSF_{ij,t-1}$	-0.587***	-0.612***	-0.625***	-0.619***	-0.611***	-0.651***	-0.695***	-0.647***
	(0.211)	(0.173)	(0.115)	(0.118)	(0.221)	(0.156)	(0.123)	(0.121)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})LOAN_{ij,t-1}$	0.0262**	0.0274***	0.0267	0.0278***	0.0262**	0.0261***	0.0249	0.0266***
	(0.0108)	(0.00862)	(0.0180)	(0.00752)	(0.0112)	(0.00934)	(0.0175)	(0.00830)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})DEBT_{ij,t-1}$	-0.0292	-0.0306*	-0.0286	-0.0277***	-0.0289	-0.0297*	-0.0268	-0.0273***
	(0.0218)	(0.0166)	(0.0225)	(0.0103)	(0.0216)	(0.0168)	(0.0225)	(0.0103)
$(\Delta\log Y_{i,t} - \Delta\log Y_{j,t})EQUITY_{ij,t-1}$	-0.0310**	-0.0307**	-0.0319***	-0.0350***	-0.0310**	-0.0307**	-0.0322***	-0.0354***
	(0.0137)	(0.0146)	(0.00398)	(0.00936)				
$EFSF_{ij,t-1}$					-0.283	-0.393	-0.696**	-0.347
					(0.265)	(0.298)	(0.300)	(0.389)
$LOAN_{ij,t-1}$					0.000348	-0.0112	-0.0111	-0.0165
					(0.0323)	(0.0758)	(0.0537)	(0.0711)
$DEBT_{ij,t-1}$					-0.0726	-0.111	-0.157	-0.179*
					(0.0902)	(0.149)	(0.130)	(0.104)
$EQUITY_{ij,t-1}$					0.0463	0.0338	0.0582	0.0628
					(0.0442)	(0.0774)	(0.0691)	(0.0763)
$\Delta VAT_{ij,t-1}$	-0.0219	-0.0236	-0.0577	-0.00800	-0.0200	-0.0231	-0.0600	-0.00571
	(0.156)	(0.0681)	(0.120)	(0.0698)	(0.162)	(0.0699)	(0.120)	(0.0697)
$\Delta PIT_{ij,t-1}$	-0.0118	-0.0105	-0.0134	-0.00266	-0.0119	-0.0109	-0.0138	-0.00330
	(0.0246)	(0.0130)	(0.0172)	(0.0145)	(0.0248)	(0.0127)	(0.0167)	(0.0145)
$\Delta INFL_{ij,t-1}$	0.0672	0.0712	0.0970	0.0537	0.0684	0.0734	0.101	0.0581
	(0.118)	(0.0631)	(0.114)	(0.0537)	(0.119)	(0.0665)	(0.104)	(0.0540)
$\Delta YIELD_{ij,t-1}$	-0.179***	-0.179***	-0.183**	-0.170***	-0.180***	-0.181***	-0.186**	-0.172***
	(0.0448)	(0.0542)	(0.0801)	(0.0486)	(0.0493)	(0.0565)	(0.0824)	(0.0489)
$\Delta DCREDIT_{ij,t-1}$	0.0964***	0.0965***	0.103***	0.105***	0.0970***	0.0976***	0.105***	0.106***
	(0.0253)	(0.0128)	(0.0205)	(0.0100)	(0.0261)	(0.0134)	(0.0201)	(0.0100)
Constant	0.202	0.0768	3.990**	0.179	0.168	0.0985	4.401**	0.116
	(0.254)	(0.180)	(1.346)	(0.795)	(0.263)	(0.228)	(1.483)	(0.810)
# of observations	715	715	715	715	715	715	715	715
# of unique country pairs	55	55	55	55	55	55	55	55
# countries	11	11	11	11	11	11	11	11
Pair Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES

Notes: The first four columns correspond to the estimation of the specification in Table 2 column (7) using different econometric techniques. The first column uses OLS estimation with heteroscedasticity-robust standard errors, the second corresponds to OLS estimation with Driscoll-Kraay corrected standard errors (for general cross-sectional correlation and autocorrelation up to lag 4), the third corresponds to GLS estimation with country pair-specific autocorrelation in the standard errors. The columns indexed with (8) refer to the same specifications, where we also include the levels of the interaction variables (coefficients generally not statistically significant and not reported).

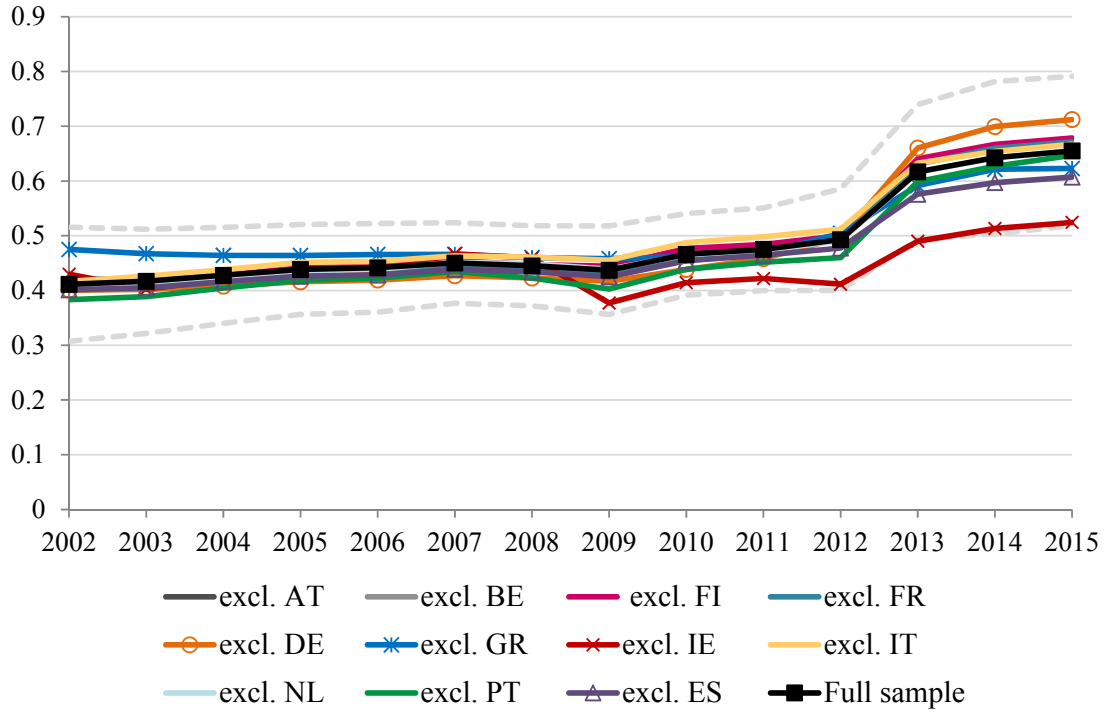
Figure A1: Financial and fiscal integration indices at country level





Notes: Country-level financial integration indices across all partners, in percentage points of GDP. "LOAN", "EQUITY", "DEBT" and "EFSF-ESM" are defined as the sum of the relevant bilateral exposure of country *i* in country *j* and the bilateral exposure of country *j* in country *i* over the sum of the GDP of countries *i* and *j*. These indices are constructed based on averages of country-pairs values, for each country *i*. "LOAN" refers to data on cross-border bank lending from the Bank of International Settlements, "EQUITY" and "DEBT" refer to the corresponding components of the IMF Coordinated Portfolio Investment Survey, and "EFSF-ESM" is official financial assistance through bilateral loans, as well as EFSF and ESM funds.

Figure A2: Baseline estimation excluding one country at the time



Notes: See *Notes* of Figure 2. We evaluate the non-linear effect in each subsample by using the relevant estimates of equation (3) and fixing the interacting variables equal the annual averages of bilateral financial and fiscal integration computed in the corresponding sub-sample of country pairs.

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