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Risk Sharing in the EMU: A Time-Varying Perspective

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Abstract

The development of effective risk sharing mechanisms is one of the main passages for the success and longevity of a monetary union. In this paper, we study risk sharing, measured as income and consumption smoothing, in the EMU. As we employ time-varying estimations, we are able to retrieve time patterns of risk sharing for each member country and to compare them with the degree of economic asymmetry within the EMU. Other than documenting the need for stronger risk sharing mechanisms in the EMU, our results also suggest that much more attention should be dedicated to fostering homogeneity in risk sharing across member countries. We document the existence of increasing heterogeneity in the risk sharing capacity between member countries that can potentially exacerbate and amplify the impact of asymmetric shocks and further destabilize the EMU.

Keywords: EMU; risk sharing; consumption smoothing; income smoothing; economic asymmetry

Introduction

The global financial crisis and the subsequent sovereign debt crisis have exposed fundamental weaknesses in the design and functioning of the EMU that had been previously overlooked. Among these, weak asymmetric shocks absorption and poor risk sharing mechanisms are believed to have exacerbated the diverging economic dynamics between the core and the periphery and have slowed down the recovery. As a result, the Five Presidents' Report (Juncker *et al*., 2015) has then urged both single member countries and European institutions to take steps towards improving risk sharing.

Despite the fact that the need for strong risk sharing mechanisms has been brought to the attention again after the EMU crisis, it has been a well known and established concept in the currency unions theory since the 1970s. In the case of inter-country payment imbalances, high degrees of markets integration can ease the adjustment pressure by means of assets flows. For instance, financial markets integration may cushion adverse disturbances through the capital flows generated by borrowing from surplus areas or by de-cumulating net foreign assets. The role of markets integration in the form of cross-country asset holding for international risk sharing is discussed in Mundell (1973a, 1973b). This contribution, defined in the literature as Mundell II, introduces the idea that differences among countries can be seen as potentially good to absorb asymmetric shocks because they can enhance international risk sharing.[1] Countries sharing a single currency can mitigate the effects of asymmetric shocks by diversifying their income sources. This can operate through income insurance when residents of a country hold claims from other countries. Such *ex ante* insurance allows the smoothing of both temporary and permanent shocks as

[1]See also McKinnon (2004) and Schelkle (2017) for other relevant contributions on the links between risk sharing, countries' differences and the design of currency unions.

long as output is imperfectly correlated. Country's residents can also respond to income fluctuations by adjusting their wealth portfolio. This *ex post* adjustment can be achieved by buying/selling assets and borrowing/lending on international credit markets. The concept of risk sharing has then also been developed in the broader macroeconomic literature independently from the context of monetary unions (Obstfeld and Rogoff, 1996). Promoting growth, diversifying idiosyncratic country risk, and smoothing the profile of both consumption and investment are benefits that also stand-alone countries would like to exploit through open markets.

In this paper, we study risk sharing dynamics in the EMU by means of the Kalman filter and evaluate how such dynamics have been linked to the degree of economic asymmetry between member countries. The employed time-varying technique allows us to retrieve the time patterns of risk sharing of individual EMU member countries, so that we can contemporaneously compare risk sharing performance across both time and countries. As only few studies have applied time-varying techniques to the estimation of risk sharing in the EMU,[2] in the existing literature there is a lack of contributions focusing on this specific aspect. We study the degree of risk sharing by constructing measures of income smoothing as well as consumption smoothing (Demyanyk *et al*., 2008). Given our definition of risk sharing, one can conclude that its relevance in a currency union is directly related to the degree of economic asymmetry among member countries. Higher levels of asymmetry imply more benefits form risk sharing and, therefore, they should call for stronger risk sharing mechanisms. The opposite happens in the case of low levels of asymmetry. As a result, the degree of economic asymmetry provides a measure of the potential gains from risk sharing. Therefore, we analyse income and consumption risk sharing in the EMU by also comparing their dynamics with the trends in the degree of economic asymmetry between member countries.

We find that the consumption channel is substantially stronger than the income channel in the EMU. Although this result holds for all the countries, our results show substantial heterogeneity among them. The impact of both channels is stronger in the peripheral countries, while core countries show lower levels of risk sharing. In both channels, this gap emerged at the beginning of the euro and has not reduced over the years. On the contrary, our results show signs of an increasing gap in recent years. Regarding the degree of asymmetry, we show how it has dropped in the period following the launch of the euro in most of the countries. However, following the global financial crisis and the sovereign debt crisis in Europe, for most of the countries in our sample the degree of asymmetry has sharply increased. It has recently reached higher levels than the ones registered in the pre-euro period. This result explains how the need for risk sharing mechanisms among EMU member countries has grown in the last 10 years and why it should be one of the priorities in the EMU nowadays.

The paper is structured as follows. In section I we discuss how risk sharing has been studied in previous contributions and explain how the present paper fits in the existing literature. Section II explains the method we employ for measuring risk sharing and briefly discusses the data employed. In Section III, we report the results for both income and consumption risk sharing in single member countries, in the EMU as a whole and in subgroups (namely, core and periphery). Section IV introduces the measure of economic

[2]See for instance Balli (2006) and Cimadomo *et al*. (2020).

asymmetry and compares its values with the evolution of the degree of risk sharing in each country. Section V concludes.

I. Relevant Literature

From the methodological point of view, the extensive empirical literature on risk sharing can be divided into three main streams.

The first stream looks at the correlation between international output and consumption in order to measure the degree of risk sharing (Obstfeld, 1994; Pakko, 1998; Kose *et al*., 2003a; Alcidi *et al*., 2017). Another branch of the literature strictly relies on solutions of theoretical models in order to estimate the links between domestic and world consumption (Obstfeld, 1995; Lewis, 1996, 1997). The third stream includes contributions that employ regression models to study different channels and measures of risk sharing (Asdrubali *et al*., 1996; Sorensen and Yosha, 1998; Alcidi and Thirion, 2016).

As we use regression equations to estimate income and consumption risk sharing in the EMU, our study falls in the third stream. Hence, in the rest of this section we will focus on the methods employed in this part of the literature and discuss its main results with respect to the EMU.

When looking at a group of countries, the situation of perfect consumption risk sharing occurs when consumption growth rates in all the countries of the group are identical and, therefore, country-specific consumption is not linked to country-specific GDP shocks (Obstfeld and Rogoff, 1996). Following a similar logic, full perfect income risk sharing occurs when the growth rate of GNI is identical in all countries and is, therefore, not correlated with the GDP growth rate of the country (Kalemli-Ozcan *et al*., 2004).

Following this intuition, the degree of income risk sharing within a group of n countries (with $i \in \{1, \ldots, n\}$) can be obtained by empirically estimating the following general relation (Asdrubali *et al*., 1996; Sorensen *et al*., 2007; Demyanyk *et al*., 2008; Balli *et al*., 2013):

$$\Delta logGNI_{it} - \Delta logGNI_t = \alpha_Y + \beta_Y(\Delta logGDP_{it} - \Delta logGDP_t) + \epsilon_{it}, \qquad (1)$$

where $\Delta logGNI_{it}$ is the growth rate of per-capita GNI in country i and $\Delta logGNI_t$ is its average in the considered group of countries. Similarly, $\Delta logGDP_{it}$ is the growth rate of per-capita GDP in country i, while $\Delta logGDP_t$ is its average in the group. The reason for removing aggregate from country fluctuations is to isolate those that are smoothable. The coefficient β_Y provides a measure for the degree of income risk sharing. It represents the average co-movement of the countries' idiosyncratic GNI growth with their idiosyncratic GDP growth when aggregate growth rates have been subtracted. The higher the co-movement, the less GNI is buffered against GDP fluctuations. If income smoothing is perfect, then idiosyncratic GNI does not co-move with idiosyncratic GDP at all. In fact, under perfect risk sharing the GNI growth rate in all countries should be the same, so that the left-hand side of equation 1 will be equal to 0, implying that $\beta_Y = 0$. Although β_Y already provides a measure of the extent of income risk sharing, it is more common to look at $1 - \beta_Y$, as this will take the value 1 if risk sharing is perfect and the value 0 in the absence of risk sharing.

Similarly, the degree of consumption risk sharing is commonly investigated by looking at the following relation (Sorensen *et al*., 2007; Kose *et al*., 2003b; Asdrubali *et al*., 2018):

$$\Delta logCon_{it} - \Delta logCon_t = \alpha_C + \beta_C(\Delta logGDP_{it} - \Delta logGDP_t) + \mu_{it}, \quad (2)$$

where now on the left-hand side of the equation we have the difference between per-capita consumption growth in country i ($\Delta logCon_{it}$) and its aggregate value in the group ($\Delta logCon_t$). Under perfect consumption risk sharing, this difference should be zero. Hence, also in this case $1 - \beta_C$ can be used as a measure of the degree of risk sharing. The higher the value of $1 - \beta_C$, the more risk sharing takes place. Then, if $1 - \beta_C = 1$, we have perfect consumption risk sharing.

When estimating risk sharing via the relations implied by equations 1 and 2, the practice in the literature often implies to look at the time and country dimensions of the problem separately. We can then identify three main methods to estimate the degree of risk sharing via simple regression equations.

(i) When the focus is on the time dimension of the problem, a set of cross-sectional regressions of equation 1 is run for each year t in order to measure the degree of income risk sharing. As in this case the risk sharing equation is estimated period-by-period for the given group of countries, in equation 1 we can substitute β_Y with $\beta_{y,t}$, meaning that $1 - \beta_{y,t}$ now measures the average degree of income risk sharing at time t in the group of countries considered. Therefore, this approach allows to retrieve one time series reporting the average level of risk sharing, between the countries in the group, over the considered period.

Similarly, a period-by-period estimate of risk sharing occurring via consumption smoothing can be obtained from cross-sectional regressions of equation 2.

In this case, $1 - \beta_C = 1 - \beta_{c,t}$ measures the average degree of consumption smoothing at time t and it allows to retrieve one time series reporting the average level of consumption risk sharing between the countries in the group.

Among the studies that have adopted this method to investigate risk sharing in the EMU, Alcidi *et al*. (2017) estimate consumption smoothing to be 0.14, with not much time variation between 1998 and 2013. Their estimated income smoothing is 0.1, with a more volatile impact of this channel as they even find evidence of dis-smoothing during the EU sovereign crisis (−0.07).[3] However, as a general result in the literature, consumption smoothing seems to be the most important channel for risk sharing among EMU countries (see also Alcidi and Thirion, 2016). These results are also confirmed by Ballabriga and Villegas-Sanchez (2017). The authors also show that income smoothing seems to have decreased between 1999 and 2010. From 2010, improvements are shown but the overall level of risk sharing remains still quite low.

(ii) A second option is available when the focus is on the degree of risk sharing in single countries. To this aim, the estimation is run on a country-by-country basis in a simple time series fashion.

[3]Evidence of shock amplification through the income channel is also evidenced for the pre-EMU period in Kalemli-Ozcan *et al*. (2004).

This implies that equations 1 and 2 have to be modified according to $\beta_Y = \beta_{y,i}$ and $\beta_C = \beta_{c,i}$, meaning that $1 - \beta_{y,i}$ and $1 - \beta_{c,i}$ will now measure the degree of income and consumption risk sharing of country i, respectively. Thus, in this second case we will have a scalar measure of risk sharing for each country in the group.

In the existing literature, there is a lack of analyses looking at the degree of risk sharing at single country level. Nevertheless, recent studies (Asdrubali *et al*., 2018; Poncela *et al*., 2019) show substantial heterogeneity among EMU countries and suggest that further research in this sense is needed.

(iii) A third option has been considered in the literature when the analysis relies on panel data estimations of the risk sharing equations 1 and 2.

Under this approach, equations 1 and 2 are modified according to $\beta_Y = \beta_y$ and $\beta_C = \beta_c$. The resulting estimated coefficients $1 - \beta_Y = 1 - \beta_y$ and $1 - \beta_C = 1 - \beta_c$ will now respectively indicate scalars measuring the average degrees of income and consumption risk sharing over the sample period for the considered group of countries.

Large part of the literature on risk sharing in the EMU has adopted this method. Pre-euro degree of income risk sharing has been shown to be null or negligible (Sorensen and Yosha, 1998; Demyanyk *et al*., 2008) with a slow increase at the beginning of the EMU (Sorensen *et al*., 2007; Poncela *et al*., 2019). For the period 2000–17, Balli *et al*. (2012) show an increase in the levels of income smoothing, with a peak value of 0.14. Similar results are reported by Demyanyk *et al*. (2008) for the period 2000–06. However, Balli *et al*. (2018) highlight how the global crisis has slowed down this process. This part of the literature has also confirmed that the consumption channel has been the most important risk sharing mechanism in the EMU (Demyanyk *et al*., 2008; Balli *et al*., 2012, 2018; Dufrénot *et al*., 2020). These aggregate dynamics have been also decomposed by looking at sub-groups of countries (GIIPS vs non-GIIPS) by Kalemli-Ozcan *et al*. (2014). Their results strengthen the impression that evidence of substantial heterogeneity in the degree of risk sharing between member countries can be provided when looking at a less aggregate level. This is what we do in the rest of the paper.

II. Measuring Time-Varying Risk Sharing

In this paper, we depart from the methods discussed in the previous section and retrieve the degree of income and consumption risk sharing in the EMU by using a time-varying estimation method. This allows us to obtain time series of risk sharing for each member country.

Methodology

The adopted time-varying method to retrieve the time series of income and consumption risk sharing in the EMU is the Kalman filter. Hence, we estimate a 'backward-looking' process for risk sharing with parameters varying with fundamental components.

The Kalman filter is a recursive procedure of computing the optimal estimator of a state vector at time t, based on the information available at time t. One of the reasons for the central role of the Kalman filter is that when the disturbances and the initial state vector are normally distributed, it enables the likelihood function to be calculated via what is known as the prediction error decomposition. This opens the way for the

estimation of any unknown parameter in a model. In our case, the time-varying methodology allows us to recover an unobservable factor that could affect the degree of risk sharing. For each endogenous variable of the model, it is therefore possible to observe how the respective coefficient has changed over time. The choice of this methodology in our study is also supported by the economic evolution of the EMU member countries within the past forty years. European countries have faced at least three main different economic periods:

1 1980s–1990s with the convergence process towards the euro;
2 1990s–2000s with the beginning of the euro;
3 After 2008, with the financial crisis in 2008 and the sovereign crisis in 2010.

Hence, we apply the following time-varying parameter model to estimate the degree of income and consumption risk sharing:

$$\Delta logGNI_{it} - \Delta logGNI_t = \alpha_{y,\,it} + \beta_{y,\,it}(\Delta logGDP_{it} - \Delta logGDP_t) + \epsilon_{it} \tag{3}$$

$$\Delta logCon_{it} - \Delta logCon_t = \alpha_{c,\,it} + \beta_{c,\,it}(\Delta logGDP_{it} - \Delta logGDP_t) + \mu_{it}, \tag{4}$$

Equations 3 and 4 are the measurement equations for the estimation of the income and consumption channel, respectively. ϵ_{it} and μ_{it} are both independent white noise (the standard approach is to model these as Gaussian error terms). Given that $\beta_{y,it}$ and $\beta_{c,it}$ are constructed as time-varying, the consistency of the risk sharing process will evolve over time as a result of changes either in factors specific for each country or in factors related to the EMU market as a whole. To be able to capture the dynamics of these parameters, we have to specify the following transition equations:

$$\beta_{y,\,it} = \gamma_{y,\,it} + F_y\beta_{y,\,it-1} + \eta_{yt} \tag{5}$$

$$\beta_{c,\,it} = \gamma_{c,\,it} + F_c\beta_{c,\,it-1} + \eta_{ct}. \tag{6}$$

The transition equations describe the evolution of the state variables as being driven by the stochastic process of the innovations η_{yt} and η_{ct}. The matrices F_y and F_c contain the autoregressive coefficients of the two risk sharing measures. We allow the coefficients $\beta_{y,it}$ and $\beta_{c,it}$ to follow a random walk process.

Data

The employed data sample includes 11 EMU countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. The original data have been retrieved, via Datastream, from the World Bank database and they cover the period 1984–2017 with annual observations. Per capita GDP and GNI are directly provided in the World Bank dataset, while the per-capita consumption series have been retrieved by dividing the household final consumption indicator by the total population.

Table 1: Descriptive Statistics

Variable	*Obs.*	*Mean*	*Std. Dev.*	*Min.*	*Max.*
$\Delta logGDP_{it}$	363	0.046	0.047	−0.109	0.288
$\Delta logGDP_{t}$	363	0.046	0.031	−0.042	0.098
$\Delta logGNI_{it}$	363	0.046	0.046	−0.146	0.275
$\Delta logGNI_{t}$	363	0.046	0.031	−0.042	0.096
$\Delta logCon_{it}$	363	0.043	0.042	−0.128	0.196
$\Delta logCon_{t}$	363	0.043	0.029	−0.029	0.095

Source: World Bank database

The series for $\Delta logGDP_{it}$, $\Delta logGNI_{it}$ and $\Delta logCon_{it}$ have then been obtained by log-differentiating the original series for each country, while log-differences of the EMU average series have allowed us to retrieve $\Delta logGDP_{t}$, $\Delta logGNI_{t}$ and $\Delta logCon_{t}$. Thus, the final dataset employed for the Kalman filter estimations is based on these first-difference variables and covers the period 1985–2017. In Table 1, the main features of these series are summarized.

III. Estimated Degree of Risk Sharing in the EMU

In this section, we discuss the results from the estimation of the systems (3)–(5) and (4)–(6). This allows us to look at the time pattern of risk sharing in any single EMU member country. As our methodology enables us to retrieve results that can be still compared with the ones obtained with more standards methods, we will compare our findings with the ones obtained from a standard time series OLS estimation.

Risk Sharing Via Income Smoothing

Table 2 reports the results of the estimation of the system formed by equations (3) and (5). In order to retrieve a benchmark to validate our basic results, in the first column of Table 2 we report the income risk sharing coefficients obtained from the standard time series OLS estimation as specified in part (ii) of section I (Demyanyk *et al*., 2008).[4] As shown in column 2 of Table 2, very similar results are retrieved with the Kalman filter estimation of the final state coefficient. However, the last four columns of Table 2 show how the estimation method employed is able to provide richer results. Column 3 reports the average degree of risk sharing over the entire sample in each country, while columns 4–6 show the degree of risk sharing in three sub-periods.

According to the results reported in column 2, our estimations are all statistically significant at 1% and they confirm the general consensus on the fact that income risk sharing is quite weak among EMU member countries. Among the considered countries, only in Italy and Ireland this channel is able to smooth more than 10 per cent of the shocks, while

[4]Different approaches for making an informed initialization of the Kalman filter have been proposed for specific problems. In cases like ours, a possible solution is to initialize the Kalman filter by using the coefficient obtained from a simple OLS estimation of the measurement equation. Given that we use such OLS coefficients as benchmark for our time-varying estimates, we decided to initialize the Kalman filter estimations at 0. Other than being a common solution in the absence of any a priori information, this solution increases the effectiveness of our robustness exercise by avoiding any artificially created link between the OLS and the Kalman estimations.

Table 2: Income Risk Sharing

	OLS − (1-$\beta_{y,i}$)	*Eqs (3)–(5) − (1 − $\beta_{y,it}$)*				
		Final state	*Average values*			
			(Tot)	*(88/97)*	*(98/07)*	*(08/17)*
Austria	0.041***	0.059***	0.075	0.134	0.045	0.047
Belgium	0.012***	0.011***	0.038	0.047	0.043	0.024
Finland	−0.061***	−0.062***	−0.083	−0.066	−0.106	−0.078
France	0.099***	0.077***	0.037	0.011	0.042	0.058
Germany	0.029***	0.038***	0.073	0.151	0.031	0.038
Greece	0.027***	0.072***	0.078	0.078	0.071	0.085
Ireland	0.153***	0.135***	0.121	0.127	0.149	0.088
Italy	0.109***	0.115***	0.147	0.165	0.158	0.119
Netherlands	0.039***	0.029***	0.014	0.003	0.009	0.029
Portugal	−0.078***	0.014***	−0.051	−0.114	−0.401	0.004
Spain	0.096***	0.065***	0.027	0.019	0.011	0.049

Notes: *** rejects the null at 1%. Lag selection for the Kalman filter obtained via AIC. Kalman filter estimation period: 1985–2017 but first three estimation points have been dropped to allow for convergence. OLS estimation period: 1988–2017.

for most of the countries this value ranges between 1.1 per cent and 7.7 per cent. In the case of Finland, we even have evidence of dis-smoothing with a slight amplification of the shocks (Kalemli-Ozcan *et al*., 2004).

Regarding the evolution across time, the last three columns of Table 2 show how some countries have even experienced a reduction in the degree of income risk sharing (that is, Austria, Germany, Ireland and Italy). At the same time, other countries seem to have registered only marginal increases in this channel (that is, Netherlands, Greece and Spain).

Overall, these results also highlight substantial heterogeneity in the degree of income risk sharing among the considered countries. This heterogeneity applies to both the level and the time pattern.

In Figure 1, we report the average values for the EMU as a whole, as well as its core (Austria, Belgium, Finland, France, Germany and Netherlands) and periphery (Greece, Ireland, Italy, Portugal and Spain). We can see that at the inception of the EMU a substantial difference between these two groups existed and it has not reduced since then. Clearly, income risk sharing in the periphery is above the EMU average, while in the core it is below the average. We can also see a reduction of the degree of risk sharing in the periphery following the global financial crisis, with a further drop during the EMU sovereign crisis until 2014. On the contrary, right after the crisis the degree of risk sharing in the core has been more erratic with an increase followed by a fully compensating reduction the year after. By looking at these two groups, it seems that there is still no convergence in the degree of income risk sharing between them.

Risk Sharing Via Consumption Smoothing

In Table 3, we report the results regarding the consumption channel of risk sharing. Again, the first two columns allow comparing the results from a standard OLS estimation

Figure 1: Income Risk Sharing in Core and Periphery. [Colour figure can be viewed at wileyonlinelibrary.com]

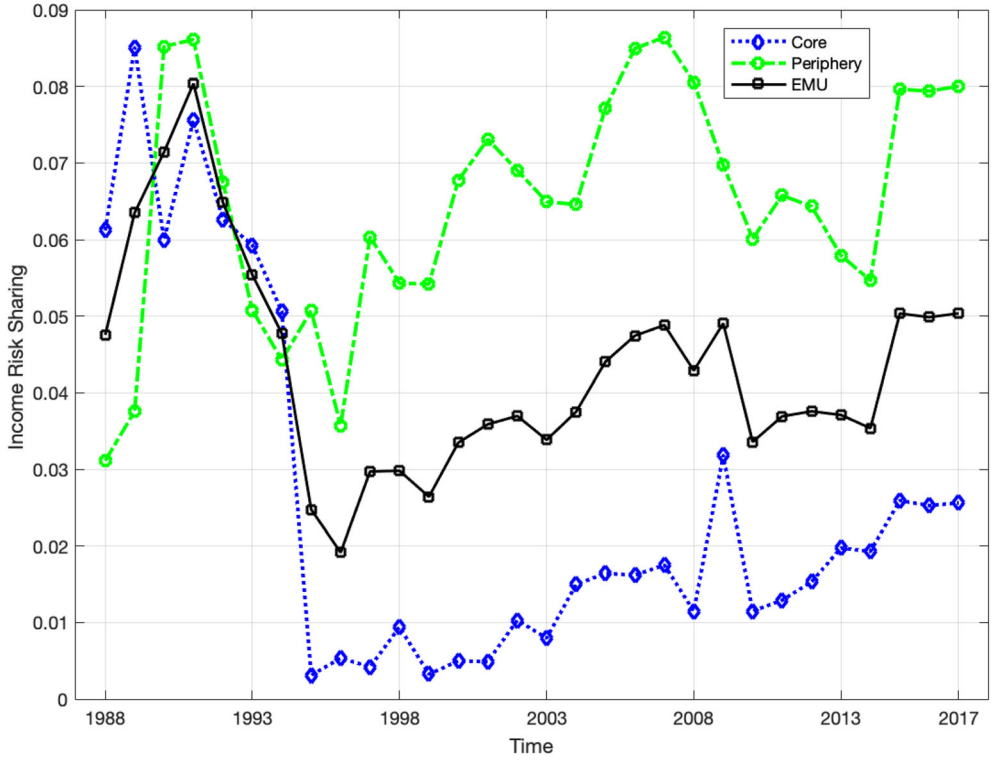


Table 3: Consumption Risk Sharing

	OLS $-$ *(1-*$\beta_{c,i}$*)*	*Eqs (4)–(6)* $-$ *(1* $-$ $\beta_{c,it}$*)*				
		Final state	*Average values*			
			(Tot)	*(88/97)*	*(98/07)*	*(08/17)*
Austria	0.076^{***}	0.124^{***}	0.089	0.049	0.102	0.119
Belgium	0.091^{***}	0.299^{***}	0.379	0.399	0.451	0.289
Finland	0.345^{***}	0.356^{***}	0.355	0.378	0.334	0.352
France	0.106^{***}	0.122^{***}	0.056	0.037	0.047	0.084
Germany	0.247^{***}	0.272^{***}	0.239	0.207	0.246	0.264
Greece	0.037^{***}	0.187^{***}	0.256	0.291	0.264	0.213
Ireland	0.618^{***}	0.637^{***}	0.347	0.286	0.342	0.413
Italy	0.411^{***}	0.489^{***}	0.483	0.431	0.569	0.449
Netherlands	0.137^{***}	0.072^{***}	0.031	0.014	0.019	0.059
Portugal	0.021^{***}	0.094^{***}	0.061	0.054	0.047	0.081
Spain	0.371^{***}	0.321^{***}	0.178	0.085	0.166	0.284

Notes: *** rejects the null at 1%. Lag selection for the Kalman filter obtained via AIC. Kalman filter estimation period:1985–2017 but first three estimation points have been dropped to allow for convergence. OLS estimation period: 1988–2017.

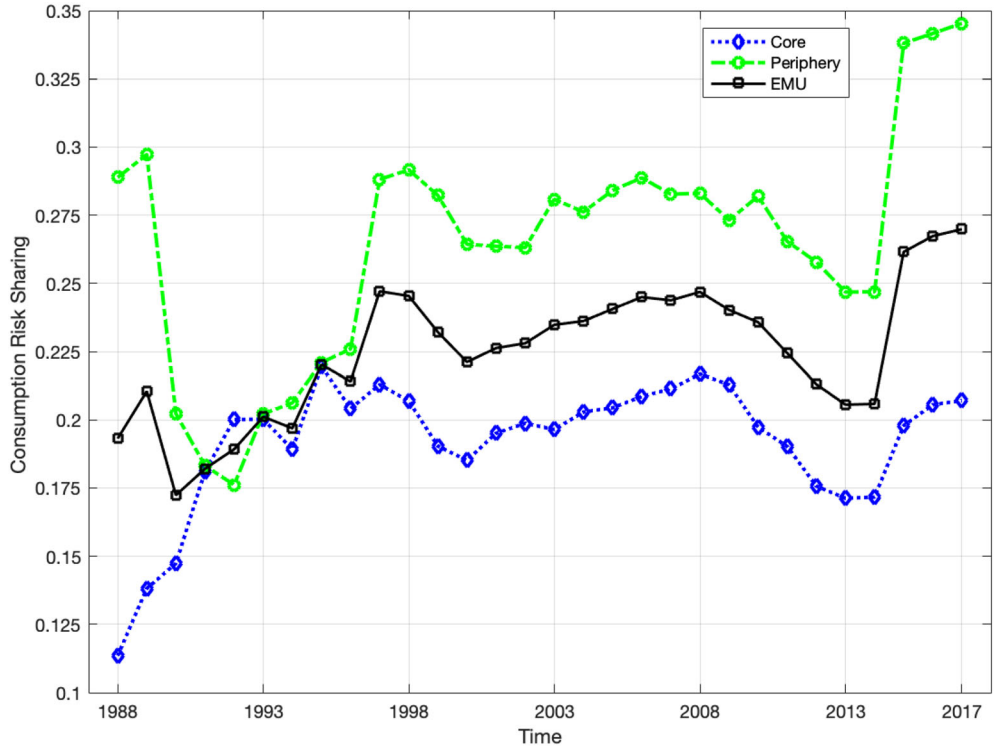
with our time-varying specification of the system formed by equations (4) and (6). Also in this case, our results obtained with the two techniques are quite similar.

According to the results reported in column 2, our estimations are all statistically significant at 1 per cent and they confirm the general consensus on the fact that the degree of consumption risk sharing is much more relevant among EMU member countries. In many countries (i.e., Belgium, Finland, Germany and Spain), this channel is able to smooth around 30% of the shocks, while in some cases (Ireland and Italy) the smoothing is even higher. Only Portugal and Netherlands register a smoothing value below 10 per cent. However, when we look at the evolution of the consumption channel across time, the last three columns of Table 3 show how entering the EMU has not significantly increased the degree of consumption risk sharing for several member countries. Steady increasing trends are registered only for Ireland and Spain.

Overall, our results highlight a substantial degree of heterogeneity among countries also in the consumption channel.

In Figure 2, we shed more light on this aspect and report the average values for the EMU as a whole together with its core and periphery.

Figure 2: Consumption Risk Sharing in Core and Periphery [Colour figure can be viewed at wileyonlinelibrary.com]



We can see that moving towards the inception of the EMU the degree of consumption risk sharing of the two groups converged. However, they soon diverged again and such difference stayed roughly constant throughout the EMU experience. Also in this case, the periphery experiences degrees of risk sharing above the EMU average, while the core is characterized by values below the EMU average. Moreover, we can see that at the start of the global financial crisis there was no substantial change in the degree of consumption risk sharing. However, once it mutated into the EMU sovereign crisis, we can see a substantial drop in the degree of risk sharing characterizing both the core and the periphery. The negative trend slowed down in 2012 and ended in 2013, where a recovery started. The increasing trend seems to have been quite strong especially in the periphery, where a 10 per cent increase in four years has been registered. The interpretation of this dynamics is the following. As in its early stages the global financial crisis had no significant country-specific effects in the EMU, it did not affect the degree of risk sharing. However, once it started having different impacts on different member countries via the the public debt and sovereign interest rates dynamics, consumption risk sharing dropped as a result of the increasing home bias in countries that were not negatively affected in this sense. Thus, we can see that risk sharing has dropped in the exact period when it was extremely needed to absorb asymmetric shocks.

This highlights even further its current importance for the EMU and suggests that, putting in place further *de jure* (institutional) measures of risk sharing could be the right solution for the EMU (Milano, 2017; Schelkle, 2017; ECB, 2018; Cimadomo *et al*., 2020). Another aspect of our results supporting this idea is that the recovery in the degree of risk sharing has started right after the implementation of policies related to its *de jure* dimension like the European Financial Stabilization Mechanism (EFSM) and the European Stability Mechanism (ESM).

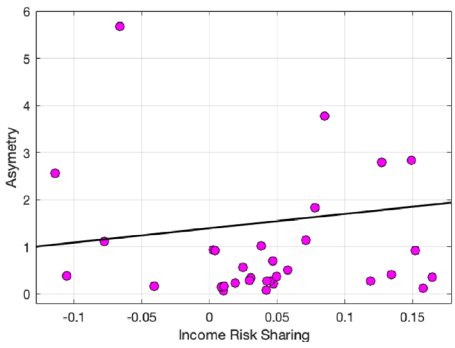
IV. Asymmetry and Potential Gains from Risk Sharing in the EMU

Although measuring the degree of risk sharing is important in itself, to give it more sense, one would also like to measure the necessity for such mechanisms in single countries. As this implies measuring the potential gains from risk sharing, Kalemli-Ozcan *et al*. (2001) argued that the greater the asymmetry in GDP fluctuations within a group of countries (or regions), the larger the benefit from smoothing these fluctuations through risk sharing within the group. This intuition provides backgrounds for the specification of a simple measure of the potential gains from risk sharing. For each country *i*, the measure we adopt in this paper is the following:

$$G_i = \frac{1}{\delta}\left(\frac{1}{2}\sigma^2 + \frac{1}{2}\sigma_i^2 - cov_i\right). \tag{7}$$

According to equation 7, the gain from risk sharing (G_i) is higher for countries with lower covariance between the variation of the GDP in the single country and in the group of countries (cov_i). Moreover, the higher the variance of GDP in country i (σ_i^2), the more it will benefit from risk sharing with the rest of the countries. Third, the higher the variance of the aggregate GDP in the considered group (σ^2), the more other countries would

Figure 3: Asymmetry and Risk Sharing [Colour figure can be viewed at wileyonlinelibrary.com]



(a) Asymmetry and Income Risk Sharing (b) Asymmetry and Consumption Risk Sharing

be willing to recompense country i for joining the risk sharing mechanism. Note that δ is the discount factor.[5]

We use equation (7) to compute the levels of asymmetry for each country in the same sub-periods used in Tables 2 and 3 (1988–97, 1998–2007 and 2008–17).

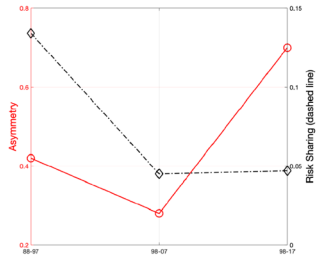
First, we look at the general links between the degree of asymmetry and risk sharing in Figure 3. In this figure, we represent two scatter plots that relate the degree of asymmetry to the degree of income and consumption risk sharing, respectively. For these representations we have pooled the computed values of the variables. In both cases the diagrams suggest that there is a positive relationship between the level of asymmetry and the degree of risk sharing. However, such positive link seems to be quite weak in the case of income smoothing and more pronounced in the case of consumption smoothing.

One can imagine that such results can also be due to potential heterogeneous dynamics among member countries. For instance, these results could be due to the fact that some countries have been able to adjust the degree of risk sharing according to changes in the degree of asymmetry, while others did not. This is what we investigate in the rest of this section.

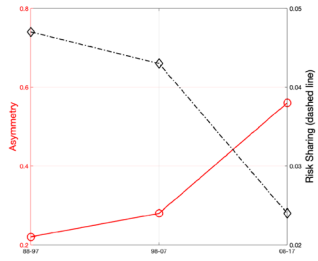
In Figures 4 and 5, we present the computed levels of asymmetry for each country and their links with the degree of risk sharing in the three sub-periods. This allows us to evaluate the time patterns of risk sharing by comparing them with the degree of asymmetry (a measure of how much such mechanisms are needed) in each single member country. First, we can see how the degree of asymmetry dropped in the period following the launch of the euro in most of the countries. This has clearly been the effect of policies trying to promote economic convergence and also the result of growing – endogenous – economic integration in the EMU.

[5]The employed measure of asymmetry is retrieved by considering a group of countries formed by risk averse identical (they all have the same utility function, the same discount factor (δ) and face the same uncertainty realizations) agents. Complete securities markets are also assumed. Please refer to Kalemli-Ozcan *et al*. (2001) and (2004) for further details on the assumptions and derivation of equation 7.

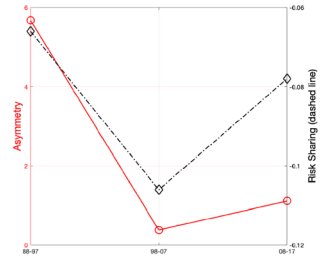
Figure 4: Asymmetry and Income Risk Sharing over Time [Colour figure can be viewed at wileyonlinelibrary.com]



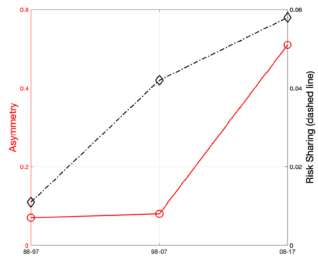
(a) Austria



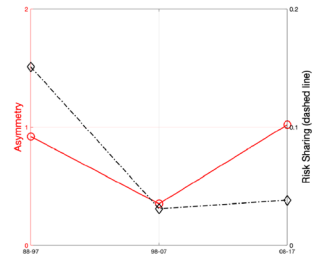
(b) Belgium



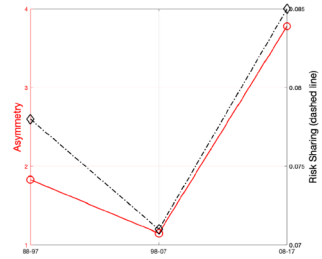
(c) Finland



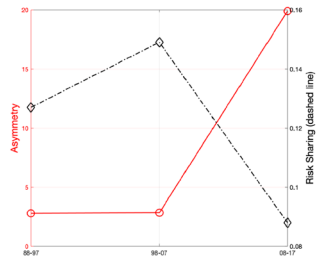
(d) France



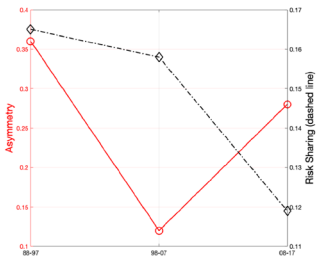
(e) Germany



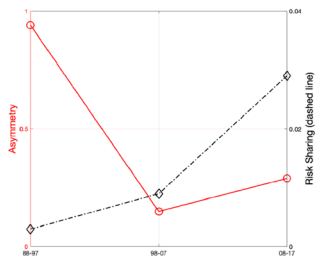
(f) Greece



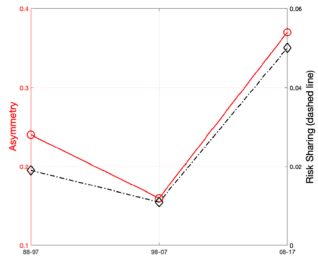
(g) Ireland



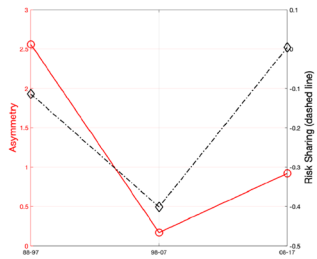
(h) Italy



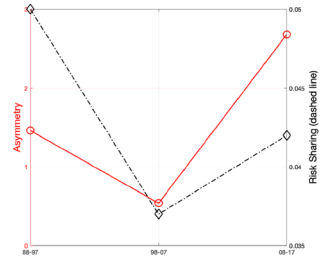
(i) Netherlands



(j) Spain

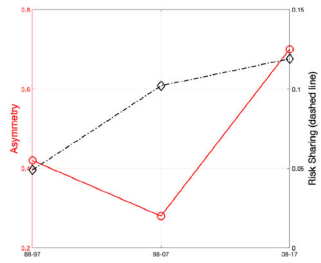


(k) Portugal

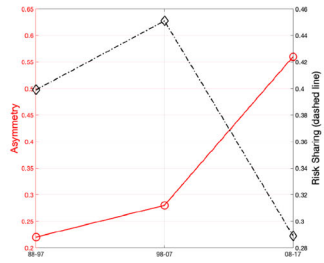


(l) Euro-Area

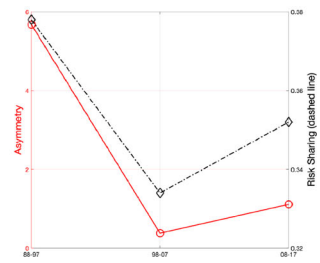
Figure 5: Asymmetry and Consumption Risk Sharing over Time [Colour figure can be viewed at wileyonlinelibrary.com]



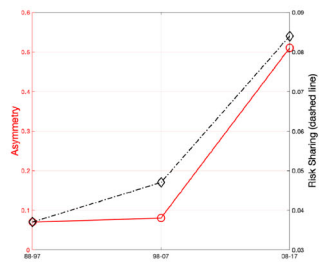
(a) Austria



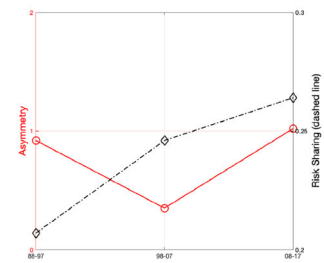
(b) Belgium



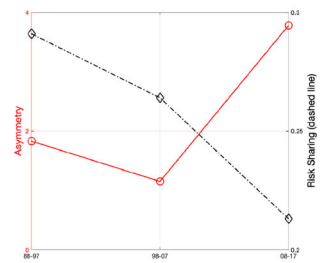
(c) Finland



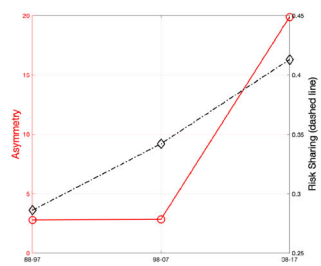
(d) France



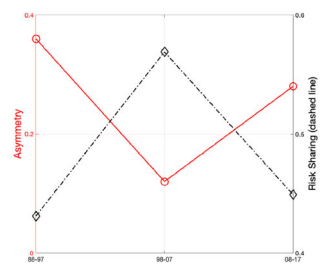
(e) Germany



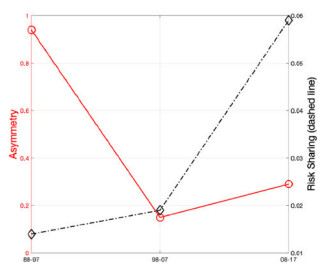
(f) Greece



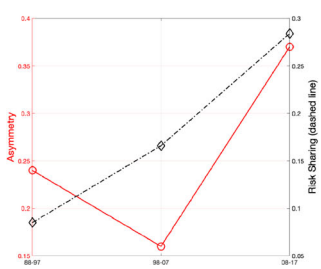
(g) Ireland



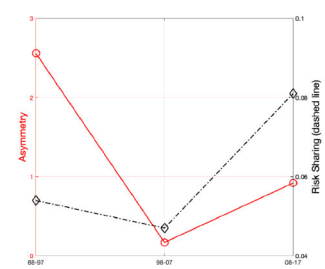
(h) Italy



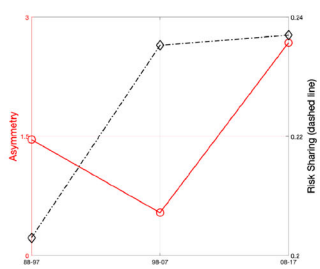
(i) Netherlands



(j) Spain



(k) Portugal



(l) Euro-Area

However, in the period following the global financial crisis and the sovereign debt crisis in Europe, for most of the countries the degree of asymmetry has sharply increased. The increased asymmetry reflects the divergent economic dynamics that have characterized EMU member countries in that period. This result shows how the need for risk sharing mechanisms among EMU member countries has grown in the last 10 years.

These trends are also confirmed in panel (l) of Figures 4 and 5, where we report the average degree of asymmetry among member countries. There, we can also see how the average degree of asymmetry has grown to a higher level than the pre-EMU one.

Regarding the links between the income channel and the degree of asymmetry, the main results highlighted in Figure 4 are the following. Despite the fact that the general level of income smoothing has always been quite low, the strength of this channel has improved in several countries (Finland, France, Greece, Netherlands, Portugal and Spain) following the increasing asymmetry. However, Italy, Ireland and Belgium show a drop in this channel of risk sharing notwithstanding the increased asymmetry. No substantial improvements are registered in Germany and Austria. Hence, one can again verify a substantial degree of heterogeneity among member countries in relation to how their degree of risk sharing has been able to adjust to the degree of asymmetry.

The evidence on the consumption channel has similar features. Most of the countries (Austria, Finland, France, Germany, Ireland, Netherlands, Portugal and Spain) show substantial improvements in the degree of risk sharing coupled with the increasing asymmetry in the period 2008–17. Still, Italy, Belgium and Greece have seen their degree of consumption risk sharing decreasing despite the increased asymmetry. Due to the fall in the degree of consumption risk sharing in some countries, as shown in panel (l), its EMU-average value in the period 2008–17 has not substantially improved despite the sharp increase in the degree of asymmetry.

The highlighted heterogeneity in the risk sharing capacity among member countries can potentially exacerbate and amplify the impact of asymmetric shocks. The explanation is the following. In case of an asymmetric shock, the countries that experience a strengthening of their risk sharing mechanism are able to cushion its impact more than the countries that do not experience such increase. As a result, the asymmetric impact of the shock is amplified by the heterogeneity in the risk sharing adjustment to the countries' needs.

Conclusion

The euro was adopted knowing that EMU members countries did not form an optimal currency area yet. However, the assumption was that the EMU would eventually evolve into one thanks to endogenous mechanisms. A necessary requirement for this to happen was the ability of the monetary union to develop effective stabilization mechanisms to smooth the impact of asymmetric shocks. Such mechanisms included also the development of effective risk sharing mechanisms between member countries.

Following the renewed interest in the degree of risk sharing in the EMU due to the global financial and sovereign debt crises, in this paper we have focused on this aspect. We have done this by empirically assessing the evolution of risk sharing and by comparing it with the dynamics in the degree of economic asymmetry between EMU countries. By employing the Kalman filter, we have been able to derive time series of consumption

and income risk sharing for each member country in our sample. This has allowed us to analyse the issue from multiple points of view.

Our results point to the failure in the development of a fully functioning risk sharing system and to the strong degree of heterogeneity between member countries. At the aggregate level, our analysis has confirmed the main results in the literature. The impact of income risk sharing is negligible, while a more prominent role is played by consumption risk sharing.

Looking at sub-groups of countries, we have shown how, despite a convergence that occurred in the pre-euro period, in the early years of the EMU there have been divergent patterns in the degree of risk sharing. These have generated a substantial gap between the core and the periphery. Surprisingly, once created, such gap has remained mostly unchanged for several years. On the contrary, despite the renewed attention by media and policy-makers on the need to improve risk sharing in the EMU, our results suggest that the two groups of countries seem to be on a path of further divergence.

Moving to the single country level, our results have provided further evidence of the marginal role of the income channel and of the stronger impact of the consumption channel. These results have also confirmed the existence of substantial heterogeneity in risk sharing among EMU countries. Moreover, the degree of risk sharing has not increased despite the higher economic asymmetry faced by member countries. On the contrary, some member countries have experienced a deterioration in the functioning of their risk sharing mechanisms in periods of increasing economic asymmetry. This can exacerbate the impact of asymmetric shocks across the union.

Other than confirming the need for stronger union-wide architectural changes (including fully-integrated banking/capital markets and an adequate central fiscal capacity) to foster international risk sharing, the highlighted heterogeneities also suggest that centralized reforms should be coupled with structural reforms at national level. By boosting economic growth, such reforms should also guarantee increased fiscal space at national level and healthier banks' balance sheets. These should then provide extra support to union-wide reforms in order to close the gap in the risk sharing heterogeneities among member countries.

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