IMK
Macroeconomic Policy Institute

The IMK is an institute of the Hans-Böckler-Stiftung

WORKING PAPER

No. 208 • March 2021 • Hans-Böckler-Stiftung

RISK SHARING REVISITED

Empirics and Concepts

Patrick C. Harms[1]

ABSTRACT

The paper adds to the literature as follows: starting from the benchmark model of Asdrubali et al. (1996), we reproduce the original specification with a data set obtained from the authors as well as possible. In a second step, this specification is brought to euro area data. Again, the results are broadly in line with the existing literature (Furceri and Zdzienicka, 2015). We report rolling window and recursive estimates and show high time variation in the coefficients. The parameter estimates are related to a recession dummy in the euro area (confirmed by structural break tests) and very sensitive to the exclusion of countries like Ireland and Luxembourg. Granger causality analysis in a VAR approach also points to a strong dependence on the macroeconomic environment. Last but not least we discuss shortcomings of the approach. All in all the high time variability of the results in a benchmark model in the spirit of Asdrubali et al. (1996) makes it difficult to draw robust policy recommendations for the euro area.

[1] E-mail: patrick.harms@gmx.de.

Risk Sharing Revisited

Empirics and Concepts

Patrick C. Harms*

Abstract

The paper adds to the literature as follows: starting from the benchmark model of Asdrubali et al. (1996), we reproduce the original specification with a data set obtained from the authors as well as possible. In a second step, this specification is brought to euro area data. Again, the results are broadly in line with the existing literature (Furceri and Zdzienicka, 2015). We report rolling window and recursive estimates and show high time variation in the coefficients. The parameter estimates are related to a recession dummy in the euro area (confirmed by structural break tests) and very sensitive to the exclusion of countries like Ireland and Luxembourg. Granger causality analysis in a VAR approach also points to a strong dependence on the macroeconomic environment. Last but not least we discuss shortcomings of the approach. All in all the high time variability of the results in a benchmark model in the spirit of Asdrubali et al. (1996) makes it difficult to draw robust policy recommendations for the euro area.

JEL Classification Codes: F41, F32, F36

Keywords: Economic and Monetary Union, Risk Sharing Mechanisms

*E-mail: patrick.harms@gmx.de. The author thanks Ulrich Fritsche for constructive criticism and methodological advice.

Introduction

The analysis of risk sharing between countries and regions has a long history in the economics literature as well as in political debates. In the euro area, the policy discussion about appropriate risk sharing mechanisms gained pace since the crisis of the euro area between 2010 and 2012 and even more so in the ongoing Covid-19 pandemic, which hit many euro area countries particularly hard. Policy makers concluded with the introduction of the single resolution mechanism (SRM) in 2014 and the commitment to strengthen the so-called capital markets union. Both reform projects mainly focus on risk sharing and insurance mechanisms based on the private sector. The Covid-19 pandemic, however, triggered a first step in the direction of a European Union-wide fiscal risk sharing mechanism.[1] At this point the implementation is still ongoing.

This political prioritisation of putting private risk sharing elements first might not only reflect the political power relations between the core and the periphery – countries with a more comfortable fiscal position might oppose fiscal risk sharing mechanisms as a reflection of fearing permanent transfers to poorer countries – but also the results from economic research. Since it is common practice to compare the euro area to the United States (US) as a currency union, the relative scope for private and public risk sharing in the euro area has been derived from findings for the US. For instance Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (2018) and Feld and Osterloh (2013) cite Asdrubali et al. (1996)'s result for the US that only 13% of inter-state risk sharing is achieved by means of fiscal risk sharing, as evidence against a fiscal risk sharing mechanism in the euro area. Because of the high relevance in the literature and its decisive policy relevance, it appears to be necessary to review its methodological foundations and the validity of the economic implications.

Asdrubali et al. (1996) identify three different risk sharing or smoothing channels: capital market, fiscal and credit market risk sharing. Since financial markets and government policies exhibit a high level of structural changes, trends and regulatory modifications, also those risk sharing mechanisms may change over time. For the methodological part of the analysis, the focus of our study is thus on the potential time variability of inter-state risk sharing. In this context, we explore the potential role of recessions for the composition and existence of risk sharing and investigate the stability of the parameters by means of structural break tests. Furthermore, we apply the analysis to a data-set for the euro area. This does not only allow us to study to what extent

[1]The European Stability Mechanism (ESM) introduced subsidized lending to stressed countries. But since these credits ultimately have to be repaid and the ESM only steps in *after* a crisis has already materialized, its macroeconomic impact is limited (Berger et al., 2019).

the empirical evidence for the US is transferable to the euro area, but also provides a broader set of results. From those results, we try to draw conclusions about the appropriateness of the methodological framework to inform the reform and economic policy discussion in the euro area.

Based on a similar econometric framework as in the original paper, we are able to replicate the qualitative nature of Asdrubali et al. (1996)'s results. On this basis, we find a lot of evidence for time variability of the risk sharing parameters in the US and in the euro area. In addition to a clear trending behavior in some of the parameters, there substantial time variation. In the US – and even more so in the euro area – some parameters have a tendency to shift during recessions. Regressions of the time varying parameters on a linear trend and a recession dummy variable as well as structural break tests for the trend equations suggest that the composition of risk sharing changes during recessions.

For the US, we also find evidence for the hypothesis that credit market and capital risk sharing parameters are negatively correlated. This result sheds doubts on the estimation procedure as well as on the interpretation as risk sharing. Furthermore – and consistent with the literature – we find that in the euro area the majority of risk sharing works through credit market risk sharing. However, credit is not necessarily a genuine form of risk sharing. In fact, there is evidence in the literature that cross-border credit may even increase the risk of financial crises (Calvo, 1998; Dräger and Proaño, 2018).

The remainder of this report is organized as follows: section 1 is a summary of the extended literature on cross-border risk sharing and fiscal risk sharing mechanisms. Section 2 introduces Asdrubali et al. (1996)'s basic methodology and some of the extensions that can be found in the literature. In section 3 we describe and conduct our empirical analysis both for the US and the euro area. Section 4 points out potential shortcomings of the methods on measuring risk sharing and brings them together with the results of our empirical analysis. Section 5 concludes.

1 Literature

Asdrubali et al. (1996) have introduced the most common concept for the empirical measurement of risk sharing into the literature. Based on a decomposition of gross state product of the 50 US states, they argue that regression coefficients based on this decomposition can be interpreted as risk sharing or shock smoothing shares. They identify three different channels of risk sharing: capital market risk sharing, fiscal or government risk sharing and credit market risk sharing. One of the key results of their analysis is that the majority of cross-state smoothing is achieved through capital and credit markets, which are both private mechanisms. In combination they account for 62% of smoothing, fiscal risk sharing only accounts for 13% while 25% of income variation is not smoothed at all.

Asdrubali and Kim (2004) investigate risk sharing and consumption smoothing in the US, OECD countries and the European Union. Their primary focus is dynamic risk sharing and a panel VAR is employed for this purpose. Hence, the methodology is not fully comparable to the original version of the analysis. The main result here is that the degree of risk sharing is higher in the US than in the European Union and that there is ample scope for more risk sharing in the European Union – the authors suggest through deepening of financial markets and a greater flexibility of national fiscal policies.

Afonso and Furceri (2008) investigate business cycle synchronization across euro area and EU countries and apply Asdrubali et al. (1996)'s methodology to determine the degree of risk sharing. The authors find that the stabilization costs arising from adopting the euro are higher for some countries (such as Estonia, Lithuania and Slovakia) than for others (Cyprus, Hungary and Malta). Concerning risk sharing, the authors find a much higher degree of non-smoothed income shocks in both the euro area, the old EU-15 countries and the enlarged EU. They also find that in all country samples, smoothing through savings – or credit market smoothing – provided the largest share of risk sharing, with values ranging from 25% to 50%.

Furceri and Zdzienicka (2015) expand the Afonso and Furceri (2008) analysis and explore the *time variability* of risk sharing mechanisms. They confirm earlier results that risk sharing across EMU countries is low compared to federations such as the US or Germany. Furthermore, the degree of shock smoothing falls in deep recessions implying that it is absent when it is needed most. They propose a fiscal stabilization scheme that could be designed to provide full shock smoothing with fairly small contributions.

Farhi and Werning (2017) show in a theoretical model that risk sharing and insurance through financial markets are inefficiently low in monetary unions. They argue that the efficient level of risk sharing can be implemented by a fiscal transfer.

Taking the lack of risk sharing in the euro area as given, Engler and Voigts (2013) discuss a fiscal transfer mechanism in a theoretical model of a monetary union. They find that such a transfer scheme would not only decrease business cycle volatility but also increase the efficiency of counter-cyclical policies.

Enderlein et al. (2013) build on this result and propose a cross-country transfer scheme for the euro area, which automatically distributes transfers according to the position of national output gap estimates relative to the euro area as a whole. Based on simulations, they find that their transfer scheme could have reduced relative business cycle volatility by around 15 to 40%.

Dullien and Fichtner (2013) have proposed and analysed the introduction of a common European unemployment insurance scheme and find that cyclical imbalances across euro area countries could be dampened effectively. Enders and Vespermann (2018) also discuss this idea and find that a European unemployment insurance scheme has a potential to stabilize consumption after supply shocks but that the transfer is spent on relatively inefficient production in the receiving countries. Their general assessment is that the impact of this type of transfer system is limited.

In a more general account of euro area policies, Berger et al. (2019) judge that without decisive progress to foster fiscal risk sharing, the euro area will continue to face existential risks. At a more political level, the IMF (Allard et al., 2013) has advocated the implementation of a fiscal union in the euro area. On the other end of the spectrum, the German council of economic experts remains critical of a cross-border transfer (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung, 2018) arguing that national fiscal policies are the best suited means of stabilizing the business cycle and international transfers are not necessary as an additional instrument for stabilization.

2 Methodological Review

Because of Asdrubali et al. (1996)'s importance in the literature, its methodology will be discussed in some detail in the following. Also, we contrast the approach to other applications in the literature.

The authors use a decomposition of the gross state product (or gross domestic product in national statistics), which must hold by definition:

$$gsp_i = \frac{gsp_i}{si_i}\frac{si_i}{dsi_i}\frac{dsi_i}{c_i}c_i, \tag{1}$$

where gsp_i refers to gross state product of state i, si_i is state income including the cross-border flow of factor incomes such as dividends, interest payments and wages, dsi_i is disposable state income subtracting taxes and transfers and c_i is consumption. All values are expressed in per capita terms and at current prices. Using logs and differences on both sides of the equations, multiplying by state income and taking expectations yields a relationship of variances and cross-sectional (across states) co-variances. Those relationships are equivalent to the OLS parameters of the following set of equations:

$$\Delta log(gsp_t^i) - \Delta log(si_t^i) = \upsilon_{K,t} + \beta_K \Delta log(gsp_t^i) + u_{K,t}^i \tag{2}$$

$$\Delta log(si_t^i) - \Delta log(dsi_t^i) = \upsilon_{F,t} + \beta_F \Delta log(gsp_t^i) + u_{F,t}^i \tag{3}$$

$$\Delta log(dsi_t^i) - \Delta log(c_t^i) = \upsilon_{C,t} + \beta_C \Delta log(gsp_t^i) + u_{C,t}^i \tag{4}$$

$$\Delta log(c_t^i) = \upsilon_{U,t} + \beta_U \Delta log(gsp_t^i) + u_{U,t}^i \tag{5}$$

It is important to note the interpretation attached to this exercise: $\beta_U = 0$ implies that the cross-sectional co-variance between (nominal) per capita consumption and per capita gross state product is zero. Thus, when a change in the difference between state products occurs, there is – on average – no change in the difference in consumption across states. This *full smoothing* can be achieved in different ways: first, maybe trivially, the cross state variance might be zero. Then there is no scope for risk sharing as there is no income risk across states in the first place. More realistically, smoothing can be achieved if there is no cross-sectional co-variance between state product and state income – for example if the income flows from other states' products fully compensate the difference. Asdrubali et al. (1996) interpret this mechanism as *capital market risk sharing.* If *full smoothing* is not achieved at this level, the federal tax and transfer system may fully stabilize state product losses in disposable income, which they call *fiscal risk sharing.* If *full smoothing* is still not achieved, the last possible stage of risk sharing may be through savings. In this case consumption does not co-move with state product. This mechanism is interpreted as *credit smoothing.* If full smoothing has not taken place and the cross-sectional co-variance of consumption and production is not zero, this part of variation is *non-smoothed.*[2]

Methodologically, the authors make several adjustments vis-à-vis a standard time fixed effects setting. First, they note that the gross state product series are likely to exhibit some form of measurement error. Therefore, they weight the regressions with the state-specific variance. Second, the authors take into account both heteroskedasticity and residual correlation across states. Third, they also allow for residual serial correlation. They implement the estimation in a two-step strategy, where the first step estimates the equations 2 - 5 one by one with standard OLS. The residuals from the first step

[2] The interpretation of the regression parameters as risk sharing coefficients has received considerable criticism in the literature, see section 4 for some of the issues.

are then used to construct the weighting scheme for the second step Generalized Least Squares (GLS) estimates. In total, they apply a weighting scheme corresponding to $\Sigma = \Omega \otimes \Gamma \otimes R$, where Ω is the cross-equation correlations matrix from the initial residuals and $\Gamma \otimes R$ is the matrix of cross-equation co-variances after taking into account the time series correlations for each state.

Furceri and Zdzienicka (2015) expand on the method of Asdrubali et al. (1996). First, they extend the system of equations and therefore allow for more potential smoothing factors. Second, they apply a different estimation technique and also investigate the time variability of the risk sharing coefficients.

For the first dimension, they use the more detailed decomposition of GDP

$$GDP_i = \frac{GDP_i}{GNP_i}\frac{GNP_i}{NI_i}\frac{NI_i}{DNI_i}\frac{DNI_i}{(C+G)_I}(C+G)_i, \tag{6}$$

where GNP_i is gross national product, NI_i is national income, DNI_i is disposable national income and $C+G$ is private and government consumption respectively. This decomposition allows to somewhat refine the analysis: what Asdrubali et al. (1996) called capital market smoothing can now be decomposed into factor flows via GNP_i and depreciation via NI_i. The fiscal risk sharing relation remains the same with DNI_i. However, *credit market* or the consumption smoothing motive can be decomposed into a private (C_i) and a public (G_i) part.

For estimation, Furceri and Zdzienicka (2015) use OLS with panel-corrected standard errors (PCSE) based on Beck and Katz (1995) instead of the two-stage GLS estimator in Asdrubali et al. (1996). PCSE is shown to be more accurate when the time dimension is not dramatically larger than the cross section and for complicated panel correlations. Both conditions appear to be fulfilled for applications involving sub-samples in the time dimension or the shorter euro area samples.

3 Empirical exercise: replication and beyond

This section consists of six parts. Section 3.1 states the methodological adjustments we have made relative to Asdrubali et al. (1996)'s original exercise, section 3.2 tries to replicate the central result in the original paper.[3] This replication exercise serves two purposes. First, while the estimation techniques are described in detail in the

[3] Bent Sörensen was very kind in providing the original data set and even 8 years of extension, which was very helpful in conducting the analyses.

original paper, they give room for interpretation in some cases. For example, it is not entirely clear what the authors mean by *weighting the regressions with the state-specific variance*. Second, we expand the analysis in several directions. In a first step, we want to explore potential time variation in the parameters for the original data-set to assess the behavior of the estimation results in times of recession. It turns out that those parameter estimates appear to follow a time trend and in addition display considerable cyclical movement.

For this purpose in particular, it is sensible to use estimates, which match the results reported in the original study in order to rule out that the results obtained in the extensions of the analysis are merely a result of a different estimation approach. In section 3.3 we apply the same method to a data-set of euro area countries.[4] Sections 3.4 and 3.5 explore the role of recessions for the level and trend of the parameter estimates both in the US and the euro area. The central result is that a similar econometric technique obtains qualitatively the same and quantitatively similar results for the US. The results based on euro area data point towards a much higher share of un-smoothed income shocks and therefore a generally lower level of risk sharing. As expected, fiscal risk sharing in the euro area is very close to zero. In the US and in the euro area, structural breaks often occur during, before and after recessions.

In section 3.6 the evidence for the relationship with the business cycle is further strengthened as we are able to link some of the risk sharing parameters to macroeconomic variables.

3.1 Approach

We go back to the original methodology from Asdrubali et al. (1996) in equations 2 - 5. Instead of their specific weighting scheme, we apply two modifications to the basic panel OLS estimate with time fixed effects in all applications[5]:

[4] Two issues deserve attention in the context of comparing the US and the euro area. First, the USA consist of 50 states, which is a considerably larger number than the 12 or 10 euro area countries we consider. One might be suspicious that the number of units may matter for risk sharing. Ultimately, this is unlikely to be the case: there is no reason to assume that the estimated parameters should be different for, say, two highly integrated states, which have a highly integrated economic structure, national banks and share a very active general government than for 50 such states. Hepp and Von Hagen (2013) in fact applied Asdrubali et al. (1996)'s method to the 10 *Länder* of the Federal Republic of Germany and found substantially higher overall risk sharing than Asdrubali et al. (1996) in the USA (with only 8.5% unsmoothed, compared to 25% in the US). Second, a comparability problem may arise due to the fact that Asdrubali et al. (1996) use their own estimates for their aggregates as there is no state level "national accounts" system, while national accounts data was used in this analysis for the euro area. Asdrubali and Kim (2004) discuss this problem in more detail.

[5] This is of course not true for the cross-section estimates in the appendix, where no fixed effects can be applied due to the lacking time dimension.

First we apply period-specific GLS weights to the data. This can be seen as an analogue to the weighting in the first step of Asdrubali et al. (1996) estimator since period specific residuals are used to form estimates of the period variances. The (feasible) GLS estimates use those variances to re-weight the data before the final estimation step.

Second, we use period PCSE weights to re-scale the standard errors as Furceri and Zdzienicka (2015) already did in similar applications. In the following, we keep track of the modifications we made to the original methodology and discuss potential drivers of quantitative differences. However, those minor differences do not change the qualitative result.

3.2 Regression results for US data

The first set of results tries to replicate the original Asdrubali et al. (1996) paper's estimates. Table 1 presents the regression results for the original (1963 - 1990) sample and the extension of the data-set.

For both time samples there are two sets of results: In the first column we did not use any form of variance weighting and used standard fixed time effects, while the second column uses time GLS weights as described above. The two estimates differ quite dramatically in some cases – this might be due to the several sources of uncertainty in state level data collection in the US.[6] For example, there is a 6 percentage point difference between the fixed effects and the GLS-weighted estimate for the capital market smoothing parameter, which is one of the potential biases Asdrubali et al. (1996) discuss very transparently. The fixed effects estimate would thus overstate the role of capital market smoothing. In the post-1990 data-set there is also a 12 percentage point difference between the two credit smoothing estimates. Thus, for many of the equations the re-weighting of the data prior to the final estimation step appears to be important. The most remarkable difference between the estimates for the two different samples is that the role of capital market smoothing seems to have increased sharply after 1990, where the parameter estimate is about 10 percentage points higher than in the original data set.

Table 2 presents a direct comparison of the replication exercise to the original estimates. The results have to be read in the following way: 41% (compared to 39%) of total variation of state level GDP are smoothed by capital markets, 9% (compared to 13%) by federal fiscal taxes and transfers, 27% based on credit markets (compared to 23%)

[6] Asdrubali et al. (1996) discuss potential biases in great length in their estimation section.

Table 1: US Estimates for 2 different samples

		1963-1990		**1991-1999**		**change**
		FE only	*GLS+PCSE*	*FE only*	*GLS+PCSE*	
Capital	β_K	0.47	0.41	0.56	0.54	0.10
Fiscal	β_F	0.10	0.09	0.07	0.08	-0.02
Credit	β_C	0.28	0.27	0.17	0.29	-0.04
Un-smoothed	β_U	0.15	0.18	0.19	0.10	-0.02
	sum	1.00	0.96	0.99	1.01	

and 18% (compared to 25%) not being smoothed at all and thus faced by the states on their own.

Table 2: Comparison to original specification (coefficients times 100)

	β_K	β_F	β_C	β_U
Asdrubali (1996)	39	13	23	25
GLS+PCSE	41	9	27	18

While those estimates are far from being a perfect replication, they yield the same result at least qualitatively: the largest part of inter-state income risk is shared through the private sector and capital markets most prominently. Fiscal risk sharing plays a limited role in the whole process while states still face a significant portion of idiosyncratic risk.

Figure 1 goes one step further and plots the time-varying parameter estimates for 5-year rolling windows.[7] There are two fairly stable trends that can be observed: while the solid black line (capital market smoothing) appears to have an increasing trend at least until the late 1980's, the importance of credit smoothing (the darker gray dashed line) has decreased. Both trends seem to have reversed in the late 1980's or the early 1990's. On the other hand, the share of fiscal risk sharing (black dashed line) has only seen limited variation. The un-smoothed part (bright gray, dashed) appears to be higher during the recessions of the late 60's, the early 80's and the early 90's.

3.3 Regression results for euro area data

A similar study can be performed based on annual nominal income statistics for the euro area. We use the Annual Macroeconomic (AMECO) database of the European Commission for data on GDP, gross national income, gross national disposable income and private consumption. All variables are expressed in current prices and per capita

[7] Recursive estimation and cross section OLS estimates for every year of the sample can be found in the appendix.

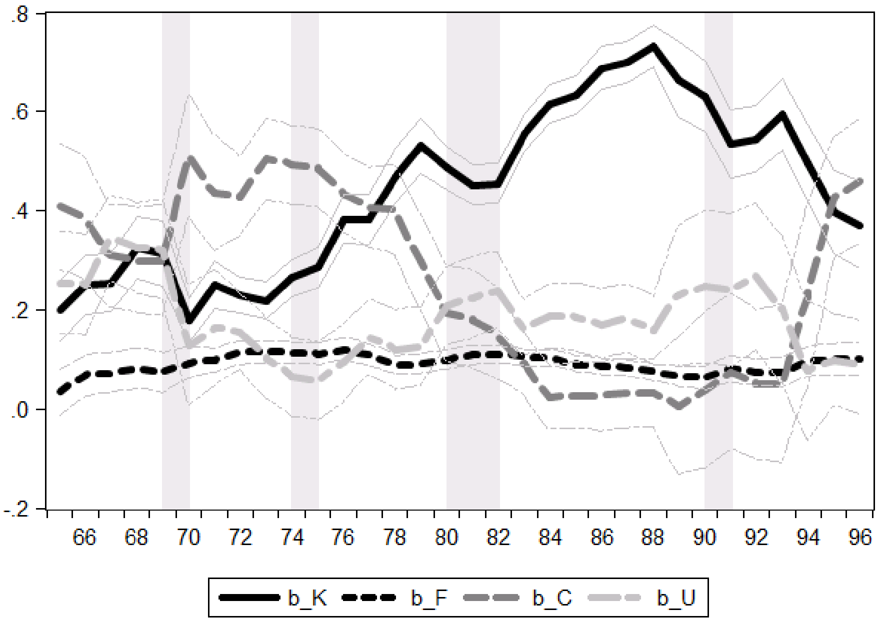

Figure 1: β_K, β_F β_C and β_U based on 5-year rolling regressions in the US, sample 1963-1999, shaded: NBER recessions (`https://www.nber.org/research/business-cycle-dating`)

values. The analyses are conducted for the founding members of the euro area and Greece, which we call EMU-12 countries in the following.[8] The sample starts in 1991 and thus the growth rates are available from 1992 - 2019.[9]

Table 3: EMU-12 results

		Full Sample		Pre-1999		Post-1999		
		FE only	*GLS+PCSE*	*FE only*	*GLS+PCSE*	*FE only*	*GLS+PCSE*	*change*
Capital	β_K	0.09	0.05	0.00	-0.01	0.21	0.20	0.21
Fiscal	β_F	0.00	0.00	0.01	0.01	0.00	0.00	-0.01
Credit	β_C	0.21	0.16	0.10	0.10	0.34	0.31	0.22
Un-smoothed	β_U	0.69	0.73	0.89	0.87	0.45	0.53	-0.39
	sum	1.00	0.95	1.00	0.97	1.00	1.05	

Table 3 shows the results of applying the methodology as described above. The sample was split in 1999 to see potential effects of the introduction of the euro, thus there are three sets of estimates available. The first column refers to the full sample estimates, the column in the middle to the pre-euro part of the sample and the third column refers

[8]The complete set of countries is Germany, France, Italy, Spain, Netherlands, Belgium, Austria, Finland, Greece, Portugal, Ireland, Luxembourg,

[9]Furceri and Zdzienicka (2015) uses a similar framework but allows for a longer time horizon and thus an unbalanced panel. As described above, their analysis is more complex. On a limited basis, the results can be compared to our analysis.

to the results obtained for the period after the euro was introduced. Also, we report the average changes of the pre- and post euro parameter estimates across estimation methods.

The first important result is that the part of un-smoothed income fluctuations is higher in the euro area than in the US. The full sample estimate derived from the GLS procedure is 73% of un-smoothed income shocks.[10] With fiscal policy providing no risk sharing at all, and capital market risk sharing being as low as 5%, only the savings or credit channel seems to be relevant with a value of 16%.[11]

From the sample split exercise one can see that the results changed profoundly after the euro was introduced: capital market and credit market risk sharing increased by about 20 percentage points after 1999 while fiscal risk sharing remained unchanged. This implies that the un-smoothed share of income shocks had been much higher, with about 87% (compared to at most 10 - 19% in the US), in the 8 years before the start of the euro. It then decreased by almost 40 percentage points, but leaving a still comparatively high value of more than 50% even after the euro was introduced. While in the US private risk sharing is driven by capital markets, the contribution of credit markets is relatively larger in the euro area, according to the reported estimates of about 30%.

Figure 2 shows the result of a 5-year-rolling window estimation for the euro area sample. While the time-varying parameter for fiscal risk sharing (black dashed line) is flat throughout the whole sample, the other three series appear to follow some kind of trend. The capital market risk sharing parameter (black solid line) and the credit market risk sharing parameter (gray dashed line) follow an upward trend, while the share of un-smoothed shocks seems to follow a downward path. However, compared to the results in the US, the volatility of the parameters appears to be larger while the trends are somewhat less stable. In particular, the two shaded areas – the 2008/2009 global financial crisis and the recession in the euro area 2011/2012 – coincide with the largest shifts in the series.

The volatility of the results might in fact be caused by individual countries. Private risk sharing supposedly working through financial markets, accounts for most of this extreme volatility. Using a smaller sample of EMU countries thus seems to be a reasonable robustness check. Countries with traditionally high factor income volatility and highly

[10] For their larger country and time sample, Furceri and Zdzienicka (2015) obtain a value of 66% for the un-smoothed part of income shocks.

[11] With 7-8%, the values reported by Furceri and Zdzienicka (2015) are again in a similar range for capital market smoothing, the estimate for fiscal policy is somewhat higher with 4% as well as the credit channel with about 30%. Note, however, that they report a significant degree of dis-smoothing by capital depreciation of 8%, which we do not take into account since we are using gross values only.

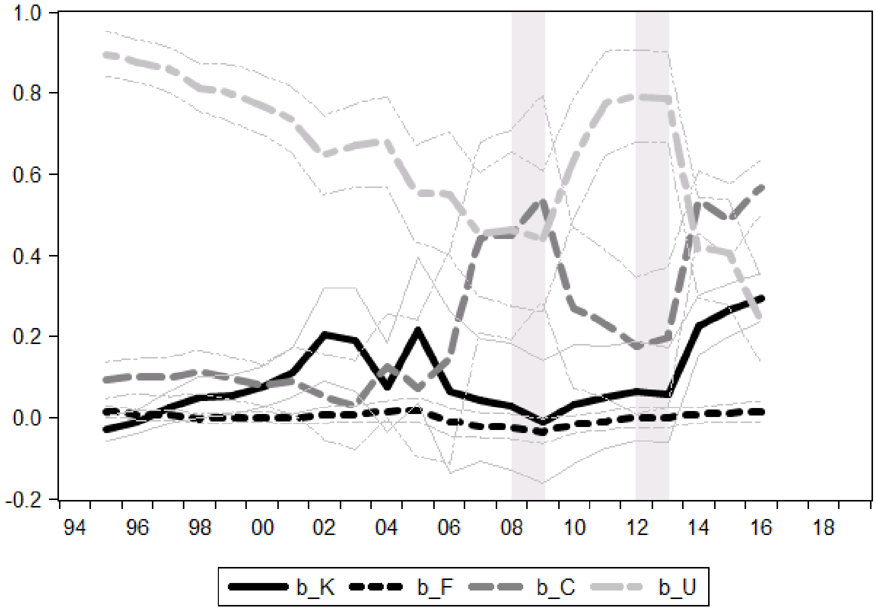

Figure 2: β_K, β_F β_C and β_U based on 5-year rolling regressions in the euro area 12, full sample 1991-2019, shaded: EABCN recessions (`https://eabcn.org/dc/chronology-euro-area-business-cycles`)

active financial markets are Luxembourg and Ireland which are therefore excluded from the robustness exercise in the following.

Table 4: EMU results excluding Ireland and Luxembourg

		Full sample		**Pre-1999**		**Post-1999**		
		FE only	*GLS+PCSE*	*FE only*	*GLS+PCSE*	*FE only*	*GLS+PCSE*	*change*
Capital	β_K	-0.01	-0.02	-0.04	-0.04	0.06	0.05	0.10
Fiscal	β_F	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Credit	β_C	0.10	0.11	0.10	0.10	0.11	0.12	0.02
Unsmoothed	β_U	0.90	0.88	0.93	0.91	0.81	0.84	-0.09
	sum	1.00	0.97	1.00	0.97	1.00	1.02	

Table 4 shows the results without Ireland and Luxembourg: the high level of private risk sharing for the euro sample is no longer confirmed. While both capital and credit market smoothing still seem to have increased, the magnitude is much smaller than before with 10 and 2 percentage points respectively. Conversely, the share of un-smoothed income fluctuations remains very high and has only decreased by 9 percentage points, compared to almost 40 before. With now 84% of un-smoothed income shocks the results for the euro sample are now very similar to the pre-1999 sample in the EMU-12 analysis above. This might be an indication that the two small, but volatile countries have driven a large share of the results before.

Figure 3 shows the 5-year-rolling regression estimates without the extreme effects

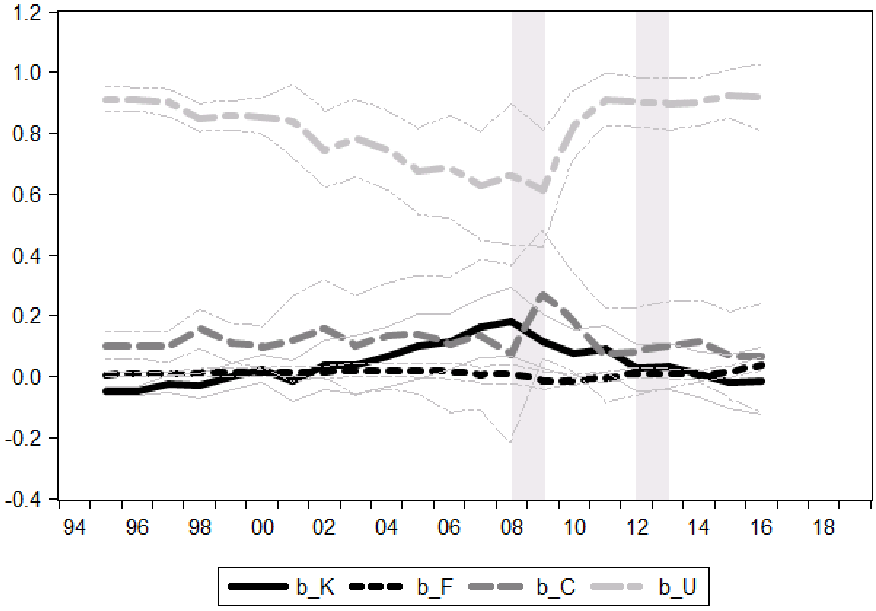

Figure 3: β_K, β_F β_C and β_U based on 5-year rolling regressions in the euro area (excluding Luxembourg and Ireland),full sample 1991-2019, shaded: EABCN recessions

induced by Ireland and Luxembourg. Now, there seems to have been a downward trend of the un-smoothed share of income shocks only until the global financial crisis – since then, this parameter has increased again. Credit and capital market smoothing do no longer show the upward trend we have seen before. Those results imply that there has been a high degree of capital and credit market smoothing in 2009 and that the opposite is true for the euro area crisis in 2011/2012, where the highest time varying parameter of un-smoothed fluctuations is obtained.

The empirical analysis so far has shown that cross-country risk sharing in the euro area plays a much smaller role than inter-state risk sharing in the US. Based on the robustness check result, this is not only true for fiscal risk sharing, but also for private risk sharing.

3.4 The role of recessions

To investigate the role of recessions, two different strategies are followed: first, simple regressions are used for the time-varying risk sharing parameters to explore a statistical relationship with a recession indicator variable. In a second step, structural breaks are determined on the level and time trend of the risk sharing parameters.

To answer the first question, regressions of the form

$$\hat{\beta}_{t,i} = c_i + \gamma_i t + \alpha_{l,i} D^{REC}_{l,t+p} + \epsilon_t \tag{7}$$

are estimated for $i = K, F, C, U$. Variable t is a linear trend and D^{REC}_t is an indicator variable, which takes on the value of 1 if the country as a whole is in a recession and 0 if it is not.[12] $p = -1, 0, +1$ for one lag, the current value and one lead of the recession indicator.[13]

Table 5 summarizes the regression coefficients along with p-values for the corresponding significance tests for the US and the two euro area samples. All coefficient estimates with a p-value of below 10% are depicted in bold in the table. In the US, there is only one bold value in the row for the fiscal risk sharing parameter. The parameter appears to increase slightly if there was a recession in the previous period.

Table 5: Relationship between recessions and risk sharing parameters

		US		**EMU-12**		**EMU (excluding Ireland and Luxembourg**	
		Coefficient	*Prob.*	*Coefficient*	*Prob.*	*Coefficient*	*Prob.*
$\hat{\beta}_K$	$D^{RECESSION}_{t-1}$	-0.05	0.46	-0.02	0.68	0.02	0.54
	$D^{RECESSION}_{t}$	-0.06	0.40	-0.07	0.16	**0.06**	**0.09**
	$D^{RECESSION}_{t+1}$	-0.01	0.86	-0.06	0.26	**0.09**	**0.01**
$\hat{\beta}_F$	$D^{RECESSION}_{t-1}$	**0.01**	**0.08**	**-0.01**	**0.09**	**-0.02**	**0.00**
	$D^{RECESSION}_{t}$	0.01	0.43	**-0.02**	**0.03**	-0.01	0.23
	$D^{RECESSION}_{t+1}$	0.00	1.00	**-0.02**	**0.04**	-0.01	0.31
$\hat{\beta}_C$	$D^{RECESSION}_{t-1}$	0.02	0.81	**0.19**	**0.05**	**0.06**	**0.01**
	$D^{RECESSION}_{t}$	0.02	0.79	0.14	0.17	0.02	0.49
	$D^{RECESSION}_{t+1}$	0.00	0.99	0.12	0.24	-0.03	0.21
$\hat{\beta}_U$	$D^{RECESSION}_{t-1}$	-0.01	0.78	-0.10	0.35	-0.01	0.91
	$D^{RECESSION}_{t}$	0.01	0.64	-0.04	0.73	-0.06	0.33
	$D^{RECESSION}_{t+1}$	0.03	0.29	-0.03	0.75	-0.05	0.41

In the euro area full country sample (middle column), all three fiscal risk sharing values are bold, which implies that the parameter generally changes around recessions. However, the sign points into the other direction and fiscal risk sharing appears to fall during recessions. However, just as in the US, the magnitude is very small here as well. In the same sample, credit market smoothing increases dramatically if a recession has taken place in $t-1$. This result reflects the large swings in the parameter estimate in figure 2, which already pointed towards higher values of the parameter around recessions.

[12] Recession dates are from `https://www.nber.org/cycles.html` in the US and `https://eabcn.org/dc/chronology-euro-area-business-cycles` in the euro area. Since annual data is used, every year which is included in the range from peak to trough is counted as a *1* in the recessions indicator.

[13] One might also use all three recession indicators in one regression setting. However, this might imply a high level multicollinearity in the regressions, which is why we have chosen to estimate the parameters separately.

This result is confirmed in the sample excluding Ireland and Luxembourg – though with a parameter of 0.06, which is about $\frac{1}{3}$ of the size. In this sample, also the capital market smoothing parameters increase during recessions and before.

Those results support the suspicion that recessions appear to change the size of measured risk sharing parameters in the context of time-varying parameter estimates.

3.5 Structural break tests

To dig deeper into this topic and to strengthen the robustness of the results, we employ structural break tests for the level and the trend of the 5-year-rolling window estimates. Thus, we estimate the simple regressions

$$\hat{\beta}_{t,i} = c_i + \gamma_i t + \epsilon_t. \tag{8}$$

In a first step, we apply the Quandt-Andrews test (Andrews, 1993) for one unknown break point. The results for all three samples are summarized in table 6. The null hypothesis of no structural breaks in the equation can be rejected on conventional confidence levels in all equations except for the credit risk sharing equation for the EMU-12 sample. Interestingly, in the euro area the results show that there has not been any break in the 1990s and early 2000s. All breaks seem to have happened directly before the great recession and around the 2011/2012 euro area crisis. In the US, all except for the 1986 structural break in the capital market risk sharing parameter also can be related to recessions.[14]

Table 6: Test for one unknown structural break in equation 8

Maximum LR F-statistic	**USA**			**EMU-12**			**EMU (ex. Ireland and Luxembourg)**		
	Year	**Value**	**Prob.**	**Year**	**Value**	**Prob.**	**Year**	**Value**	**Prob.**
$\hat{\beta}_K$	1986	37.51	0	2006	12.75	0.0001	2007	105.43	0
$\hat{\beta}_F$	1974	47.97	0	2006	19.98	0	2009	19.54	0
$\hat{\beta}_C$	1992	18.08	0	2007	4.31	0.1629	2009	7.71	0.0094
$\hat{\beta}_U$	1970	13.17	0.0001	2011	23.91	0	2010	167.30	0

Notes: Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data
probabilities calculated using Hansen (1997)'s method

[14]However, there was a large stock market crash in 1987 – Black Monday – which might be related to this structural break in capital market risk sharing.

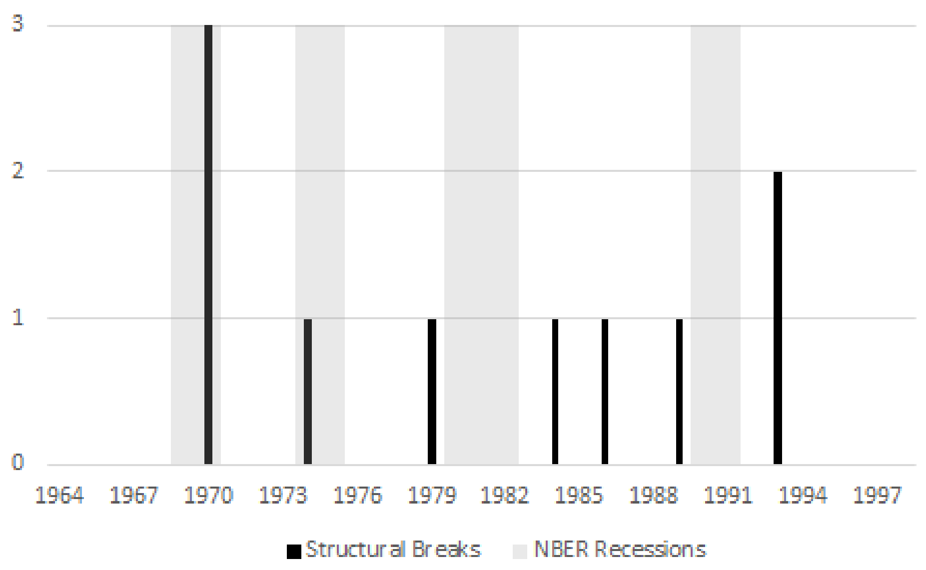

Figure 4: US data: Structural breaks determined by Bai-Perron tests based on the 5-year-rolling window parameter estimates and NBER recessions shaded

Since the Quandt-Andrews test only determines the highest probability structural break in the full sample, we also use the Bai and Perron (2003) test for the sequential application of structural break test to potentially identify multiple breaks. The results are summarized in figures 4 to 6.

Besides the 1986 parameter break identified before, all other identified structural breaks occurred within a two-year window around a recession. In total, the Bai-Perron test has added 7 additional structural breaks to the 4 identified by the Quandt-Andrews test – all 7 happened around recessions as figure 4 indicates.

For the euro area, the picture is similar. Except for one structural break identified at the date of the introduction of the euro (in 1999), all other additional structural breaks in figures 5 and 6 happened around the two most recent recessions.

The results in this section have provided strong evidence that

1. The risk sharing parameters are not stable over time.
2. This instability consists of trending behavior *and* additional time variation.
3. Recessions appear to play a key role in explaining the variability of the parameter estimates.

We thus also confirmed the key finding of Furceri and Zdzienicka (2015), that the degree of risk sharing in the euro area is state dependent.

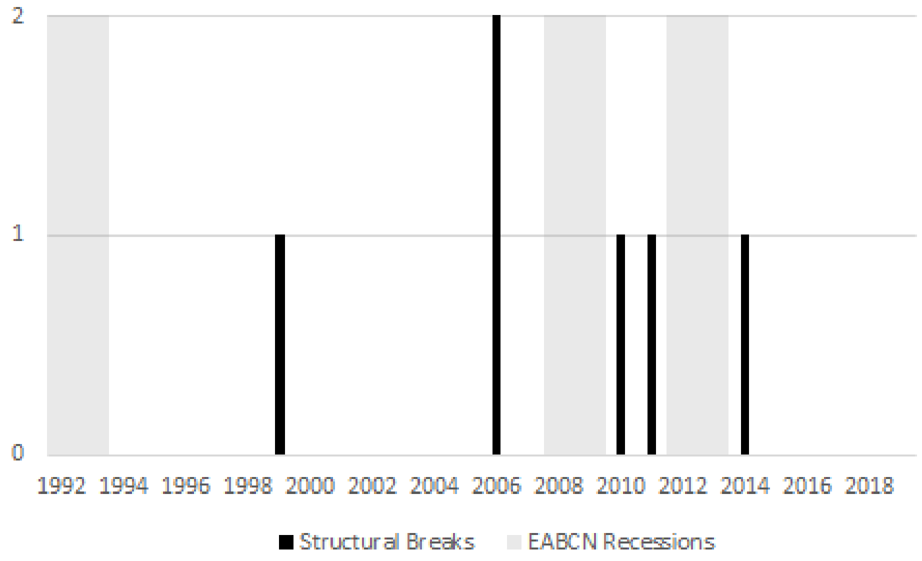

Figure 5: EMU-12 data: Structural breaks determined by Bai-Perron tests based on the 5-year-rolling window parameter estimates and EABCN recessions shaded

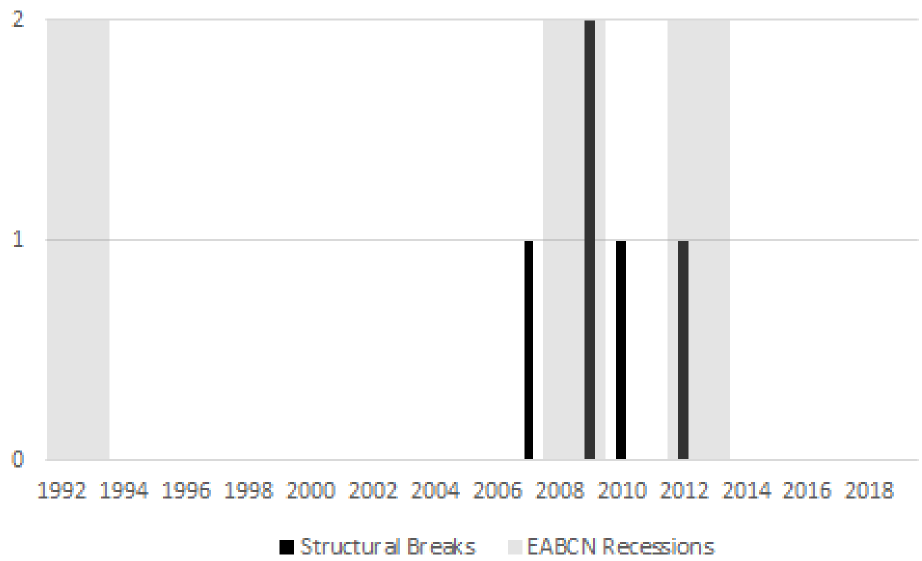

Figure 6: EMU (excluding Ireland and Luxembourg) data: Structural breaks determined by Bai-Perron tests based on the 5-year-rolling window parameter estimates and EABCN recessions shaded

3.6 VAR Analysis

To shed more light on the potential drivers of the time variability of the risk sharing parameters, we use a vectorautoregression (VAR) in reduced form to estimate the dynamic relationship between the estimated time-varying parameters and a range of macroeconomic variables.

The VAR takes on the following form

$$y_t = c + Ay_{t-1} + \epsilon_t, \tag{9}$$

where $y_t = [\hat{\beta}_i, u_t, \Delta p_t^{Stocks}, \pi_t, i_t]$. So for every sample there are four different VARs to be estimated, one for each of the $\hat{\beta}_i$, where $i = K, F, C, U$. The macroeconomic variables are the unemployment rate (u_t), the annual percentage change in stock prices (Δp_t^{Stocks}), the inflation rate (π_t) and an interest rate measure (i_t).[15]

We explore the role of those macroeconomic variables by using the well-established tool of Granger (1969) non-causality tests. This approach allows us to explore the relationships by testing the hypothesis that lagged values of macroeconomic variables *do not help* to forecast actual values of the risk sharing parameters, in other words whether an endogenous variable can be treated as exogenous. For each equation in the VAR, the output displays χ^2 (Wald) statistics for the joint significance of each of the other lagged endogenous variables in that equation. The statistic in the last row (All) is the χ^2-statistic for joint significance of all other lagged endogenous variables in the equation. If the hypothesis is rejected for one variable, we will conclude that in fact it *does* have some explanatory power as it can be seen as a (weakly) exogenous driver in a dynamic system.

The results for those tests are summarized in tables 11 to 13 in the appendix.[16] All values that are marked as bold imply a rejection of the null hypothesis of *no Granger causality*.[17] Thus, in the US there appears to be explanatory power in the unemployment rate for the capital market risk sharing parameter $\hat{\beta}_K$. In the euro area, there is more

[15] All macroeconomic variables are from the Federal Reserve Bank of St. Louis Database (`https://fred.stlouisfed.org/`).

[16] There is a generated regressor problem in those VAR estimations, which has the potential to make inference about parameter values incredible. However, since this problem only applies to the cases where the estimated time-varying risk sharing parameter shows up on the right hand side of the equation and since we are interested in the parameter estimates for the macroeconomic variables, the problem vanishes in this application.

[17] Because of the small sample and relatively high number of parameters to be estimated in each equation (6, including the constant term), we apply a significance level of 10% rather than the more common 5%.

than just one significant relationship: across samples, the change in the stock price has explanatory power for $\hat{\beta}_K$ and the interest rate "Granger causes" the parameter for the un-smoothed part of income shocks $\hat{\beta}_U$. Since all three variables are closely related to the business cycle, those results can be seen as complementary to the evidence on the role of recessions in influencing the risk-sharing channels. The result is much more pronounced for the euro area compared to the US.

4 Shortcomings of the Asdrubali et al. (1996) approach

While some features of the original method have already become clear in the literature section, there is more to be said about the implementation and the concept of the dominant approach of measuring cross-border risk sharing.

First, the results are obtained from a data-set with specific features that is a reasonable choice but comes with caveats. In the original Asdrubali et al. (1996) specification, the panel series are expressed in nominal (or real values deflated with the same measures for all cross-sectional units) per capita values. Obviously – and as shown by the example with real values deflated with national indices for the euro area in table 7 of the appendix – the risk sharing coefficients do no longer sum up to one and thus are not necessarily consistent with the results obtained from nominal aggregates. The per capita specification induces an equal treatment of all cross-sections in the panel estimation, so that small states in the US or small countries in the euro area receive a disproportionately high weight to their economic importance. This point has been particularly important in the euro area analysis, where Luxembourg and Ireland – comprising about 2-3% of the EU GDP – seem to have driven the results to a large extend as shown in the empirical analysis above. So, to be precise, what the method measures is the degree of cross-sectional co-variance of nominal, unweighted per capita aggregates, which in a more narrow sense is different from what most people – in particular on a policy level – would perceive as macroeconomic cross-border risk sharing for a currency area as a whole.

The particular interpretation of the regression coefficient involving state consumption and gross state product as the percentage of shocks to gross state product that are *not insured* suggests that the other mechanisms provide genuine insurance, which is not necessarily the case. In particular, the interpretation of *credit market smoothing* – which is the smoothing of consumption through savings – has been doubted in the literature. Mélitz and Zumer (1999) first argue that changes in consumption and savings do not only arise as a reaction towards changes of income, but also as a result of the change of preferences and tastes. Second, if the Modigliani and Miller (1958) theorem applies, households would respond to retained corporate earnings with an increase in consumption. This would lead to a negative relationship between β_K and β_C and thus make a separate estimation and thus identification of the two different parameters impossible.[18] Table 14 in the appendix shows the simple correlation coefficients between the five-year rolling window coefficients in the US. There is a substantial negative correlation of the time-varying estimates of about -0.9. Third, and maybe most importantly, there is no reason to assume that *credit* is a form of insurance or that it serves the purpose of risk mitigation as it ultimately has to be repaid.[19] This point is particularly important in the euro area, where cross-border credit plays an important role. While of course the level of consumption in any economy can be smoothed via credit, many have argued that the excessive reliance on cross-border credit to finance a *higher* level of consumption today in fact *increases* the overall future macroeconomic risk and vulnerability of an economy. Calvo (1998) and others have pointed out the high importance of current account deficits as predictors of future sudden stops and macroeconomic crises and Merler et al. (2012) pointed out the importance for the most recent euro area crisis. At the same time, the theoretical literature on sovereign defaults also suggests that a country faces zero default risk if there is a positive net foreign asset position, i.e. a persistent surplus in the current account (Arellano, 2008). Hence, the credit channel of risk sharing, if it becomes persistent, is likely to drastically alter cross-border macroeconomic risk. Dräger and Proaño (2018) emphasize the crucial role of cross-border lending in the particular case of a monetary union. They conclude from their theoretical analysis that cross-border lending may amplify the effects of a region-specific shock in both regions of the monetary union – this is the exact opposite of what risk sharing intends to do.

Furthermore, the method and interpretation employed by Asdrubali et al. (1996) has led to some confusion, in particular in the policy debate. Van den Noord (2000) for instance cite the paper in the context of automatic stabilization. Fiscal stabilization – however – is clearly not what the coefficient of fiscal risk sharing in the original reference measures: the coefficient β_F measures the cross-sectional co-variance of the difference between state income and disposable income (taxes and transfers) on the one hand and gross state product on the other. Fiscal stabilization typically refers to the effect of government policies on the volatility of output as pointed out by Dullien (2019).

[18] This maybe one of the reasons why the combination of β_K and β_C in the replication exercise is closer to the original estimate than the two separate values.

[19] Of course, there is the possibility of default, but in this case risk sharing happens in a much more indirect way, which is likely to limit its relevance from a macroeconomic perspective.

On a more general note, the risk sharing interpretation of the regression based analysis might not be entirely convincing due to the interpretation of *shocks*. The estimated parameters are treated as fractions of inter-state smoothing to idiosyncratic shocks in gross state product. They are derived from regressions relating the difference in growth rates between – for example – disposable state income and consumption and the growth rate of gross state product. The proposed interpretation as smoothing of shocks to gross state product thus excludes the potential impact a shock to state consumption might have on gross state product. In other words, the identifying assumptions allowing to interpret the parameter β_U as the response of state consumption to a shock in gross state product are not clearly stated. The parameter could just as well be interpreted as a transformation of the response of gross state product to state consumption shocks (such as an improvement in consumer sentiment). This is of course true for all other estimated parameters as well.

Furthermore, in the regression approach all emerging differences in gross state products are treated as idiosyncratic shocks, while they are in fact just observations. The implicit assumption here is that the data generating process for gross state product is equal across states. However, shocks might have very heterogeneous impacts on the different states so that a common shock – such as a negative foreign oil supply shock which increases the oil price in New York and Texas – may result in different responses even in the same variable.

In the rolling window analysis for the euro area we found that there was a declining trend in the parameter for the un-smoothed part until the financial crisis. In both samples – and in the cross section regressions in the appendix – the lowest values for the un-smoothed part of income shocks were experienced around the global financial crisis. At the same, there were fairly high values of the un-smoothed part in the euro area crisis. While it might be true that risk sharing has decreased since 2008/2009, it is more likely that the global financial crisis was a different type of shock (common shock with similar reactions) with a different type of income, consumption and policy reaction than the euro area crisis in 2011/2012 (idiosyncratic, with heterogeneous reactions).

But the assumption that there are only idiosyncratic shocks to gross state product leads to a situation where separate common (for example external) shocks can by definition not be distinguished from idiosyncratic shocks. There appears to be scope for improvement of the empirical basis for a meaningful policy discussion in the euro area.

5 Conclusion

The paper adds to the literature as follows: starting from the benchmark model of Asdrubali et al. (1996), we are able to closely reproduce the original specification with a data set obtained from the authors. In a second step, this specification is brought to euro area data. Again, the results are mainly in line with the existing literature (Furceri and Zdzienicka, 2015). We report rolling window and recursive estimates and show high time variation in the coefficients. Results are especially sensitive to the inclusion of recession dummies in the euro area (confirmed by structural break tests) and the exclusion of "outlier" countries as Ireland and Luxembourg. Last but not least we discuss shortcomings of the approach. While its simplicity and internal consistency makes results based on this estimation approach very accessible, researchers and policy makers have to be careful with the interpretation attached to the coefficients and should be aware of the instability of parameters during recessions – which is likely to be the moment when the need for risk sharing is at its peak.

Based on the analysis, an alternative econometric framework for the measurement of risk sharing would be desirable. While Furceri and Zdzienicka (2015) have allowed for a broader set of risk sharing mechanisms and Asdrubali and Kim (2004) discuss the dynamic features of risk sharing, this measurement framework based on the variance decomposition of GDP seems to be exhausted to a large extent.

Hence, the policy discussion would benefit from a complementary measure, which may also attempt to estimate the importance of private and public risk sharing mechanisms, but in addition...

1. allows for *automatic stabilization* in contrast to government risk sharing,
2. allows for *different sources and a clear characterization of the shocks* affecting output,
3. allows for *heterogeneity across regions* in the responses to the shocks and for transmission between regions and
4. is less prone to time variation.

On a policy level, it will be interesting to observe the further steps of European integration. While the banking union is to a large degree already implemented, it remains to be seen how the capital markets union and the new fiscal capacity may have a long lasting impact on risk sharing. Our analysis has shown that especially for fiscal risk sharing there is a lot of room for improvement in the euro area.

References

Afonso, António and Davide Furceri, "EMU enlargement, stabilization costs and insurance mechanisms," *Journal of International Money and Finance*, 2008, *27* (2), 169–187.

Allard, Céline, Petya Koeva Brooks, Mr John C Bluedorn, Fabian Bornhorst, Franziska Ohnsorge, and Mrs Katharine M Christopherson Puh, *Toward a fiscal union for the Euro area* number 13-19, International Monetary Fund, 2013.

Andrews, Donald W. K., "Tests for Parameter Instability and Structural Change With Unknown Change Point," *Econometrica*, 1993, *61* (4), 821–856.

Arellano, Cristina, "Default risk and income fluctuations in emerging economies," *American Economic Review*, 2008, *98* (3), 690–712.

Asdrubali, Pierfederico and Soyoung Kim, "Dynamic risksharing in the United States and Europe," *Journal of Monetary Economics*, 2004, *51* (4), 809–836.

_ , Bent E Sørensen, and Oved Yosha, "Channels of interstate risk sharing: United States 1963–1990," *The Quarterly Journal of Economics*, 1996, *111* (4), 1081–1110.

Bai, Jushan and Pierre Perron, "Critical values for multiple structural change tests," *The Econometrics Journal*, 2003, *6* (1), 72–78.

Beck, Nathaniel and Jonathan N Katz, "What to do (and not to do) with time-series cross-section data," *American political science review*, 1995, pp. 634–647.

Berger, Helge, Giovanni Dell'Ariccia, and Maurice Obstfeld, "Revisiting the economic case for fiscal union in the Euro area," *IMF Economic Review*, 2019, *67* (3), 657–683.

Calvo, Guillermo A, "Capital flows and capital-market crises: the simple economics of sudden stops," *Journal of applied Economics*, 1998, *1* (1), 35–54.

den Noord, Paul Van, "The size and role of automatic fiscal stabilizers in the 1990s and beyond," 2000.

Dräger, Lena and Christian R Proaño, "Cross-Border Banking And Macroprudential Policies In Asymmetric Monetary Unions," *Macroeconomic Dynamics*, 2018, pp. 1–36.

Dullien, Sebastian, "Risk-sharing by financial markets in federal systems: a critique of existing empirical assessments," *Review of Keynesian Economics*, 2019, *7* (3), 361–368.

_ **and Ferdinand Fichtner**, "A common unemployment insurance system for the euro area," *DIW Economic Bulletin*, 2013, *3* (1), 9–14.

Enderlein, Henrik, Jann Spiess, Lucas Guttenberg, and António Vitorino, *Blueprint for a cyclical shock insurance in the euro area*, Notre Europe Brussels, 2013.

Enders, Zeno and David A Vespermann, "Effects of a European Unemployment Insurance," in "University of Heidelberg Working Paper" 2018.

Engler, Philipp and Simon Voigts, "A transfer mechanism for a monetary union," Technical Report, SFB 649 Discussion Paper 2013.

Farhi, Emmanuel and Iván Werning, "Fiscal unions," *American Economic Review*, 2017, *107* (12), 3788–3834.

Feld, Lars P and Steffen Osterloh, "Is a fiscal capacity really necessary to complete EMU?," Technical Report, Freiburger Diskussionspapiere zur Ordnungsökonomik 2013.

Furceri, Davide and Aleksandra Zdzienicka, "The euro area crisis: Need for a supranational fiscal risk sharing mechanism?," *Open Economies Review*, 2015, *26* (4), 683–710.

Granger, Clive WJ, "Investigating causal relations by econometric models and cross-spectral methods," *Econometrica: journal of the Econometric Society*, 1969, pp. 424–438.

Hansen, Bruce E, "Approximate asymptotic p values for structuras-change tests," *Journal of Business & Economic Statistics*, 1997, *15* (1), 60–67.

Hepp, Ralf and Jürgen Von Hagen, "Interstate risk sharing in Germany: 1970–2006," *Oxford Economic Papers*, 2013, *65* (1), 1–24.

Mélitz, Jacques and Frédéric Zumer, "Interregional and international risk-sharing and lessons for EMU," in "Carnegie-Rochester Conference Series on Public Policy," Vol. 51 Elsevier 1999, pp. 149–188.

Merler, Silvia, Jean Pisani-Ferry et al., "Sudden stops in the euro area," *Bruegel policy contribution*, 2012, *6* (12), 1–13.

Modigliani, Franco and Merton H Miller, "The cost of capital, corporation finance and the theory of investment," *The American economic review*, 1958, *48* (3), 261–297.

Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung, "Jahresgutachten 2018/19," *Vor wichtigen wirtschaftspolitischen Weichenstellungen*, 2018.

6 Appendix

Table 7: EMU results excluding Ireland and Luxembourg: real terms

		Pre-1999 *FE*	**Post-1999** *FE*
Capital	$\hat{\beta}_K$	-0.16	0.05
Fiskal	$\hat{\beta}_F$	-0.22	-0.12
Credit	$\hat{\beta}_C$	0.38	0.17
Un-smoothed	$\hat{\beta}_U$	0.78	0.77
	sum	0.78	0.88

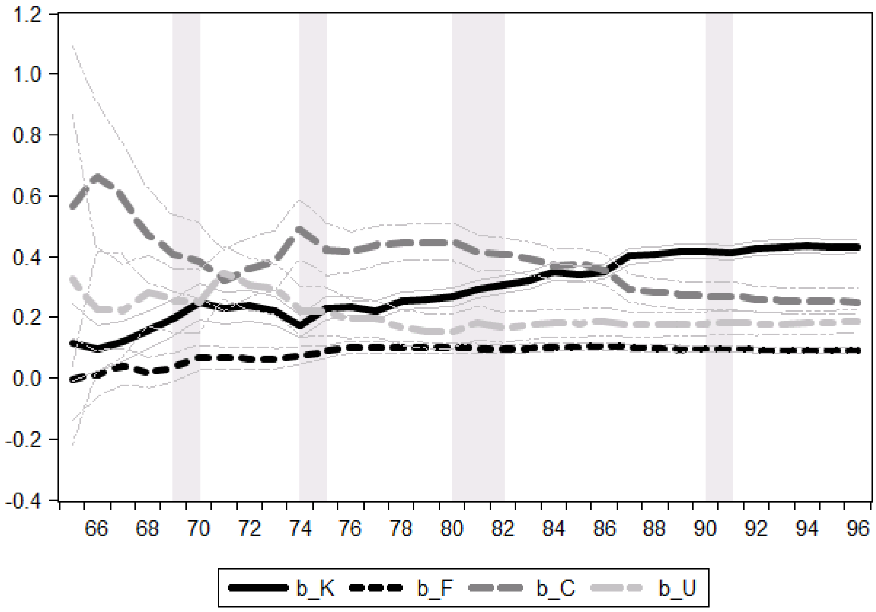

Figure 7: β_K, β_F β_C and β_U based on recursive regressions in the US, full sample 1963-2019, shaded: NBER recessions

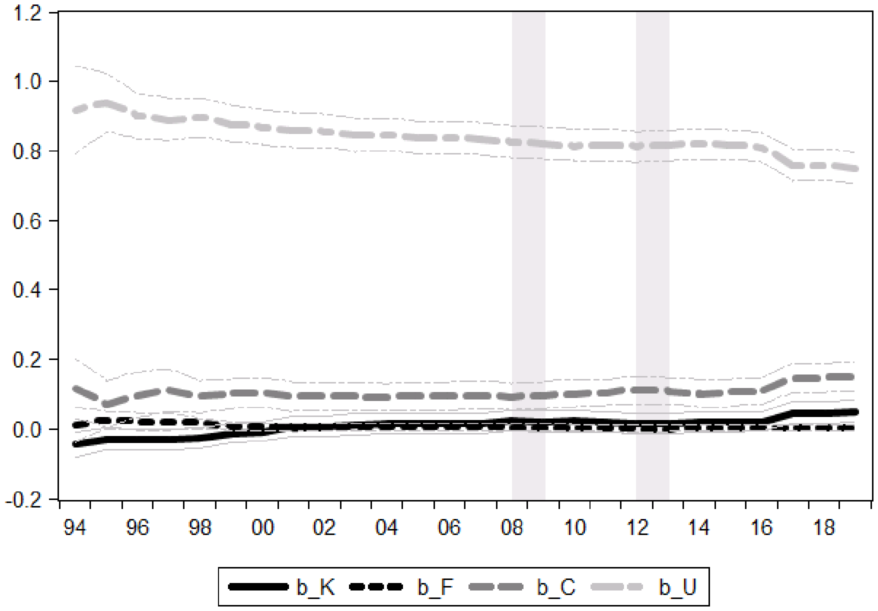

Figure 8: β_K, β_F β_C and β_U based on recursive regressions in the euro area (EMU-12), full sample 1991-2019, shaded: EABCN recessions

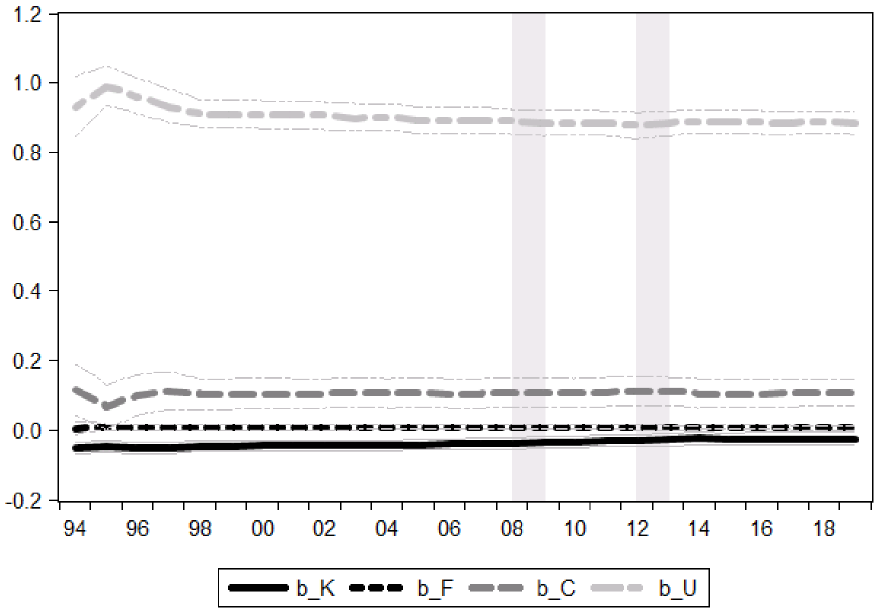

Figure 9: β_K, β_F β_C and β_U based on recursive regressions in the euro area (excluding Luxembourg and Ireland),full sample 1991-2019, shaded: EABCN recessions

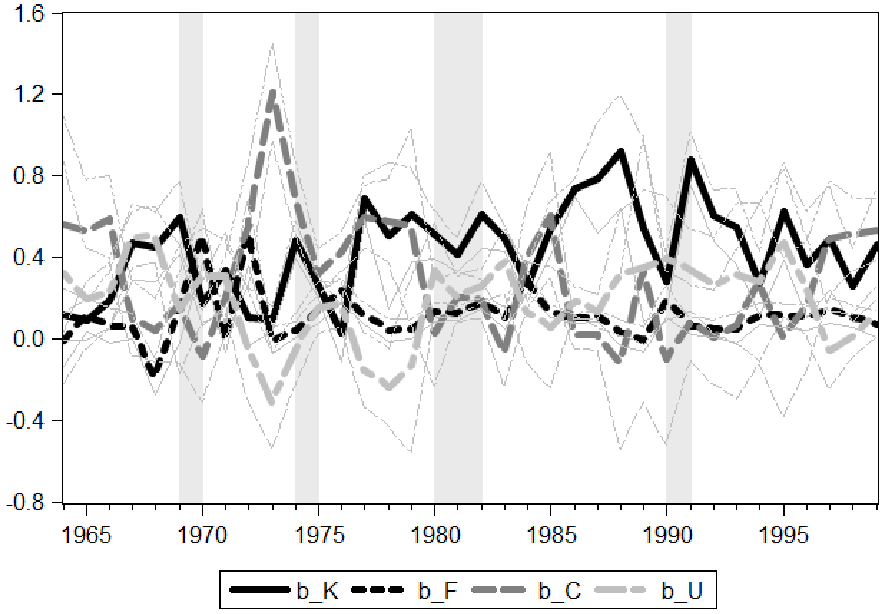

Figure 10: β_K, β_F β_C and β_U based cross-section regressions in the US, full sample 1963-1999, shaded: NBER recessions

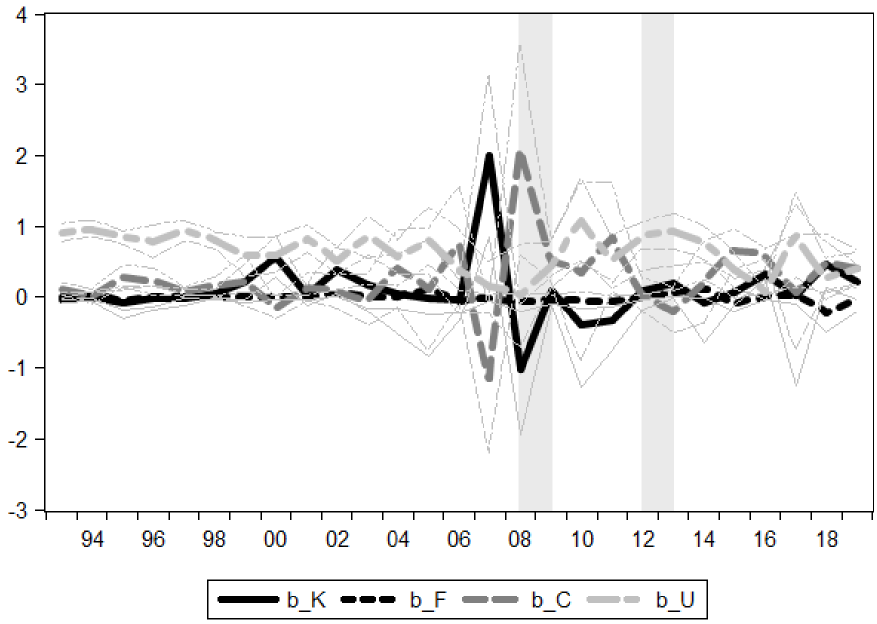

Figure 11: β_K, β_F β_C and β_U based on cross-section regressions in the euro area (EMU-12),full sample 1991-2019, shaded: EABCN recessions

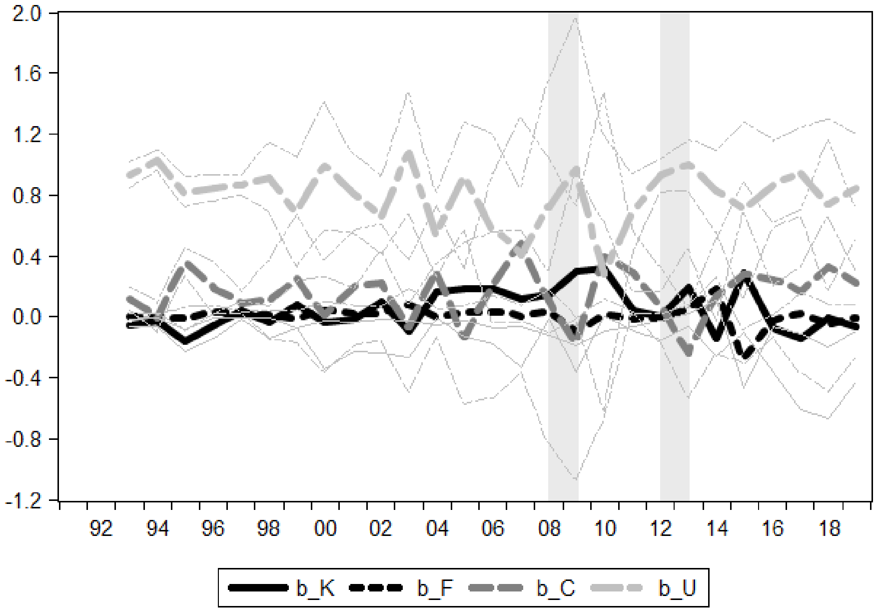

Figure 12: β_K, β_F β_C and β_U based on cross-section regressions in the euro area (excluding Luxembourg and Ireland),full sample 1991-2019, shaded: EABCN recessions

Table 8: Bai-Perron test for equation 8 for the US 5-year rolling window estimates

Parameter	**Break Test**	**F-statistic**	**Scaled F-statistic**	**Critical Value****	**Year(s)**
$\hat{\beta}_K$	0 vs. 1 *	37.5	75.0	11.5	1986
	1 vs. 2 *	14.9	29.8	13.0	1970
	2 vs. 3	3.5	6.9	14.0	
$\hat{\beta}_F$	0 vs. 1 *	24.0	48.0	11.5	1974
	1 vs. 2 *	15.8	31.6	13.0	1989
	2 vs. 3 *	7.1	14.3	14.0	1981
	3 vs. 4	2.9	5.8	14.9	
$\hat{\beta}_C$	0 vs. 1 *	18.4	36.7	11.5	1993
	1 vs. 2 *	24.2	48.5	13.0	1979
	2 vs. 3 *	8.7	17.4	14.0	1970
	3 vs. 4 *	18.4	36.7	14.9	1984
	4 vs. 5	1.9	3.8	15.3	
$\hat{\beta}_U$	0 vs. 1 *	13.2	26.3	11.5	1970
	1 vs. 2 *	14.0	28.0	13.0	1993
	2 vs. 3	5.2	10.5	14.0	

* Significant at the 0.05 level.
** Bai and Perron (2003) critical values.

Table 9: Bai-Perron test for equation 8 for the EMU-12 5-year rolling window estimates

Parameter	**Break Test**	**F-statistic**	**Scaled F-statistic**	**Critical Value****	**Year(s)**
bk	0 vs. 1 *	12.7	25.5	11.5	2006
	1 vs. 2 *	13.9	27.9	13.0	2014
	2 vs. 3	2.0	4.1	14.0	
bf	0 vs. 1 *	20.0	40.0	11.5	2006
	1 vs. 2 *	8.4	16.8	13.0	2010
	2 vs. 3 *	25.1	50.2	14.0	1999
	3 vs. 4	4.7	9.3	14.9	
bc	0 vs. 1	4.3	8.6	11.5	
bu	0 vs. 1 *	23.9	47.8	11.5	2011
	1 vs. 2	5.6	11.2	13.0	

* Significant at the 0.05 level.
** Bai and Perron (2003) critical values.

Table 10: Bai-Perron test for equation 8 for the EMU (ex. Ireland and Luxembourg) 5-year rolling window estimates

Parameter	**Break Test**	**F-statistic**	**Scaled F-statistic**	**Critical Value****	**Year(s)**
$\hat{\beta}_K$	0 vs. 1 *	105.4	210.9	11.5	2007
	1 vs. 2	3.7	7.3	13.0	
$\hat{\beta}_F$	0 vs. 1 *	19.5	39.1	11.5	2009
	1 vs. 2	6.1	12.3	13.0	
$\hat{\beta}_C$	0 vs. 1 *	7.7	15.4	11.5	2009
	1 vs. 2 *	11.7	23.4	13.0	2012
	2 vs. 3	1.8	3.7	14.0	
$\hat{\beta}_U$	0 vs. 1 *	167.3	334.6	11.5	2010
	1 vs. 2	2.8	5.5	13.0	

* Significant at the 0.05 level.
** Bai and Perron (2003) critical values.

Table 11: Granger-causality analysis for US sample

Dependent variable:	$\hat{\beta}_K$		$\hat{\beta}_F$		$\hat{\beta}_C$		$\hat{\beta}_U$	
	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
Excluded:								
u_t	**12.2**	**0.00**	0.2	0.62	1.0	0.32	1.3	0.25
Δp_t^{Stocks}	0.2	0.63	0.0	0.99	0.2	0.68	0.8	0.36
π_t	2.3	0.13	1.3	0.26	0.0	0.87	0.6	0.45
i_t	0.8	0.37	0.7	0.40	1.6	0.20	0.1	0.81
All	**13.8**	**0.008**	1.5172	0.82	5.833	0.212	2.29	0.683

Table 12: Granger-causality analysis for EMU-12 sample

Dependent variable:	$\hat{\beta}_K$		$\hat{\beta}_F$		$\hat{\beta}_C$		$\hat{\beta}_U$	
	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
Excluded:								
u_t	1.7	0.19	1.5	0.21	0.4	0.50	0.1	0.76
Δp_t^{Stocks}	**3.1**	**0.08**	**3.5**	**0.06**	0.4	0.54	0.0	0.87
π_t	**3.4**	**0.06**	**5.6**	**0.02**	**2.8**	**0.10**	0.2	0.68
i_t	0.2	0.63	2.2	0.14	**5.7**	**0.02**	**2.9**	**0.09**
All	**8.6**	**0.072**	**10.964**	**0.03**	5.786	0.216	3.89	0.421

Table 13: Granger-causality analysis for EMU sample (excluding Luxembourg and Ireland)

Dependent variable:	$\hat{\beta}_K$		$\hat{\beta}_F$		$\hat{\beta}_C$		$\hat{\beta}_U$	
	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
Excluded:								
u_t	**13.2**	**0.00**	0.8	0.38	0.5	0.48	**7.1**	**0.01**
Δp_t^{Stocks}	**10.1**	**0.00**	0.6	0.42	0.7	0.41	2.6	0.11
π_t	1.3	0.25	2.3	0.13	0.2	0.65	**6.6**	**0.01**
i_t	**3.1**	**0.08**	0.3	0.57	0.0	1.00	**5.6**	**0.02**
All	**18.7**	**9E-04**	5.6759	0.22	5.47	0.242	**22.2**	**2E-04**

Table 14: Correlation matrix of risk sharing parameters: US, based on 5-year rolling window estimates

correlation	$\hat{\beta}_K$	$\hat{\beta}_F$	$\hat{\beta}_C$	$\hat{\beta}_U$
$\hat{\beta}_K$	0.17			
$\hat{\beta}_F$	-0.18	0.02		
$\hat{\beta}_C$	-0.89	0.35	0.18	
$\hat{\beta}_U$	0.06	-0.62	-0.42	0.08

Imprint

Publisher
Macroeconomic Policy Institute (IMK) of Hans-Böckler-Foundation, Georg-Glock-Str. 18,
40474 Düsseldorf, Germany, phone +49 211 7778-312, email imk-publikationen@boeckler.de

IMK Working Paper is an irregular online publication series available at:
https://www.imk-boeckler.de/de/imk-working-paper-15378.htm

The views expressed in this paper do not necessarily reflect those of the IMK or the Hans-Böckler-Foundation.

ISSN 1861-2199