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Risk sharing in currency unions: The migration channel

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Abstract

Country-specific business cycle fluctuations are potentially very costly for member states of currency unions because they lack monetary autonomy. The actual costs depend on the extent to which consumption is shielded from these fluctuations and thus on the extent of risk sharing across member states. The literature to date has focused on financial and credit markets as well as on transfer schemes as channels of risk sharing. In this paper, we show how the standard approach to quantify risk sharing can be extended to account for migration as an additional channel of cross-country risk sharing. In theory, migration should play a key role when it comes to insulating *per capita* consumption from aggregate fluctuations, and our estimates show that it does so indeed for US states, but not for the members of the Euro area (EA). Consistent with these results, we also present survey evidence which shows that migration rates are about 20 times higher in the US. Lastly, we find, in line with earlier work, that risk sharing is generally much more limited across EA members.

Keywords: Risk sharing, Currency unions, Labour migration, Migration rates, Euro Area
JEL-Codes: F41, F22, G15, J61

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1 Introduction

Risk sharing allows individuals to smooth consumption relative to income shocks. Important mechanisms of risk sharing include lending and borrowing, diversification of income sources, and the social security system. The extent to which risk sharing takes place can be recognized from the degree to which individuals' consumption paths over time exhibit a smoother pattern than their income paths. This holds true also for international risk sharing. There is a presumption that international integration makes the mechanisms of risk sharing potentially more effective. International borrowing and lending increases the scope of financial intermediation, while factor trade allows for cross-border diversification of income sources. Also, international integration or harmonization of policies may involve international transfers that contribute to consumption smoothing. Thus, the scope of international risk sharing among a certain set of countries should depend on the type and degree of international integration of these countries and on the specific institutional arrangements that govern international integration and specialization (Kalemli-Ozcan et al. 2003). A case of particular interest are currency unions because their members have surrendered monetary autonomy to a common central bank and thus lack monetary policy tools to deal with country-specific shocks.

In this paper, we quantify and compare the empirical significance of different channels of risk sharing in the most important currency unions currently in existence: the US and the Euro area (EA). Arguably, market integration is different in the US compared to the EA. In particular, a consensus view holds that integration of credit markets as well as labor markets is significantly higher among US states than among EA members. Is this reflected in different empirical patterns of risk sharing? We use the accounting framework introduced by Asdrubali et al. (1996), hereafter abbreviated as ASY, in order to identify the pattern of risk sharing. The advantage of this approach is twofold. First, it is "outcome-oriented" in that it directly measures the degree of consumption smoothing relative to output shocks. And secondly, it allows for a decomposition of consumption smoothing into different channels of risk sharing. We consider four such channels: (i) cross-country/state borrowing or lending (credit channel), (ii) international/across-state diversification of income sources (factor trade channel), iii) the (international) transfer channel and (iv) the migration channel. While channels (i) through (iii) have been explored in previous literature, our contribution lies in extending the ASY-framework to the migration channel.

In exploring the migration channel, we are motivated by the Mundellian criterion of an optimum currency area. Mundell (1961) argues that labor mobility between countries serves as a powerful adjustment mechanism which can limit the adverse employment effects of asymmetric shocks if a common currency prevents exchange rate adjustments. As a result, the larger the labor mobility across countries, the less exposed each country's per capita income (and, eventually, its consumption) to country-specific output fluctuations. Prior to the inception of the Euro—back in the 1990s—many economists warned that a currency area including all members of the EU would face severe problems, exactly because such a currency union would fail the Mundellian criterion of labor mobility (see, for instance, Feldstein 1997). Proponents of the European monetary union have responded that the Euro area would eventually fulfill this and other criteria of an optimum currency area through long-run adjustment to the new environment created by the currency union. The literature speaks of an *ex post, or endogenous* fulfillment of these criteria (Frankel and Rose 1998; Mundell 1973; Warin et al. 2009). At least, the architects of the Economic and Monetary Union (EMU) have acknowledged the Mundellian criterion by including provisions for internal labor mobility among the so-called "four freedoms" of the Single Market established at the time the currency union was set on track in 1992. There are numerous studies concluding that international labor mobility among Euro area countries has, indeed, increased over time (see, for instance, Arpaia et al. 2018; Basso et al. 2019; Beyer and Smets 2015; Mitze 2019). However, the extent to which cross-country labor movements do in fact serve as a vehicle of risk-sharing among EA member states is an open question that we want to take up in this paper.

As to the fiscal criterion for optimum currency areas, the EA was never going to have a unified fiscal system, let alone a fiscal system involving strong risk sharing elements. Indeed, during the past decade significant controversy and tension have surfaced between member states about the principal desirability of risk-sharing among member countries of the European Union (EU). And while the EA is only a subset of the EU, the EU-budget does include transfer elements, which is why drawing up the budget every seven years is typically a controversial affair. But up until very recently these transfer elements have been structural in nature, motivated by concerns orthogonal to consumption smoothing over short-term asymmetric shocks.[1] The extent to which they nevertheless contributed to international risk sharing similarly is an open question that we address below.

The Single Market of the EU, the hallmark of European Integration, also provides for smooth factor trade. Factor trade means foreign primary income from labor or capital, which allows for *national* income to differ from gross *domestic* income deriving from domestic output. Foreign labor income implies commuting to a foreign work place. The possibility of taking up a job across the border in case of deteriorating domestic employment perspectives surely involves a risk-sharing potential, but this potential is relevant only for a small part of the population. A more powerful risk-sharing potential emanates from the possibility of cross-border holdings of financial wealth which reduces the capital owner's *income* exposure to country-specific production shocks.

In addition to factor trade, the Single Market also provides for free movement of people, which means absence of policy barriers to international labor mobility. To the extent that people are in fact willing to migrate when hit by adverse shocks, this generates a further, potentially significant, channel of international risk sharing. However, this type of risk sharing will never be captured by the factor trade channel since it does not generate foreign factor income. This, together with the prominence of the labor mobility criterion in discussions about optimum currency areas, calls for a suitable extension of the ASY-approach in order to quantify the contribution of migration to consumption smoothing, as we do in this paper.

[1]In response to the Covid-19 pandemic, the EU agreed on a recovery fund worth 750 billions within the "Next Generation EU" framework, arguably meant to address short-term issues. By historical standards this fund is exceptionally large and, given the way it is funded in the long-term, involves considerable cross-country transfers.

The approach introduced by ASY relies on a simple variance decomposition of output *per capita* that allows measuring the extent of consumption smoothing in a regression framework. Intuitively, without any consumption smoothing, changes in consumption *per capita* are perfectly "explained" by changes in output *per capita.* Conversely, with perfect consumption smoothing, changes in consumption per capita are orthogonal to changes in output. Consumption is then perfectly insulated from output shocks. Allowing for intermediate cases, the approach by ASY offers a straightforward way to quantify the fraction of output fluctuations that is smoothed via risk sharing by means of a simple regression analysis. And it can also be refined by first addressing smoothing of disposable income relative to output through the factor trade channel and the transfer channel, and then looking at smoothing of consumption relative to disposable income through the credit channel. On the basis of US-inter-state data, ASY conclude that capital market integration (factor trade channel) smooths 39 percent of state-specific output shocks while transfers from the federal government and credit market integration smooth 13 percent and 23 percent, respectively. The residual 25 percent of output shocks remain unsmoothed and are therefore absorbed by changes in consumption.

We propose to extend this framework in order to measure the contribution of migration to consumption smoothing. Absent any inflow or outflow of labor, a demand or supply shock will affect aggregate output and output *per capita* by the same percentage amount. Applying the above logic, output *per capita* is perfectly "explained" by *aggregate* output. But with labor mobility, an adverse shock is likely to generate an incentive for outward migration, and conversely for positive shocks. To the extent that migration does take place, the shocks will be absorbed with a muted reaction of output per capita relative to that of aggregate output. To take an extreme case, if there is a one-to-one relationship between the real wage and output per capita and if migration restores the initial real wage, then output per capita is perfectly insulated against demand and supply shocks. Our extension of the ASY approach allows us to measure the extent to which this type of insulation constitutes an additional channel of international risk sharing, alongside the ones mentioned above.

We apply the extended approach to annual US-inter-state data for the period 1963–2017 as well as to quarterly data for EA member states for the period 1998–2018. We find that the degree of risk sharing among the latter is generally much lower: for EA members we find that only about 1/3 of output fluctuations are buffered by risk sharing. For the US it is about 4/5. More importantly still, we find that the migration channel makes a sizeable contribution to risk sharing in the US: it smooths up to 17 percent of output fluctuations. On the contrary, it does not provide any risk sharing for EA members. These results are consistent with evidence which we compile on the basis of the American Community Survey and the European Labor Force Survey: interstate migration rates are about 20 times higher for US states compared to migration rates for EA members.

In what follows, we first place our paper into a broader context of the literature (Section 2). Afterwards, we present descriptive statistics on business cycles and migration flows, paving the ground for the subsequent analysis. In Section 4 we present the econometric framework of the ASY-approach, with due emphasis on our novel element which is the migration channel. Section 5 presents our main results. And finally, we conclude in Section 6 with a brief summary.

2 A brief review of the literature

The framework of ASY has been used extensively to quantify channels of risk sharing. Early contributions with a focus on Europe include Sorensen and Yosha (1998), Kalemli-Ozcan et al. (2004), and Balli and Sørensen (2006). More recently, the literature has focused on changes of the extent of risk-sharing over time. A robust finding is that risk-sharing in Europe still falls short of the levels observed for the US (European Commission 2016; Milano 2017). And while the role of fiscal policy (e.g. Evers 2015; Nikolov and Pasimeni 2019) as well as financial and banking integration has received particular attention in a risk-sharing context (Cimadomo et al. 2020; Demyanyk et al. 2007; Hoffmann et al. 2019), the literature following ASY has thus far ignored the role of migration as a distinct channel through which risk sharing takes place.[2] This is somewhat surprising, given the emphasis that critics of the Euro have placed on the Mundellian criterion of labor mobility.

There are a number of studies using methods other than ASY in order to investigate the role of migration in absorbing macroeconomic shocks. Blanchard and Katz (1992) use VAR-techniques to study the response of labor markets to asymmetric demand shocks for goods produced by different US states after 1950. They find that adverse (favorable) demand shocks typically lead US states to gradually revert to their pre-shock growth rates, but on somewhat lower (higher) levels of employment. Typically, however, changes in employment are not mirrored in corresponding changes in unemployment or labor market participation. This implies that outward (inward) migration subsequent to adverse (favorable) shocks serves to stabilize regional unemployment. Notably, they reach this conclusion without ever observing migration flows directly.

Using the same method, Decressin and Fatás (1995) find that labor market adjustment in large Western European regions relies more heavily on labor market participation and less on migration than in the US. Focusing on regions within the US and Canada on the one hand and the UK, Germany and Italy on the other, Obstfeld and Peri (1998) find that labor market adjustment to asymmetric demand shocks in European regions was slower and has involved significantly less migration than was the case in the US. These studies are based on evidence predating the formation of the EA. Employing similar techniques but using more recent data, Beyer and Smets (2015) reach a somewhat more nuanced conclusion. Looking at 47 NUTS2 regions in Europe, they find that the importance of *inter-regional* labor migration as an adjustment mechanism to asymmetric regional labor demand shocks was about the same in Europe and in the US during the period 1976–2013.[3] However, splitting their sample into 1977-1999 and 1990-2013, they find convergence over time in the importance of labor mobility: increasing in Europe and falling in the US.[4]

[2]An exception is ongoing work by Parsley and Popper (2020), but their focus is on possible differences in risk sharing among red and blue states in the US.

[3]In both cases mobility contributed about 50 percent to long-run adjustment, but in Europe adjustment takes about twice the time it takes in the US. In contrast, they find that *international* labor mobility is a much less important adjustment mechanism in Europe than interstate migration in the US. As in the aforementioned studies, migration is calculated as the change in population implied by changes in employment, unemployment and labor market participation rates.

[4]An increasing role of labor migration in shock absorption within the EU is also found in Arpaia et al. (2016), again using the VAR-approach pioneered by Blanchard and Katz (1992). Interestingly, this study also finds an increased

This latter result has also been established, using a similar methodology, by Dao et al. (2017). In addition to the long-run trend since 1970 of interstate labor mobility in the US, they also explore cyclical behavior of labor mobility. Moreover, while the Blanchard and Katz (1992) methodology infers the role of migration from the change in the population implied by a certain change in employment, unemployment and labor market participation, Dao et al. (2017) extend the analysis to include migration data. Their general conclusion is that interstate labor mobility in the US plays a smaller role in short-run cyclical adjustment than previously thought. Moreover, the trend reduction in interstate labor mobility is primarily due to less outward migration in depressed states while inward migration in booming states remains relatively high.

A second strand of literature focuses on the responsiveness of migration to local labor market conditions. Jauer et al. (2019) estimate the responsiveness of net-immigration rates, calculated from population growth, with respect to domestic labor market conditions relative to the corresponding averages in different areas of economic integration. Strikingly, and in line with the results obtained by Beyer and Smets (2015), they find that the responsiveness of net-immigration to unemployment and non-employment is negative,statistically significant, and of about the same magnitude in Europe and in the US. The responsiveness with respect to income per capita, however, is considerably less robust compared to employment conditions.[5] Following a similar approach, Huart and Tchakpalla (2019) estimate the responsiveness of net-immigration in 14 Euro area countries (11 initial members plus Greece, Slovenia and Slovakia) to the domestic unemployment rate relative to the averages of three different country groups, the Euro area, the EU and the entire rest of the world. A key result is that the responsiveness of net-immigration with respect to unemployment is statistically significant for all source-country-groups, but stronger for the non-EU group and lowest for the Euro area, although the differences are lower for the post-2008-era. In contrast to unemployment, and in line with Jauer et al. (2019), wage growth seems no important driver of migration. A further study of the responsiveness of net-immigration to local labor market conditions is Mitze (2019). The special feature of this study is the high level of regional disaggregation (255 NUTS2 regions and 1.246 NUTS3 regions). Regional labor market conditions are captured through rates of employment and unemployment, respectively, as well as growth of income per capita. In addition, population density is used to measure regional agglomeration benefits. The study aims at identifying differences in responsiveness between pre- and post-crisis (2008) times. The most noteworthy result is a "regime shift" over time: While responsiveness of net migration to local labor market conditions was hardly in existence before the crisis, it rose to significance thereafter. This holds true for both, employment perspective as well as income growth.

A third strand of literature relies on structural models to explore the adjustment of migration to business cycle shocks. Monras (2020) focuses on migration between US metropolitan areas as a result of adverse regional shocks occurring during the Great Recession following the financial crisis of 2008. At an empirical level, the analysis shows that adjustment takes place mostly through lower

responsiveness in real wages, although migration should be expected to reduce the need for wage adjustments.

[5] Their sample period covers 2006–2016 and data for EU27 plus EFTA, the Euro area (17) and the US.

inward migration, rather than higher outward migration. At a theoretical level, the analysis offers a full-fledged dynamic general equilibrium model incorporating forward-looking migration decisions. A calibrated version of the model shows that internal migration in the US has played a big role for absorbing the Great Recession. Within 10 years, the response of estimated migration has recovered 60 percent of the impact-drop on the values of regions caused by the Great Depression.[6]

A study explicitly placed in the context of Mundell's view on optimum currency areas is House et al. (2019).[7] It analyzes labor mobility in Europe compared to the US and Canada and asks to what extent missing labor mobility in Europe hampers macroeconomic stabilization across countries of the Euro area, in particular regarding unemployment differentials across Euro area countries, compared to that across US states. Remarkably, they report that the elasticity of net migration with respect to unemployment is three times higher in the US (-0.27) compared to Europe (-0.09). Then, they develop a multi-country DSGE model featuring search-and-matching unemployment which they calibrate to 29 European countries (plus the rest of the world), in order to quantify the effect of the low labor mobility in Europe. The key result is that increasing labor mobility among European countries to the level observed for US states, would cut the unemployment differentials across European countries by about one fifth. They also analyze a second counterfactual defined by flexible exchange rates between European countries. Flexible exchange rates also dampen unemployment differentials, but by a much smaller amount.

Simulation studies like these offer additional insights over the mere quantifications of the migration-responsiveness to labor market conditions considered above. Like the VAR-approach, they allow for a detailed analysis of the dynamic adjustment to such shocks, but they permit a more detailed analysis of specific scenarios coming closer to the risk sharing perspective that we are interested in. However, they do so at a cost which comes in the form of being restricted to specific mechanisms highlighted by the underlying, untested structural model of the economy. As we shall argue below, the ASY approach, being a mere accounting framework, offers the advantage of "structural agnosticism": It allows us to capture the consumption smoothing effect of migration regardless of the detailed mechanisms at work.

[6]A dynamic general equilibrium model with worker preferences for regions is also used in Caliendo et al. (2017) to investigate the welfare effects of dismantling migration barriers between old and new EU-members in the 2004-eastern-enlargement of the EU. They estimate that within 10 years the stock of new member states' nationals living in the EU15 increases by 1.65 percentage points. They also conduct a detailed welfare analysis which indicates that outward-migration from new to incumbent EU-members has delivered significant gains for new members, while it would have harmed incumbent members. However, considering trade alongside migration effects, most incumbent members have gained from eastern enlargement. Caliendo et al. (2019) present a study along the same lines investigating the role of internal migration between different US labor markets (defined as 22-sector×50-states) for the effect of the surge in US imports from China during the period from 2000 to 2007. Neither of these studies, however, addresses the role of migration for shock absorption and risk sharing.

[7]See also Farhi and Werning (2014): they analyze whether mobility can stabilize the macroeconomy across a currency union and find, in particular, that in equilibrium there is generally too little labor mobility from a social planner's perspective.

3 Descriptive statistics for EA members and US states

In order to set the stage for our analysis of the risk-sharing channels that operate across US states (or regions) on the one hand and across EA member states on the other, we compile a number of descriptive statistics. For the US, our sample covers annual data for the period 1963 to 2018 and all 50 states and the District of Columbia. In addition, we also consider the major regions of the US as defined by the US Census Bureau. It offers a coarse (four regions) and a fine (nine regions) classification. The sample period for the EA runs from the inception of the euro in 1999 up until the end of 2018. For the EA there is high-quality quarterly data on which we rely in our main analysis below. For the sake of comparability, in this section we compute statistics for the EA using annual data.[8] Table A.1 in the appendix lists our data sources, while Tables A.2 and A.3 provide details regarding the regional classification for the US and country groupings for the EA, respectively.

3.1 The co-movement of macroeconomic aggregates

In theory, risk sharing is about idiosyncratic shocks—aggregate shocks impact all participants in a risk-sharing arrangement alike and hence there is no or less scope for risk sharing. In practice, the distinction is not always clear-cut because aggregate shocks may transmit differently across countries—the unfolding of the Covid-19 pandemic illustrates this point rather sharply. In this case, an aggregate shock comes with an idiosyncratic component and hence there is some potential for risk sharing. We account for this complication as we focus directly on business cycle fluctuations and observe that there is scope for risk sharing to the extent that business cycles are not perfectly synchronized across countries and states of the world.

In order to assess the extent of business cycle synchronization, we compute a measure of GDP-synchronicity originally proposed by Kalemli-Ozcan et al. (2013). It is based on the growth difference of economic activity across countries. For EA members we rely on GDP, for US states we use Gross State Product (GSP) as a comprehensive measure of economic activity. Still, for an easier exposition we use "GDP" when referring to the GSP of US states. Formally, we use $\phi_{i,j,t}$ to denote the negative of the absolute value of the difference of GDP growth between EA members (or between US states) i and j:

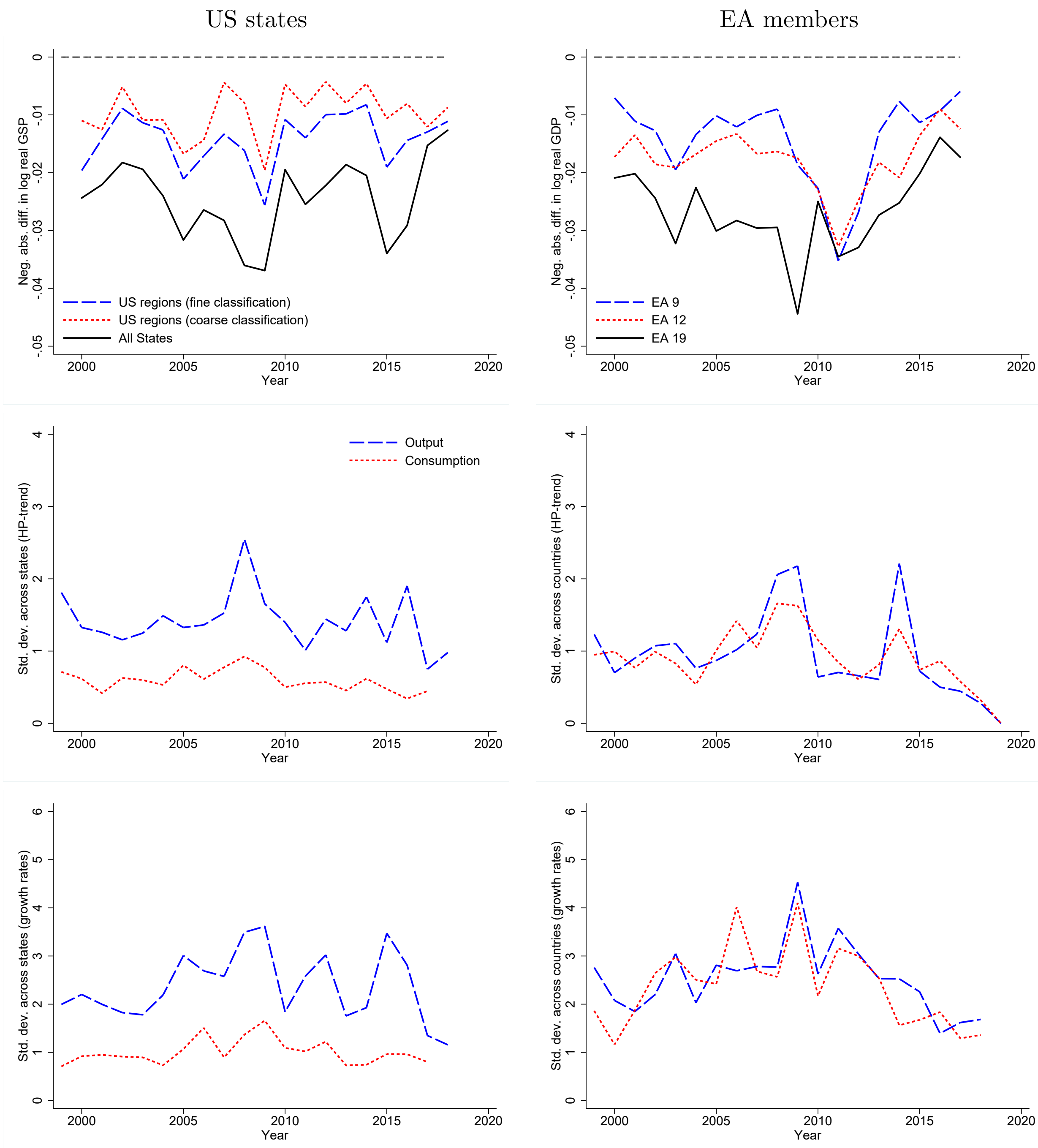
$$\phi_{i,j,t} \equiv -|(\ln gdp_{i,t} - \ln gdp_{i,t-1}) - (\ln gdp_{j,t} - \ln gdp_{j,t-1})| \tag{1}$$

Note that this measure always takes on negative values: a lower absolute value indicates a higher degree of business-cycle synchronicity. We first compute $\phi_{i,j,t}$ on a country-by-country (state-by-state) basis for each year in our sample and for all possible pairs of EA members and US states. Next, we compute the (unweighted) mean of $\phi_{i,j,t}$ over all pairs in a given year.

We show the time series of ϕ_t in the top panels of Figure 1, for the US in the left panel and for

[8] Enders et al. (2013) provide a comprehensive analysis of business cycle statistics for the EA: they focus on possible changes as a result of the introduction of the euro.

Figure 1: Business cycle co-movement across US states and EA members



Notes: top panels display synchronicity of output for US states (left) and EA members (right), computed according to equation (1). Middle panels show dispersion of output and (per-capita) consumption fluctuations across US states/EA members, measured in terms of log deviation from HP-trend (smoothing parameter $\lambda = 6.25$). Bottom panels show dispersion based on growth rates of output and per-capita consumption. Data for EA members is aggregated to annual frequency for the sake of comparison with US data. Data sources: see Appendix 2.

the EA in the right panel. For the sake of comparability we report statistics for the period since 2000, computed on the basis of annual observations. For the US, we show the synchronicity measure not only across US states (black solid line) but also across major regions, using both the fine (blue dashed line) and on the coarse (red dotted line) classification based on GSP data aggregated to the region level. For the EA we report the synchronicity measure for three subgroups: EA9 (blue dashed line), EA12 (red dotted line), and EA19 (black solid line), see again Table A.3 in the appendix for details on the classification. By and large, the picture is similar for the US and the EA. Once we focus on US states and the EA19 group, we find the lowest degree of synchronicity. Moreover, in all instances synchronicity declined during the 2000s and reached rock bottom during the financial crisis. Last, we observe that synchronicity tends to be somewhat higher in the US than in the EA—suggesting that the potential for risk sharing is higher in the EA than in the US.

On a very fundamental level, risk sharing is about insulating *per capita* consumption from *aggregate* output fluctuations. In order to get an idea of the extent of risk that is taking place it is instructive to compare the dispersion of output and consumption across countries/states. For this purpose, we first detrend the data either by using an HP-Filter (using a smoothing parameter of 6.25) or by computing growth rates. We do so both for aggregate output and per-capita consumption and compute the standard deviation across countries/states for each year. The middle panels of Figure 1 show the results based on the HP-Filter, while the bottom panels of the same figure show the results based on differencing the data. As before, we show results for the US in the left panel and for the EA in the right panel. Independently of how we detrend the data, we find that the co-movement of consumption and output dispersions across EA members is much stronger than across US states. In particular, the dispersion of per-capita consumption across US states is low during our sample period, including the global financial crisis of 2007–08 during which the output across US states dispersion picks up sharply. In contrast, no such disconnect between output and consumption dispersion is observed for the crisis years in the EA. Here, the dispersion of consumption tracks the dispersion of output very closely. These patterns suggest that risk sharing across US states is considerably higher than across the members of the Euro area.

Table 1 reports correlation coefficients between output (GDP) and various measures of income per capita as well as consumption per capita over the entire time span for the US and the EA, respectively. Gross national income (GNI) includes net income from factor trade while gross disposable income (GDI) includes net foreign transfers. The top panel reports correlation coefficients for the cyclical component of the variables obtained from applying the HP-filter, while the bottom panel reports it for growth rates of the variables.

A number of observations stand out. First, independently of the measure under consideration the correlation of GDP and the other variables is quite strong and significant in all instances. Second, the correlation declines once we move from GNI to GDI to consumption (all in per capita terms). This suggests that risk sharing is indeed taking place. Third, the decline tends to be quite a bit stronger in the US than in the EA. The correlation of GDP and per-capita consumption, in particular, is not even half as large in the US as it is in the EA. Again, this is suggestive of stronger

Table 1: Correlations between output, income and consumption across the US and the EA

	US states			EA members		
	4 Regions	9 Regions	All states	EA9	EA12	EA19
A) HP-Filter						
$\rho(\text{GDP}, \text{GNI})$	0.74***	0.72***	0.60***	0.75***	0.62***	0.51***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\rho(\text{GDP}, \text{GDI})$	0.64***	0.63***	0.51***	0.74***	0.62***	0.55***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)
$\rho(\text{GDP}, \text{C})$	0.25***	0.22***	0.17***	0.72***	0.30***	0.44***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
B) Growth rates						
$\rho(\text{GDP}, \text{GNI})$	0.68***	0.66***	0.72***	0.90***	0.81***	0.79***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\rho(\text{GDP}, \text{GDI})$	0.61***	0.58***	0.63***	0.89**	0.81***	0.80***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.04)
$\rho(\text{GDP}, \text{C})$	0.25****	0.23***	0.26*	0.77***	0.74***	0.78***
	(0.00)	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)

Notes: Correlation between output, income, disposable income and consumption, across US states and regions and EA members. Top panel: Variables are HP-filtered to isolate cyclical component (smoothing paramter $\lambda = 6.25$). Bottom panel: growth rates. Output (GDP), income (GNI), disposable income (GDI) and consumption (C) are expressed in log real terms. Income and consumption are measured in per capita terms, GDP is not. For the US, data extends from 1963 to 2018 (annual frequency). For the EA the sample extends from 1999 to 2018 (annual frequency). The sample of EA countries exclude observations for Ireland in 2015 due to changes in accounting of GDP. P-values are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

risk sharing in the US than in the Euro area.

3.2 Migration

Our main interest in this paper is to investigate the role of migration as a potential risk-sharing channel and to quantify its importance. As a first step towards this end, we compile a number of basic statistics for EA members and US states. We stress that our econometric strategy (introduced in Section 4 below) does not rely on migration data, but allows us to quantify the migration channel indirectly. Against this background, the descriptive statistics, which we report in what follows, serve as an important cross-check for our main results because they rely directly on migration data. Specifically, we use data from the American Community Survey (ACS) run by the US Census Bureau and the Labor Force Survey (LFS) of Eurostat.

The ACS is an ongoing survey that provides information on movers or migrants within the US since 2005. The US Census Bureau contacts 3.5 million American households on an annual basis to collect information about personal characteristics (such as age, sex and race), income, home ownership etc. Importantly, respondents are also asked whether they resided in the same house or apartment one year ago, and if they have moved, where in the US or abroad they lived one year ago.[9] Based on these data, the ACS provides estimates of migration to, within and between US states, at an annual level. For our analysis, we focus on migration across US states (and the District of Columbia) and ignore within-state migration as well as migration from outside the US. We sum up in- and outmigration for each state and region, taking as the counterparty the remaining states and regions, respectively.

The data for the LFS is collected by national statistical agencies on behalf of Eurostat. Data are available at an annual frequency since 1998. Across the member states of the European Union, about 1.5 million households are surveyed every quarter which amounts to about 0.3% of the total population. Similar to the ACS, the LFS asks a question about the country of residence one year before. Based on these household-level data we compute annual migration flows for each EA member state individually. In doing so, we limit our analysis on migration from and to the remaining countries of the EA9, EA12, and EA19 group, respectively.[10]

In Table 2 we report descriptive statistics for gross migration (average of in- and outmigration) for each US region (left panel) and EA member states (right panel).[11] In principle, a Mundellian perspective would call for a focus on net migration, but gross migration is more informative about labor mobility in general. In each instance, we report absolute numbers, the mean for each region/country over time, as well as a number of statistics expressing migration in percent of the population (mean, median, and standard deviation). In terms of means, there is considerable variation among EA members and among US states. Among EA members, migration is lowest for Italy, Slovakia and Spain, and highest for Luxembourg and Cyprus. In fact, the migration rate for Luxembourg (1.3%) dwarfs the numbers for all EA member states. Hence, in our analysis below, we verify that our results for EA19 members presented in Section 5.1 are not driven by Luxembourg.[12] The mean migration rate in the EA is 0.16 percent compared to 2.84 percent for US regions. It is 2.77 for US states (Table A.4) and thus almost 20 times higher compared to EA members. For the median the difference is even larger, since in this case the high migration rate of Luxembourg matters less. Also the standard deviation is about 2.5 times higher in the US.[13]

The top panels of Figure 2 show the median (gross) migration rate over time. The left panel shows the median state-to-state migration rate across all US states (solid black line) and the median region-to-region migration rate across major US regions (red line coarse classification; blue line fine classification). The right panel shows data for different country groups in the EA. We observe that the median migration rates have been fairly stable over time. For our sample period we do not find

[9]For more information, see https://www.census.gov/acs/www/about/why-we-ask-each-question/migration/

[10]Here, we omit Finland, Ireland and Malta because we lack (reliable) microdata in these instances.

[11]Data for individual US states are reported in the Table A.4 in the appendix to economize on space.

[12]See Section 5.2 for details.

[13]These observations are in line with recent evidence put forward in House et al. (2019). Using administrative (national) data for EA countries, they obtain somewhat higher migration rates (0.34 on average), but they consider in- and outmigration with respect to EU27countries, rather than EA19 member states.

Table 2: Migration in US regions and EA member states

Major US regions					EA members				
	Mean	Mean	Median	SD		Mean	Mean	Median	SD
		% of pop					% of pop		
New England	62030	2.88	2.88	0.14	Austria	12486	0.15	0.14	0.03
Mid-Atlantic	253828	1.89	1.88	0.10	Belgium	19532	0.18	0.18	0.05
EN Centr	172545	1.87	1.85	0.08	Cyprus	2743	0.33	0.30	0.09
WN Centr	76890	2.93	2.92	0.11	Estonia	913	0.07	0.07	0.02
South Atlantic	193285	3.55	3.48	0.18	France	40638	0.06	0.06	0.01
ES Centr	115251	2.48	2.44	0.14	Germany	55062	0.07	0.08	0.02
WS Centr	191055	2.38	2.26	0.30	Greece	8026	0.07	0.07	0.02
Mountain	100080	3.75	3.68	0.21	Italy	15812	0.03	0.02	0.01
Pacific	198708	3.81	3.89	0.34	Latvia	1629	0.08	0.07	0.04
					Lithuania	2920	0.09	0.09	0.05
					Luxemburg	6050	1.13	1.27	0.45
					Netherlands	10059	0.06	0.06	0.02
					Portugal	9264	0.09	0.09	0.02
					Slovakia	1971	0.04	0.04	0.02
					Slovenia	1200	0.06	0.06	0.04
					Spain	22115	0.05	0.05	0.01
Average	151519	2.84	2.87	0.73	Average	13260	0.16	0.07	0.29

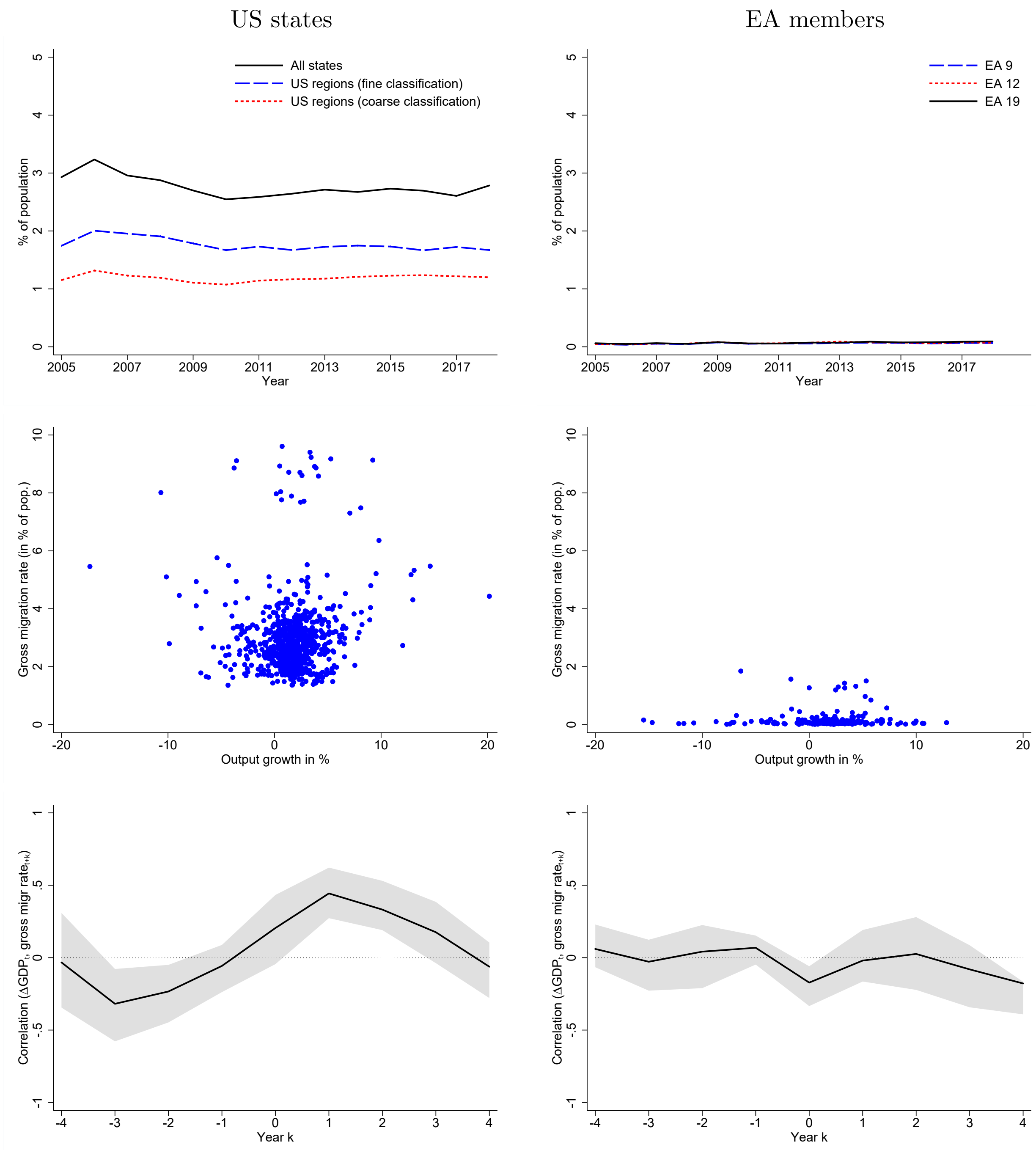
Notes: Migration is average of in- and outmigration (gross migration) for each region/country. Mean is average value per year. For US regions the data runs from 2005 to 2018, regions as defined in Table A.2. For EA members the data runs from 2005 to 2018. No data available for FIN, IRE and MLT. Data sources: see Appendix

much of a decline in mobility across US states documented elsewhere (Basso and Peri 2020; Dao et al. 2017; Kaplan and Schulhofer-Wohl 2017; Molloy et al. 2011).[14] The difference between the US and the EA is again rather stark. Regarding the US, as we move from regions to states, thus taking a more granular perspective, migration rates increase considerably (black solid line in top left panel of Figure 2 vs red dotted line). Intuitively, there is much more migration over the short distance, say from Massachusetts to Connecticut or even New York, than over the long distance, say from the Northeast to the Midwest of the US. Still, also for inter-region migration, migration rates in the US are an order of magnitude larger than for EA member states.

The middle panels of Figure 2 correlate output growth and gross migration rates for all time-state/country observations in the US (left) and the EA (right). Taken at face value, there is no

[14]Basso and Peri (2020) find that average immigration rates have come down from around 2.5 percent in 2005 to around 2.1 percent in 2017. These numbers are also based on ACS data. Yet, Basso and Peri (2020) accesses them through IPUMS (Integrated Public Use Microdata Series). As a result they exclude individuals living in group quarters (see the legend of their Figure 1). Molloy et al. (2011) and Kaplan and Schulhofer-Wohl (2017) also find a (modest) decline in migration, albeit mostly before 2005. Like us, House et al. (2019) document that average gross migration rates have been fairly stable in the US as well as in Europe since 2005.

Figure 2: Migration rates and output growth



Notes: top panels show median gross migration rates in % of population for US interstate and inter-region migration (left) and across EA9, EA12 and EA19 member states (right). Middle panels correlate output growth and gross migration rate. Bottom panels show correlation of output growth in year t and gross migration rate in year $t+k$, with $k = 0, ..., \pm 4$. Shaded areas indicate 25% and 75% interquartile range. Observations for Ireland in 2015 are dropped from the sample. Data sources: see appendix .

systematic variation. The correlation coefficient for US states is 0.07 and 0.009 for EA members.[15]

The contemporaneous correlation may be an insufficient metric to capture the cyclical nature of migration rates for there may be non-trivial lags because, say, migration takes time to adjust in the face of cyclical fluctuations. To account for this complication, we compute the cross-correlation function for output growth in year t and gross migration rates in year $t \pm k$, where k runs from -4 to +4. We compute the cross correlation function state-by-state/country-by-country and display the mean (black solid line) in the bottom panels of Figure 2, for the US in the left panel and for the EA in the right panel. The shaded area indicates the 25% and 75% interquartile range. We find a positive correlation of current output growth and future gross migration rates for US states, while the correlation is close to zero for EA members for all leads and lags of gross migration rates.[16]

4 Econometric framework

In this section, we explain how we extent the framework of ASY to account for migration as a distinct channel of risk sharing. We first provide an intuitive discussion of international risk sharing in the baseline case, focusing on the factor trade channel, the transfer channel, and the credit channel. Then, we extend the approach by introducing the migration channel. Finally, we describe the sample and the empirical implementation.

4.1 The baseline case

To simplify, we briefly collapse the transfer and the factor trade channels of risk sharing into a single mechanism connecting output shocks to disposable income. We generally use lower case letters to indicate levels *per capita*, q for output, y_d for disposable income and c for consumption. With zero insulation of national income from output, all output shocks translate into income shocks, and we observe a high covariance between output shocks and income shocks. In the absence of income shocks, the covariance is equal to the variance of output: $\text{Cov}(\Delta \log q, \Delta \log y_d) = \text{Var}(\Delta \log q)$. Conversely, with full insulation, there is a wedge between output and income changes, $\Delta \log q - \Delta \log y_d$, and this wedge is perfectly correlated with output changes, such that $\text{Cov}\left(\Delta \log q, \Delta \log q - \Delta \log y_d\right) = \text{Var}(\Delta \log q)$. This logic can be summarized by the following variance decomposition:

$$\text{Var}(\Delta \log q) \equiv \text{Cov}\left(\Delta \log q, \Delta \log q - \Delta \log y_d\right) + \text{Cov}(\Delta \log q, \Delta \log y_d). \tag{2}$$

Intuitively, the first term on the right hand side is the larger, relative to the second term, the larger the extent of risk sharing via the transfer and factor trade channel.[17]

Analogous logic applies for the insulation of consumption c from disposable income y_d, that is,

[15] At the state and country level correlations are also small, see Tables A.5 and A.6 in the Appendix.

[16] We also computed this measure for output growth and net migration rates and found that these cross correlation functions are zero for all leads and lags, both for the US and the EA.

[17] To obtain (2), let $\mathbb{E}$ denote the expectations operator, such that $\text{Cov}\left[q, q - y_d\right] = \mathbb{E}\left[q(q - y_d)\right] - \left[\mathbb{E}(q)\right]^2 + \mathbb{E}(q)\mathbb{E}(y_d)$ and $\text{Cov}(q, y_d) = \mathbb{E}(q y_d) - \mathbb{E}(q)\mathbb{E}(y_d)$. Adding, we obtain $\text{Cov}\left[q, q - y_d\right] + \text{Cov}(q, y_d) = \mathbb{E}(q^2) - \left[\mathbb{E}(q)\right]^2 = \text{Var}(q)$.

the credit channel. The two layers of risk sharing can be consolidated into a single decomposition by using $\text{Cov}(\Delta \log q, \Delta \log y_d - \Delta \log c) \equiv \text{Cov}(\Delta \log q, \Delta \log y_d) -$ $\text{Cov}(\Delta \log q, \Delta \log c)$, which allows us to rewrite Eq. (2) as

$$\begin{aligned} \text{Var}(\Delta \log q) \;\; &\equiv \;\; \text{Cov}\left(\Delta \log q, \Delta \log q - \Delta \log y_d\right) + \text{Cov}(\Delta \log q, \Delta \log y_d - \Delta \log c) \\ &\quad + \text{Cov}(\Delta \log q, \Delta \log c). \end{aligned} \tag{3}$$

Again, high values of $\text{Cov}\left(\Delta \log q, \Delta \log q - \Delta \log y_d\right)$ and $\text{Cov}(\Delta \log q, \Delta \log y_d - \Delta \log c)$ indicate a high degree of insulation of, in turn, disposable income from output fluctuations and consumption from fluctuations of disposable income. If either of these insulations is perfect, then consumption will be fully stabilized in the face of output fluctuations: $\text{Cov}(\Delta \log q, \Delta \log c) = 0$. Conversely, if both of these covariances are zero, then neither of the risk-sharing channels provide any insulation and output fluctuations will be passed-through into consumption: $\text{Var}(\Delta \log q) = \text{Cov}(\Delta \log q, \Delta \log c)$.

Dividing both sides of equation (3) by $\text{Var}(\Delta \log q)$, we obtain

$$1 \equiv \hat{\beta}_{qd} + \hat{\beta}_{dc} + \hat{\gamma}_{cq}, \tag{4}$$

where $\hat{\beta}_{qd}$ and $\hat{\beta}_{dc}$ indicate the estimate in an OLS-regression of $\Delta \log q - \Delta \log y_d$ and $\Delta \log y_d - \Delta \log c$ on $\Delta \log q$, respectively. In turn, $\hat{\gamma}_{cq}$ is the OLS-estimate in a regression of $\Delta \log c$ on $\Delta \log q$. Thus, $\hat{\beta}_{qd}$ and $\hat{\beta}_{dc}$ estimate the relative contribution of the factor trade plus transfer channel and the credit channel, respectively, to smoothing of consumption relative to output per capita, and $\hat{\gamma}_{cq}$ measures the share of output shocks that are passed through, unsmoothed, to consumption. It is now straightforward to disentangle the factor trade and the transfer channel by adding a further layer of decomposition in Eq. (3) and replacing $\hat{\beta}_{qd}$ in Eq. (4) by $\hat{\beta}_{qg} + \hat{\beta}_{gd}$, where $\hat{\beta}_{qg}$ and $\hat{\beta}_{gd}$ indicate the estimate in an OLS-regression of $\Delta \log q - \Delta \log y_g$ and $\Delta \log y_g - \Delta \log y_d$ on $\Delta \log q$, respectively. Here, y_g indicates (gross) national income (domestic income plus net foreign factor income).

The approach is agnostic about why, exactly, factor trade, transfers or credit markets do, or do not, contribute to consumption smoothing relative to output per capita. That, in our view, is the big advantage of this approach, relative to a structural approach relying on specific models, say a DSGE-type model. It is also agnostic about the nature of shocks affecting output per capita to start with.

4.2 Extension: migration

The baseline approach outlined above and applied in ASY treats shocks to *per capita* output as the fundamental source of fluctuations which risk sharing may smooth in order to stabilize per capita consumption. Arguably, however, asymmetric macroeconomic shocks that form the starting point of debates about international risk sharing are, first and foremost, shocks to *aggregate* output (or, output, for short). The degree to which such shocks translate into changes in output per capita is exactly the question that the Mundellian criterion of an optimum currency area focuses on. With perfect labor mobility, the putative answer is 'to degree zero'. We now informally trace out possible adjustment paths to demand and supply shocks where labor mobility, to a varying degree, leads to a smoothing of output per capita, relative to output. In all scenarios considered below, we assume an irrevocably fixed exchange rate.

The literature on optimum currency areas typically assumes some form of price rigidity. However, the migration channel of international risk sharing may also be relevant in a world with flexible prices. Suppose, for instance, that an economy produces several traded goods, differentiated from other countries' goods, alongside non-traded goods using sector-specific capital and labor which is mobile across sectors. Then, a positive demand shock for this country's traded goods leads to a reallocation of labor towards traded goods, a price increase for all goods produced by this country, including non-traded goods, and to an increase in GDP. Relative goods prices will change in favor of traded goods. Crucially, the "neoclassical ambiguity" implies that the real wage for workers may rise or fall, depending on the share of workers' expenditure shares.[18] But if a high enough share of expenditure falls on non-traded goods and on other countries' traded goods, then workers will enjoy a real wage increase.[19] With labor mobility across countries in response to real wages, the country will receive immigration. This will further increase output, but with diminishing returns to labor in production. Output per worker will fall, relative to a case without immigration. In turn, the labor inflow will lower the wage, making this a stable adjustment process.[20] The same flexible-price adjustment process works analogously, but with an opposite sign, for countries experiencing a negative demand shock. And it is well known that the general equilibrium effects (on factor prices) of Hicks-neutral but sector-biased technology shocks are isomorphic to relative goods price changes, hence the above adjustment process also holds for such technology (supply) shocks.

The more relevant case for the present context, however, are economies with rigid, or sticky wages and/or prices, as typically assumed in the theory of optimum currency areas ever since Mundell (1961).[21] In one way or another price rigidity potentially prevents the real wage adjustment described in the previous paragraph. Suppose, for instance, there is a negative demand shock requiring lower prices of domestic goods to restore equilibrium on goods markets. If for institutional reasons nominal goods prices or wages cannot fall to the extent required to restore equilibrium, then, other things equal, a rationing situation will ensue, with output falling in sync with the demand

[18]The term "neoclassical" means that the relative wage change is a weighted average of goods price changes, whence the real wage effect is ambiguous; see Feenstra (2015), Chapter 3.

[19]Note that with country-based product differentiation (Armington assumption), the law of one price for tradables does not hold.

[20]The type of adjustment described here is based on the well-known Ricardo-Viner model. The long-run view of the Heckscher-Ohlin model is certainly less plausible in the present case, since it assumes perfect inter-sectoral mobility also of capital. Crucially, the well-known result of "factor price insensitivity" implies that in the long run an inflow or outflow of labor under certain conditions might be absorbed without factor price adjustment, and thus also without any effect on the marginal productivity of capital and labor; see again Feenstra (2015). In such a long-run scenario, a labor inflow would not lower output per capita.

[21]The responsiveness of migration primarily to unemployment (as opposed to real wages) is a key result also of Blanchard and Katz (1992) and some of the subsequent literature discussed in Section 2 above.

shock. Unemployment will rise as a result. With labor mobility, we may expect an outflow of labor, which—as in the flex-price case above—makes output per capita increase, compared to a case without labor mobility.

A similar adjustment process obviously arises for a negative supply shock. But the case of wage rigidity is somewhat less plausible for a positive demand or technology shock. For instance, Schmitt-Grohé and Uribe (2013) provide detailed empirical evidence which illustrates that during the boom-phase in the 2000s wages in peripheral countries of the Euro area have shown a significant upward flexibility but have lacked similar downward rigidity in the subsequent bust caused by the financial crisis of 2008.[22] The consequence was a marked increase in unemployment after 2008, which Schmitt-Grohé and Uribe (2013) explain along the lines above, invoking a lack of exchange rate adjustment (for a thorough theoretical analysis see Schmitt-Grohé and Uribe 2016).[23]

For a positive demand shock, a likely adjustment with a potential for migration to smooth output per capita (relative to output), very briefly, runs as follows. We know from the above that in a flexible-price environment any increase in demand for a country's tradable goods requires an increase in the wage as well as the prices of traded and non-traded goods, with an increase in the price of traded goods relative to both, non-tradables and other countries' tradables, and a reallocation towards tradable goods. The principal idea now is that nominal prices and wages are sticky in the short run, but gradually adjust to achieve a flex-price outcome in the long run. Assuming unemployment to be at its natural rate before the demand shock, the short-run adjustment to the demand shock for tradables will then involve an increase in overall output and employment, coupled with some reallocation towards traded goods, and an incomplete adjustment of goods and wages towards their long-run equilibrium. Crucially, under standard paradigms of aggregate demand and supply analysis with sticky wages, the reduction of unemployment causes upward pressure for wages, which in turn generates reallocation and upward pressure also on goods prices.[24]

With the presence of unemployment, migration will be driven by both real wages and employment perspectives, as in Harris and Todaro (1970). Our approach allows us to be agnostic as to relative strength of these two forces. It also allows us to be agnostic regarding the precise mechanisms through which unemployment comes about in the first place, and the mechanisms through which migration, in turn, affects output and output per capita. Whatever the details, to the extent that migration does respond to real wage rates and unemployment, the adjustment process will be characterized by smoothing of output per capita, relative to output. If one wants to quantify the effects of labor mobility on unemployment across countries, as in House et al. (2019) or on

[22]Born et al. (2019) also provide evidence supporting the notion that downward nominal wage rigidity shapes macroeconomic adjustment under fixed exchange rates: a positive government spending shock appreciates the real exchange rate, while a negative government spending shock does not alter it.

[23]The key point in Schmitt-Grohé and Uribe (2016) is an externality that derives from the asymmetry in wage rigidity: The fact that in a subsequent bust downward wage rigidity will cause unemployment calls for an optimal restraint on expansion during the boom, which could, for instance, take the form of an international borrowing constraint.

[24]Standard paradigms of unemployment and wages are the fair-wages paradigm, efficiency-wages, bargaining in a search-and-matching environment, or collective wage bargaining.

welfare, as in Caliendo et al. (2017) or in Caliendo et al. (2019), then there is no way around specifying a structural model. But if one is primarily interested in empirical measures of risk sharing through different channels, then it seems important to follow an approach which offers the luxury of "structural agnosticism", as our extension of ASY does.[25]

This extension is straightforward given the outline of the approach presented above: it allows to introduce international labor mobility ("migration") as a further channel of international risk sharing. Thus, by complete analogy to expression (2) above, consider the following variance decomposition of aggregate output, denoted by Q, into its smoothed and unsmoothed component—as far as output per capita, q, is concerned:

$$\text{Var}(\Delta \log Q) \equiv \text{Cov}\left(\Delta \log Q, \Delta \log Q - \Delta \log q\right) + \text{Cov}(\Delta \log Q, \Delta \log q). \tag{5}$$

Carrying the analogy further, we may use $\text{Cov}(\Delta \log Q, \Delta \log q - \Delta \log y_d) \equiv \text{Cov}(\Delta \log Q, \Delta \log q) - \text{Cov}(\Delta \log Q, \Delta \log y_d)$, which allows us to rewrite Eq. (5) as

$$\begin{aligned} \text{Var}(\Delta \log Q) \quad \equiv \quad & \text{Cov}\left(\Delta \log Q, \Delta \log Q - \Delta \log q\right) + \text{Cov}(\Delta \log Q, \Delta \log q - \Delta \log y_d) \\ & + \text{Cov}(\Delta \log Q, \Delta \log y_d) \end{aligned} \tag{6}$$

Repeating this logic, familiar by now, we finally obtain the following relationship between OLS-coefficients measuring the contribution of different channels of international risk sharing:

$$1 \equiv \hat{\beta}_{Qq} + \hat{\beta}_{qg} + \hat{\beta}_{gd} + \hat{\beta}_{dc} + \hat{\gamma}_{cq}, \tag{7}$$

The new element here is what we call the migration channel, appearing as an additional layer at the top of the cascade of risk sharing channels smoothing consumption per capita relative to output. Note that this also implies a change in the "explanatory variable" in the cascade of regressions from per capita output q to output Q.

The big advantage of this extension is that we are able to quantify the contribution of the migration channel to international risk sharing relative to the channels so far discussed in the literature in a unified framework.[26] An assumption implicit in our extension is that any insulation

[25] The approach is also agnostic regarding the precise nature of the shock leading to a change in output. Developing a DSGE-model of a currency union of countries featuring price rigidity and producing traded as well as non-traded goods, Farhi and Werning (2014) demonstrate that migration provides no help for countries in absorbing demand shocks for non-traded goods whereas it does for demand shocks for traded goods. Against this backdrop, if our application of the extended ASY approach reveals very little risk sharing through migration, the reason might be limited migration, but it may also be that the underlying shocks were of the "wrong type".

[26] ASY acknowledge the risk sharing potential of migration by separately regressing $\Delta \log q$ on $\Delta \log q^*$, where q^* is output Q divided by migration-adjusted population, interpreted as per capita output in a counterfactual situation without migration. They interpret an estimated coefficient equal to 0.73 (based on decadal changes) as indicating that 73 percent of the changes $\Delta \log q^*$ are passed on to $\Delta \log q$. Since the latter includes migration-induced changes (if any), ASY conclude that only 27 percent of the shocks are smoothed through migration. There are two major drawbacks of this approach. The first is that it assumes migration to have an effect on output. This is, of course, questionable, and ASY therefore interpret their result as an upper bound of smoothing. The second drawback is that the approach does not treat the migration channel and the other channels of risk sharing on an equal footing within a unified approach, which is what we do in our extension of the ASY-framework.

of per captia output from fluctuations in aggregate output is due to migration. In principle, demographic changes may also account for a wedge in the co-movement of per capita and aggregate output, but we assume that their effect is negligible in the short run.

4.3 Sample and empirical implementation

At the practical level, we estimate the following (panel) regression equations:

$$\Delta \log Q_{it} - \Delta \log q_{it} = \tau_{t,Qq} + \eta_{i,Qq} + \beta_{Qq} \Delta \log Q_{it} + \varepsilon_{it,Qq} \tag{8}$$

$$\Delta \log q_{it} - \Delta \log y_{it,g} = \tau_{t,qg} + \eta_{i,qg} + \beta_{qg} \Delta \log Q_{it} + \varepsilon_{it,qg} \tag{9}$$

$$\Delta \log y_{it,g} - \Delta \log y_{it,d} = \tau_{t,gd} + \eta_{i,gd} + \beta_{gd} \Delta \log Q_{it} + \varepsilon_{it,gd} \tag{10}$$

$$\Delta \log y_{it,d} - \Delta \log c_{it} = \tau_{t,dc} + \eta_{i,dc} + \beta_{dc} \Delta \log Q_{it} + \varepsilon_{it,dc} \tag{11}$$

$$\Delta \log c_{it} = \tau_{t,cq} + \eta_{i,cq} + \gamma_{cq} \Delta \log Q_{it} + \varepsilon_{it,cq} \tag{12}$$

where $\tau_{t.}$ are time fixed effects and $\eta_{i.}$ are state- or country-fixed effects, respectively, and $\varepsilon_{it.}$ denotes the error term. Again, Q is real *aggregate* output, q is real per capita output, y_g is gross (state or national) real per capita income, y_d is disposable real per capita income and c denotes real per capita consumption. All variables are expressed in log differences (year-on-year). We estimate this system of (panel) regressions one by one using OLS with panel-corrected standard errors, using annual data for the US and on quarterly data for the EA.[27] The frequency differs across these currency unions in our estimation because we lack quarterly observations of state-level variables for the US. At the same time, the sample for the EA is relatively short so that we prefer quarterly to annual observations to increase the sample size. For the US, the sample runs from 1963 to 2017 and includes all 50 US states as well as the District of Columbia. For the Euro area the sample runs from 1998 to 2018 and includes all EA19 countries.[28] However, we also present results for subgroups of the Euro area, namely EA9 and EA12.

5 Results

We now report our results, contrasting, as in Section 3 above, those for the US with those for the EA. We first present estimates for the baseline specification and then explore the sensitivity of our results.

[27]We verified that our results are robust to estimating Equations (8) to (12) by feasible GLS which has been used by ASY and European Commission (2016) to estimate channels of risk sharing.

[28]Still, we exclude observations for Ireland in 2015 due to an extraordinary increase in GDP because of changes in accounting.

5.1 Baseline specification

Throughout, we provide estimates based on data for both, the US and the EA. For the US, we distinguish three different levels of regional disaggregation: 4 regions (coarse classification), 9 regions (fine classification), and 51 states (see Table A.2). For the EA, we distinguish between different delineations of the Euro area: EA9, EA12 and EA19 (see Table A.3 for details). It should be noted that these latter country groupings do not represent different levels of regional disaggregation, but instead follow the historic evolution of European integration and the adoption of the euro.

Table 3 reports the results for the baseline. Each panel provides details on one of the five regressions, as detailed in the equations (8) – (12) above. The coefficients reported provide measures for specific channels of risk sharing or, in case of equation (12), a measure for the residual fraction of output fluctuations that are uninsured and passed-through into per capita consumption. The result of this latter regression is reported in the bottom panel of the table. For US states that fraction amounts to 20 percent, for the EA19 the corresponding number is 66 percent—more than three times as large. Thus, according to this metric, there is considerably less risk sharing among members of the Euro area than among US states.

These results confirm findings of earlier studies established for smaller samples and less recent time spans. As regards the unsmoothed fluctuations of output per capita, the European Commission (2016) reports values of 17.6 and 75.7 percent for US states and a sample of 13 EA countries, respectively. A much earlier study by Sorensen and Yosha (1998) reports similarly high values for the unsmoothed part of income fluctuations in the members of the European Community considering the 1960s to the 1990s; and the original estimate for US states obtained by ASY is as low as 25 percent, that is, in the same ballpark as our result for US states.[29] Turning to US regions (rather than states) and subsamples of the EA, we find that differences in risk sharing are less dramatic, but still sizeable. Between the 4 large US regions 48 percent of income fluctuations remain unsmoothed and 36 percent between the 9 smaller regions. For EA9 and EA12 the number is 59 and 57 percent, respectively. Again, this result is in line with recent estimates for selected EA countries (Cimadomo et al. 2020; Hoffmann et al. 2019). In view of Section 4, it should be noted that all of these earlier studies have explored smoothing of consumption per capita relative to output per capita, whereas our extension covering the migration channel explores smoothing of consumption per capita relative to *aggregate* output.

In order to see what accounts for the difference in risk sharing across US states and EA members, we turn to the estimates for specific risk sharing channels in the upper panels of Table 3. The factor-trade channel plays the largest role for risk sharing in the US. It smooths 46 percent of income fluctuations. Based on their much shorter sample, ASY report a similar number (for what they call

[29]Traditionally, estimates for the EA are only based on selected member states. The European Commission (2016) does not include new member states as well as Austria and Greece. Their sample covers the period from 2000 to 2015. Sorensen and Yosha (1998) focus on the former members of the European Community until 1990 including Denmark and UK but leave out southern European countries as well as new member states in their analysis. The estimates of ASY for US states are based on data from 1964 to 1990.

Table 3: Quantification of risk sharing channels in US states and EA members

	US			EA members		
	4 Regions	9 Regions	All states	EA9	EA12	EA19
Migration						
$\hat{\beta}_{Qq}$	0.13	0.11	0.08***	0.03	0.01	0.02
	(0.15)	(0.06)	(0.02)	(0.03)	(0.02)	(0.02)
R^2	0.61	0.56	0.78	0.59	0.75	0.73
N	216	486	2754	693	916	1447
Factor Trade						
$\hat{\beta}_{qg}$	0.28	0.36***	0.46***	0.16**	0.13*	0.09
	(0.09)	(0.03)	(0.06)	(0.03)	(0.05)	(0.06)
R^2	0.83	0.70	0.51	0.16	0.16	0.10
N	216	486	2754	661	876	1383
Transfers						
$\hat{\beta}_{gd}$	−0.02	0.05*	0.06***	0.01	−0.01	0.03*
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
R^2	0.95	0.93	0.84	0.18	0.11	0.05
N	216	486	2754	661	876	1383
Credit						
$\hat{\beta}_{dc}$	0.13	0.11	0.21***	0.25*	0.31	0.21
	(0.07)	(0.08)	(0.06)	(0.08)	(0.15)	(0.11)
R^2	0.97	0.94	0.82	0.39	0.35	0.16
N	216	486	2754	661	876	1383
Unsmoothed						
$\hat{\gamma}_{cq}$	0.48**	0.36***	0.20***	0.59***	0.57**	0.66***
	(0.07)	(0.07)	(0.03)	(0.08)	(0.15)	(0.07)
R^2	0.98	0.96	0.89	0.77	0.68	0.74
N	216	486	2754	693	916	1447

Notes: results from regression of different wedges on the change in log real Gross State Product (GSP) or Gross Domestic Product, respectively, see equations (8) - (12). For US states, the sample extends from 1963 to 2017 (yearly frequency) and for EA members the sample extends from 1998 to 2018 (quarterly frequency). State-/country- and time fixed effects are included but not reported. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

the "capital markets" channel). According to our estimates, this channel is basically not operative for the EA19 at all, though somewhat active for EA9 and EA12; in these cases we find that 16 and 13 percent of output fluctuations are smoothed. Again, the European Commission (2016) also finds similar results for risk sharing via cross border factor income: 44.8 percent for the US and 5.6 percent for a subsample of the EA. The lack of risk sharing via the factor trade channel suggests that the degree of capital market integration in the EA is rather limited.[30]

The credit channel is the second most important channel for risk sharing in the US, and while it accounts for 21 percent of risk sharing across US states we find that its role for risk sharing in the EA is even larger, at least for the EA9 and the EA12, although estimates are only marginally significant. Again, our estimates are very similar to those of ASY and the European Commission (2016). Transfers, in turn, play a moderate role for risk sharing in the US (at least when we consider all states) and virtually none in the Euro area, except marginally for the EA19 members. The latter finding is consistent with results of the European Commission (2016), while our estimates for the US suggest that the role of transfers for risk sharing declined somewhat, relative to the earlier estimate of 13 percent obtained by ASY. Still, the larger role of transfers for risk sharing across US states seems noteworthy in light of the efforts in Europe to increase risk sharing via a common budget and/or a union-wide unemployment reinsurance scheme (e.g, Ignaszak et al. 2020; Nettesheim 2020).

So far, we have focused on the channels of risk sharing which have traditionally been investigated within the framework of ASY. By and large, our results confirm earlier findings, even though our sample includes more countries and more recent observations. These results provide a context for the core contribution of our analysis, namely the estimate for the quantitative relevance of migration for risk sharing. This channel has traditionally been neglected in the analysis of risk sharing à la ASY and yet their framework, as shown in Section 4, can be extended to account for migration as a distinct channel of risk sharing in a straightforward way. This is what we do in the top panel of Table 3, again based on equation (8). We find a non-negligible contribution of migration to risk sharing across US states: they buffer a full 8 percent of output fluctuations at the state level and the estimates are similar, though not statistically significant for US regions. The fact that the migration channel is not significant across regions is consistent with the notion that migration often takes place across states but within US regions, see again the upper-left panel of Figure 2. For instance, people rather move from Massachusetts to New York, say to start a new job, than going all the way to Texas or Oregon. Turning to the role of migration as a channel for risk-sharing in the Euro area our results are clear cut: there is none (so far). This result is perhaps not surprising, given the received wisdom and the descriptive statistics presented in Section 3 above. Still, the contrast between our estimates for the US and the EA is quite striking.

As we describe in Section 4.3, we estimate our baseline on annual data for the US and on quarterly data for the EA. The data frequency may matter for our results, however, because different channels of risk sharing may operate over different time horizons; and our results for migration may to some extent be explained by the fact that we consider only annual data for the US—after all, migration is likely to take place at somewhat lower frequencies. To asses this issue systematically, we reestimate our baseline model after differencing the data over alternative intervals. In this way,

[30]The EU commission has initiated various efforts to "complete" the so-called "capital markets union" (European Commission 2020). In fact, in the present context capital market integration plays a dual role: the factor trade channel operates through cross-border ownership of financial assets (the stock view), while the credit channel considered below operates through cross-border lending or borrowing (the flow view).

Table 4: Quantification of risk sharing channels in US states and EA members for changing difference intervals.

	US all states					EA19				
	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=4$	$k=8$	$k=12$	$k=16$	$k=20$
Migration										
$\hat{\beta}_{Qq}$	0.08***	0.12***	0.14***	0.16***	0.17***	0.02	0.03	0.04	0.05	0.06
	(0.02)	(0.02)	(0.02)	0.02	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)
R^2	0.78	0.82	0.85	0.87	0.89	0.73	0.76	0.79	0.82	0.85
N	2754	2703	2652	2601	2550	1447	1371	1298	1223	1147
Factor Trade										
$\hat{\beta}_{qg}$	0.46***	0.39***	0.36***	0.35***	0.34***	0.09	0.05	0.03	0.01	−0.02
	(0.06)	(0.04)	(0.03)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
R^2	0.51	0.52	0.53	0.53	0.56	0.10	0.16	0.23	0.29	0.38
N	2754	2703	2652	2601	2550	1383	1307	1234	1159	1083
Transfers										
$\hat{\beta}_{gd}$	0.06***	0.07***	0.07***	0.07***	0.07***	0.03*	0.03**	0.03*	0.03*	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R^2	0.84	0.88	0.90	0.89	0.89	0.05	0.07	0.09	0.13	0.17
N	2754	2703	2652	2601	2550	1383	1307	1234	1159	1083
Credit										
$\hat{\beta}_{dc}$	0.21***	0.14**	0.09*	0.07	0.04	0.21	0.22	0.23	0.26	0.25
	(0.06)	(0.05)	(0.04)	(0.04)	(0.04)	(0.11)	(0.14)	(0.15)	(0.15)	(0.17)
R^2	0.82	0.83	0.86	0.87	0.88	0.16	0.24	0.31	0.37	0.42
N	2754	2703	2652	2601	2550	1383	1307	1234	1159	1083
Unsmoothed										
$\hat{\gamma}_{cq}$	0.20***	0.29***	0.33***	0.36***	0.39***	0.66***	0.69***	0.68***	0.68***	0.69***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.08)	(0.09)	(0.11)	(0.11)	(0.11)
R^2	0.89	0.91	0.92	0.93	0.94	0.74	0.84	0.88	0.90	0.93
N	2754	2703	2652	2601	2550	1447	1371	1298	1223	1147

Notes: results from regression of different wedges on the change in log real Gross State Product (GSP) or Gross Domestic Product, respectively, see equations (8) - (12). The data are differenced using intervals of k years (US) or quarters (EA), respectively. For US states, the sample extends from 1963 to 2017 (yearly frequency) and for EA members the sample extends from 1998 to 2018 (quarterly frequency). State-/country- and time fixed effects are included but not reported. Standard errors are reported in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

we consider a time horizon of 1 to 5 years, both for US states and EA19 members. In this way we account for longer time horizons over which risk sharing may (or may not) take place.

Table 4 reports the results. For US states, for which we show results as before in the left part of the table, we observe that different channels play indeed a different role at different time horizons.

Note first that risk sharing as a whole works best in the short run, when only 20 percent of output fluctuations are left unsmoothed. That fraction increases gradually as we consider longer time horizons. Once we consider a five year horizon, 39 percent of output fluctuations are left unsmoothed. This is perhaps to be expected because theory suggests that transitory fluctuations are easier to (self) insure (Baxter and Crucini 1995). And indeed, we find that the importance of the credit channel, in particular, declines strongly for longer time horizons. This finding is also in line with earlier estimates by ASY. They find a substantial decline in the importance of the credit channel over longer horizons, too. We also see some decline in the importance of the factor trade channel. For the transfer channel we do not observe a systematic change across horizons, but we do for the migration channel: its importance increases strongly as the time horizon increases—from 8 percent in the baseline when the time horizon is one year to 17 percent when the time horizon is 5 years. We think this finding is quite striking and plausible since one would expect migration to play a more important role at lower frequencies because of relocation costs.

For the Euro area, however, we find no systematic differences across time horizons, as evidenced by the right part of Table 4. The extent of risk sharing is low—in general and for each channel under consideration in particular. That said, for the Euro area, too, we observe a somewhat increased role for migration once we increase the time horizon under consideration. But estimated contribution of migration to consumption smoothing remains insignificant even for longer time horizons. Our main result is thus robust: migration contributes substantially to risk sharing across US states; it does not add to risk sharing across EA members.

5.2 Sensitivity analysis

We also consider a number of alternative specifications to explore the robustness of our results. First, we estimate equations (8) – (12) for a number of subperiods. In this case we focus on US states since in this case the sample is much longer. Table 5 reports the results, with each column pertaining to a specific subperiod, starting with the period 1963–1970 in column one. The last period runs from the global financial crisis to the end of our sample period. We see some variation across sample periods, but by and large the basic pattern is robust: there is considerable risk sharing taking place mostly via the factor trade and the credit channel. There is an important exception, however: the role of migration as a risk sharing channel has clearly been declining over time—in line with the received wisdom and some of the work to which we refer in Section 3 above. Also, we observe that during and after times of economic crises (see column 3 and 6 of Table 5) risk sharing through migration drops sharply: naturally, relocating in order to improve one's economic perspective is difficult when a symmetric shock occurs.

Second, we note that the global financial crisis affected countries and states quite differently, notably in the EA. One may thus ask whether results are driven by this episode. Hence, we estimate our model on two distinct samples. The first runs up to 2007 and hence excludes the global financial crisis. The second starts in 2008 and runs to the end of our sample period. Thus, it includes the

Table 5: Quantification of risk sharing channels in US states for subperiods.

	US all states					
	1963-1970	1971-1980	1981-1990	1991-2000	2001-2007	2008-2017
Migration						
$\hat{\beta}_{Qq}$	0.10***	0.06**	0.00	0.04*	0.06**	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
R^2	0.84	0.91	0.75	0.95	0.87	0.88
N	357	459	459	459	306	459
Factor Trade						
$\hat{\beta}_{qg}$	0.27***	0.33***	0.67***	0.59***	0.61***	0.39***
	(0.04)	(0.08)	(0.14)	(0.05)	(0.14)	(0.10)
R^2	0.48	0.49	0.67	0.59	0.67	0.46
N	357	459	459	459	306	459
Transfers						
$\hat{\beta}_{gd}$	0.03	0.06***	0.09***	0.02	0.03	0.11*
	(0.03)	(0.01)	(0.02)	(0.02)	(0.05)	(0.05)
R^2	0.82	0.79	0.75	0.70	0.85	0.80
N	357	459	459	459	306	459
Credit						
$\hat{\beta}_{dc}$	0.37***	0.44**	0.11	0.07	0.22*	0.37***
	(0.09)	(0.15)	(0.12)	(0.11)	(0.09)	(0.10)
R^2	0.52	0.22	0.2	0.95	0.6	0.49
N	357	459	459	459	306	459
Unsmoothed						
$\hat{\gamma}_{cq}$	0.23*	0.11	0.14	0.28**	0.09	0.13
	(0.09)	(0.08)	(0.08)	(0.09)	(0.07)	(0.07)
R^2	0.68	0.51	0.42	0.95	0.88	0.68
N	357	459	459	459	306	459

Notes: results from regression of different wedges on the change in log real Gross State Product (GSP), see equations (8) - (12). The total sample extends from 1963 to 2017 (yearly frequency). State- and time-fixed effects are included but not reported. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

global financial crisis and also the crisis in the EA which developed in its wake. Tables A.7 and A.8 in the appendix report the results. Consistent with our results for the subsamples reported in Table 5, we do not find much of a change in the US. Also, for the EA results for the periods before and after 2007/8 are fairly similar. In the more recent period, that is, the period which includes the euro crisis, risk sharing was further reduced in the EA. Notably, the importance of the credit channel declined. This decline has been compensated somewhat, but not completely, by an increased importance of the factor trade channel.

Third, we verify that our results for the EA are not driven by outliers, that is, countries with specific economic characteristics. This is particularly relevant because, as discussed above, earlier studies of risk sharing in the EA have typically been conducted on the basis of less encompassing samples while our baseline includes all 19 member states. Table A.9 in the appendix shows results for samples which exclude, in turn, Luxembourg, Ireland, and Greece. Luxembourg, as shown in Section 3.2 above, stands out in terms of migration. The time series for Ireland are subject to a major revision of the national accounts during our sample period while Greece has been at the heart of the crisis in the EA in the first half of the 2010s. And yet, as Table A.9 shows, none of our results for the baseline changes in a material way once we leave out one of these countries.

Finally, Table A.10 in the appendix reports results for alternative time horizons for risk sharing for US regions and for EA9 and EA12, by analogy to Table 4 above. This table illustrates for US states, in particular, that the differencing interval matters for the extent of risk sharing, as one would expect it to do. It turns out that a similar effect is present for US regions once we use the fine classification. Here, the migration channel becomes more important over longer horizons, while the importance of the credit channel declines. For the coarse classification we do not find that the importance of the migration channel increases with the horizons. For EA9 we find that the importance of the migration channel also rises with the length of the time interval, but the channel is generally not statistically significant. The importance of the credit channel also declines strongly for the EA9 sample (but less so for EA12). For the factor trade channel the decline is stronger for the EA12 sample.

6 Conclusion

In this paper we suggest a straightforward extension of the framework introduced by ASY that allows us to account for migration as an additional channel of risk sharing. The extension is remarkably simple, requiring no more than refocusing the analysis on fluctuations of *aggregate* rather than *per capita* output. Taking a Mundellian perspective on optimum currency areas, we employ this framework in order to compare the contribution of migration to consumption smoothing across US states and regions with that of migration across member countries of the Euro area.

We find that there is considerably more risk sharing among US states than among countries of the EA. For US states only 20 percent of output fluctuations are unsmoothed, for the members of the EA the corresponding number is 66 percent. The relative importance of the various risk sharing channels differs, too. In particular, migration among US states smooths as much as 8 percent of output fluctuations at a one year horizon and up to 17 percent at a five year horizon. In stark contrast, migration makes no significant contribution to risk sharing in the EA, no matter what time horizon one looks at.

We complement this analysis with survey evidence on migration across US states and across the member states of the EA. Consistent with our results on risk sharing we find that migration rates are about 20 times higher in the US than in the EA (2.84 vs 0.16 percent on average). These findings suggest that—even though the freedom of movement is one of the pillars of the EU's single market—policies aimed at further increasing intra-EA mobility hold great potential in terms of raising the risk-sharing capacity of the EA.

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Appendix

Table A.1: Data sources for US states and EA members

Variable	Description	Source
US states		
GSP	Real gross state product (based on aggregate GDP deflator, own calculations)	US Bureau of Economic Analysis (BEA), retrieved from FRED St. Louis
State Income	Real state income (based on aggregate GDP deflator, own calculations)	US Bureau of Economic Analysis (BEA), US Census Bureau Government Finances, The Whitehouse
Disposable State Income	Real disposable state income (based on aggregate GDP deflator, own calculations)	US Bureau of Economic Analysis (BEA), US Census Bureau Government Finances, The Whitehouse
Consumption	Real consumption (based on aggregate GDP deflator, own calculations)	US Bureau of Economic Analysis (BEA), US Census Bureau Government Finances
GDP deflator	GDP (implicit) price deflator (2012=100), seasonally adjusted (federal level only)	US Bureau of Economic Analysis (BEA), retrieved from FRED St. Louis
Gross migration	The average of absolute immigration and emigration based on 1-year estimates of movers (US citizens) between US states. For more information, see Section 3.2	US Census Bureau, American Community Survey (ACS)
Gross migration rate	Gross migration in percent of total (state) population, see gross migration	
Population	US Census Bureau midyear state population estimates	US Census Bureau, retrieved from FRED St. Louis
EA members		
GDP	Real gross domestic product, seasonally and calendar adjusted (chain linked volumes (2010), own calculations)	Eurostat, Statistical Office of the Slovak Republic (SVK)
GNP	Real gross national product, seasonally and calendar adjusted (chain linked volumes (2010), own calculations)	Eurostat, Italian National Institute of Statistics (ITA), AMECO (LUX)
GNDI	Real gross national disposable income, seasonally and calendar adjusted (chain linked volumes (2010), own calculations)	Eurostat, Italian National Institute of Statistics (ITA), AMECO (LUX, MLT)
Consumption	Real final consumption expenditure, seasonally and calendar adjusted (chain linked volumes (2010), own calculations)	Eurostat, OECD (SVK)
GDP deflator	GDP (implicit) price deflator (2010=100)	Eurostat, Statistical Office of the Slovak Republic (SVK)
Gross migration	The average of absolute immigration and emigration based on bilateral migration flows among EA19 member states. For details, see Section 3.2	Eurostat LFS (see Section 3.2)
Gross migration rate	Gross migration in percent of total population, see gross migration	
Population	Population as of 1. January of each year	Eurostat

Notes: In constructing the data for US states we essentially followed Asdrubali et al (1996) and European Comission (2016). Further information on calculations available upon request. Observations for Ireland in 2015 are excluded due to changes in the accounting of GDP. Data for US states is in annual frequency and data for EA members is in quarterly frequency.

Table A.2: Region classifications for the US

A) Fine region classification (9 regions)	
New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Mid-Atlantic	New Jersey, New York, Pennsylvania
East North Central	Illinois, Indiana, Michigan, Ohio, Wisconsin
West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
South Atlantic	Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, DC
East South Central	Alabama, Kentucky, Mississippi, Tennessee
West South Central	Arkansas, Louisiana, Oklahoma, Texas
Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific	Alaska, California, Hawaii, Oregon, Washington
B) Coarse region classification (4 regions)	
Northeast	New England, Mid-Atlantic
Midwest	East North Central, West North Central
South	South Atlantic, East South Central, West South Central
West	Mountain, Pacific

Notes: Region classification follows official classification of US Census Bureau

Table A.3: Sample definitions of Euro area member states

EA9 (founding members except LUX & IRL)	BEL, DEU, FIN, FRA, ITA, NLD, AUT, PRT, ESP
EA12 (founding members + GRC)	BEL, DEU, FIN, FRA, IRL, ITA, LUX, NLD, AUT, PRT, ESP, GRC
EA 19 (all members, last accession 2015)	BEL, DEU, FIN, FRA, IRL, ITA, LUX, NLD, AUT, PRT, ESP, GRC, EST, LVA, LTU, MLT, SVK, SVN, CYP

Table A.4: Migration in US states and the District of Columbia

State	Mean	Mean	Median	SD	State	Mean	Mean	Median	SD
		% of pop					% of pop		
Alabama	109889	2.30	2.28	0.17	Montana	35119	3.51	3.57	0.28
Alaska	51900	7.28	7.75	1.71	Nebraska	50004	2.71	2.64	0.20
Arizona	219946	3.38	3.35	0.27	Nevada	113953	4.17	4.10	0.44
Arkansas	76778	2.63	2.50	0.28	New Hampshire	44725	3.37	3.38	0.23
California	558551	1.48	1.46	0.12	New Jersey	178730	2.03	2.05	0.13
Colorado	188015	3.64	3.68	0.19	New Mexico	65617	3.20	3.18	0.24
Connecticut	88853	2.49	2.49	0.16	New York	346280	1.78	1.77	0.10
Delaware	32502	3.57	3.45	0.32	North Carolina	266226	2.76	2.71	0.20
DC	53926	8.57	8.71	0.66	North Dakota	29695	4.21	4.35	0.56
Florida	500772	2.59	2.49	0.23	Ohio	199085	1.72	1.74	0.07
Georgia	270391	2.76	2.71	0.26	Oklahoma	103318	2.73	2.74	0.15
Hawaii	57971	4.22	4.20	0.33	Oregon	121992	3.14	3.09	0.21
Idaho	61264	3.85	3.80	0.26	Pennsylvania	236476	1.86	1.86	0.10
Illinois	258046	2.02	2.05	0.11	Rhode Island	32699	3.09	3.12	0.21
Indiana	140405	2.16	2.13	0.13	South Carolina	142174	3.03	3.00	0.12
Iowa	76254	2.49	2.48	0.13	South Dakota	27260	3.29	3.26	0.21
Kansas	92340	3.23	3.23	0.15	Tennessee	170985	2.67	2.66	0.13
Kentucky	105139	2.41	2.41	0.12	Texas	479630	1.86	1.80	0.16
Louisiana	104492	2.30	2.04	0.66	Utah	88139	3.13	3.11	0.24
Maine	33123	2.49	2.51	0.20	Vermont	22193	3.55	3.52	0.24
Maryland	169310	2.90	2.90	0.15	Virginia	256920	3.17	3.16	0.15
Massachusetts	150587	2.27	2.26	0.11	Washington	203125	2.95	2.90	0.17
Michigan	157944	1.59	1.60	0.08	West Virginia	47349	2.58	2.57	0.13
Minnesota	109218	2.04	2.05	0.12	Wisconsin	107245	1.88	1.89	0.10
Mississippi	74991	2.53	2.43	0.27	Wyoming	28586	5.09	5.20	0.52
Missouri	153460	2.56	2.57	0.12					
Average	143012	3.01	2.77	1.29					

Notes: Migration is average of in- and outmigration (gross migration) for each state. Mean is average value per year. The data runs from 2005 to 2018. Data sources: see Appendix

Table A.5: Correlation between output growth and gross migration rate for all US states

State	$\rho(\Delta$ log gsp, gross migr)	State	$\rho(\Delta$ log gsp, gross migr)
Alabama	-0.27	Montana	0.15
Alaska	0.14	Nebraska	0.23
Arizona	0.36	Nevada	0.22
Arkansas	-0.01	New Hampshire	0.05
California	0.42	New Jersey	0.57
Colorado	0.47	New Mexico	0.46
Connecticut	0.43	New York	-0.08
Delaware	-0.16	North Carolina	0.37
DC	0.25	North Dakota	-0.18
Florida	0.30	Ohio	0.03
Georgia	-0.30	Oklahoma	0.16
Hawaii	-0.30	Oregon	0.37
Idaho	0.37	Pennsylvania	0.40
Illinois	0.06	Rhode Island	0.01
Indiana	-0.19	South Carolina	0.53
Iowa	0.01	South Dakota	-0.17
Kansas	-0.08	Tennessee	0.23
Kentucky	-0.14	Texas	0.37
Louisiana	0.13	Utah	0.34
Maine	-0.01	Vermont	-0.41
Maryland	0.15	Virginia	0.14
Massachusetts	0.12	Washington	0.49
Michigan	-0.47	West Virginia	-0.21
Minnesota	-0.18	Wisconsin	0.01
Mississippi	0.47	Wyoming	-0.02
Missouri	0.28		
Average	0.12		

Table A.6: Correlation between output growth and gross migration rate for EA19 member states

Country	$\rho(\Delta \log \text{gdp, gross migr})$	Country	$\rho(\Delta \log \text{gdp, gross migr})$
Austria	-0.23	Latvia	0.27
Belgium	-0.18	Lithuania	-0.17
Cyprus	-0.20	Luxembourg	-0.53
Estonia	-0.16	Netherlands	-0.49
France	-0.15	Portugal	0.10
Germany	-0.38	Slovakia	-0.40
Greece	-0.37	Slovenia	0.48
Italy	-0.03	Spain	0.23
Average	-0.14		

Notes: No (reliable) microdata for FIN, IRE and MLT available

Table A.7: Quantification of risk sharing channels in US states and EA members before 2008.

	US states			EA members		
	4 Regions	9 Regions	All states	EA9	EA12	EA19
Migration						
$\hat{\beta}_{Qq}$	0.12	0.11	0.08***	0.04	−0.01	−0.02
	(0.16)	(0.06)	(0.02)	(0.03)	(0.03)	(0.01)
R^2	0.60	0.54	0.80	0.86	0.91	0.90
N	176	396	2244	324	432	676
Factor Trade						
$\hat{\beta}_{qg}$	0.26	0.37***	0.47***	0.15	0.36**	0.12
	(0.10)	(0.03)	(0.06)	(0.09)	(0.11)	(0.11)
R^2	0.62	0.53	0.46	0.18	0.23	0.19
N	176	396	2244	292	392	612
Transfers						
$\hat{\beta}_{gd}$	−0.02	0.05*	0.06***	0.01	−0.01	0.07
	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)	(0.04)
R^2	0.92	0.90	0.19	0.18	0.15	0.07
N	176	396	2244	292	392	612
Credit						
$\hat{\beta}_{dc}$	0.11	0.08	0.19**	0.51**	0.56***	0.33
	(0.09)	(0.09)	(0.07)	(0.13)	(0.08)	(0.18)
R^2	0.97	0.95	0.03	0.38	0.29	0.23
N	176	396	2244	292	392	612
Unsmoothed						
$\hat{\gamma}_{cq}$	0.53*	0.39**	0.21***	0.50**	0.24	0.59***
	(0.11)	(0.08)	(0.03)	(0.11)	(0.11)	(0.09)
R^2	0.98	0.97	0.04	0.87	0.78	0.81
N	176	396	2244	324	432	676

Notes: results from regression of different wedges on the change in log real Gross State Product (GSP) or Gross Domestic Product, respectively, see equations (8) - (12). For US states, the sample extends from 1963 to 2007 (yearly frequency) and for EA members the sample extends from 1998 to 2007 (quarterly frequency). State-/country- and time fixed effects are included but not reported. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table A.8: Quantification of risk sharing channels in US states and EA members after 2008.

	US states			EA members		
	4 Regions	9 Regions	All states	EA9	EA12	EA19
Migration						
$\hat{\beta}_{Qq}$	-0.02	0.00	0.01	-0.07^{*}	-0.03	0.02
	(0.19)	(0.10)	(0.02)	(0.03)	(0.02)	(0.02)
R^2	0.77	0.76	0.88	0.54	0.99	0.98
N	36	81	459	333	436	695
Factor Trade						
$\hat{\beta}_{qg}$	-0.73^{*}	-0.19	0.39^{***}	0.08	0.07	0.14^{**}
	(0.15)	(0.33)	(0.05)	(0.05)	(0.09)	(0.05)
R^2	0.80	0.70	0.46	0.15	0.13	0.10
N	36	81	459	333	436	695
Transfers						
$\hat{\beta}_{gd}$	0.63	0.38^{*}	0.11^{**}	0.00	-0.01	0.02
	(0.12)	(0.15)	(0.05)	(0.01)	(0.03)	(0.01)
R^2	0.58	0.66	0.80	0.19	0.04	0.02
N	36	81	459	333	436	695
Credit						
$\hat{\beta}_{dc}$	0.89^{*}	0.64^{*}	0.37^{***}	0.44^{**}	0.27	0.13
	(0.22)	(0.22)	(0.10)	(0.11)	(0.13)	(0.09)
R^2	0.90	0.77	0.49	0.40	0.23	0.16
N	36	81	459	333	436	695
Unsmoothed						
$\hat{\gamma}_{cq}$	0.23^{*}	0.17^{**}	0.13	0.55^{***}	0.69^{***}	0.69^{***}
	(0.05)	(0.04)	(0.07)	(0.11)	(0.15)	(0.08)
R^2	0.95	0.90	0.68	0.64	0.57	0.6
N	36	81	459	333	436	695

Notes: results from regression of different wedges on the change in log real Gross State Product (GSP) or Gross Domestic Product, respectively, see equations (8) - (12). For US states, the sample extends from 2008 to 2017 (yearly frequency) and for EA members the sample extends from 2008 to 2018 (quarterly frequency). State-/country- and time fixed effects are included but not reported. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table A.9: Quantification of risk sharing channels in EA19 members excluding Luxembourg, Ireland and Greece.

	EA19 members		
	w/o Luxembourg	w/o Ireland	w/o Greece
Migration			
$\hat{\beta}_{Qq}$	0.02	0.03	0.02
	(0.02)	(0.02)	(0.02)
R^2	0.69	0.72	0.74
N	1370	1378	1370
Factor Trade			
$\hat{\beta}_{qg}$	0.08	0.09	0.08
	(0.06)	(0.06)	(0.07)
R^2	0.10	0.11	0.59
N	1306	1318	1310
Transfers			
$\hat{\beta}_{gd}$	0.04**	0.03*	0.03*
	(0.01)	(0.01)	(0.01)
R^2	0.06	0.05	0.06
N	1306	1318	1310
Credit			
$\hat{\beta}_{dc}$	0.19	0.17	0.24
	(0.11)	(0.10)	(0.08)
R^2	0.15	0.16	0.12
N	1306	1318	1310
Unsmoothed			
$\hat{\gamma}_{cq}$	0.68***	0.68***	0.63***
	(0.07)	(0.07)	(0.08)
R^2	0.77	0.75	0.74
N	1370	1378	1370

Notes: results from regression of different wedges on the change in log real Gross Domestic Product, see equations (8) - (12). The sample extends from 1998 to 2018 (quarterly frequency). Country- and time fixed effects are included but not reported. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table A.10: Quantification of risk sharing channels between US regions for changing difference intervals.

	US states — 4 regions					US states — 9 regions				
	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$
Migration										
$\hat{\beta}_{Qq}$	0.13	0.14	0.13	0.13	0.13	0.11	0.15*	0.16*	0.17**	0.18**
	(0.15)	(0.15)	(0.15)	(0.15)	(0.14)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)
R^2	0.29	0.39	0.45	0.50	0.55	0.27	0.37	0.45	0.51	0.57
N	216	212	208	204	200	486	477	468	459	450
Factor Trade										
$\hat{\beta}_{qg}$	0.28	0.23	0.24	0.24	0.23	0.36***	0.32***	0.30***	0.29***	0.29***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
R^2	0.83	0.80	0.71	0.67	0.71	0.70	0.68	0.61	0.58	0.63
N	216	212	208	204	200	486	477	468	459	450
Transfers										
$\hat{\beta}_{gd}$	−0.02	0.01	0.03	0.03	0.04	0.05*	0.06**	0.07***	0.07***	0.07***
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
R^2	0.95	0.96	0.96	0.96	0.95	0.93	0.95	0.95	0.95	0.94
N	216	212	208	204	200	486	477	468	459	450
Credit										
$\hat{\beta}_{dc}$	0.13	0.00	−0.05	−0.04	−0.06	0.11	0.01	−0.02	−0.03	−0.03
	(0.07)	(0.05)	(0.05)	(0.03)	(0.03)	(0.08)	(0.05)	(0.04)	(0.04)	(0.04)
R^2	0.97	0.96	0.96	0.97	0.97	0.94	0.94	0.95	0.95	0.96
N	216	212	208	204	200	486	477	468	459	450
Unsmoothed										
$\hat{\gamma}_{cq}$	0.48**	0.63**	0.66**	0.64**	0.66**	0.36***	0.46***	0.49***	0.49***	0.51***
	(0.07)	(0.09)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.09)	(0.09)
R^2	0.98	0.98	0.98	0.98	0.98	0.96	0.97	0.97	0.97	0.98
N	216	212	208	204	200	486	477	468	459	450

Notes: results from regression of different wedges on the change in log real Gross State Product (GSP), see equations (8) - (12). The data are differenced using intervals of k years. The sample extends from 1963 to 2017 (yearly frequency). State- and time fixed effects are included but not reported. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table A.11: Quantification of risk sharing channels for EA9 and EA12 members for changing difference intervals.

	EA9					EA12				
	$k=4$	$k=8$	$k=12$	$k=16$	$k=20$	$k=4$	$k=8$	$k=12$	$k=16$	$k=20$
Migration										
$\hat{\beta}_{Qq}$	0.03	0.05	0.08	0.10	0.14	0.01	0.02	0.02	0.03	0.04
	(0.03)	(0.04)	(0.05)	0.06	(0.08)	(0.02)	(0.02)	(0.03)	(0.04)	(0.05)
R^2	0.59	0.64	0.69	0.74	0.78	0.75	0.78	0.80	0.83	0.85
N	693	657	621	585	549	916	868	823	776	728
Factor Trade										
$\hat{\beta}_{qg}$	0.16**	0.16***	0.14***	0.13***	0.13*	0.13*	0.11*	0.11**	0.07	0.05
	(0.03)	(0.03)	(0.02)	(0.02)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.06)
R^2	0.16	0.24	0.26	0.25	0.27	0.16	0.25	0.36	0.42	0.52
N	661	625	589	553	517	876	828	783	736	688
Transfers										
$\hat{\beta}_{gd}$	0.01	0.01	0.01	0.01	0.01	−0.01	0.00	0.00	0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
R^2	0.18	0.20	0.23	0.25	0.26	0.11	0.14	0.18	0.25	0.27
N	661	625	589	553	517	876	828	783	736	688
Credit										
$\hat{\beta}_{dc}$	0.25*	0.13	0.06	0.03	0.01	0.31	0.32	0.30	0.30	0.29
	(0.08)	(0.07)	(0.06)	(0.07)	(0.09)	(0.15)	(0.23)	(0.27)	(0.30)	(0.32)
R^2	0.39	0.48	0.50	0.53	0.55	0.35	0.45	0.49	0.49	0.49
N	661	625	589	553	517	876	828	783	736	688
Unsmoothed										
$\hat{\gamma}_{cq}$	0.59***	0.70***	0.73***	0.74***	0.73***	0.57**	0.59**	0.59*	0.62**	0.64**
	(0.08)	(0.07)	(0.07)	(0.09)	(0.11)	(0.14)	(0.17)	(0.19)	(0.19)	(0.18)
R^2	0.77	0.85	0.89	0.91	0.93	0.68	0.75	0.78	0.82	0.85
N	693	657	621	585	549	916	868	823	776	728

Notes: results from regression of different wedges on the change in log real Gross Domestic Product, see equations (8) - (12). The data are differenced using intervals of k quarters. The sample extends from 1998 to 2018 (quarterly frequency). Country- and time fixed effects are included but not reported. Standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01.