Twenty Years of Convergence

By Jean Imbs and Laurent Pauwels[1]

Abstract

Real convergence in the Economic and Monetary Union is manifest over the past 20 years: the growth rates in GDP and consumption have converged significantly, reaching by some measures higher levels of similarity than US States. To explain convergence in GDP, we introduce a measure of bilateral export intensity, based on input-output linkages at sector level. The measure is distinct from directly observed trade and is available for 50 sectors, including services. It takes exceptionally high values in EMU member countries, much higher than the US or China. Pairs of sectors with high export intensity are significantly more correlated, which explains aggregate convergence in GDP. Convergence in consumption, in turn, is by some measure more complete in the EMU than between US States. We show this can be ascribed to financial integration in the monetary union.

Introduction

The European project is about economic integration. More than 30 years ago, the Cecchini report evaluated the expected benefits of the Single Market of 1992 to a minimum of 5 percent of European GDP, as barriers were removed between member countries. With added monetary and financial integration, the Single Currency was expected to reinforce and multiply these gains, with expected permanent, far-ranging benefits to real growth, consumption, and welfare.[2]

Of particular interest are the consequences of EMU on real convergence between member countries, and especially convergence in GDP and consumption. Convergence in GDP implies a homogeneous monetary union, which alleviates one of the main costs of a single currency, i.e., the inability to use monetary policy in response to country-specific shocks. Whether EMU created convergence in GDP is therefore a key reason why EMU can become an optimal currency ex post, even though it may not have been one ex ante. Convergence in GDP is customarily ascribed to economic integration, especially in goods markets.

Convergence in consumption can follow simply from convergence in GDP. But it can also happen over and above GDP, with correlated consumption across countries despite uncorrelated income. This requires agents in each member country hold similarly diversified portfolio of financial assets. And this happens if international

1 Imbs: NYU Abu Dhabi, PSE (CNRS), and CEPR. Pauwels: University of Sydney Business School.
Andrea Mencarelli provided stellar research assistance. All errors are our own.

2 Cecchini, 1988, European Economy, 1990.

frictions in financial markets are kept to a minimum. Convergence in consumption is therefore customarily ascribed to financial integration.

Twenty years into EMU, this paper takes stock on both questions. We start with some stylized facts obtained from a measure of real convergence based on absolute differences in growth rates. For the 12 original EMU member countries, we compute the n(n-1)/2 distinct bilateral differences in GDP and consumption growth rates.[3] We describe how both distributions evolved since the introduction of the Euro, between 1999 and 2018. We compare them with equivalent estimates obtained for US States. The punchline is that GDP growth rates in EMU countries have converged sizeably since 1999, up to a level comparable to the US. But the EMU continues to be characterized by substantial cross-sectional heterogeneity, much larger than in the US (for example Greece in 2011 or Ireland in 2015). Consumption growth rates converged as well, although not at a rate obviously outpacing convergence in GDP.

We then turn to the question of what explains such fast convergence. We introduce a novel measure of market integration based on input-output data. The measure evaluates the proportion of a sector's value chain that is directed towards exports, which we label "Export Intensity". It tells us how close across the border two sectors are, in the sense that both tend to serve downstream activities that eventually trade with each other. Over a decades-long process of deepening economic integration, one would expect it to be increasingly likely that two sectors serve downstream activities that trade across borders, even though they themselves do not trade with each other internationally. The measure is distinct from actually observed bilateral trade; it captures a mechanism that is likely relevant to EMU, and it is available for all sectors, including services.

We compute export intensity across all 12 core EMU member countries and compare values with the US and China. We show the EMU is much more export intensive than the US, and comparable with China, both in 2000 and again at the end of the sample in 2014. We show these patterns pervade all sectors in the economies: manufacturing as well as services.

We evaluate how much export intensity can explain of the bilateral convergence in sector-level growth rates in value added. This is not a small effort. We consider all bilateral convergence between 50 sectors in 12 countries and 15 years: This constitutes a very large dataset, with almost 2.5 million observations.[4] We investigate whether the export orientation of input-output linkages can account for the similarity in sector-level growth rates. In particular we seek to explain the correlation in manufacturing sectors between countries, but also the correlations in services, or between services and manufactures, services and agriculture, utilities and services, etc. To our knowledge, this is unprecedented – mostly because bilateral measures of openness or proximity were not available at sector level up until this.

[3] Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherland, and Portugal. We focus on the 12 member countries with as close to 20 years of available data as possible.

[4] 50 x 50 x 12 x 11 / 2 x 15. The measure of export intensity is not symmetric at sector level.

Comparing regions, we find that *bilateral* sector-level export intensity is much higher between EMU member countries than between the US, or even China, and the rest of the world. The EMU is highly integrated, much more so than the US or China are with the world economy. This fact would be entirely missed with a measure based on actually observed direct bilateral trade. We also find that export intensity is highly significant and robust in accounting for convergence in sector-level growth rates. Interestingly, while export intensity matters for conventionally traded sectors, such as manufacturing, it is in services that we find the largest effects, both economically and statistically. We find that growth rates in the value added of services are correlated internationally (0.55 on average, versus 0.50 for manufactures). And in fact, we find services are increasingly correlated between EMU member countries, because they increasingly serve sectors that trade across borders. These results survive large batteries of fixed effects, afforded by the large dimensionality of our panel data (sector-pair in country-pair over time).

How much does export intensity matter in the aggregate? We use a property of quasi-correlation coefficients to decompose the aggregate quasi-correlation between two countries' GDP growth rates into a weighted sum of sector-level bilateral quasi-correlations. We use our model to predict values for bilateral sector quasi-correlations and aggregate them up to country level. Thus we can evaluate how much of GDP correlation can be explained by export intensity. We find that export intensity explains a sizable share of the increase in GDP correlation – up to 20 percent. Interestingly, export intensity appears to be more relevant than bilateral trade, presumably because it is able to explain highly correlated growth rates between non-traded sectors like services.

Absolute differences in consumption growth rates also display a significant downward trend in the EMU, consistent with international risk sharing. Conventional tests of risk sharing are typically performed in time series, checking whether changes in income are reflected by changes in consumption, and whether that can be ascribed to financial integration. Here we extend the test to a cross-sectional environment and estimate the extent of risk sharing year by year. We find the relation between consumption and GDP is eroding over time and has been insignificant since 2015 in the EMU. In the US, the same methodology yields estimates that are significantly different from zero, and stationary over time. In other words, by this measure, risk sharing in the EMU has been on an upward trend since 1999 and has recently achieved levels that appear to be more complete than between US states. We show at least part of this finding can be related with the trend of financial deregulation in the European Union.

The measure of convergence used here is typically found in the recent literature about business cycle synchronization (Giannone, Lenza, and Reichlin, 2010, Kalemli-Ozcan, Papaiannou, and Perri, 2013). This literature is ripe with candidate explanations to business cycle synchronization: The most robust appears to be bilateral trade (Baxter and Kouparitsas, 2005, Rose, 2008). Given the boom in trade between EMU members, the emergence of an EMU business cycle should be uncontroversial. And yet the literature is inconclusive: Aguiar-Conraria and Soares (2011), Artis and Zhang (2008), Gachter and Ridel (2014), Goncalves, Rodrigues and Soares (2009) all document an increase in synchronization (not in convergence) between EMU member countries. But Caporale, De Santis and Girardi (2015), Christodoulopoulou (2014), Crespo-Cuaresma and Fernandez-Amador (2013), and Lehwald (2012) all document the opposite. One explanation is measurement: the correlation coefficients typically used in this literature are estimated with error. Another one is the existence of confounding factors within the EMU.

A potential such factor is financial integration, one of the inherent elements of the single currency. If financial integration results in asymmetric cycles, as argued in Kalemli-Ozcan, Papaiannou, and Peydro (2013), then EMU could have ambiguous effects on cycle synchronization. It is therefore important to allow for financial flows to affect cycle synchronization, or convergence in GDP. It is of course also of direct interest to investigate the effect of financial integration on consumption convergence, since financial integration is expected to allow consumption risk sharing (Cochrane, 1991, Lewis, 1996). The test we introduce builds from Fratzscher and Imbs (2009) and augments it with the instrument variables proposed by Kalemli-Ozcan, Papaiannou, and Peydro (2013), updated to recent years. It is also possible for financial integration to facilitate specialization in production, and thus result both in divergence in GDP and convergence in consumption (Kalemli-Ozcan, Sorensen and Yosha, 2004).

Our measure of export intensity builds on input-output linkages, and can be computed for all sectors. It is directly adapted from the measures of upstreamness and downstreamness introduced in Antras and Chor (2018), modified to capture export intensity rather than the length of the value chain.

The rest of the paper is organized as follows. The next section introduces data sources, the definition of key variables, and offers a first look at some stylized facts. Section 2 introduces the measure of export intensity, illustrates the exceptional proximity of EMU sectors to export markets as compared with other economies, and investigates how much this position can explain the convergence of GDP in the EMU. Section 3 introduces a cross-sectional test of consumption risk sharing, applies it to EMU and US data, and draws comparison between the two regions. Section 4 concludes.

1 A first look at the data

1.1 Data sources

Data on quarterly real (chain-linked) GDP, consumption, population, and productivity growth come from the Quarterly National Accounts compiled by Eurostat for EMU member countries. Total employment (from 15 to 64 years of age) comes from Eurostat's Population and Social Conditions data. Absolute bilateral differences in growth rates are computed as $ABSy_{ijt} = -|gy_{it} - gy_{jt}|$, $ABSc_{ijt} = -|gc_{it} - gc_{jt}|$, $ABSprod_{ijt} = -|gprod_{it} - gprod_{jt}|$, and $ABSn_{ijt} = -|gn_{it} - gn_{jt}|$, with self-explanatory notation. The difference is computed quarter by quarter and averaged by year. All values are negative so that convergence means the differences increase towards zero.

Our measure of export intensity is computed from the World Input-Output Tables (WIOT). WIOT covers 40 developed and developing countries and provides annual data from 1995 to 2014. The covered countries account for approximately 85% of world GDP. The data is in millions of U.S. dollars at current prices. We use the 2016 release of WIOT, which contains 43 countries and 50 industries (ISIC Rev. 4) spanning from 2000 -- 2014.[5] This is also the source for sector-level measures of value added.

As a check on our results, we compute direct bilateral intermediate exports as implied by the WIOT. Exports are measured free on board, in dollars at sector level. We include intermediate goods exports between all pairs of sectors in the WIOT. Define:

$$Trade_{ij,t}^{rs} = \frac{Z_{ij,t}^{rs} + Z_{ji,t}^{rs}}{VA_{i,t}^{r} + VA_{j,t}^{s}}$$

where $VA_{i,t}^{r}$ denotes value added in sector r of country I, and $Z_{ij,t}^{rs}$ is intermediate input use of sector r's output in country i by sector s in country j. This measure focuses on *direct* trade between all pairs of sectors and countries. It is a constituent part of our measure of export intensity, but does not necessarily correlate much with it.

The measure of financial deregulation in Europe is taken from Kalemli-Ozcan et al. (2013). They focus on the directives part of the Financial Services Action Plan (FSAP), issued by Brussels and implemented by member countries at different dates. The variable considers the number of directives implemented in the same year by two countries. This implies a time-varying measure of bilateral financial integration. Importantly, Kalemli-Ozcan et al. (2013) describe an adoption mechanism for these directives that suggests they can be taken as exogenous to the economic conditions in each adopting countries at the time of implementation. The directives are available from 1999; We update the original data and compute the index until 2014.

Annual real and nominal Gross State Product (GSP) and state-level Personal Consumption Expenditures (PCE) come from the Bureau of Economic Analysis. PCE is a relatively recent development at the BEA, with series beginning from 1997, and is focused on households' consumption. State population comes from the State Intercensal datasets put together by the US Census Bureau. A variable capturing whether States are contiguous is constructed in Merryman (2005), using the USSWM Stata module. And bilateral geodetic distance between US States was calculated from LatLong.net, using latitude and longitude for each State's centroid. Shipment values between States is collected from the Commodity Flow Survey and is available in 2002 and 2007.

[5] We removed sectors 51 to 56, which include public administration, defence, social security, education, human health, social work activities, households as employers, household activities for own use, and extraterritorial organizations and bodies.

1.2 Some Stylized facts

The analysis is focused on the panel formed by bilateral (absolute) differences in growth rates and their change over time. In Table 1, we start with the simplest possible check for any convergence: we estimate whether absolute differences display a trend in the EMU. This is done for differences in the growth rates of GDP, consumption, employment, and labor productivity. The results are mixed: while consumption displays significant trend convergence over the 20 years since 1999, the same is not true of GDP, employment, or productivity. GDP growth in particular appears to have converged only in the earlier period, before the great recession of 2007.

The right panel of Table 1 shows this apparent heterogeneity is an artefact of extreme outliers in the distribution of GDP growth in recent years. In 2011, Greece contracted by 9.1%, and in 2015, Ireland grew at 25.6%. Excluding these two observations gives stable results: an upward trend in convergence is now apparent in both GDP and consumption, over the whole sample period and in each sub-period. Interestingly, convergence in GDP outpaces consumption until 2006, but the opposite occurs after 2007. This is an interesting result, for it is consistent with consumption in member countries becoming increasingly unrelated with local income. We note the convergence in employment and labor productivity is less evident in the data, and so focus the rest of the paper on the behaviour of GDP and consumption.

Table 1

Trends in Convergence in EMU

	Full Sample			Excluding GRC 2011 & IRL 2015		
Convergence in	1999-2018	1999-2006	2007-2018	1999-2018	1999-2006	2007-2018
GDP growth	-0.026**	0.114***	-0.013	0.018***	0.114***	0.058***
	(0.012)	(0.030)	(0.036)	(0.006)	(0.030)	(0.015)
Consumption growth	0.043***	0.092***	0.116***	0.048***	0.092***	0.106***
	(0.008)	(0.025)	(0.014)	(0.008)	(0.025)	(0.012)
Employment growth	-0.010	0.043**	0.096***	-0.006	0.043**	0.085***
	(0.013)	(0.019)	(0.015)	(0.012)	(0.019)	(0.015)
Labor Productivity Growth	-0.033**	-0.001	0.011	0.002	-0.001	0.077***
	(0.015)	(0.024)	(0.002)	(0.007)	(0.024)	(0.010)

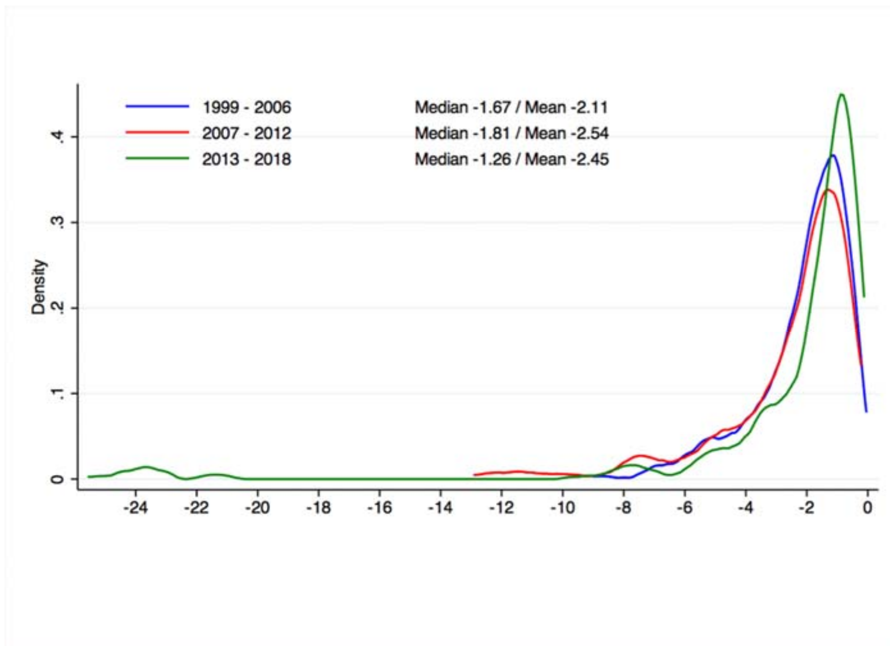
Sources: Eurostat, Author's computations
Notes: The Table reports coefficients on time trends, with robust standard errors. *(**)(***) denote significance at 10(5)(1) percent confidence level. All estimations include country-pair fixed effects.

Table 1 illustrates the importance of outliers, as bilateral differences can take large values. In Charts 1 and 2 we plot the distribution of $ABSy_{ijt}$ for three sub-periods of similar length. Chart 1 shows that the distribution has shifted observably to the right since 2013, but not much between 1999 and 2012. But as the distribution's mode shifted to the right, the lower tail grew with large outliers. As a result the mean (absolute) growth difference actually increases over time, whereas the median does fall, from 1.67 to 1.26. Chart 2 performs the same exercise but abstracting from

Ireland 2015 and Greece 2011. The Chart illustrates clearly the convergence in GDP has accelerated in the past 5 years in the EMU: neither mean nor median change much between 1999 and 2013, but between 2013 and 2018, the median GDP absolute difference falls to 1.22 (against 1.77 in the previous period) and the mean falls to 1.76 (against 2.33). The whole distribution for 2013-2018 is also almost systematically to the right of the estimates for the two earlier periods. Convergence in GDP is manifest in the EMU, but it is a relatively recent phenomenon.

Chart 1

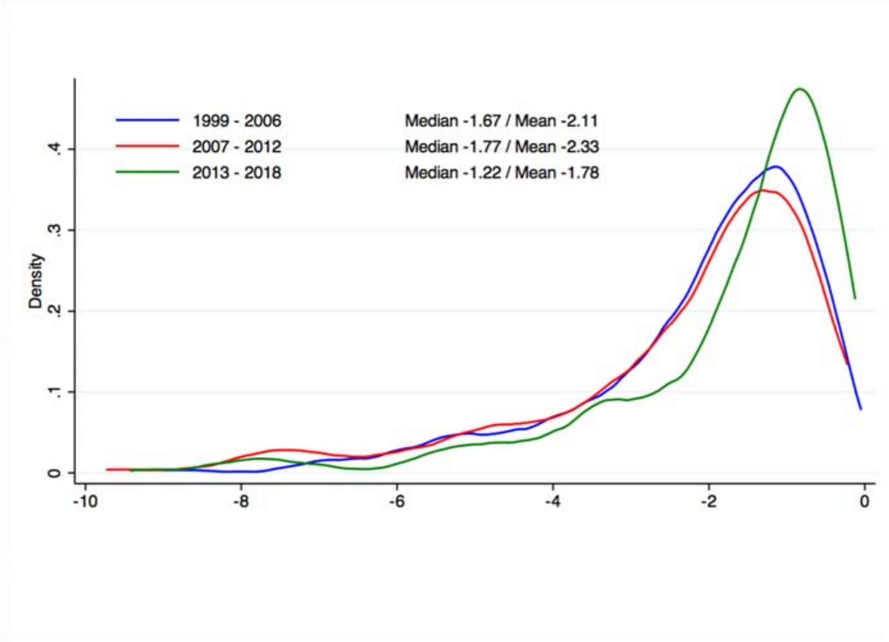
Absolute difference in GDP growth - EMU



Sources: Eurostat.
Notes: Density plots of annual difference in GDP growth in pairs of EMU countries.

Chart 1
Absolute difference in GDP growth - EMU

Excluding Greece (2011) and Ireland (2015)



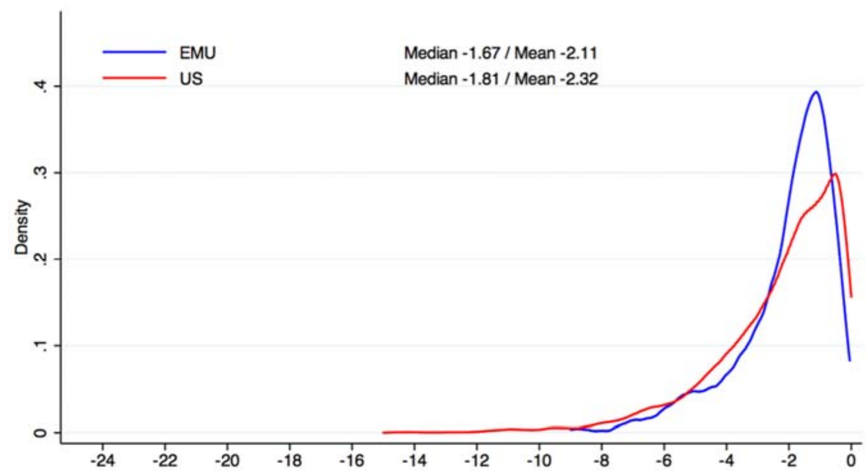
Sources: Eurostat.
Notes: Density plots of annual difference in GDP growth in pairs of EMU countries without Greece in 2011 and Ireland in 2015.

It is frequent to compare EMU member countries with US States. The idea is that the US provides a laboratory of what economic regions should look like when they have reached a maximum level of deep economic integration, i.e. where the only remaining frictions have to do with distances and/or imperfect information. Charts 3, 4, and 5 replicate the exercise in Charts 1 and 2 for US States and plot the absolute differences in growth rates for real Gross State Products. For comparison purposes, each chart plots the estimated distributions for both US States and EMU member countries, obtained over three sub-periods since 1999.

The three graphs suggest that convergence between EMU members is of comparable magnitude to convergence between US states. Both the means and the medians of both distributions are very close to each other across the three periods, although both moments tend to be slightly closer to zero in the EMU. This comes from two features of the data: the mode of the absolute difference is closer to zero in the US in all three graphs, but there is more extreme heterogeneity across US states than there is across EMU members: The left tail of the distribution is systematically longer in US data.

Chart 3

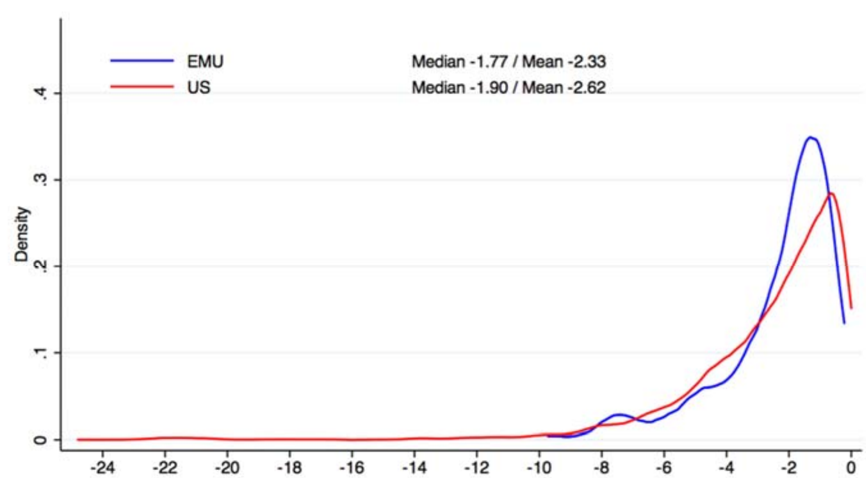
Absolute difference in GDP growth from 1999 to 2006 – EMU and US



Sources: Eurostat.
Notes: Density plots of annual difference in GDP growth in pairs of EMU countries and pairs of US states.

Chart 4

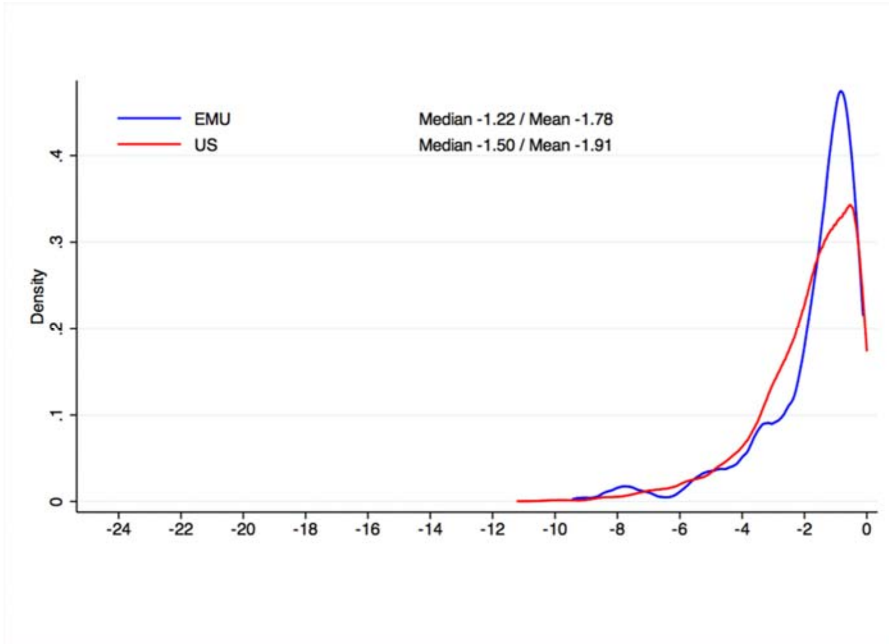
Absolute difference in GDP growth from 2007 to 2012 – EMU and US



Sources: Eurostat.
Notes: Density plots of annual difference in GDP growth in pairs of EMU countries and pairs of US states.

Chart 5

Absolute difference in GDP growth from 2013 to 2018 – EMU and US



Sources: Eurostat.
Notes: Density plots of annual difference in GDP growth in pairs of EMU countries and pairs of US states.

2 Convergence in GDP

In this Section, we introduce a measure of export intensity between sectors. It is possible that sectors are closely related across a border even if there is no direct trade between them: This will happen if each sector trade with downstream sectors in their own country, and it is the downstream sectors whose output crosses the border. In that case, the two sectors are close to each other in the sense that they tend to cater for traded activities, but that fact is completely absent from trade data. They are also close to each other in the sense that shocks propagate via downstream linkages, and so export proximity ought to explain convergence.[6]

One definition of deep integration is precisely that a rising fraction of sectors are catering for exporting ones, i.e. that the value chain becomes increasingly integrated internationally, at second, third, or higher orders. This phenomenon is completely missed by actual trade data, which focus on first order effects, a potentially tiny fraction of what deep integration implies. A salient example are services: most are probably traded little (data availability notwithstanding), and yet in integrating economies it is likely that services are catering for large exporting sectors. Shocks to

[6] See for instance Acemoglu, Akcigit, and Kerr (2015).

service sectors then diffuse internationally, even though they do not appear to trade with each other in the data.

2.1 Measuring Export Intensity

We start from a simple identity. Gross output in each country-sector can be either used as an intermediate input in another sector (in the same country or not), or as a final good (in the same country or not). This identity can be formalized as:

$$Y_i^r = \sum_s \sum_j Z_{ij}^{rs} + \sum_j F_{ij}^r$$

where Y_i^r denotes gross output in country i and sector r, Z_{ij}^{rs} is intermediate input use in country j and sector s, and F_{ij}^r is final use in country j. The identity can readily extend to a decomposition into traded and domestic components:

$$Y_i^r = \left[\sum_s \sum_{j\neq i} Z_{ij}^{rs} + \sum_{j\neq i} F_{ij}^r\right] + \left[\sum_s Z_{ii}^{rs} + F_{ii}^r\right]$$

where the first term in brackets denotes international uses of domestic gross output in sector r, and the second term captures purely domestic linkages.

Following Antras and Chor (2013), define $a_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_j^s}$, the dollar amount of sector r's output from country i needed to produce one dollar worth of industry s's output in country j. By definition, a_{ij}^{rs} is the entry in a direct requirement input-output matrix. The identity becomes:

$$Y_i^r = \left[\sum_s \sum_{j\neq i} a_{ij}^{rs} Y_j^s + \sum_{j\neq i} F_{ij}^r\right] + \left[\sum_s a_{ii}^{rs} Y_i^s + F_{ii}^r\right]$$

In words, the output of sector r can be exported in country j as an intermediate input or as a final good, or it can stay in country i as an intermediate input into sector s or as a final good. Iterating:

$$\begin{aligned} Y_i^r = & \left[\sum_{j\neq i} F_{ij}^r + \sum_s \sum_{j\neq i} \left(a_{ij}^{rs} F_j^s + a_{ii}^{rs} F_{ij}^s\right)\right. \\ & \left. + \sum_t \sum_s \sum_{j\neq i} \left(a_{ij}^{rs} a_{jj}^{st} F_j^t + a_{ii}^{rs} a_{ij}^{st} F_j^t + a_{ij}^{rs} \sum_k a_{jk}^{st} F_k^t\right) + \cdots \right] \\ & + \left[F_{ii}^r + \sum_s a_{ii}^{rs} F_{ii}^s + \sum_s a_{ii}^{rs} a_{ii}^{st} F_i^t + \cdots \right] \end{aligned}$$

where $F_i^t = \sum_j F_{ij}^t$ is the total final demand for good t produced in country i. The first bracket in the expression captures all the orders at which a good can cross the border: as an exported final good (order 1), as an intermediate good used either in the production of a final good abroad or used as an input for a domestic exporting sector (order 2), and so on. The second bracket captures similarly all the manners in which a good reaches final demand, but focusing on domestic linkages. Since it is an identity, the decomposition traces exactly the orders at which the production of sector r crosses a border until it meets final demand: For example, it is entirely possible that good r crosses the border once as an intermediate export into sector s in country j, and then crosses the border back into its original country i as a final re-import into sector t. This would constitute a highly integrated international value chain, with border crossings at various orders, and would by definition be incorporated in the first bracket of the decomposition above. The second bracket would include strictly domestic input-output linkages only.

It is therefore important to keep track of the orders separating production from final demand: We want to draw a difference between a sector whose production crosses the border immediately as a final good, from a sector whose production crosses the border at higher orders. The former would simply be an exporting sector; the latter would not appear to be actually exporting, but could still be proximate to exports via vertical linkages. Antras and Chor (2013) introduce a scheme with rising weights associated with distance from final demand to define a measure of upstreamness U_i^r given by:

$$U_i^r = \Bigg[\sum_{j\neq i} F_{ij}^r + 2\times\sum_s\sum_{j\neq i}\left(a_{ij}^{rs}F_j^s + a_{ii}^{rs}F_{ij}^s +\right) + 3\times\sum_t\sum_s\sum_{j\neq i}\left(a_{ij}^{rs}a_{jj}^{st}F_j^t + a_{ii}^{rs}a_{ij}^{st}F_j^t + a_{ij}^{rs}\sum_k a_{jk}^{st}F_k^t\right)+\cdots\Bigg] + \left[F_{ii}^r + 2\times\sum_s a_{ii}^{rs}F_{ii}^s + 3\times\sum_s a_{ii}^{rs}a_{ii}^{st}F_i^t+\cdots\right]$$

They do not differentiate between domestic and final demand, but show that in general U_i^r is given by the typical element in $[\boldsymbol{I}-A]^{-2}\boldsymbol{F}$, where A is the direct requirement matrix whose typical element is a_{ij}^{rs}, and $\boldsymbol{F}$ is the vector of final demand.

By analogy, if follows that $F_{ii}^r + 2\times\sum_s a_{ii}^{rs}F_{ii}^s + 3\times\sum_s a_{ii}^{rs}a_{ii}^{st}F_i^t+\cdots$ is given by the typical element in $[\boldsymbol{I}-A^{DOM}]^{-2}\boldsymbol{F^{DOM}}$, where A^{DOM} is the purely domestic direct requirement matrix whose typical element is a_{ii}^{rs}, and $\boldsymbol{F^{DOM}}$ is the vector of domestic final demand. Note that A and A^{DOM} have the same dimension, as A^{DOM} is constituted of a sub-set of A focused on its block diagonal elements, i.e., its purely domestic input-output linkages.

We can therefore define a vector of export proximities in country i, given by $\boldsymbol{EP} = [\boldsymbol{I}-A]^{-2}\boldsymbol{F} - [\boldsymbol{I}-A^{DOM}]^{-2}\boldsymbol{F^{DOM}}$. Finally we can define the export intensity of a given sector r in country i, given by the ratio of EP_i^r, the typical element of $\boldsymbol{EP},$ to the total length of the value chain U_i^r. The index of export intensity measures the extent to which the sectors of country i serve downstream sectors that are across a border, holding constant the length of the value chain (the upstreamness index of Antras and Chor). The typical element of export intensity $\boldsymbol{EI}$ is given by $EI_i^r = EP_i^r/U_i^r$.

Computing $\boldsymbol{EI}$ is straightforward with the information from the World Input-Output tables (WIOT), which contain direct requirement matrices A and A^{DOM} as well as vectors of final demand $\boldsymbol{F}$ and $\boldsymbol{F^{DOM}}$. It is in fact straightforward to exclude first-order final goods' trade from the measure of export intensity, focusing it instead on higher order intermediate trade only. The idea is that such an amended measure is abstracting from the more conventional approach to measuring openness, based on observed direct trade between countries or sectors. We define a measure of export intensity in intermediates:

$$EII_i^r = \frac{EP_i^r - \sum_{j \neq i} F_{ij}^r}{U_i^r}$$

EII_i^r measures the export intensity of sector r in country i abstracting from any exports in final goods arising from sector r. It captures the export intensity of sector r in terms of indirectly serving other domestic sectors that eventually exports final goods, or directly trading intermediates with other countries.

As their indexes suggest, both EI_i^r and EII_i^r capture the export intensity of a sector r in country i. Neither variable have any bilateral dimension: They tell us how much of the value chain in sector r and country i is in fact exported to the rest of the world. They do not tell us where.

Consider now a version of the two variables computed on the basis of a subset of WIOT focused on two countries i and j, A_{ij}. By definition, A_{ij} embeds all the input-output linkages between countries i and j: it tells us how much of output in sector r of country i is necessary to produce one dollar of output in country j's sector s. By analogy with earlier notation, denote with A_{ij}^{DOM} the direct requirement matrix for countries i and j focused on strictly domestic linkages. It is straightforward to define a bilateral version of export proximity, denoted with $\boldsymbol{EP_{ij}} = [\boldsymbol{I} - A_{ij}]^{-2}\boldsymbol{F_{ij}} - [\boldsymbol{I} - A_{ij}^{DOM}]^{-2}\boldsymbol{F_{ij}^{DOM}}$, where $\boldsymbol{F_{ij}}$ is the vector of final demands emerging from both countries, and $\boldsymbol{F_{ij}^{DOM}}$ is the vector of domestic final demand in both countries i and j. Then the measure of export intensity between sector r in country i and country j is given by $EI_{ij}^r = EP_{ij}^r / U_{ij}^r$, where U_{ij}^r is the typical element of $[\boldsymbol{I} - A_{ij}]^{-2}\boldsymbol{F_{ij}}$. By analogy export intensity in intermediates is given by $EII_{ij}^r = (EP_{ij}^r - F_{ij}^r)/U_{ij}^r$.

Both measures are uni-directional in the sense that $EI_{ij}^r \neq EI_{ji}^r$ and $EII_{ij}^r \neq EII_{ji}^r$. We introduce measures of bilateral export intensities $BI_{ij}^{rs} = EI_{ij}^r \times EI_{ji}^s$ and bilateral export intensity in intermediates $BII_{ij}^{rs} = EII_{ij}^r \times EII_{ji}^s$. The measures combine the intensity of exports from country-sector (i,r) to country j, with the intensity of exports from country sector (j,s) to country i. It is bilateral in the sense that sectors (r,s) in countries (i,j) tend to be close to each other if sector r in country i has high export intensity with country j, and sector s in country j has high export intensity with country i.

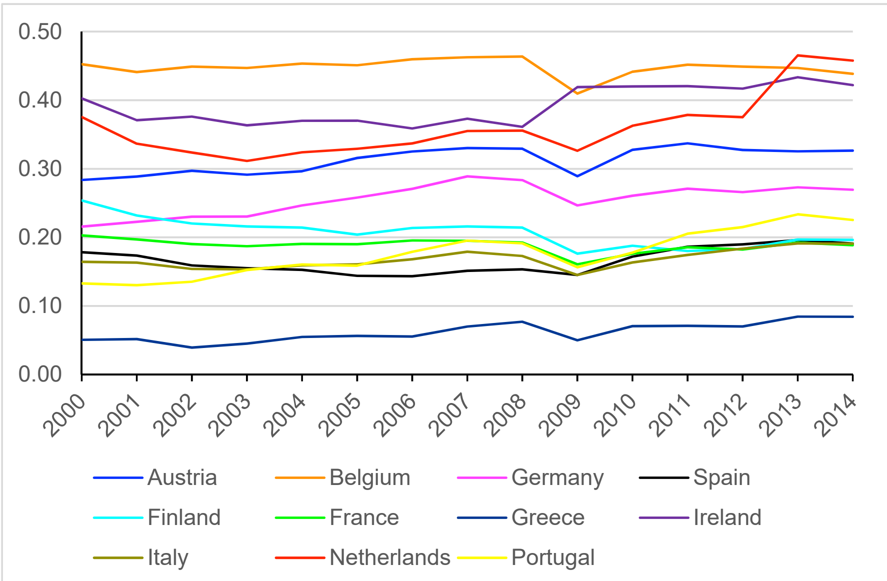
2.2 Export Intensity in EMU

We now characterize economic integration within the EMU with computations of EI_i^r, and EII_i^r for individual EMU member countries and for the EMU as a whole. We also draw comparisons with the main players in the world economy.

We first isolate the EMU from world input-output tables. We do this focusing on input-output linkages between all 12 core EMU member countries in the WIOT. We compute an EMU-wide direct requirement matrix normalizing the entries in the I/O table that pertain to core EMU countries by sector gross output in the core EMU countries. This gives us the values for a_{ij}^{rs} in the EMU. We proceed similarly with sector-level final demand. Finally, we isolate the domestic I/O matrices for each of the 12 EMU core member country, along with the corresponding (domestic) final demands. This makes it possible to compute EI_i^r for all 56 sectors in the core of the EMU. Chart 6 reports average measures of export intensity at country-level, averaging EI_i^r up to country level using sector gross output shares as weights.

Chart 6

Export Intensities for EMU Member countries (without Luxembourg)



Sources: World Input Output Database.

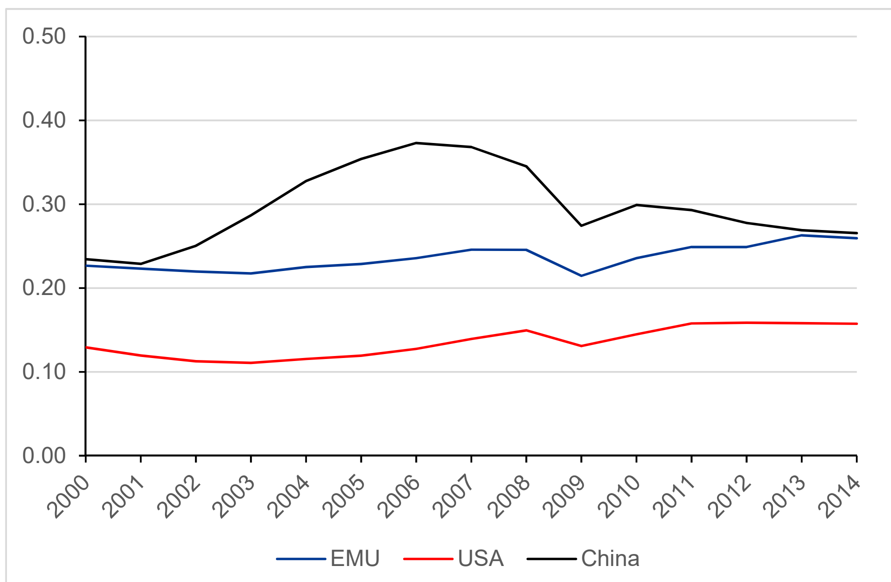
Several results are worth mentioning. First, small countries like Luxembourg, Belgium, or Ireland are exceptionally intensive in exports. In fact, Luxembourg is omitted from Chart 6, for its export intensity index dwarves that of other EMU members, culminating to 74% on average. It is followed by Belgium, Ireland, the Netherlands and Austria, all with averages between 30 and 50%. This is not surprising and is the mirror image of what raw exports (imports) data imply: these economies are geared towards foreign trade. The chart confirms this fact, with allowances for export intensity even in sectors that do not effectively trade internationally. The large economies in the Union – Germany, France, Italy, Spain – come immediately next, with value between 20 and 25%, with highest values in Germany. Finally, Greece is the least open country in the Union.

Second, EMU member countries experience very similar trends, close to being flat, with an increase until 2007, a slight dip around 2008, and a mild recovery post-2008. The dispersion between countries is much larger than the changes over time.

How do EMU members countries compare with other large economies in the world? In Chart 7, we compare the average export intensity of EMU countries (with the rest of the Union) with the average export intensity in China and the US.[7] Several results stand out. First, the US and Europe display the same, slightly upward trend, whereas China's export intensity booms from 30 to 42% until 2006, but then plateaus (before the crisis) and falls back after 2008. In fact, by 2014 China's intensity index falls to 27%, barely above that in the EMU, 26%. The US, in contrast, is a much less export oriented economy, with a maximum value of 15%. The recent upward trend in the EMU, combined with the fall in export intensity in China, imply EMU countries that are as open to each other as China is to the rest of the world.

Chart 7

Export Intensities for the three main areas in the world economy



Sources: World Input Output Database.

An obvious question is the role of individual sectors in driving these results. Tables 2 and 3 report a selected sample of values for EI_i^r in the EMU, the US, and China. Rather than reporting all 56 sectors, we report the three sectors with top values in each region, and a subset of sectors representative of primary, secondary, and tertiary activities. One of the great advantages of our measure of export intensity is that it can be computed just on the basis of input-output linkages. And so it is

[7] For the EMU, we consider the I/O linkages within the Union only, aggregate the entries across the 12 countries, and compute the direct requirement matrix accordingly. For the US and China, we consider I/O linkages from each country with the rest of the world. The comparison is between the average within-EMU export intensity and the average export intensities of China and the US with the rest of the world.

straightforward to compute for services, even those that are customarily deemed to be “non traded”. In fact, since the index is not built from actual trade data, it is blind to traded or non-traded-ness.

Table 2 reports the three sectors with highest export intensity values in the EMU, the US, and China, in 2000, 2007, and 2014. Across all three regions the most export intensive sectors are in manufacturing. In the EMU and the US, heavy manufacturing takes the top spots, with Chemicals, Metals, Transport manufacturing, and Mining. In China, light manufacturing is somewhat more prominent, with Textile, Computers, and Other manufactures. Top values for export intensities in the EMU have increased from around 60% in the 2000’s to around 70% in 2014. These are in fact higher than the top industry in China, Computers, which has become much less export intensive since 2007, down to 66% from 85%. In fact, on the basis of its most intensive sectors, the EMU is more export intensive than China. It is clearly much more export intensive than the US, whose most intensive sector – Metals – reached 58% in 2014.

Table 2
Export Intensities: top 3 sectors in EMU, China and USA

EMU					
2000		**2007**		**2014**	
Chemicals	0.63	**Chemicals**	0.69	**Chemicals**	0.76
Metals	0.61	**Metals**	0.67	**Mining**	0.74
Computers	0.58	**Computers**	0.61	**Metals**	0.68
China					
2000		**2007**		**2014**	
Computers	0.53	**Computers**	0.76	**Computers**	0.61
Textile	0.44	**Air Transport**	0.65	**Other Manufacturing**	0.51
Air Transport	0.42	**Textile**	0.64	**Textile**	0.46
USA					
2000		**2007**		**2014**	
Water Transport	0.64	**Water Transport**	0.57	**Manuf. of Transp. Equip.**	0.52
Manuf. of Transp. Equip.	0.49	**Manuf. of Transp. Equip.**	0.49	**Chemicals**	0.44
Computers	0.46	**Computers**	0.45	**Computers**	0.44

Sources: World Input Output Database.

Table 3 focuses on nine sectors chosen to be representative of agriculture, manufactures, and services. The patterns in agriculture and manufacturing is quite systematic: EMU countries display a manifest trend upwards, while China’s trend turns downwards from 2007. As a result, EMU sectors are more export intensive than China’s by the end of the sample. This is true of Agriculture, Mining, Textile, Machinery, and Pharmacy. These are also much more intensive in exports in the EMU than in the US, where the trend is essentially flat.

For services, the pattern is different. China's services are substantially more export oriented than the EMU's, and, by a long margin, than the US. While export intensity continues to be hump-shaped in China with a peak in 2007, the levels in China by the end of the sample tend to remain slightly above EMU's, and far above the US's. The most intensive services in the EMU are wholesale and business (legal and accounting) services: Their level in 2014 is roughly on par with China's, while they were far below earlier in the 2000's. China is by far the most export intensive in Retail and Finance.

Table 3

Export Intensities: Selected sectors in EMU, China and USA

	EMU			China			USA		
	2000	2007	2014	2000	2007	2014	2000	2007	2014
Agriculture	0.24	0.28	0.35	0.15	0.29	0.21	0.18	0.23	0.26
Mining	0.50	0.60	0.74	0.30	0.41	0.30	0.18	0.22	0.32
Textile	0.45	0.51	0.65	0.44	0.64	0.46	0.24	0.31	0.27
Pharmacy	0.39	0.54	0.61	0.11	0.24	0.14	0.28	0.33	0.36
Machinery	0.44	j0.51	0.57	0.24	0.45	0.35	0.36	0.43	0.42
Wholesale	0.28	0.30	0.36	0.29	0.42	0.34	0.23	0.25	0.27
Retail	0.18	0.21	0.14	0.29	0.41	0.34	0.02	0.02	0.03
Finance	0.19	0.25	0.24	0.23	0.37	0.27	0.12	0.15	0.21
Legal & Acct	0.25	0.27	0.36	0.39	0.49	0.35	0.17	0.18	0.21

Sources: World Input Output Database.

Table 4 repeats the exercise with a breakdown into the same nine sectors for individual EMU countries. The upper panel focuses on three large EMU economies (Germany, France, and Italy); the lower panel presents results for three small economies (Austria, Greece, and the Netherlands). The same broad conclusions emerge in the large European economies: export intensity is increasing, sometimes fast, across agriculture and most manufacturing sectors. No such trend is apparent for services. Greece is by far the most inward-looking country in the sample, with lower export intensities across the board. Austria and the Netherlands have services that are quite outward-oriented, especially Finance and Business Services.

Table 4

Export Intensities: Selected sectors in selected EMU countries

	Germany			France			Italy		
	2000	2007	2014	2000	2007	2014	2000	2007	2014
Agriculture	0.17	0.24	0.34	0.24	0.25	0.29	0.11	0.13	0.20
Mining	0.32	0.53	0.69	0.31	0.46	0.47	0.18	0.25	0.20
Textile	0.61	0.89	0.85	0.51	0.66	NA	0.33	0.35	0.52
Pharmacy	0.29	0.64	0.58	0.31	0.42	0.62	0.25	0.31	0.57
Machinery	0.42	0.53	0.56	0.55	0.70	0.73	0.35	0.38	0.49
Wholesale	0.29	0.38	0.35	0.24	0.23	0.33	0.18	0.20	0.22
Retail	0.08	0.11	0.13	0.23	0.23	0.07	0.16	0.18	0.11
Finance	0.15	0.22	0.19	0.15	0.15	0.16	0.13	0.16	0.16
Legal & Acct	0.22	0.28	0.28	0.21	0.20	0.23	0.17	0.19	0.18
	Austria			Greece			Netherlands		
	2000	2007	2014	2000	2007	2014	2000	2007	2014
Agriculture	0.26	0.36	0.46	0.04	0.06	0.09	0.64	0.75	0.69
Mining	0.38	0.67	0.57	0.13	0.19	0.31	NA	NA	NA
Textile	0.77	0.90	0.87	0.16	0.12	0.06	0.89	0.93	0.87
Pharmacy	0.46	0.65	0.62	0.04	0.17	0.22	0.74	0.86	0.83
Machinery	0.67	0.73	0.71	0.05	0.08	0.14	0.54	0.88	0.79
Wholesale	0.35	0.40	0.45	0.07	0.10	0.14	0.53	0.45	0.66
Retail	0.08	0.09	0.10	0.03	0.03	0.05	0.41	0.41	0.15
Finance	0.26	0.29	0.28	0.04	0.06	0.08	0.32	0.33	0.40
Legal & Acct	0.32	0.36	0.35	0.06	0.09	0.12	0.43	0.40	0.82

Sources: World Input Output Database.

2.3 Export Intensity and Convergence

We now compute bilateral indices of export intensity, BI_{ij}^{rs} and BII_{ij}^{rs}. Each index can be computed in each year, and we seek to establish whether bilateral export intensity can explain the convergence in sector-level growth rates, and ultimately in GDP. Our approach is from the bottom up, in the sense that we seek to explain the convergence in aggregate GDP growth on the basis of convergence at sector level. The conjecture is that sectors that co-move between countries are ones with strong bilateral export intensity. This in turn reflect deep integration in terms of input-output linkages, rather than large volumes of exports, and it increases aggregate co-movements.

We start with a simple description of the values of BII_{ij}^{rs} obtained for EMU countries, as compared with China and the US. In the EMU we consider all country pairs between the core 12 member countries, i.e. a total of 66 country pairs. We construct

A_{ij}, $\boldsymbol{F_{ij}}$, and their domestic constituents for each one of these pairs. We also apply Leontief's inverse to compute value added and gross output corresponding to each country pair. We proceed similarly for the US and China, focusing on all bilateral pairs involving one or the other.

Table 5

Bilateral Export Intensities in sectors for EMU(blue), USA(red) and China(black)

	AGR	Light MFG	Heavy MFG	Utilities	Retail/Whole	Transp.	Hotels	Bus. Serv.
AGR	6.906	6.195	7.550	4.471	3.481	6.052	3.570	3.944
	2.172	2.009	2.371	1.366	1.455	1.706	1.269	1.486
	0.927	0.945	1.384	0.879	0.923	1.297	0.709	0.816
Light MFG	7.037	6.387	7.980	4.516	3.562	6.144	3.570	3.968
	1.725	1.585	1.948	1.093	1.173	1.338	0.997	1.198
	1.031	1.036	1.529	0.947	1.004	1.424	0.770	0.877
Heavy MFG	7.950	7.335	9.132	5.232	4.100	7.091	4.116	4.580
	2.473	2.272	2.790	1.568	1.677	1.921	1.426	1.711
	1.157	1.182	1.728	1.106	1.153	1.618	0.890	1.028
Utilities	4.040	3.709	4.639	2.687	2.064	3.603	2.092	2.312
	1.282	1.200	1.493	0.837	0.870	1.012	0.758	0.912
	0.841	0.860	1.254	0.806	0.843	1.182	0.648	0.751
Retail/Whole	3.733	3.393	4.228	2.411	1.896	3.301	1.944	2.154
	0.718	0.668	0.831	0.460	0.491	0.570	0.426	0.519
	1.005	1.023	1.501	0.950	0.994	1.401	0.766	0.883
Transp.	5.548	5.044	6.316	3.643	2.845	4.905	2.890	3.207
	1.587	1.490	1.930	1.068	1.105	1.326	0.964	1.163
	1.136	1.133	1.670	1.043	1.086	1.549	0.848	0.955
Hotels	3.798	3.488	4.284	2.531	2.074	3.488	2.226	2.431
	0.804	0.767	0.984	0.537	0.555	0.663	0.494	0.609
	0.877	0.897	1.321	0.834	0.870	1.228	0.671	0.775
Bus. Serv.	4.219	3.942	4.864	2.846	2.358	3.942	2.542	2.792
	0.993	0.937	1.192	0.651	0.688	0.814	0.612	0.760
	0.950	0.968	1.428	0.898	0.937	1.326	0.724	0.836

Sources: World Input Output Database. Averages of BII_{ij}^{rs} . EMU in blue, USA in red and China in black. All numbers are multiplied by 1,000.

We find the average value for BII_{ij}^{rs} is about four times larger in EMU than in China or the US: it is equal to 4.21 in EMU, 1.19 in the US, and 1.05 in China. Are these differences homogeneous across sector pairs? We partition the 50 sectors in WIOT into 8 categories – Agriculture, Light Manufacturing, Heavy Manufacturing, Utilities, Retail/Wholesale, Transport, Hotels, and Business Services. We compute the average values for BII_{ij}^{rs} in each of the 64 bilateral cells defined by this partition. Table 5 reports these average values for BII_{ij}^{rs} for the EMU as compared with the US and China. The table illustrates considerable heterogeneity across sector-pairs. In the EMU, BII_{ij}^{rs} takes highest value within heavy manufactures, where it is equal to

6.19, followed by light manufacturing and agriculture. The lowest value is in retail / wholesale, where it is 2.88. The highest bilateral value is within heavy manufacturing, with 9.13. Interestingly, the dispersion in the values of BII_{ij}^{rs} is quite similar across countries. The most integrated sectors in China and the US are also in heavy manufactures, followed by light manufactures. But they are considerably smaller, 1.98 and 1.23, respectively. The pair with highest value is also within heavy manufactures both in the US (2.79) and in China (1.73). The lowest value in the Table for the US is in services, like in the EMU: within retail / wholesale (0.49), and between retail / wholesale and hotels (0.42). And the lower value in the Table for China is also in services: 0.67 within hotels, and 0.64 between utilities and hotels.

The cross-sectional distribution of BII_{ij}^{rs} across sector-pairs is in fact quite stable across regions, with high values within manufacturing, and relatively low values within services. The key difference apparent in the Table is that numbers in the EMU are considerably larger than in the US and in China. EMU member countries are considerably more integrated bilaterally with each other than the US or China are integrated with individual countries in the world economy. This is a fact that raw trade data would miss completely.

We then turn to the question whether export intensity can explain convergence in GDP. We seek to establish if β is significant in the estimation of

$$-\left|gy_{it}^{r} - gy_{jt}^{s}\right| = \alpha_{ij}^{rs} + \beta BII_{ij,t}^{rs} + \gamma Trade_{ij,t}^{rs} + \eta_{ij,t}^{rs}$$

The estimation is performed within country-sector pair, and positive estimates of β are interpreted as suggestive that bilateral export intensity (as opposed to observed trade intensity) does contribute to convergence.

Table 6

Export Intensities and Convergence in EMU countries

	(1)	(2)	(3)	(4)	(5)	(6)
BII_{ij}^{rs}	0.20***	0.20***	0.10***	0.12***	0.16***	0.15***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
$Trade_{ij}^{rs}$		0.23***	0.24***	-0.0048	0.0073	0.012
		(0.08)	(0.07)	(0.03)	(0.04)	(0.04)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects			Yes			
Year-Country-Sector				Yes		
Year-Country					Yes	
Year-Country-Pair						Yes
N	2292400	2292391	2292391	2128492	2128492	2128492
R^2	0.00018	0.00018	0.053	0.34	0.035	0.051
	(7)	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
BI_{ij}^{rs}	0.14***	0.14***	0.07***	0.10***	0.10***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$Trade_{ij}^{rs}$		0.25***	0.25***	-0.005	0.009	0.013
		(0.08)	(0.07)	(0.03)	(0.04)	(0.04)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects			Yes			
Year-Country-Sector				Yes		
Year-Country					Yes	
Year-Country-Pair						Yes
N	2292391	2292391	2292391	2128492	2128492	2128492
R^2	0.0002	0.0002	0.05	0.34	0.04	0.05

Sources: World Input Output Database. The dependent variable is $-|gy_{it}^r - gy_{jt}^s|$ and the standard errors are in brackets. ***, **, * denote the 1%, 5% and 10% level of significance respectively.

Table 6 reports the estimates of β for all country-sector pairs i,j,r,s in the EMU. The different specifications include additional intercepts, with a view to ensuring the robustness of the estimates. All specifications include α_{ij}^{rs} and are performed within-country-sector pair. The first specification includes export intensity BII_{ij}^{rs} only. Specification (2) is augmented with controls for bilateral direct trade. Specification (3) includes year effects in order to absorb any EMU-wide aggregate shocks. Specification (4) includes country-sector-year effects to allow for country-specific sector shock. Specification (5) includes country-year effects only, meant to control for any macroeconomic shock. Finally, specification (6) introduces country-pair year effects, allowing for changes in the patterns of aggregate country-level correlations. The first six specifications use $BII_{ij,t}^{rs}$ as a regressor; the last six use $BI_{ij,t}^{rs}$ instead, with similar permutations of fixed effects. In all cases the value of β is estimated to be strongly positive and significant, with point estimates that are quite robust between 0.10 and 0.20. The same cannot be said of actually observed bilateral trade, which does not survive the inclusion of country-sector-year, country-year, or country-pair-year effects. The consequence of export intensity is a robust effect, obtained in a broad bilateral dataset at sector-level. The natural next question is: what are the sectors that drive the effects of export intensity.

Table 7

Export Intensities and Convergence in EMU for primary/secondary/tertiary sectors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	AGR-AGR	AGR-MFG	AGR-SER	MFG-AGR	MFG-MFG	MFG-SER	SER-AGR	SER-MFG	SER-SER
BII_{ij}^{rs}	0.04	-0.01	0.18***	0.02	0.13***	0.26***	0.23***	0.41***	0.57***
	(0.06)	(0.04)	(0.05)	(0.03)	(0.02)	(0.02)	(0.04)	(0.03)	(0.03)
$Trade_{ij}^{rs}$	-1.86	0.34***	-8.48	-3.05	0.26*	-1.87***	7.28	2.08***	-1.42***
	(2.05)	(0.11)	(5.72)	(2.76)	(0.14)	(0.45)	(6.63)	(0.49)	(0.32)
N	14168	80183	84220	78428	443828	466108	82078	464470	487784
R^2	0.0001	0.0001	0.0002	0.00003	0.0001	0.0003	0.00047	0.0004	0.0007

Sources: World Input Output Database. The dependent variable is $-|gy_{it}^r - gy_{jt}^s|$ and the standard errors are in brackets. ***, **, * denote the 1%, 5% and 10% level of significance respectively. AGR is Agriculture, MFG is Manufacturing and SER are Services.

Tables 7 and 8 break the estimation down to the sector level. Table 7 partitions all sectors into primary, secondary, and tertiary activities, and reports estimates of β for all nine bilateral combinations of these three categories. Two results stand out. First, manufacturing sectors that are intensive in exports tend to correlate bilaterally. This is not too surprising, as these are highly traded merchandises. Much more surprising is the systematically high and significant estimates of β for pairs involving service sectors. These are quintessentially non-traded sectors, and yet their bilateral export intensity is significantly associated with converging growth rates: These are in fact the activities where estimates of β take their largest values. These are also the pairs of sectors where a standard measure of direct trade would be unable to explain the convergence in sector growth rates: the estimates of the effects of trade on $-|gy_{it}^r - gy_{jt}^s|$ are unstable, sometimes insignificant, sometimes negative and significant.

Table 8
Export Intensities and Convergence in EMU for 8 categories

	Variables	AGR	Light MFG	Heavy MFG	Utilities	Retail/Whole	Transp.	Hotels	Bus. Serv.
AGR	BII_{ij}^{rs}	0.04	-0.10	-0.02	0.20**	0.14	0.22***	0.12	0.16*
		(0.06)	(0.08)	(0.06)	(0.10)	(0.16)	(0.08)	(0.13)	(0.09)
	$Trade_{ij}^{rs}$	-1.86	-0.93	0.36***	0.44	7.12	-9.7	-11.0*	29.1
		(2.05)	(0.75)	(0.13)	(0.55)	(15.60)	(23.20)	(5.85)	(27.50)
Light MFG	BII_{ij}^{rs}	0.09*	0.07	0.16***	0.21**	0.39***	0.29***	0.36***	0.44***
		(0.05)	(0.07)	(0.05)	(0.09)	(0.14)	(0.07)	(0.12)	(0.08)
	$Trade_{ij}^{rs}$	1.72	0.44	9.00**	-5.43	4.07	-2.66	0.47	4.27
		(5.41)	(0.65)	(3.96)	(7.15)	(6.19)	(7.35)	(2.22)	(3.30)
Heavy MFG	BII_{ij}^{rs}	-0.01	0.11**	0.12***	0.20***	0.11	0.22***	0.24***	0.33***
		(0.04)	(0.05)	(0.03)	(0.06)	(0.10)	(0.04)	(0.08)	(0.05)
	$Trade_{ij}^{rs}$	-4.27	-0.92	0.12	-2.03	-0.91	-1.67***	-15.9***	-38.6***
		(3.48)	(3.01)	(0.16)	(1.36)	(3.80)	(0.55)	(4.60)	(5.30)
Utilities	BII_{ij}^{rs}	0.11	0.24	0.05	-0.29	-0.58	0.16	0.24	0.44**
		(0.11)	(0.16)	(0.14)	(0.24)	(0.40)	(0.14)	(0.32)	(0.22)
	$Trade_{ij}^{rs}$	-5.96	7.30	3.95***	2.43***	13.0	-3.59	-27.9***	-23.0***
		(8.70)	(4.73)	(0.70)	(0.93)	(12.40)	(12.60)	(7.94)	(8.50)
Retail/Whole	BII_{ij}^{rs}	0.057	0.29	0.29	-0.13	-0.35	0.39**	0.16	0.41*
		(0.11)	(0.20)	(0.20)	(0.29)	(0.45)	(0.17)	(0.36)	(0.25)
	$Trade_{ij}^{rs}$	16.9	6.12	6.12	2.09	18	5.89	-3.14	9.13
		(14.20)	(4.29)	(4.29)	(6.81)	(15.50)	(19.20)	(4.43)	(6.41)
Transp.	BII_{ij}^{rs}	0.33***	0.79***	0.79***	0.73***	0.88***	0.60***	1.51***	1.06***
		(0.08)	(0.11)	(0.11)	(0.11)	(0.22)	(0.10)	(0.18)	(0.11)
	$Trade_{ij}^{rs}$	-88.9***	-36.7***	-36.7***	-15.8	5.34	-2.01*	-31.4***	-5.33*
		(29.70)	(9.53)	(9.53)	(11.70)	(5.42)	(1.21)	(6.62)	(2.94)
Hotels	BII_{ij}^{rs}	0.17*	0.14	0.14	0.065	-0.34	0.24*	0.36*	0.42***
		(0.10)	(0.16)	(0.16)	(0.19)	(0.24)	(0.14)	(0.19)	(0.13)
	$Trade_{ij}^{rs}$	18.1*	3.77	3.77	-72.5***	7.22**	2.34	-1.94*	-0.73
		(9.49)	(6.20)	(6.20)	(14.20)	(3.29)	(8.70)	(0.99)	(0.74)
Bus. Serv.	BII_{ij}^{rs}	0.15**	0.26***	0.26***	0.08	-0.19	0.46***	0.34***	0.46***
		(0.06)	(0.10)	(0.10)	(0.13)	(0.17)	(0.09)	(0.12)	(0.08)
	$Trade_{ij}^{rs}$	17.8**	8.61*	8.61*	0.60	7.32***	-10.8**	-0.37	-1.47***
		(7.46)	(4.55)	(4.55)	(2.04)	(2.24)	(5.18)	(0.60)	(0.38)

Sources: World Input Output Database. The dependent variable is $-\left|gy_{it}^{r} - gy_{jt}^{s}\right|$ and the standard errors are in brackets. ***, **, * denote the 1%, 5% and 10% level of significance respectively.

Table 8 now partitions all 50 WIOT sectors in eight categories, following the same classification as in Table 5, and reports estimates of β in each of the thus defined 64 cells. The coefficient is typically significant and positive whenever sector r belongs to manufactures (light and heavy) and transport, but these point estimates are largest when sector s belongs to services, especially transport, hotels, and business services. In fact, the most consistently positive and large estimates of β obtain for pairs of sectors involving business services. This is intuitive as business services constitute presumably a key input for activities that export: even though there is very little direct trade in those sectors, they contribute to a first order to convergence between sectors.

How much do these results contribute to aggregate convergence? Absolute differences in growth rates cannot answer this important question, since absolute values do not have palatable aggregation properties. To answer this crucial question, we turn to an alternative measure of co-movements, the quasi-correlation coefficient

$$q_{ij,t}^{rs} = \frac{(g_{it}^{r} - \bar{g}_{i}^{r})(g_{jt}^{s} - \bar{g}_{j}^{s})}{\sigma_i^r \sigma_j^s}$$

where g_{it}^{r} denotes value added growth in sector r of country i at time t, $\bar{g}_{i}^{r}$ is its average over time, and σ_i^r is its standard deviation.

The main appeal of the quasi-correlation coefficient is its simple aggregation properties. Define the aggregate quasi correlation

$$q_{ij,t} = \frac{(g_{it} - g_i^*)(g_{jt} - g_j^*)}{\sigma_i \sigma_j}$$

where g_{it} denotes the GDP growth rate in country i at time t, g_i^* is its average over the period, and σ_i is its standard deviation. It is straightforward that

$$q_{ij,t} = \frac{\sum_r \sum_s \omega_i^r \omega_j^s (g_{it}^{r} - \bar{g}_{i}^{r})\,(g_{jt}^{s} - \bar{g}_{j}^{s})}{\sigma_i \sigma_j}$$

where we assumed constant sector shares, and $E g_{it}^{r} g_{it}^{s} = 0$ for all r,s,i,t, i.e., the meaningful correlation between sectors is international. Simple algebra implies

$$q_{ij,t} = \sum\nolimits_r \sum\nolimits_s \frac{\omega_i^r \omega_j^s \sigma_i^r \sigma_j^s}{\sigma_i \sigma_j} q_{ij,t}^{rs}$$

Aggregate co-movements are given by a weighted average of all bilateral quasi-correlations at sector level, with weights given by relative standard deviations.

Table 9 presents the results of estimating

$$q_{ij,t}^{rs} = \alpha_{ij}^{rs} + \beta BII_{ij,t}^{rs} + \gamma Trade_{ij,t}^{rs} + \eta_{ij,t}^{rs}$$

including a battery of fixed effects akin to what we did previously, with and without controls for bilateral trade. The table confirms the results obtained with absolute differences carry through with quasi-correlation coefficients, with positive and significant estimates of β everywhere.[8]

[8] An issue with the quasi-correlation coefficient $q_{ij,t}^{rs}$ is that it is measured with considerable error: both moments $\bar{g}_{i}^{r}$ and σ_i^r are estimated over the whole period, which includes the global financial crisis of 2007-2008. As a result, $q_{ij,t}^{rs}$ displays (very) large volatility over time. This is a serious problem for an estimation that is performed within country-sector pairs, which is known to exacerbate measurement error. To alleviate this issue, the estimation is performed using average values of all variables over two periods: 2000-2007, and 2008-2014.

Table 9

Export Intensities and Quasi Correlation in EMU countries

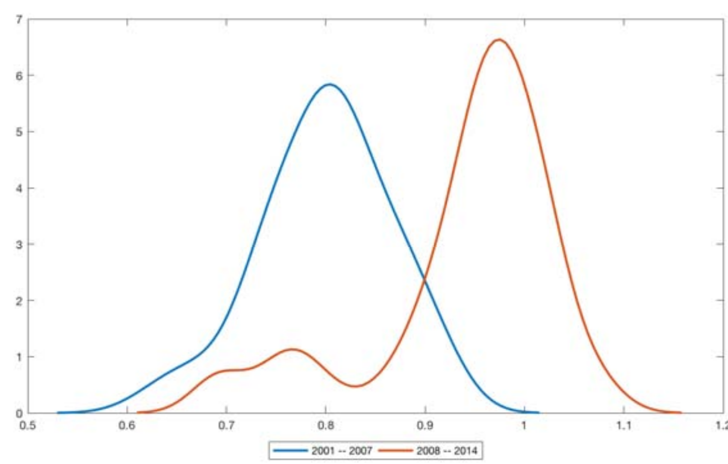
	(1)	(2)	(3)	(4)	(5)	(6)
BII_{ij}^{rs}	4.15***	4.08***	2.10***	2.15***	2.32***	2.18***
	(0.11)	(0.11)	(0.11)	(0.10)	(0.11)	(0.12)
$Trade_{ij}^{rs}$		3.81***	3.32***	2.53***	4.15***	3.82***
		(0.74)	(0.72)	(0.26)	(0.31)	(0.31)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects			Yes			
Year-Country-Sector				Yes		
Year-Country					Yes	
Year-Country-Pair						Yes
N	325600	325600	325600	162800	162800	162800
R^2	0.0089	0.0091	0.054	0.33	0.013	0.03

Sources: World Input Output Database. The dependent variable $q_{ij,t}^{rs}$ and the standard errors are in brackets. ***, **, * denote the 1%, 5% and 10% level of significance respectively.

We finally investigate the ability of export intensity to explain the convergence in GDP, i.e., the change in quasi-correlation between GDP growth rates in the EMU. Since we have so far focused on a measure of convergence based on absolute differences, we first verify that the quasi correlation between aggregate GDP growth did indeed shift upwards over the past 20 years. Chart 8 plots density estimates for the value of $q_{ij,t}$ averaged over 2000-2007 and over 2008-2014. The chart illustrates unambiguously the increase in average bilateral correlations over that period.

Chart 8

Density of $q_{ij,t}$ over two periods: 2001 – 2007 and 2008 – 2014



Sources: World Input Output Database.
Notes: Density plots of observed $q_{ij,t}$.

This is also the period during which an increase in $BII_{ij,t}^{rs}$ was associated with a rise in sector-level correlations $q_{ij,t}^{rs}$, as per Table 9. We now ask how much of the aggregate convergence can be explained by sector-level developments. To do so, we fit values for $\hat{q}_{ij}^{rs}$ using the model in Table 9. First, we fit $\hat{q}_{ij}^{rs}(BII)$, the value for bilateral correlations at sector level implied by export intensity only (along with the fixed effects) in specification (1). For comparison purposes, we fit $\hat{q}_{ij}^{rs}(Trade)$, the value for bilateral correlations at sector level implied by bilateral trade only (again, along with the fixed effects) in specification (1). We fit these values over the two periods 2000-2007 and 2008-2014. We then use the aggregation formula and obtain fitted values of aggregate correlations, $\hat{q}_{ij}(BII)$, and $\hat{q}_{ij}(Trade)$, measured again over the same two periods. Both fitted values are only allowed to change over time because of changes in export intensity and changes in trade: Thus, we focus the analysis on the ability of our new measure to explain aggregate convergence.We compare it with the well-known fact that bilateral trade explains bilateral cycle correlations.

We collect aggregate GDP growth rates from WIOT, and compute quasi-correlation coefficients over the same two periods. Finally, we estimate $q_{ij,t} = \alpha_{ij} + \beta\hat{q}_{ij}(BII) + \varepsilon_{ij,t}$ and $q_{ij,t} = \alpha_{ij} + \beta\hat{q}_{ij}(Trade) + \varepsilon_{ij,t}$ with t = 2000-2007, 2008-2014. Table 10 presents the results. The results are interesting: estimates of β are positive and significant in both specifications when the fitted values $\hat{q}_{ij}(BII)$ and $\hat{q}_{ij}(Trade)$ are included in isolation. The within R squared are in the same ballpark in either case: 20.6% for bilateral export intensity, and 16.9% for bilateral trade. When both fitted values are included simultaneously, however, $\hat{q}_{ij}(Trade)$ stops being significant, and it is only $\hat{q}_{ij}(BII)$ that displays any explanatory power. The R squared is virtually unchanged, at 20.9%. We conclude that export intensity is at least as relevant as trade in explaining GDP convergence in the aggregate.

Table 10
Estimates of $q_{ij,t} = \alpha_{ij} + \beta\hat{q}_{ij}(BII) + \varepsilon_{ij,t}$ and $q_{ij,t} = \alpha_{ij} + \beta\hat{q}_{ij}(Trade) + \varepsilon_{ij,t}$

	Aggregate Quasi-Correlation		
	(i)	(ii)	(iii)
Export Intensity	2.722***		2.221*
	(0.675)		(1.240)
Direct Trade		48.753***	12.756
		(13.375)	(24.020)
N. Obs	132	132	132
Within R2	0.206	0.169	0.209
Pair fixed effects	Yes	Yes	Yes

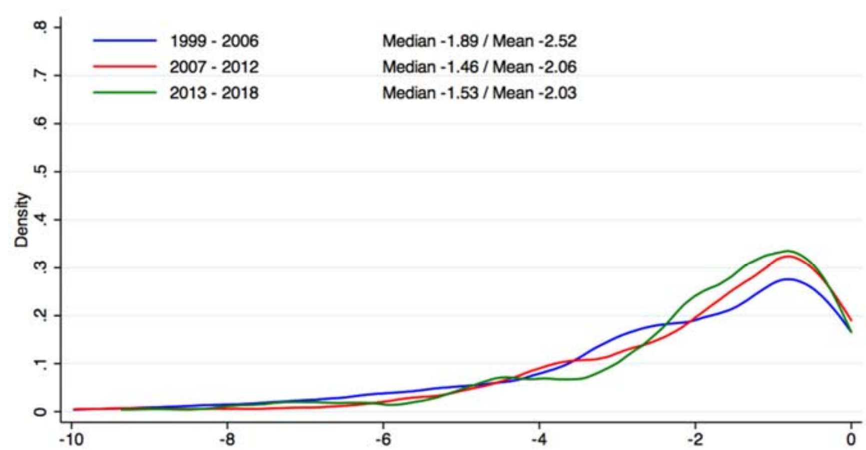
Sources: World Input Output Database. The dependent variable is $q_{ij,t}$ and standard errors are in brackets. ***, **, * denote the 1%, 5% and 10% level of significance respectively.

3 Convergence in Consumption

We start with an illustration of the convergence in per capita consumption between EMU members countries, and then compare it with US states. Chart 8 plots the estimated distribution for the absolute differences in per capita consumption growth rates across the 12 core EMU members. Once again, the trend is one of increased convergence, and it is between 1999-2006 and 2007-2012 that the increase is most pronounced. Both mean and median absolute differences fall observably between the two periods, from -2.52 to -2.06, and -1.89 to -1.45, respectively. The latest period 2013-2018 does not witness much of a shift in the distribution. Interestingly, this is very different from convergence in GDP, which mostly occurred after 2013. It suggests the evidence in the intermediate period could be due to financial integration (since this is when consumption converge without much of a change in GDP differences). And it suggests the opposite for the most recent period, since GDP converged while consumption did not.

Chart 9

Absolute difference in Consumption growth - EMU



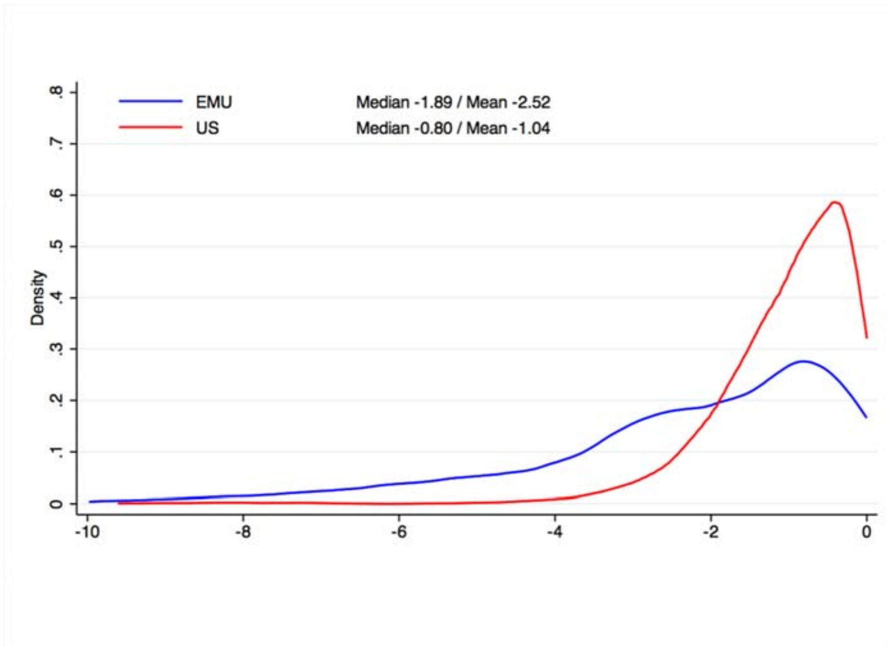
Sources: Eurostat.
Notes: Density plots of annual difference in Consumption growth in pairs of EMU countries.

How do absolute difference in consumption compare between the EMU and the US? Charts 9, 10, and 11 begin to answer the question, comparing distributions in the two regions over the three periods considered. The evidence is unambiguous: per capita consumption growth is substantially more homogeneous across US states than it is between EMU member countries. The mean, median, and mode of the estimated distribution for absolute differences are substantially closer to zero in the US, with values often less than half what they are in the EMU. For example, the mean absolute difference is -1.04 between 1999 and 2006 in the US, against -2.52 in the

EMU. The same pattern emerges in all three periods. Increased convergence is also apparent in the US, especially in the last period after 2013. While mean and median are virtually unchanged in the US between 1999-2006 and 2007-2012, they fall sizeably after 2013, going from -0.80 to -0.60, and from -1.06 to -0.75, respectively. Of course, in the US this is also the period during which GDP converge, which suggests this recent convergence in consumption growth does not necessarily originate in improved financial integration. Next Section investigates rigorously how disconnected from local income consumption has become over time, both in the EMU and in the US.

Chart 10

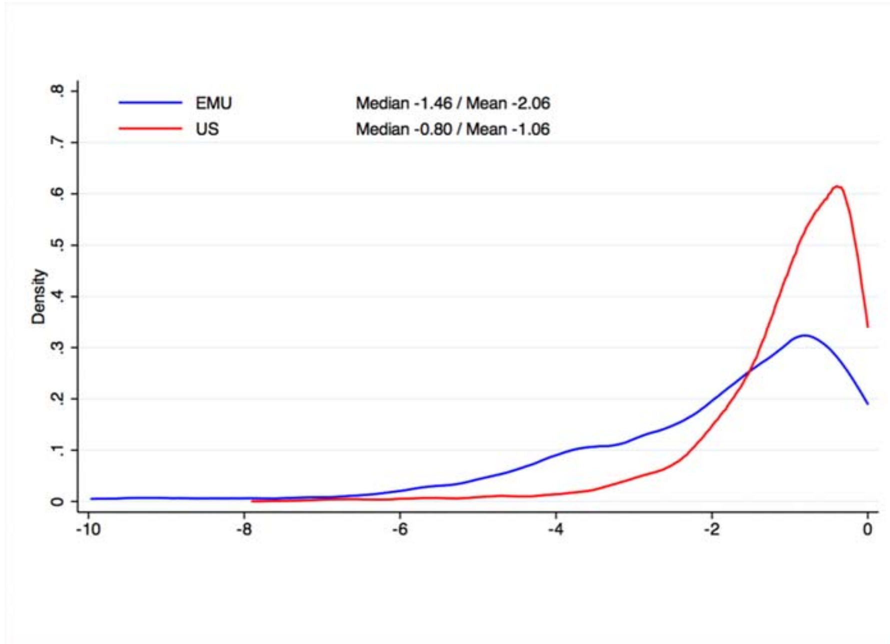
Absolute difference in GDP growth from 1999 to 2006 – EMU and US



Sources: Eurostat.
Notes: Density plots of annual difference in Consumption growth in pairs of EMU countries and pairs of US states.

Chart 11

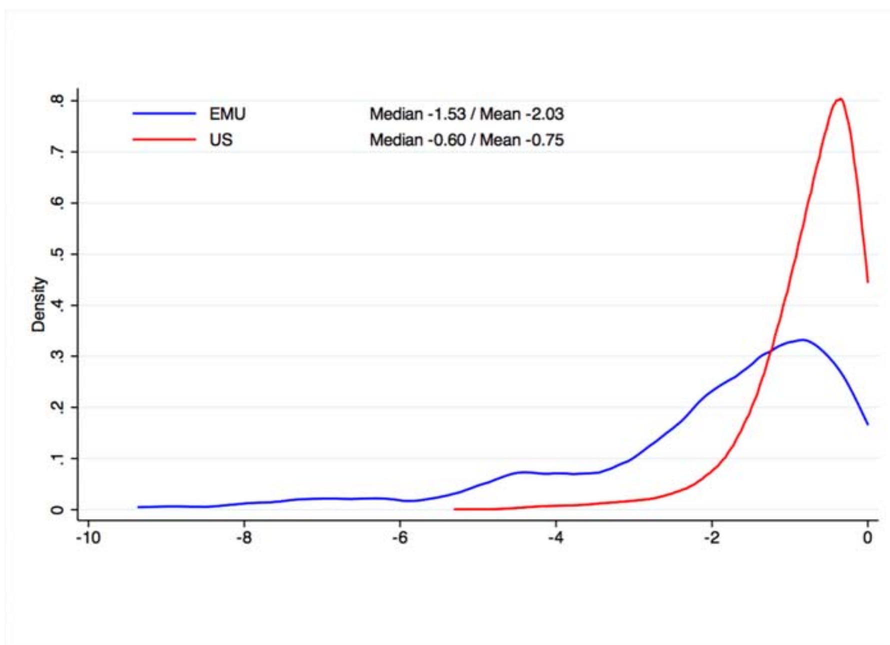
Absolute difference in Consumption growth from 2007 to 2012 – EMU and US



Sources: Eurostat.
Notes: Density plots of annual difference in Consumption growth in pairs of EMU countries and pairs of US states.

Chart 12

Absolute difference in Consumption growth from 2013 to 2018 – EMU and US



Sources: Eurostat.
Notes: Density plots of annual difference in Consumption growth in pairs of EMU countries and pairs of US states.

3.1 Two tests of consumption risk sharing

The conventional test for consumption risk sharing investigates how changes in consumption (per capita) are related with changes in GDP (per capita). Lewis (1996) estimates

$$gc_{i,t} = \gamma_t + \beta gy_{i,t} + \epsilon_{i,t}$$

where $gc_{i,t}$ ($gy_{i,t}$) denote the growth rate of per capita consumption (per capita GDP). γ_t is a time effect that controls for changes in income that are common in the cross-section of i. In a panel of countries, γ_t controls for common shocks across countries. β tests whether country-level consumption responds to idiosyncratic, country-specific income shocks: under perfect risk sharing, β should be indistinguishable from zero. Lewis (1996) augments this regression with interaction terms meant to reflect whether restrictions to free capital flows can explain large estimates for β.

A natural extension to the bilateral setting in this paper is to estimate

$$\left|gc_{i,t} - gc_{j,t}\right| = \delta\left|gy_{i,t} - gy_{j,t}\right| + \varepsilon_{ij,t}$$

where it is now the pairwise convergence in consumption that is explained by convergence in income per capita. Since the estimation is performed in international differences, it filters automatically any common shocks without the necessity for time effects. As such the estimation can be estimated in cross-section. But using international differences also creates a novel problem: consumption between countries i and j could be identical because they are both financially integrated with the same third country, k.

For example, consider the country pair (i,j), and suppose per capita GDP is perfectly correlated between the two countries. In other words, there is no incentive for risk sharing between i and j. Now suppose a third country k experiences income fluctuations that are perfectly negatively correlated with i, and with j. Then optimally both countries i and j will integrate financially with country k, and δ will be estimated to be zero between i and j, even though the two countries have no financial integration (because they choose not to).

What is missing in the estimation is a measure of the potential for risk sharing from the standpoint of a country i: a measure that captures the potential for risk sharing with country j, relative to the same potential vis à vis third party countries, k. That measure should capture the cross-section of correlations in per capita GDP between country i and all potential counterparts in the sample. Conceptually this is akin to the multilateral resistance term introduced by Anderson and Van Wincoop (2003), that controls for openness vis à vis all third-party countries. Multilateral resistance is well captured by a country-pair specific fixed effect, provided the cross-section in bilateral GDP correlations is time-invariant. Under this assumption, a bilateral test for risk sharing becomes:

$$\left|gc_{i,t} - gc_{j,t}\right| = \alpha_{ij} + \delta\left|gy_{i,t} - gy_{j,t}\right| + \varepsilon_{ij,t}$$

where α_{ij} hold constant the cross-section of GDP correlations from the standpoint of country i. Then δ estimates the effect of risk sharing between countries i and j, controlling for how desirable it is to share risk between countries i and j. Obviously the magnitude of δ is different from β, even though perfect risk sharing implies both point estimates are zero.

In what follows, we present results of estimating both approaches on EMU and on US data. In each case we split the sample into three periods. Then we bring some measures of financial integration in the EMU and investigate how much financial integration can contribute to the estimated extent of risk sharing.

3.2 US vs. EMU

Table 10 presents the estimates for risk sharing obtained from the conventional time series approach. The upper panel reports the estimates for β across US states, compared in the middle panel with the same parameter across EMU member countries. The lower panel focuses on the EMU, where financial deregulation is measured by the number of FSAP directives implemented in each country at each point in time.

Table 11

Estimates of β in $gc_{i,t} = \gamma_t + \beta gy_{i,t} + \epsilon_{i,t}$

	US States			
	1999-2017	1999-2006	2007-2012	2013-2017
Growth in per capita GDP	0.281***	0.296***	0.247***	0.336***
	(0.014)	(0.024)	(0.020)	(0.031)

	EMU Member Countries			
	1999-2018	1999-2006	2007-2012	2013-2018
Growth in per capita GDP	0.449***	0.728***	0.718**	0.171***
	(0.023)	(0.044)	(0.048)	(0.023)

	EMU Member Countries with financial deregulation					
	1999-2014	1999-2014	1999-2006	1999-2006	2007-2014	2007-2014
Growth in per capita GDP	0.716***	0.710***	0.728***	0.821***	0.707***	-0.531*
	(0.031)	(0.054)	(0.044)	(0.055)	(0.044)	(0.82)
Interaction with FSAP Directives		0.000		-0.017***		0.034***
		(0.002)		(0.006)		(0.008)
FSAP Directives		0.065		0.106**		0.113
		(0.045)		(0.054)		(0.078)

Notes: The Table reports the estimates of β in the conventional time series test for consumption risk sharing. *(**)(***) denote significance at 10(5)(1) percent confidence level. All estimations include time effects. Data on FSAP directives stop in 2014

Three key results emerge from the upper two panels in the table. First, risk sharing between US states is stable over time, with estimates of β largely unchanged across periods. This suggests the increase in consumption correlations apparent in the US since 2013 is in fact not a manifestation of improved risk sharing, but due to an increase in the correlation in GDP. Second, risk sharing between US states is on average more complete than between EMU member countries. This result was already in Asdrubali et al (1996), but it is interesting that it is confirmed in much more recent data, inclusive of personal consumption expenditures at State level. Third, interestingly since 2013 consumption risk sharing is estimated to be more complete in the EMU than in the US, with a lower value for β.

The lower panel of Table 10 augments the test for risk sharing with a measure of financial deregulation. The idea is to investigate whether the measured effect of local idiosyncratic income on local consumption is affected by the degree of financial integration. In particular we estimate

$$gc_{i,t} = \gamma_t + \beta_1 gy_{i,t} + \beta_2 gy_{i,t} \times FSAP_{i,t} + \beta_3 FSAP_{i,t} + \epsilon_{i,t}$$

where β_1 and β_2 measure whether financial deregulation affect the relationship between consumption and income. Over the full period, financial deregulation does not affect any estimate. We then split the sample over which financial deregulation is observed into two periods of equal length, before and after the global financial crisis of 2007. Interestingly, β_2 is negative and significant between 1999 and 2006, suggesting that financial deregulation did help smooth country-specific shocks over that period. We also estimate $\beta_3 > 0$ over that period, suggesting financial integration has a direct effect on consumption, akin to a diversification effect that increases consumption correlation unconditionally.

In contrast, the post-crisis period displays opposite patterns. Between 2007 and 2013, we estimate $\beta_2 > 0$, which means that financial integration results in more dependence on local income. A natural interpretation is that financial deregulation created contagion in the sense of diffusing bank balance sheets shocks across the Union, rather than fostering portfolio diversification. Interestingly, conditional estimates of β_1 are not significant in that period, suggesting that imperfect risk sharing is in fact due to financial integration then. Unfortunately, we do not have data on the FSAP directives are 2014, which is the period during which the EMU seems to have been able to smooth consumption the most.

How robust are these conclusions? In Table 11 we present the results obtained form an alternative specification, based on the cross-section of bilateral differences in growth rates. The table is organized similarly to Table 10. The two upper panels of Table 11 confirm that consumption smoothing is more complete in the US than in EMU, with estimates of δ that are systematically higher in Europe, across all periods. Over time, risk sharing remains stable, although estimates of δ increase somewhat in the latest period since 2013 in both regions.

The lowest panel introduces the measure of financial integration in the EMU. The augmented estimation is specified in the same spirit as Table 10. We estimate

$$\left|gc_{i,t} - gc_{j,t}\right| = \alpha_{ij} + \delta_1 \left|gy_{i,t} - gy_{j,t}\right| + \delta_2 \left|gy_{i,t} - gy_{j,t}\right| \times FSAP_{ijt} + \delta_3 FSAP_{ijt} + \varepsilon_{ij,t}$$

We confirm the earlier result that financial directives help smooth consumption in the period pre-GFC, in fact quite sizably. Between 1999 and 2006, we estimate δ_2 to be negative and significant, with large effect on the estimate of δ_1, which goes from 0.193 in the unconditional regression in column (3) to 0.824 in the conditional regression in column (4). In other words, financial integration does affect consumption risk sharing sizably over this period. As in Table 10, the result is reversed in the more recent period: δ_2 becomes positive and significant after the GFC. In fact financial deregulation appears to be the main reason for imperfect risk sharing after 2007, since conditional estimates of δ_1 are in fact not different from zero then.

The results are therefore robust to two alternative estimations approaches for consumption risk sharing. While financial integration improved risk sharing in the EMU between 1999 and 2006, albeit not to the level observed in the US, it worsened it after the global financial crisis.

Table 12
Estimates of δ in $|gc_{i,t} - gc_{j,t}| = \alpha_{ij} + \delta|gy_{i,t} - gy_{j,t}| + \varepsilon_{ij,t}$

	US States			
	1999-2017	1999-2006	2007-2012	2013-2017
Difference in per capita GDP	0.062***	0.048***	0.035***	0.127***
	(0.003)	(0.005)	(0.005)	(0.004)

	EMU Member Countries			
	1999-2018	1999-2006	2007-2012	2013-2018
Difference in per capita GDP	0.157***	0.193***	0.086***	0.226***
	(0.024)	(0.043)	(0.038)	(0.045)

	EMU Member Countries with financial deregulation					
	1999-2014	1999-2014	1999-2006	1999-2006	2007-2014	2007-2014
Difference in per capita GDP	0.135***	0.362***	0.193***	0.824***	0.078**	-0.169
	(0.027)	(0.069)	(0.043)	(0.105)	(0.035)	(0.161)
Interaction with FSAP Directives		-0.010***		-0.043***		0.009*
		(0.003)		(0.007)		(0.005)
FSAP Directives		-0.009		-0.012		0.047**
		(0.008)		(0.022)		(0.024)

Notes: The Table reports the estimates of δ in cross-sectional tests for consumption risk sharing. *(**)(***) denote significance at 10(5)(1) percent confidence level. All estimations include time effects. Data on FSAP directives stop in 2014

4 Conclusion

We document significant convergence in GDP and in consumption between twelve core EMU member countries over EMU's twenty years of existence. To explain convergence in GDP growth rates, we develop a novel measure of export intensity that captures how much of a value chain is exported. The measure is fundamentally distinct from actually observed direct trade, in the sense that export intensity can be high without any direct trade, via downstream linkages. Export intensity is exceptionally high between EMU member countries, much higher than between the US or China and the rest of the world. It is a large and robust predictor of bilateral correlation between sector-level growth rates, especially between services. In fact, the export orientation of EMU countries can explain a sizable fraction of convergence in GDP, substantially more than what directly observed bilateral trade can explain. Finally, to explain convergence in consumption growth, we invoke financial deregulation in the EMU.

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