Macroeconomic Dynamics, **24**, 2020, 69–92. Printed in the United States of America.
doi:10.1017/S1365100518000329

STRUCTURAL DIFFERENCES IN THE EUROZONE: MEASURING FINANCIAL STABILITY BY FCI

Matteo Foglia and Alfredo Cartone
"G.d'Annunzio" University of Chieti-Pescara

Cristiana Fiorelli
University of Teramo

In this paper, we apply two novel methodological approaches, Tucker three-way principal component analysis and locally weighted principal component analysis, to construct financial conditions index for Eurozone countries. The aim is to point out how real and financial macroeconomic variables affect the credit channel and which variables are more relevant in each occasion, highlighting structural differences within the Eurozone. The results suggest that the Eurozone is involved into a low easing pattern, which is difficult to reverse and affects considerably the financial conditions, surrounding the hypothesis that this pattern has been worsened by structural differences between the European Monetary Union (EMU) countries. Empirical evidence shows that European Central Bank (ECB) policy has managed to cool financial tensions and has made financial conditions homogeneous, but it has not been able to restore them at a precrisis level.

Keywords: FCI, Eurozone Crisis, Three-Way, LWPCA

1. INTRODUCTION

The global financial crisis and the euro area sovereign debt crisis have largely highlighted the importance of financial conditions under the macroeconomy lens, showing the high interconnection between financial market and real economy [COM (2014)]. Financial conditions identify all major factors, which characterize the functioning of financial markets and the access to credit by nonfinancial agents [Paries et al. (2014)].

During the crisis, the interbank market block affected the macroeconomic fundamentals through reduction of credit flow to the private sector, generating recession on real economic activity. To prevent the consequences of future shocks, it is

We would like to thank Roberto Benedetti, Eliana Angelini, and Valentina Meliciani for helpful comments on an earlier draft of the paper. Furthermore, we wish to thank participants of the 8th International Conference "Economics, Economics Policies and Sustainable Growth in the Wake of the Crisis," University of Ancona, September 8–10 (2016), for very helpful suggestions. None of them are responsible for any errors in this paper. Address correspondence to: Matteo Foglia, Department of Economics, "G.d'Annunzio" University of Pescara, Viale Pindaro 42, Pescara, Italy; e-mail: matteo.foglia@unich.it.

© 2018 Cambridge University Press 1365-1005/18

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

necessary ensuring the economic and financial stability, basic prerequisite for sustainable equilibrium [Stiglitz (2010)].

The financial stability is not easy to define or measure, given the interdependence and the interactions of different elements of the financial system [Schinasi (2004)]. Nevertheless, economic and financial institutions should analyze the behavior both of main *trait d'union* among the monetary policies, financial markets, economic activity, i.e., the credit channel, and of financial market frictions, that could thwart the efforts of policy makers, impairing the normal flow of lending [Eickmeier and Hofmann (2013)]. Understanding those frictions is of primary importance, and policy makers must evaluate carefully the scenario before they act.

As traditional macroeconometrics models include in their structures only the monetary instrumental variables, it is clear that they are not enough to capture tightness or easing of credit conditions. A method to capture the broader connections between variables influencing financial conditions can be implemented by constructing indices that incorporate information about real economy, financial markets, financial institutions and based on macro variables [Gilchrist et al. (2009), Born et al. (2012)]. The financial conditions index (FCI) summarizes the information about the future state of the economy contained in these current financial variables [Carlson et al. (2014)].

Three basic approaches have been used to construct FCIs. The first is a simple average of the variables included. This method is applied by European Central Bank (ECB) (2009) and Bloomberg FCI [Rosenberg (2009)]. Usually, because of its simplicity, they used a limited number of variables from 6 to 10.

The second, called weighted-sum approach, weights on each financial variable based on the estimated relative impacts of changes in these on real gross domestic product (GDP) [Goldman Sachs FCI, Deutsche Bank FCI, Citi FCI; Beaton et al. (2009), Hollo et al. (2011)]. In this approach, methods used to estimate the weight of the financial components are the estimation of reduced aggregate demand equations and the estimation by VAR model [Dudley and Hatzius (2000), Mayes and Viren (2002), Gauthier et al. (2004)]. This model has been commonly used, is simple to estimate, and the impact of potential transmission channels can be easily identified by calculating the weight of each variable based on the impact level using a VARs impulse response functions to reflect the impact of the money supply, interest rates, asset price on the aggregate demand. VARs are typically less theoretically based than macromodels, although structural VARs may seek to take theoretical considerations into account. The main disadvantage is that only a limited number of indicators can be accommodated in view of relatively small degrees of freedom.

The last approach is factor analysis (FA) and principal component analysis (PCA), which typically allow selection of a large number of variables weighted by their impact on the multivariate phenomenon [van Roye (2011), Matheson (2012)]. The assumption is that common factors can be representing the fundamental forces influencing the financial system and can be used as a set of weight for the FCI. These new dimensions of course are demonstrated [Jolliffe (2002)] to capture

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

the largest amount of variance into a small set of components and represent syntactically the financial phenomenon. PCA (or FA) does not depend on any kind of economic model [English et al. (2005)], i.e., it tends to be atheoretical. The method also gauges the contribution of financial indicators consistent with the historical importance to fluctuations in the broader financial system and allows for an interpretation of the systemic importance of each component [Brave and Butters (2011)]. A theoretical framework representing a basis for the construction of an FCI is presented in detail in Hatzius et al. (2010). Extensive work has been done to analyze financial conditions for euro area [Angelopoulou et al. (2014), Paries et al. (2014)], Asia [Osorio et al. (2011)], and groups of developed countries [Erdem and Tsatsaronis (2013), Wacker et al. (2014)]. However, FA (or PCA) faces several problems mainly related to the exclusion of variables, presence of outliers likely to influence the structure of the variance and assumption of stationarity in time and space.

In this paper, to tackle the set of problems usually faced by PCA, we apply two novel approaches in the field of FCI, Tucker three-way PCA [T3, Kroonenberg (1983, 2008), Kiers (2000)] and locally weighted principal component analysis [LWPCA, Harris et al. (2011)].

T3 decomposes the same variance of standard PCA, but identifies the circumstances in which different components from the B-mode are relevant. The underlying idea is to understand three-dimensional (country, variable, and time) interactions included into the data array in a way that is possible to determine "prototype conditions." In this paper, our focus is not only on determining a set of weight for the FCI but also understanding what are the leading dynamics behind the evolution of financial conditions. To this purpose, T3 offers a deeper insight with respect to other bi-dimensional techniques of data reduction to showcase the complex chain of events changing financial scenarios. In this sense, by tracking the evolutions of the forces shaping the level of the index, different intervariable interactions, including monetary policy leverages, are connected to different prototype conditions.

The resulting evidence shows that the Eurozone is involved into a low easing pattern, which is difficult to reverse and affects considerably the financial conditions. The composite FCI indicator from T3 displays higher relevance of the typical EU crisis variables, sovereign interest rates, volatility, and loans flow to private sector according to theory. The persistent reduction in foreign capital flow due to 2008 sudden-stop was even worsened by the subsequent dip of 2012, when the credit conditions gap was more evident between core and noncore countries. In several circumstances, the ECB tried to reduce financial markets volatility using more instrument of monetary policy without being able to restore financial conditions to a precrisis level, due to heterogeneity in financial conditions and differing structures across countries.

Moreover, as we observe deep loose of financial conditions since 2010, we also focus on the increasing of between-countries differences as a possible reason of the turmoil. Many authors have showed the emerging differences in financial

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

conditions and relevant economic diversities that affect the Eurozone [Shambaugh (2012)]. In the case of economic growth, the heterogeneous effects have been widely demonstrated and modeled [as in Postiglione et al. (2012)]. Hence, at a monetary level, Peter Praet in 2012, in a speech as a member of the ECB board, affirmed that: "The financial crisis has led to a strong increase in heterogeneity within the euro area. The re-emergence of cross-country differentials in terms of financial conditions has contributed to divergence in macroeconomic and financial fundamentals." Thus, it is very important trying to improve the information given by the FCI as a global statistic with information from models accounting for significant heterogeneity across the Euro area.

However, standard PCA assumes stationarity of loadings across these different countries and index homogeneity in the EU. Therefore, to account for significant heterogeneity, we project the countries on an artificial plane, where the dimensions are long-term interest rate and Harmonised Index of Consumer Prices (HICP). We then perform LWPCA for the only year of 2010, and we consider a different variance–covariance matrix for each country based on weights that reflect the proximity on the artificial plane. Building heterogeneous local FCI loadings per each country allows us to verify if a global indicator assumption is reliable. The substantial heterogeneity of eigenvalues and eigenvectors is tested by a Monte-Carlo simulation, which shows relative low significance for global indicator hypotheses in 2010. LWPCA local indicators for 2010 emphasize the dangerous effects due to differences between core and peripheral countries.

The paper is organized as follows. In Section 2, we describe the data, in Section 3, we present the three-way approach, used to build the FCI, then we discuss the results (Section 4). Section 5 aims to show the LWPCA results. Finally, Section 6 offers the main conclusions.

2. DATA

Following the literature, we include variables representing the financial activities of nonfinancial corporations (NFCs) and households (HH), as well as the activities of monetary financial institutions (MFIs). A detailed list and the description of the variables can be found in Table 1, but they can generally be summarized under the following categories: *prices*, *quantities* (e.g., loans to HHs and NFCs, debt securities issued by MFIs and NFCs), *risk measures* (e.g., interest rate spreads, volatility), *balance sheet indicators* [such as nonperforming loans (NPL)[1]], *survey data*, and *ECB rate*. We add also the real exchange rate or relative consumer price (deflator: consumer price indices). Relative consumer price is an indicator of competitiveness among the countries, an increase of that index should have negative effects on FCI.

We construct a quarterly macroeconomic data set—22 financial variables—for eight Eurozone countries (Austria, Belgium, Germany, Spain, Greece, Ireland, Italy, Portugal) as we do not consider the Eurozone countries for which some data are not available. The estimation sample covers the period from the second quarter

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

TABLE 1. List and description of variables for each country

Num.	Variable	Description	Unit	Source
1	Loans to NFCs	Flow of loans to nonfinancial corporations	Billions of euros	ECB
2	Loans to Households	Flow of loans to households and non profit institutions serving households	Billions of euros	ECB
3	Interest rate spread for NFCs	Spread between the interest rate on new loans to nonfinancial corporations and the interest rate on total deposits of nonfinancial corporations	Level	ECB
4	Interest rate spread for NFCs on overdrafts	Spread between the interest rate on revolving loans and overdrafts to nonfinancial corporations and the interest rate on total deposits of non financial corporations	Level	ECB
5	Interest rate spread for consumer loans	Spread between the interest rate on new loans for consumption to households and the interest rate on deposits of households with agreed maturity up to 1 year	Level	ECB
6	Interest rate spread for mortgage loans	Spread between the interest rate on new loans for house purchase and the interest rate on deposits to households with agreed maturity up to 1 year	Level	ECB
7	Debt securities issued by NFCs	Annual growth rate gross issues of debt securities issued by nonfinancial corporations; nominal value.	Percent	ECB/ Bank of Greece
8	Debt securities issued by MFIs	Annual growth rate gross issues of debt securities issued by monetary financial institutions; nominal value.	Percent	ECB/ Bank of Greece

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

TABLE 1. Continued

Num.	Variable	Description	Unit	Source
9	Property prices	Month-on-month percent change of residential property price	Percent	OECD
10	Harmonized index of consumer price	Month-on-month percent change in the harmonized index of consumer prices	Percent	ECB
11	Short-term interest rate on government debt spread	Interest rate on 2-year bond minus 3-month EURIBOR	Level	Datastream/ Bank of Greece
12	Long-term interest rate on government debt spread	Interest rate on 10-year bond minus 3-month EURIBOR	Level	Datastream
13	Rate of change of stock Prices	Month-on-month rate of change of common shares of companies traded on national or foreign stock exchanges	Percent	OECD
14	Volatility of stock prices	Annualized volatility of daily returns of main stock market indices	Level	Own calculation on data from Datastream
15	Volatility of bond prices	Annualized volatility of monthly 10-year yield	Level	Own calculation on data from Datastream
16	Nonperforming loans	Value of nonperforming loans over total value of the loan portfolio	Percent	World Bank/EBA - Risk Dashboardfor Germany, France and Italy (2015)
17	Relative consumer price	Real effective exchange rate; indicator of competitiveness which takes into account both exports and imports	Percent	OECD
18	Banks' access to market financing	Survey question on impact of ability to access to market financing	Diffusion index	ECB

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

TABLE 1. Continued

Num.	Variable	Description	Unit	Source
19	Banks' liquidity position	Survey question on impact of liquidity position	Diffusion index	ECB
20	Housing market prospects	Survey question on impact of housing market prospects	Diffusion index	ECB
21	Consumer creditworthiness	Survey question on impact of creditworthiness of consumers	Diffusion index	ECB
22	ECB discount rate	Interest rate on principal refinancing operations	Level	ECB

Notes: According to Angelopoulou et al. (2014), we include in our analysis the same variables that have been used by them, except four variables (items 7, 8, 13, 16). However, we add two variables, nonperforming loans (NPL; quarterly data for this item are not available. We use a constant percentage during the same year) and relative consume price, according to the literature [Hatzius et al., (2010), Paries et al. (2014)], that are able to provide a better explanation of financial conditions. The yield on 3-year bond is used in 11th item for Greece. Moreover, we change the original sign of some variables, that, according to the theory, affect the FCI in a negative way. These variables are identified with items 3–6, 11–12, and 14–21.

of 2005 to the fourth quarter of 2015. We standardize the variables so that the mean across time is zero and the variance is one.[2] According to other experiences, the sign is changed for some variables that have a negative effect on financial conditions to ensure that all variables affect the index in the same direction.

3. BUILDING A FCI WITH THREE-WAY APPROACH

We proceed to the derivation of a global FCI using three-way PCA [Kroonenberg (1983, 2008)] from a Tucker 3 [Tucker (1966)]. This factorial analysis can entangle more complex relationships between the three modes of our data array: countries, variables, and time occasions. The aim is to identify a set of weighted loadings composing the indicator to enlighten the time occasions that shift the FCI attitude.

T3 is a factorization of a three-mode array $\mathbf{Z} \in \mathbf{R}^{lxmxn}$ so that

$$z_{ijk} = \sum_{p=1}^{s} \sum_{q=1}^{t} \sum_{r=1}^{u} g_{ip} h_{jq} e_{kr} c_{pqr} + \varepsilon_{ijk}, \qquad (1)$$

where g_{ip}, h_{jq}, e_{kr}, are the component matrices scores for the three modes for which s, t, u are the retained components from the G, H, and E orthonormal matrices of components and ε_{ijk} is the error term. Most important c_{pqr} is the core matrix element from the $pxqxr$ core array $\mathbf{C} \in \mathbf{R}^{sxtxu}$ associated at each combination of the modes. Those values indicate both the percentage of variance represented by each combination and the strength of the interaction between modes observation, resembling the role of eigenvalues diagonal matrix in the PCA.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

The parameters are estimated defining a mean squared loss function of the error terms

$$f(\mathbf{G},\mathbf{H},\mathbf{E},\mathbf{C}) = [[\mathbf{Z} - \tilde{\mathbf{Z}}]]^2 = \sum_{p=1}^{l}\sum_{q=1}^{m}\sum_{r=1}^{n}(z_{ijk} - \tilde{z}_{ijk})^2 = \\ = \sum_{p=1}^{l}\sum_{q=1}^{m}\sum_{r=1}^{n}(z_i jk - \sum_{p=1}^{s}\sum_{q=1}^{t}\sum_{r=1}^{u} g_{ip}h_{jq}e_{kr}c_{pqr})^2. \tag{2}$$

minimized by alternative least squares.

Commonly to other factorial analysis in three-way, the number of components to retain is chosen a priori. To identify a representative solution, we select the combination suggested by a generalized scree test according to the convex hull procedure [Celeumans and Kiers (2006)] of $s = 4$, $t = 6$, and $u = 7$, respectively, of A, B, and C-mode components.[3] For this combination, the fit is 59.24%, which is quite satisfying if we consider that we deal with a very small sample and a large set of variables. No diagonalization is performed.

The orthogonal B-mode components are permuted to obtain values of the country indicators in line with FCI literature. To calculate the indicator, loadings of the B-components are multiplied for their proportion of B-variance. The proportions are obtained from the intrinsic eigenvalues of the B-mode based on the core array. The matrix of intrinsic eigenvalues for the B-mode is diagonal so that we treat them as in PCA and calculate the representativeness of variables components from the diagonal decreasing eigenvalues.

Relations between the B- and C-modes are quite straightforward to interpret and the B-mode components link clearly with their correspondent in C-mode. This represents an advantage from the PCA as we are able to relate different components to different occasions so that single components can be considered specific time indicators. The interactions between B-mode and C-mode shed more light on the different occasion that contributes to the indicator composition. We adopt the R *package* ThreeWay [Giordani et al. (2014)].

4. EMPIRICAL RESULTS

The T3 is able to specify the relations existing between the different components of three modes. This allows us a better insight of the effects showed by the different countries, the different financial variables, and the different periods for which we study the evolution of the FCI. Using three-way analysis, we calculate the loading of principal components for three dimensions (modes) that affect financial conditions. A-mode refers to Eurozone countries (Table 2), B-mode refers to financial variables (Table 3), and C-mode refers to periods (Table 4).

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

TABLE 2. Loadings for A-mode

	Countries	PC1	PC2	PC3	PC4
AT	Austria	−0.350	−0.368	0.028	−0.601
BE	Belgium	−0.333	−0.347	0.158	0.321
DE	Germany	−0.254	−0.693	−0.012	0.185
ES	Spain	−0.382	0.187	−0.391	−0.453
EL	Greece	−0.347	0.268	0.454	0.163
IR	Ireland	−0.367	0.159	−0.703	0.439
IT	Italy	−0.387	0.206	0.290	0.216
PT	Portugal	−0.393	0.303	0.200	−0.181

Table 3 shows the values of orthogonal loadings for each B-mode component, along with the share of variance explained by each component and, therefore, the share of variance explained by the overall index. The overall B-component FCI indicator from T3 displays higher relevance of the typical EU crisis variables, sovereign interest rates, volatility, and loans flow to private sector according to the theory. The first and second factors explain 22% and 16% of total variance suggesting they play a relevant role in the variance from 2005 to 2015.

4.1. Composite FCI for Eurozone Countries

To calculate the overall FCI for each country, we use all six B-mode factors (Table 3) weighted by the component percentage of fit. The sum of the product by variables and correspondent weighted loadings provide the value of FCI. Figure 1 presents the FCIs computed for eight Eurozone countries since the second quarter of 2005. In each chart, a higher value of the FCI represents an improvement in the financial surrounding and an easing of credit conditions, while a lower value of FCI represents credit deterioration and tightness of financial conditions.

The country FCIs capture the main financial events occurred within the Eurozone and international financial markets. The precrisis period is characterized by a strong increase of credit flow to private sector due to favorable conditions of financial system.

The financial conditions tightened at the wake of financial crisis after the collapse of Lehman Brothers in September 2008 and worsened in the period of sovereign debt crisis indeed. The global financial crisis affected the countries that had a strong exposition to foreign markets (such as Germany, Ireland). Ireland was the first in 2007. Less exposed countries (such as Greece, Italy, and Portugal) suffered lower credit deterioration. The bail-out of major financial institutions by ECB avoided the collapse of entire financial system [Benchimol and Fourans (2016)] and helped FCIs to rise.

The financial conditions of peripheral countries started to worse again at the end of 2011 when after various improvements following the ECB intervention (Security Market Program, SMP), the positive effects were sterilized immediately

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

TABLE 3. Loadings for B-mode

	Variable	PC1	PC2	PC3	PC4	PC5	PC6	Weighted loadings
B1	Loans to NFCs	0.365	0.043	−0.011	0.113	−0.003	−0.017	0.091
B2	Loans to Households	0.222	0.25	0.021	−0.245	−0.119	−0.152	0.068
B3	Interest rate spread for NFCs	0.332	−0.068	0.172	−0.102	−0.169	0.138	0.071
B4	Interest rate spread for NFCs on overdrafts	0.185	−0.064	0.352	0.294	0.073	−0.046	0.08
B5	Interest rate spread for consumer loans	0.158	−0.284	0.278	0.02	0.017	0.271	0.026
B6	Interest rate spread for mortgage loans	0.003	−0.263	0.345	0.188	−0.04	0.34	0.01
B7	Debt securities issued by NFCs	0.043	−0.007	0.038	−0.139	0.054	0.11	0.01
B8	Debt securities issued by MFIs	0.259	−0.061	0.03	−0.089	−0.06	0.104	0.046
B9	Property prices	0.076	0.288	−0.15	0.092	0.005	−0.225	0.046
B10	HICP	0.272	−0.164	0.177	0.04	0.075	−0.544	0.039
B11	Short-term interest rate	0.206	0.059	−0.433	0.293	0.126	0.258	0.042
B12	Long-term interest rate	0.349	0.11	−0.216	0.297	0.021	0.282	0.099
B13	Rate of change of stock Prices	−0.088	0.307	0.235	−0.361	−0.066	0.387	0.04
B14	Volatility of stock prices	0.053	0.383	0.308	−0.174	0.064	0.082	0.096
B15	Volatility of bond prices	0.116	0.242	−0.246	−0.081	0.016	0.24	0.044
B16	Nonperforming loans	0.357	0.009	−0.108	−0.248	−0.105	−0.134	0.049
B17	Relative consumer price	−0.08	−0.027	−0.058	0.219	−0.923	−0.009	−0.051
B18	Banks' access to market financing	−0.046	0.351	0.15	0.117	−0.066	−0.093	0.06
B19	Banks' liquidity position	−0.073	0.313	0.112	0.111	−0.115	−0.028	0.044
B20	Housing market prospects	0.011	0.235	0.265	0.285	−0.002	−0.09	0.076
B21	Consumer creditworthiness	−0.016	0.265	0.152	0.427	0.166	0.017	0.081
B22	ECB discount rate	0.412	0.027	0.079	−0.129	−0.073	−0.038	0.092
	Percentage of fit	22.13%	15.65%	9.33%	5.34%	3.79%	3.00%	
	Cumulated percentage of fit	22.13%	37.78%	47.11%	52.45%	56.24%	59.24%	

TABLE 4. Loadings for C-mode

Occasions	PC1	PC2	PC3	PC4	PC5	PC6	PC7
C1 - 2005Q2	−0.129	−0.156	−0.018	−0.103	0.148	−0.117	0.247
C2 - 2005Q3	−0.132	−0.166	−0.038	−0.132	0.121	0.019	0.204
C3 - 2005Q4	−0.161	−0.148	−0.079	−0.999	0.109	−0.078	0.223
C4 - 2006Q1	−0.156	−0.169	−0.102	−0.109	0.052	0.039	0.163
C5 - 2006Q2	−0.182	−0.122	−0.124	−0.026	−0.097	−0.225	0.177
C6 - 2006Q3	−0.186	−0.113	−0.073	−0.006	0.005	−0.052	0.179
C7 - 2006Q4	−0.207	−0.163	−0.072	−0.016	0.006	0.197	0.059
C8 - 2007Q1	−0.204	−0.111	−0.093	0.028	0.007	0.164	−0.01
C9 - 2007Q2	−0.226	−0.089	−0.153	0.079	−0.027	0.067	−0.063
C10 - 2007Q3	−0.238	−0.043	−0.004	0.112	0.044	0.100	−0.156
C11 - 2007Q4	−0.266	0.022	−0.032	0.133	−0.132	0.078	−0.215
C12 - 2008Q1	−0.273	0.158	0.092	0.137	−0.063	−0.029	−0.214
C13 - 2008Q2	−0.251	0.189	−0.022	0.063	−0.202	0.087	−0.191
C14 - 2008Q3	−0.232	0.246	0.136	0.082	0.185	0.051	−0.207
C15 - 2008Q4	−0.153	0.465	0.427	0.078	0.086	−0.141	0.156
C16 - 2009Q1	−0.008	0.228	0.328	−0.228	−0.319	0.041	0.379
C17 - 2009Q2	0.052	0.011	0.234	−0.401	−0.141	0.199	−0.029
C18 - 2009Q3	0.101	−0.087	0.157	−0.381	−0.099	0.105	−0.261
C19 - 2009Q4	0.071	−0.125	0.102	−0.313	−0.092	0.027	−0.068
C20 - 2010Q1	0.080	−0.048	0.100	−0.199	0.346	−0.101	−0.143
C21 - 2010Q2	0.074	0.047	0.065	−0.201	0.333	−0.269	−0.205
C22 - 2010Q3	0.068	0.049	−0.074	−0.143	0.024	−0.199	−0.129
C23 - 2010Q4	0.059	0.022	−0.181	−0.093	−0.085	−0.242	−0.166
C24 - 2011Q1	0.068	0.019	−0.197	−0.097	0.032	−0.151	−0.138
C25 - 2011Q2	0.057	0.100	−0.267	−0.074	−0.173	−0.161	−0.039
C26 - 2011Q3	0.077	0.254	−0.205	0.069	0.177	−0.270	0.057
C27 - 2011Q4	0.142	0.316	−0.247	−0.001	0.017	0.087	0.306
C28 - 2012Q1	0.165	0.219	−0.210	−0.038	0.178	0.460	0.107
C29 - 2012Q2	0.156	0.162	−0.163	0.053	0.007	−0.027	0.079
C30 - 2012Q3	0.163	0.114	−0.126	0.046	0.129	0.213	−0.038
C31 - 2012Q4	0.137	0.026	−0.135	0.029	−0.223	0.145	−0.012
C32 - 2013Q1	0.147	0.031	−0.068	0.047	−0.119	0.112	−0.192
C33 - 2013Q2	0.147	0.013	−0.030	0.101	−0.109	0.020	−0.027
C34 - 2013Q3	0.144	−0.091	0.006	0.096	−0.161	−0.037	0.007
C35 - 2013Q4	0.148	−0.145	0.034	0.091	−0.192	−0.008	−0.061
C36 - 2014Q1	0.149	−0.127	0.085	0.143	−0.123	−0.032	−0.057
C37 - 2014Q2	0.137	−0.138	0.121	0.166	−0.019	−0.056	0.011
C38 - 2014Q3	0.131	−0.111	0.160	0.198	0.151	−0.035	−0.012
C39 - 2014Q4	0.121	−0.107	0.148	0.195	0.017	−0.152	0.038
C40 - 2015Q1	0.127	−0.131	0.180	0.151	0.320	0.288	0.048
C41 - 2015Q2	0.099	−0.129	0.094	0.163	0.139	0.102	0.005
C42 - 2015Q3	0.091	−0.068	0.121	0.217	−0.205	−0.166	0.132
C43 - 2015Q4	0.090	−0.104	0.133	0.181	−0.053	−0.054	0.057

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

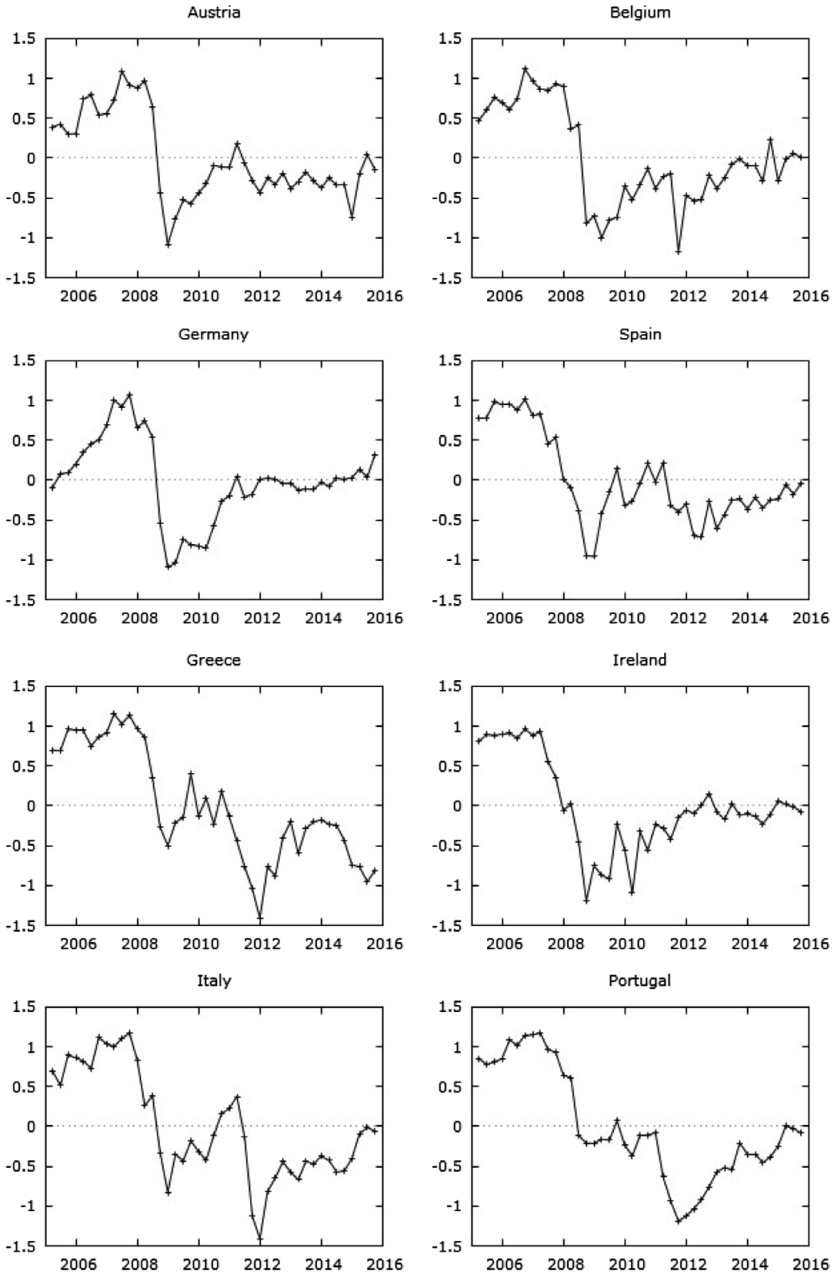


FIGURE 1. FCI for eight EZ countries – 2005Q2 to 2015Q4.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

by an increase in main refinancing operation (MRO) rate. Higher level of sovereign interest rate, short- and long-term, increase of percentage of NPLs and reduction of value of collaterals increased the level of private risk premium, with reduction of loans for NFC and HH. The FCIs levels clearly showcase the shape of a double-dip recession for the no-core countries due to the intensification of turbulences in sovereign bond markets. There is not prove of the same deterioration in financial conditions in core countries. In Italy, for example, the impact of the initial "Lehman shock" on FCI was moderate, but then there was a larger double-dip decline in 2011, as the country became entangled in the sovereign debt crisis. On the other hand, in Germany, the initial shock, was considerably more intense than in the periphery, but positive rates of growth returned already in end-2010. After 2012, the index points out two nonstandard policy measures, the very long-term refinancing operation (VLTRO), (beginning of 2012) and the announcement of outright monetary transactions (OMT) (*whatever it takes*, summer 2012) and the cut of reserve ratio from 2% to 1% (into force at the beginning of 2012). These measures as well as the recapitalization of the banking sector in early 2013, allowed a slow easing of credit conditions. However, they remained significantly tighter than the precrisis periods. The period since early 2014 has seen more positive developments. There has been a significant reduction in business interest rates in noncore countries, with ECB policies have played an important role. These policies have also reduced the perceived default risk. Financial fragmentation started to recede, but not entirely due to nonperforming assets left by the crisis and doubts about the strength of banks' balance sheets.

Therefore, in March 2015 the ECB implemented new measures, expanded asset purchase program (QE), to achieve its inflation target and facilitate access to credit market inter alia. It is interesting to note that a benefit is currently observed even in Greece that was not included into the program. This is because Greece have benefited of ELA, the emergency support lines available to NCBs to individual banks.

Although these countries are subject to a single monetary policy (one size fits all), the results provide evidence of heterogeneous financial conditions both before and after the financial crisis given differing financial structures across countries. In fact, the monetary policy affected heterogeneously the euro area specially during the sovereign debt crisis, when the credit conditions gap is more evident between core and noncore countries. This has caused some differentiation in the transmission of monetary policy, given bank-based nature of financing to NFCs and households in the euro area [ECB (2012)]. However, in the last trait, the accommodative policy has led countries (except Greece) to zero threshold level that may identify a neutral point, a possible starting point for future easing or tightness of credit conditions.

ECB's policy has restored more homogeneous financial conditions and has eliminated financial imbalances. This is an important result for monetary policy, as an integrated financial market with broadly homogeneous financial conditions is the basis for a smooth transmission of monetary policy across the euro area economy as a whole.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

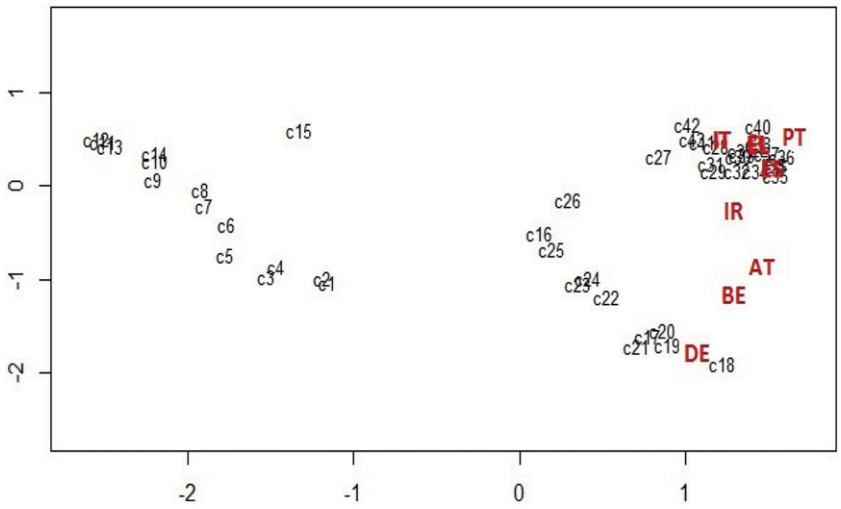


FIGURE 2. Joint plot for the first B-component. Fit 98%.

4.2. Major Advantages of T3-FCIs

The graphical analysis of T3 components provides an original interpretation for the results. The first B-mode component can be read as *crisis pattern*. It is possible to link the variables that represent, a high impact of the level on loans flow for NFC and HH, bank interest rate spread, short- and long-term interest rates, NPL, MRO rate. Results are graphically shown by a joint plot of the first component. The joint plot represents components calculated from the scores and the occasions obtained by PCA. The results are then plotted together for the first two components to visualize the contribution of occasions and countries. The joint plot displays the relations entangled into the core matrix so that high representative joint plots can be very helpful to interpret the relations enclosed into the data [Kiers (2000)].

Figure 2 shows the countries and the occasions scores for the B1-component. It is easy to recognize that it is more relevant for no-core country. This is consistent with financial dynamics of those countries that were affected by high levels of negative variables correlated with financial indicators and with the crisis pattern of course.

Looking at the occasions (c1, c2,.., c43), we find a circular display. The c_i near core countries anticipate the sovereign crisis explosion (occasion 19, 20,.., 25), while the occasions of major breakdowns gather around the no-core countries suggesting higher impact. Germany, for example, was influenced by the period 18, 19 (at the end of 2009) but after c26 (2011Q3) the main effect seems to raise and move toward the most hit countries. The second B-mode component has high levels of loadings on a variety of variables like property prices, volatility of stock and bond prices, interest rates of consumer and mortgage loans, and bank lending survey data. Thus, we call this factor *great movement on market capital*

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

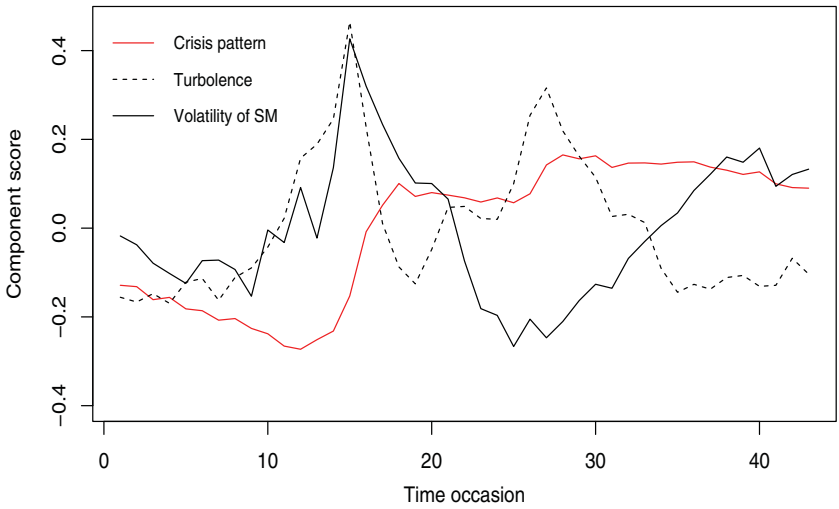


FIGURE 3. Scores plot for first, second, and third C-components.

because of the high level of volatility measures loadings, the impact of the bank surveys, the role of expectation, and the movement of capital through more or less exposed financial products. On the other side, third B-component showcases typical attitudes of stock market high volatility circumstances.

As the three-way allows us to create relations between B-mode and C-mode, we examine deeply the temporal relevance of the different B-components that build our FCI. The core matrix interactions between B-mode and C-mode are quite linear to interpret in our case and they connect the first three B-components to the C-components 1, 2, 3, respectively. In Figure 3, the first three C-components are reported.

This plot appears quite informative and indicates the early crisis of subprime in the United States that triggered a period of financial tension on financial markets and high volatility on both bond (dotted line) and stock markets (black line). This represents a crucial point for the beginning of the persistent Eurozone crisis (red line) ignited by the turmoil of sovereign debts. The second peak of financial tension was reached in the 2012 (occasion 27) in correspondence with the maximum of the debt crisis. In this occasion, the intrinsic stock market volatility is much less relevant to the Eurozone crisis that exacerbates the credit conditions. The turbulence in government securities markets play the most powerful role in explaining the decrease of financial condition, i.e., the upward of *crisis pattern*. The shapes of 2nd and 3rd components appear as a spiral around the crisis pattern. Moments of financial turbulence alternate with periods of low volatility of stock market and vice versa. These levels of volatility affect alternatively stock and bond markets surrounding the hypothesis that great movement on financial market are not available to create significant improvement on credit channel.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

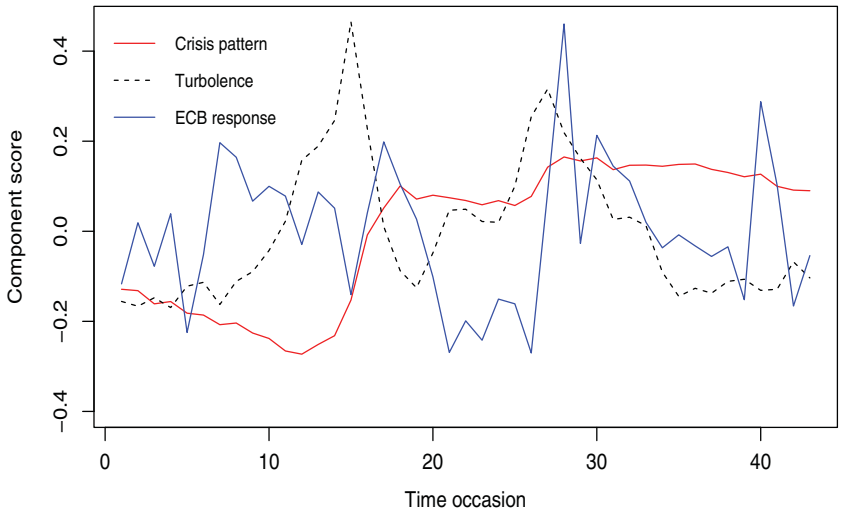


FIGURE 4. Scores plot for first, second, and six C-components.

Observing Figure 4 where C components 1, 2, and 6 are reported, we identify the 6th component as *ECB response* to main financial tensions.

The maximum of the blue line corresponds clearly to the monetary policies implemented by the ECB. The first section draws the precrisis equilibrium (occasions 1–14). After the 2008 break, the ECB responded with one important cut of the MRO rate (occasion 17). The subsequent measure regarded the introduction of VLTROs and the reduction to 1% of reserve ratio (occasion 28), and immediately the announcement of OMT program (occasion 30). The ECB's commitment to its OMT policy has played an important role in reducing the perceived chances of noncore countries exiting. Last, the left spike points exactly the QE (occasion 40). Despite the efforts of monetary policy, the Eurozone is still affected by a crisis condition (red line). In fact, the ECB responses have been able to reduce the financial tension on bond and stock market and to improve financial conditions, but not to restore these to precrisis level and seem converge to a new steady-state equilibrium close to neutral point.

This result has at least three policy implications. First, it seems reasonable to argue that the ECB has triggered, a rebound of financial conditions. It means that the use a range policy instruments has permitted to restore more homogeneous financial conditions throughout the Eurozone (except Greece). This is a crucial condition because the financial system is the primary channel through which the monetary policy reaches the economy, and ultimately, the price level. Second, as chart 4 shows, the ECB's intervention suffers from time delay's (difference of blue and black peaks). A more rapid intervention might have averted the emergence of financial imbalances or at least would restore before the homogeneity of financial conditions. Third, possible issues may arise either from the structural negligence

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

of banking sector (credit supply) to invest into the real market, either from the stiffness of investment demand and the bearish expectations that cause a sort of *credit deflation spiral*. A closer cooperation between the euro area governments and the ECB to support investment, would contribute to the sustained rise of demand and supply credit [Blot et al. (2016)].

5. LOCAL INDICATORS OF FINANCIAL CONDITIONS BY LWPCA

An overall statistic is strictly related to the assumption of stationarity, which does not often correspond to the real case. So far, much attention has been paid to the presence of heterogeneity in many economic phenomena while very a few has been paid to the financial conditions diversities under the macroeconomic lens. Thus, it is very important trying to improve the information given by the FCI as a global statistic with the information from models accounting for significant heterogeneity across the Euro area to put more emphasis on differences in financial channels, which jeopardize the effectiveness of the monetary policy, the economic conditions, and political stability of the European Monetary Union (EMU).

In PCA variance–covariance matrix decomposition is performed under the assumption of stationarity of eigenvectors and eigenvalues. However, significant differences in the covariance matrix structure suggested by great differences in the structure of the Eurozone credit conditions, may lead to relevant lack of representativeness and reliability for the set of weight on which the indicator is built.

LWPCA as a derivation of geographically weighted principal component analysis [GWPCA, Fotheringham et al. (2002), Harris et al. (2011)] operates single PCA at every location, calculating smoothed set of weights so that nearer countries resemble to each other. While GWPCA considers the covariance matrix using geographical distance, we decided to build a space (Figure 6) in which the coordinates $l_i(u_i, v_i)$ of each country are set to be the long-term interest rate (u_i) and the HICP (v_i). Those values are classically used to derive the real interest rate, and we consider them to assess the magnitude of differences in European countries as they are accounted to evaluate the stability of a financial system.

According to the boxplot analysis, we consider Greece and Ireland as outliers and exclude them. On the other hand, Finland, France, and the Netherlands are included into the data set as we did not consider surveys for this method.

The year selected is 2010—a crucial period indicated by the *crisis pattern* occasion. The 2010 represents a break after which financial conditions worsened only for noncore countries anticipating the double-dip recession.

LWPCA on the standardized data $\mathbf{Z}$ considers a separate variance–covariance matrix at each location $l_i(u_i, v_i)$ so that

$$\Sigma(u_i, v_i) = \mathbf{Z}^t \mathbf{W}(u_i, v_i)\mathbf{Z}, \tag{3}$$

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

in which **W** is a diagonal matrix of weights obtained in our case by a continuous Gaussian kernel[4]:

$$w_{ij} = \exp\left[-\frac{1}{2}\left(\frac{d_{ij}}{\gamma}\right)^2\right]. \quad (4)$$

In equation (4), d is the Euclidean distance on the artificial plane and γ is the kernel bandwidth, a largely important parameter that has a lot of influence on LWPCA results.

To detect for optimal bandwidth a cross-validation (CV) function [Harris et al. (2015), Gollini et al. (2015)] is calculated based on the goodness-of-fit that represents the amount of variance not explained by the user-determined components k. For each k component, we have different validation and the optimal bandwidth is selected at the minimum (Figure 5, high). In our analysis, different values of k do not show a clear minimum so that the choice of k is related to the chance to find clear minimum on a reduced number of options, $k = 2$, 3, and 4.

In order to test if eigenvalues vary significantly across the artificial space, we perform a Monte Carlo simulation for the three different bandwidth-components combinations. The test is simulated by randomizing paired location and calculating for each randomization LWPCA, as in Harris et al. (2011).

Figure 5 displays that all 2, 3, and 4 components levels suggest clear optimum level of the bandwidth. P-values are about 0.1 for $k = 2$ (0.08) and $k = 4$ (0.1) and a bit higher for the three retained components (0.15). The three cases demonstrate that accepting local stationarity is a weak condition, and it may be misleading. As our aim is to include as more variance as possible, we select the first four components and their relative bandwidth of 0.622.

Results from local indicators are in Table 5. They explicate different financial and structural conditions for countries in 2010. Real interest rates affect ultimately investment and consumption decisions as they represent the real cost of borrowing. Since inflation rates differ across countries at different points of the business cycle, real interest rates are usually very diverging in the monetary union (Figure 6).

Structural financial differences with a divergence in real interest rate have implied a divergence in economic and financial investment. The financial sector transferred this divergence in real interest rates of countries to the credit conditions: banks and firms had to pay a higher premium on borrowed money due to the connection between banks and sovereigns, i.e., "diabolical loop" [Eichengreen (2012)]. As German banks were perceived as safer and reduced their borrowing costs, banks from no-core countries faced serious tightness. Diverging situations are largely reflected in the LWPCA first components of local rotations. In Germany, for example, the major impact is from the level MFI debt securities improvement through the year. In France, the winning variable[5] is represented by the deposit effect of loans. Austria seems clearly to benefit from the level of HH loans.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

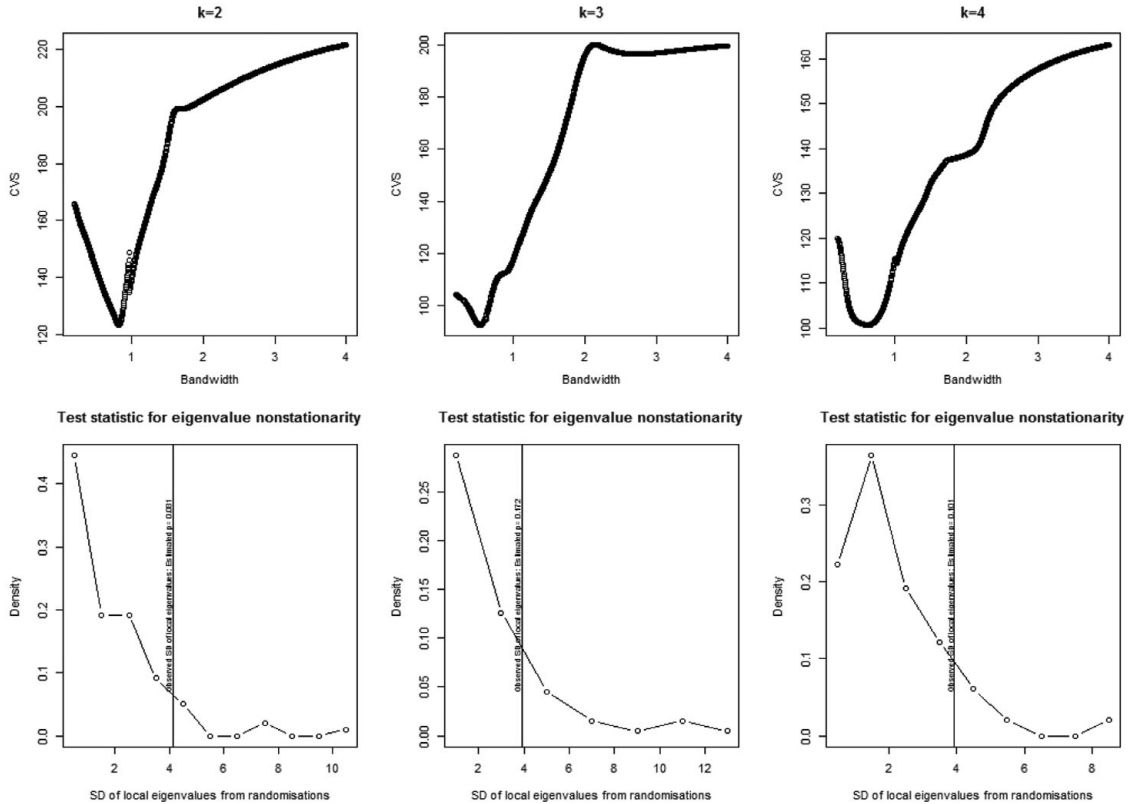


FIGURE 5. CV functions for 2, 3, 4 selected components (high) and Monte Carlo randomizations for the first three components of the same *k* (low).

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

TABLE 5. Loadings for the first component of each country – LWPCA

	Austria	Belgium	Germany	Spain	Finland	France	Italy	the Netherlands	Portugal
B1	0.265	−0.221	−0.32	−0.419	−0.241	0.248	0.361	0.306	−0.316
B2	0.45	−0.025	−0.089	−0.186	−0.505	0.493	0.259	0.067	−0.283
B3	−0.009	0.18	−0.167	0.192	−0.013	0.001	−0.096	0.144	−0.41
B4	−0.035	−0.209	−0.193	−0.359	−0.013	−0.009	−0.08	0.175	0.087
B5	−0.411	0.028	0.055	−0.013	0.384	−0.402	−0.358	−0.1	0.283
B6	−0.23	0.42	−0.501	0.312	0.283	−0.27	−0.045	0.526	−0.03
B7	0.422	−0.052	−0.403	−0.202	−0.446	0.433	0.277	0.383	−0.198
B8	0.266	0.275	−0.515	0.146	−0.303	0.289	0.101	0.514	0.179
B9	−0.04	−0.243	0.101	−0.223	−0.07	0.024	−0.31	−0.156	−0.064
B10	0.011	−0.083	0.049	0.086	−0.023	0.015	−0.046	−0.101	−0.11
B11	−0.119	−0.225	0.008	−0.159	0.069	−0.087	−0.205	0.001	−0.257
B12	−0.119	−0.167	0.073	−0.129	0.076	−0.09	−0.19	−0.062	−0.28
B13	−0.212	−0.417	0.285	−0.294	0.167	−0.182	−0.265	−0.275	0.077
B14	−0.284	−0.455	0.085	−0.306	0.278	−0.279	−0.194	−0.054	0.156
B15	0.015	−0.171	−0.047	−0.235	−0.023	0.02	0.037	0.048	−0.484
B16	−0.293	−0.121	−0.151	0.059	0.183	−0.224	−0.534	0.156	0.258
B17	0.113	0.223	−0.11	0.356	−0.113	0.112	0.011	0.1	0.013
Fit	93%	98%	98%	98%	95%	94%	96%	98%	98%

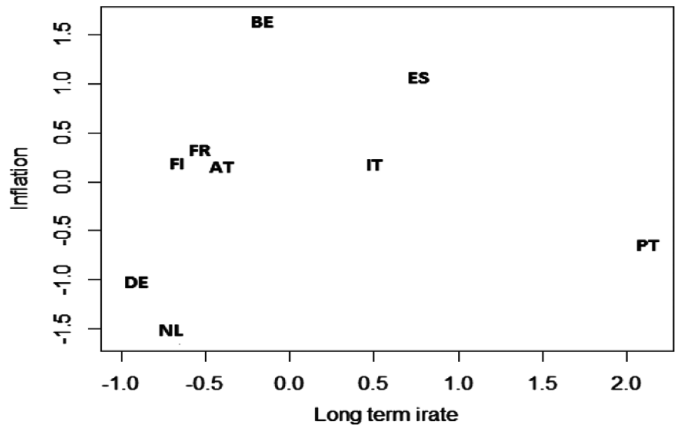


FIGURE 6. Artificial plane of the Eurozone. Coordinates indicate different levels of long-term interest rate on sovereign debt (ui) and HICP (vi).

Italy, on the other side, is impacted by NPLs, a consequence of the higher level of interest rates for consumer and decrease of collateral values (property price). Also, Spain shows a completely different situation. In this case, loans to NFC and relative consumer price are highly relevant as the real exchange rate has appreciated relative to core countries. This gap in competitiveness was reflected in the emergence of external imbalances and accumulating deficit of current accounts [Engler et al. (2017)]. On the locally indicator, Belgium takes advances of low level of volatility, as suggested by the weight and the sign of the corresponding loadings. Portugal is the country that has most suffered from the volatility of bonds that plays an important role for financial conditions tightening. Moreover, in the Netherlands, the Spread on mortgage loans is the largest loading. In fact, the low level had a positive impact on house demand, stimulating a price rise and improving the level of financial conditions. A possible situation because homeowners were able to deduct mortgage interests from their taxes.

As FCIs show, the main break in 2008 affected indistinctly each country of our sample, but the sovereign debt crisis hit only the noncore countries. Heterogeneity in financial condition can lead to further worsening and increase the factors friction in credit channel, i.e., no-efficient transmission in monetary policy. This is what happened from 2010, where many non-core countries (such as Italy, Spain), mortgage interest rates, and the increase of NPLs were the most important factors for credit restriction. The heterogeneous developments in the composite indicator of financial condition, also reflected the measures of dispersion of lending rates across countries. These dispersions are well captured from LWPCA approach that points out country-by-country variables more relevant for financial stability and the factor of friction on which the ECB should intervene with ad hoc policy instruments to restore a homogeneity condition.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

6. CONCLUSION

In this work, we analyze the mechanism of credit channels and the state of credit conditions under a macroeconomic perspective, which is essential for financial stability in the Eurozone.

We have constructed FCIs for the Eurozone countries over the period 2005–2015 by using T3. This factorial method can stress the substantial interactions between the different modes (countries, variables, and time), highlighting the trends of credit conditions in each country. An important result is the identification of the shift of the forces that shape the dynamic of credit conditions and the indicator composition, individuating them in principal occasions. Our analysis can add some important insight to the identification of different regimes in time whose importance is underlined by Stock and Watson (2016). The authors recall the importance of detecting situations of temporal dependence and heterogeneity to the identifications of loadings under a factorial VAR (FAVAR) model. As major difficulty is the identification of regimes in the presence of heterogeneity through time, our approach can offer details in the shifting of the composition of the indicators that suggest changes in the regime for the FAVAR model. In this sense, our approach may be also seen as complementary to FAVAR.

Problems of stationarity connected to structural differences in macroeconomics conditions resulted also affecting the definition of the indicator. For the reason of increasing the representativeness and reliability and to gain a more detailed view of this differences we performed LWPCA for 2010. This method points peculiar situation that characterize core and no-core countries and which triggered a further deterioration of credit flows and emerges as a valid tool to point out the essence of single country policies complementary to the global monetary policy. Further research may involve the derivation of heterogeneous indicators able to benefit from data of different years.

In the end, our evidence reflects a scenario in which early difficulties in convergence of real interest rates exposed the Eurozone to a precarious equilibrium. The exogenous shock of 2008 stressed the area and caused a major breakdown that resulted in a situation of high uncertainty. Financial divergences have grown from sovereign debt crisis with a heterogeneity transmission of monetary policy. Only in 2015, we observe a possible homogeneous point of financial condition. The last accommodative policies have permitted an improvement of conditions per access to credit, leveling the existing heterogeneity. The long-awaited countercyclical intervention has finally helped to mitigate negative effects of global financial crisis and previous austerity policies as well.

NOTES

1. Nonperforming loans (NPLs) indicate the health of the banking sector. A higher level of this variable is associated with tighter financial conditions.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

2. To ensure the stationarity, each series has been tested by augmented Dickey–Fuller (ADF) test. Although the test does not reject the null hypothesis, we have not differentiated the data because most series are already differentiated (flow, growth rate, etc.), following the approach of English et al. (2005).

3. The scree-test adopts principal component analysis on supermatrices (PCA-SUP) for simplicity.

4. Several different kinds of kernels are possible. Consequences of the choice are seldom invariant [Fotheringham et al. (2002)], and we adopted Gaussian kernel as the most common continuous kernel.

5. We refer to winning variables as the variable that present higher absolute value for the first component.

REFERENCES

Angelopoulou, Elina, Hiona Balfoussia, and Heather D. Gibson (2014) Building a financial condition index for the euro area and select euro area countries. What does it tell us about crisis? *Economic Modelling* 38(C), 392–403.

Beaton, Kinmberly, René Lalonde, and Corinne Lu (2009) A Financial Conditions Index for the United States. Discussion paper 2009–11, Bank of Canada, Ottawa.

Benchimo, Jonathana and André Fourans (2016) Money and monetary policy in the Eurozone: An empirical analysis during crises. *Macroeconomic Dynamics* 21(3), 677–707.

Blot, Christophe, Jérome Creel, Paul Hubert, and Fabien Labondance (2016) The Impact of ECB Policies on Euro Area Investment. Sciences Po.

Born, Benjamin, Michael Ehrmann, and Marcel Fratzscher (2012) Macroprudential policy and central bank communication. *International Finance* 15(2), 179–203.

Brave, Scott and R. Andrew Butters (2011) Monitoring Financial Stability: A Financial Conditions Index Approach. Economic perspectives, first quarter, Federal Reserve Bank of Chicago, 22–43.

Carlson, Mark, Kurt Lewis, and William Nelson (2014) Using policy intervention to identify financial stress. *International Journal of Finance & Economics* 19(1), 59–72.

COM (2014) A reformed financial sector for Europe. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 279 final.

Dudley, William and Jan Hatzius (2000) The Goldman Sachs Financial Conditions Index: The Right Tool for a New Monetary Policy Regime. Global economics paper 44.

ECB (2009) A Global Index of Financial Turbulence. Financial stability review, December, 21–23.

ECB (2012) Heterogeneity in euro area financial conditions and policy implications. Monthly Bulletin August, 63–75.

Eichengreen, Barry (2012) Europe's Vicious Spirals. Project Syndicate, January, 11.

Eickmeier, Sandra and Boris Hofmann (2013) Monetary policy, housing booms, and financial (im)balances. *Macroeconomic Dynamics* 17(4), 830–860.

Engler, Philipp, Giovanni Ganelli, Juha Tervala, and Simon Voigts (2017) Fiscal devaluation in a monetary union. *IMF Economic Review* 65(2), 241–272.

English, William, Kostas Tsatsaronis, and Edda Zoli (2005) Assessing the predictive power of measures of financial conditions for macroeconomic variables. *BIS Papers* 22, 228–252.

Erdem, Magdalena and Kostas Tsatsaronis (2013) Financial conditions and economic activity: A statistical approach. *International Banking and Financial Market Developments* 3, 37.

Fotheringham, A. Stewart, Chris Brunsdon, and Martin Charlton (2002) *Geographically Weighted Regression – The Analysis of Spatially Varying Relationships*. Chichester, UK: Wiley.

Gauthier, Céline, Christopher Graham, and Ying Liu (2004) Financial Conditions Indexes for Canada. Bank of Canada working paper 22.

Gilchrist, Simon, Vladimir Yankov, and Egon Zakrajsek (2009) Credit market shocks and economic fluctuations: Evidence from corporate bond and stock markets. *Journal of Monetary Economics* 56(4), 471–493.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press

Giordani, Paolo, Henk AL Kiers, and Maria Antonietta Del Ferraro (2014) Three-way component analysis using the R package ThreeWay. *Journal of Statistical Software* 57(7), 1–23.

Gollini, Isabella, Lu Binbin, Charlton Martin, Brunsdon Christopher, and Harris Paul (2015) GWmodel: An R package for exploring spatial heterogeneity using geographically weighted models. *Journal of Statistical Software* 63, 17.

Harris, Paul, Chris Brunsdon, and Martin Charlton (2011) Geographically weighted principal components analysis. *International Journal of Geographical Information Science* 25, 1717–1736.

Harris, Paul, Clarke Annemarie, Juggins Steve, Brunsdon Chris, and Charlton Martin (2015) Enhancements to a geographically weighted principal component analysis in the context of an application to an environmental data set. *Geographical Analysis* 47, 146–172.

Hatzius, Jan, Perter Hooper, Frederic Mishkin, Kermit Schoenholtz, and Mark Watson (2010) Financial Conditions Indexes: A Fresh Look After the Financial Crisis. NBER working paper 16150.

Hollo, Daniel, Manfred Kremer, and Marco Lo Duca (2011) Ciss-A Composite Indicator of Systemic Stress in the Financial System. ECB working paper series 1426.

Jolliffe, I.T. (2002) *Principal Component Analysis*. New York, NY: Springer.

Kiers, Henk A.L. (2000) Towards a standardized notation and terminology in multiway analysis. *Journal of Chemometrics* 14, 105–122.

Kroonenberg, Peter M. (1983) *Three-Mode Principal Component Analysis: Theory and Applications*. Leiden: DSWO.

Kroonenberg, Peter M. (2008) *Applied Multiway Data Analysis*. Hoboken: John Wiley and Sons.

Matheson, Troy D. (2012) Financial conditions indexes for the United States and euro area. *Economic Letters* 115(3), 441–446.

Mayes, David G. and Matti Virén (2002) Financial conditions indexes. *International Economics* 55(4), 521–550.

Osorio, Carolina, Feliz Unsal, and Runchana Pongsaparn (2011) A Quantitative Assessment of Financial Conditions in Asia. IMF working paper 110–170.

Darracq Paries, Matthieu, Laurent Maurin, and Diego Moccero (2014) Financial condition index and credit supply shock for the euro area. ECB working paper 1644.

Postiglione, Paolo, M. Simona Andreano, and Roberto Benedetti (2013) Using constrained optimization for the identification of convergence clubs. *Computational Economics* 42, 151–174.

Rosenberg, Michael (2009). Financial Conditions Watch. Bloomberg.

Schinasi, Garry J. (2004). Defining Financial Stability. IMF working paper 128–190.

Shambaugh, Jay C. (2012) The euros three crises. *Brookings Papers on Economic Activity* 43, 157–231.

Stiglitz, Joseph E. (2010). The Stiglitz report. Reforming the international monetary and financial systems in the wake of the global crisis. UN Commission of Financial Experts, United Nations.

Stock, James H., and Mark W. Watson (2016) Dynamic factor models, factor-augmented vector autoregressions, and structural vector autoregressions in macroeconomics. *Handbook of Macroeconomics* 2, 425–525.

Tucker, Ledyard R. (1966) Some mathematical notes on three-mode factor analysis. *Psychometrika* 31(3), 279–311.

Van Roye, Bjorn (2011) Financial Stress and Economic Activity in Germany and the Euro Area. Kiel Institute for the World Economy working paper 1743.

Wacker, Kostantin, David Lodge, and Giulio Nicoletti (2014) Measuring Financial Conditions in Major Non-Euro Area Economies. Working paper 1743, European Central Bank.

https://doi.org/10.1017/S1365100518000329 Published online by Cambridge University Press