Bachelor Thesis

Variation of monetary policy transmission over a financial cycle: analysis of the EU countries

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Abstract

Countries in the European Monetary Union (EMU) are subject to the common monetary policy, but the impact of this policy on the local economies is heterogeneous. Structural differences in the economies and the lack of synchronisation of the economic cycles across EMU countries are usually referred to as the causes of this heterogeneity. Our paper proposes one more factor: heterogeneity of financial cycles. We explore how the financial cycle phase affects the responsiveness of retail bank lending rates to the changes in the key policy rate (interest rate pass-through). To model this relationship, we employ panel error correction model of 16 EU countries (both EMU members and non-EMU members) covering the period from 1996 to 2014. We conclude that the phase of financial cycle is a significant determinant of immediate pass-through, but its effect is small. We explain this finding by an overreaction of the banks, reduced liquidity and drop in credit volume during the times of financial crisis.

Keywords: *financial cycle, monetary transmission, credit channel, interest-rate pass-through, cross-country analysis.*

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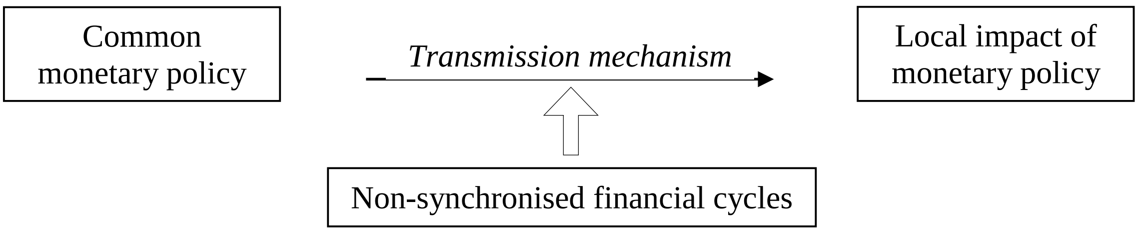
1. Introduction

The European Central Bank (ECB) conducts a single monetary policy for all countries in the European Monetary Union (EMU). A large number of studies have analysed whether the heterogeneity in structural economic parameters of these countries can interfere the transmission of the single monetary policy. A different question, however, is whether the cyclical movements of the economies can cause this distortion. We extend this question even further: there are cyclical movements not only in the economic output (business cycles), but also in financial markets (financial cycles), which can cause differences in the transmission (Figure 1). This asymmetry poses a challenge to the policy makers; therefore, we need a better understanding of monetary transmission at the different stages of a financial cycle.

Figure 1. Non-synchronised financial cycles and difference in the monetary transmission



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The link between financial cycles and monetary transmission has not been tested in the empirical literature so far. A lot of papers study the response of retail bank lending interest rates to the changes in the main policy rate (hereafter referred to as pass-through). Some papers identify the determinants of pass-through that are closely connected to the state of financial markets), for example, credit demand, liquidity and asset quality (Saborowski & Weber, 2013). However, academics do not offer any single determinant of the financial market state that policy makers should look at. Therefore, we hypothesize that interest rate pass-through can be affected by the phase of the financial cycle. Our research question is as follows: ***How does the financial cycle influence the transmission of ECB policy to the lending rates of commercial banks?***

We analyse interest rate pass-through using a panel error correction model (ECM). As a proxy for financial cycle, we use a composite measure suggested by Stremmel (2015). We also include control variables to account for persistent structural differences between the countries in our sample, which consists of 16 countries[1]. In our study we cover the period from 1996 to 2014.

We show that financial cycle is a significant determinant of the interest rate pass-through. A financial crisis improves the transmission, while the effect of financial expansion phase is not significant. We suggest three explanations of this result: overreaction of lending rates, reduced liquidity and credit volume during a breakdown in the financial system.

Our findings indicate that if the financial cycles of the European economies are not synchronized, the pass-through will vary across the countries of the EMU. On the one hand, the difference of pass-through in this case is small for two reasons. Firstly, financial cycles of the EMU countries have a tendency to become more correlated. Secondly, the influence of financial cycle itself is relatively small. On the other hand, the increasing importance of financial markets and their interconnectedness with economic performance can amplify the effect of financial cycles in the future.

Our paper fills the gap in the current empirical literature on the determinants of pass-through. While many papers on this topic agree upon the significance of the financial market variables in explaining the heterogeneity of the transmission across countries, none of the papers consider financial cycle a direct explanatory variable of pass-through.

Our paper also has some real-life implications. Although the sole existence and amplitude of financial cycles can not be directly controlled by the policy makers, the effect of divergence in financial cycles of the EMU countries can be reduced by consolidating the banking systems in these countries. The creation of the Banking Union in this sense is a step towards the synchronisation of financial cycles; hence, it will make the transmission of the ECB policy more homogeneous for all countries in the EMU.

The paper proceeds as follows. In the section 2, we review the current academic stand on the determinants of the monetary transmission and on the characteristics of financial cycles. In section 3, we develop the model for our analysis of the pass-through

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[1] Our sample includes Austria, Belgium, the Czech Republic, Germany, Denmark, Spain, Finland, France, Greece, Hungary, Ireland, Italy, the Netherlands, Portugal, Sweden, the United Kingdom.

mechanism. Section 4 contains description of our data sources and sample. In section 5, we present the financial cycle measure and the results of the error correction model. Finally, we analyse our results and discuss the robustness checks in the section 6.

2. Literature review

2.1. The mechanism of monetary transmission

In this section we explain briefly the existing theories of monetary transmission and give a general theoretical background behind our research.

Bernarke and Blinder (1988) differentiate between traditional and credit view on the monetary transmission. The traditional view is based on two channels. Interest rate channel has the following mechanism: the central bank uses its power over the short-term interest rates to lower the long-term real interest rates, which are relevant for investment decisions. Exchange rate channel has a different mechanism: the changes in the central bank's rate lead to a drop in the attractiveness of the country's assets relative to the foreign ones, which lowers the exchange rate and increases the competitiveness of exports. The market participants and households react to these changes by increasing their investment and consumption, thereby increasing aggregate demand in the economy. However, some researchers claim that this mechanism does not perform well empirically and has a number of shortcomings (Bernanke & Gertler, 1995).

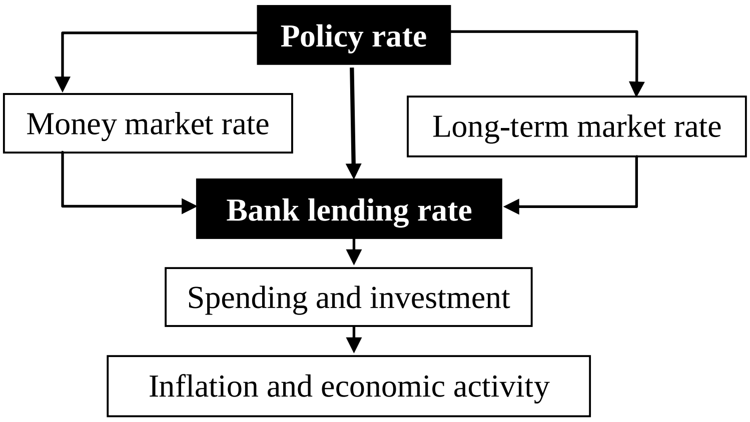
According to the credit view of monetary transmission, the monetary policy affects not only the short-term interest rates, but also the external finance premium (the difference between the cost of capital available internally and the cost of raising capital externally (Bernanke & Gertler, 1995)). This premium arises due to the existence of market frictions such as information asymmetry and costs of contract enforcement. For example, having received the credit borrowers choose riskier investments than the ones they have described to the bank

Academics identify two channels within the credit view: balance sheet and bank lending (Bernanke & Gertler, 1995). The first channel states that expansionary monetary policy results in higher stock prices and higher firms' net worth. With higher valuation firms have better perspectives of self-financing. Equity holders have a higher equity stake and, as a result are less likely to engage in risky projects. Moreover, they have more collateral to secure their debts. Banks assess such businesses as less risky, and decrease their lending rate, which leads to an increase in the credit volume.

According to the bank lending channel, a contractionary monetary policy decreases the supply of funds available to the commercial banks. If the amount of funds available to the commercial banks drops, the amount of credit provided by the banks to the borrowers also declines (Bernarke & Blinder, 1988). As the commercial banks are financial intermediaries that act to eliminate information asymmetry problems, the decrease in loans provided by them leads to a higher external finance premium (e.g. additional costs to search for a different source of financing). Finally, this results in a reduction in the real economic activity.

In our paper, we explore the bank lending channel of monetary transmission. Many empirical works on pass-through look at the link between money market rates and the bank lending rates. We aim to analyse the heterogeneous impact of the monetary policy on the real economies. Therefore, we follow the pass-through from the rate set by the central bank, which executes monetary policy, to the bank lending rates, which directly motivate the investments decisions (Figure 2). One more reason why we take the central bank rate is that it is more likely to be exogenous, whereas the money market rate and bank lending rates may have some common determinants.

Figure 2. Transmission of the policy rate to the real economy



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2.2 Empirical research on the determinants of pass-through

In this section we continue the overview of the existing literature, but here we discuss the empirical research on the pass-through, its findings and contradictions.

The transmission of monetary policy from the policy rate to the lending rates for businesses and households is theoretically explained by the marginal cost funding model suggested by Rousseas (1985). Retail bank lending interest rates (l_r) are determined by the marginal costs of lending (m) and a mark-up (α):

$$l_r = \alpha + \beta m \tag{1}$$

The marginal cost of lending for banks is the cost of interbank lending or lending from the main refinancing facility of the central bank. In this framework, coefficient β depends on demand elasticity for the banking product, the switching cost for providing credit to a new client and on the presence of asymmetric information. The coefficient α is mainly determined by the market power of the bank.

A summary of the empirical papers on the determinants of interest rate pass-through is provided in Table 1. The most common determinants are the competition in the banking industry and rigidity of banks' costs (which fit well into Rousseas (1985) model), as well as inflation and the characteristics of the economic environment as a whole (regulatory quality, financial dollarization, and financial development).

Some of the determinants listed in the Table 1 are not relevant to the European economies: there are no constraints on capital movement in the EU, the ownership structure is homogeneous across all European countries (most banks are privately owned), exchange rate flexibility is the same for all countries in the EMU. There is also a set of determinants that can be linked to the stage of financial cycle: volume of credit, liquidity and asset quality. During the expansion of financial markets, the volume of credit is at its peak (negatively effects pass-through), there is abundant liquidity (also negatively effects pass-through), and asset quality of most banks is high (positively effects pass-through). Therefore, it is not clear straightaway whether an expansion of financial markets is associated with a higher or lower pass-through.

One more determinant of pass-through from the Table 1 deserves attention here: economic development. Gigineishvili (2011) finds that GDP per capita has a positive influence on pass-through. Angeloni and Dedola (1998) test whether this determinant can lead to a divergence of lending rate responses of the economies within the EMU. They find that, although there is a consistent difference in economic activity cycles of the countries within the EMU, these cycles have a strong tendency to converge. Furthermore, Angeloni and Dedola (1998) conclude that these differences in economic development cannot impede conducting the single monetary policy. This conclusion was made before the EMU was formed. We address this issue in our paper constructing a different measure of fluctuations in economic activity – business cycle indicator.

Table 1. A summary of empirical literature on the determinants of pass-through

Determinant	**Effect on pass-through**	**Paper(s)**
Constraints on the movement of capital	Constraints are present → stickier lending rates → worse pass-through	Cottarelli & Kourelis (1994)
Ownership structure of the banking sector	Private ownership → stickier lending rates → worse pass-through	Cottarelli & Kourelis (1994)
Competition in the banking industry	Less competiton → stickier lending interest rates → worse pass-through Asymmetric effect: Higher competition → better pass-through if money market rate decreases; the opposite effect is insignificant	Cottarelli and Kourelis (1994), Mojon (2000), Sander and Kleimeier (2003), Gigineishvili (2011)
Rigidity of banks' costs	Higher overhead costs → lower pass-through	Mojon (2000), Gigineishvili (2011)
Monetary policy regime		
(1) inflation	Higher inflation → more flexible lending rates → better pass-through	Cottarelli & Kourelis (1994), Gigineishvili (2011)
(2) volatility of money market rates	Volatile money market rate → stickier lending rates → worse pass-through	Cottarelli & Kourelis (1994)
Volume of credit and real demand	Asymmetric effect: Higher volume ofcredit and real demand → worse pass-through if money market rate decreases; the opposite effect is insignificant	Mojon (2000)
Regulatory quality	Poor regulatory quality → higher intermediary costs → stickier lending rates → worse pass-through	Saborowski and Weber (2013)
Financial dollarization	Higher dollarization → central bank has limited control over the lending rates → worse pass-through	Saborowski and Weber (2013)
Financial development	More developed financial system → more flexiable lending rates → better pass-through	Cottarelli & Kourelis (1994), Saborowski & Weber (2013)
Liquidity	Abundant liquidity → stickier lending rates → worse pass-through	Saborowski & Weber (2013)
Asset quality	Weak banks' balance sheets → stickier lending rates → worse pass-through	Saborowski & Weber (2013)
Exchange rate flexibility	Stable exchange rate → higher credibility of the central bank → more flexiable lending rates → better pass-through	Saborowski & Weber (2013)
Economic performance	Higher GDP per capita → more flexiable lending rates → better pass-through	Gigineishvili (2011), Angeloni & Dedola (1998)

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2.3 Financial cycles

In this section we start the motivation of our research question and introduce the notion of financial cycles. Here we discuss theoretical foundations of this term and compare it with more well-known business cycles.

Hyman Minsky (1982) was the first one who attempted to explain the interlinkages between the economy and the financial market. In his "financial instability hypothesis", he defines the swings in financial markets as the causes of financial crises. During the expansion phase of the economy, companies accumulate more cash than it is required for debt repayments. The subsequent speculative euphoria leads to excessive borrowing. Some borrowers are not able to pay their debts back and the banks tighten lending conditions even for credible institutions. As a result, the economy shrinks. Minsky (1982) claimed that financial swings are inevitable unless the government intervenes by regulating the financial system. Views expressed by Minsky did not find support from his contemporaries as they were very novel. However, his works serve as the foundation for the literature on financial cycles.

The global financial crisis of 2007 confirmed that it is very important to develop policy tools that would safeguard financial stability. However, to apply those tools effectively, it is necessary to research the nature of the cyclical movements in the financial markets. While business cycles represent the movements in GDP (or unemployment), their financial counterparts cannot be observed naturally, they can be only inferred (Stremmel, 2015). Thus, there is an ongoing discussion about the definition of this concept and the universal method of capturing the cyclicality in the financial markets, which would be coherent across countries, but at the same time remain country-relevant.

The existing literature confirms that financial cycles are generally longer and more volatile than business ones. While business cycles have a short-term dimension with a length of 4.5 years, their financial counterparts last 11 years (Aikman, Haldane, & Nelson, 2014). Hiebert, Peltonen, and Schüler (2015) conclude that the average duration of one cyclical movement is 7.2 years, ranging from four to 17 years. Borio, Drehman, and Tsatsaronis (2012) state that the financial cycle measured as fluctuations in credit and house prices has an average length of 16 years and range from eight to 30 years. One can attribute this dispersion of durations given by different studies to the differences in the samples as the duration varies depending on the country specificities

(Hiebert et al., 2015). In the further analysis, we would assume that financial cycles are three times longer than the business ones (based on the previous literature we conclude that the average duration of the financial cycle is 14 years and the one of the business cycle is 4.5 years), while the duration of financial cycles falls in the range from 8 to 20 years (Claessens, Kose, & Terrones, 2012).

Borio et al. (2012) claim that both the duration and the amplitude of the financial cycles have increased significantly since the mid-1980s. He attributed this change to financial liberalisation. Stremmel and Zsamboki (2015) explain the increase in the variation of financial cycle indicators with the increase in the concentration of the banking sector, the share of foreign banks, the size and stability of financial institutions.

With regard to synchronization of financial and business cycles, Hiebert et al. (2015) finds that financial cycles captured by the composite measure explain 67% of variation in the business cycles. Comparing different types of economies Claessens et al. (2012) states that business and financial cycles are more synchronous in advanced countries than in emerging markets. This can be explained by a higher influence of financial market on the real economy in the developed countries.

The peaks of financial cycles are often followed by a drop in the economic activity (Borio et al., 2012). Moreover, the duration and the amplitude of the fluctuations in the economic activity depend on the strength and intensity of financial distortions (Claessens et al., 2012; Borio et. al, 2012; Borio & Lowe, 2002). Thus, economic recoveries accompanied by credit or house price booms have a higher GDP growth, while recessions associated with financial disruptions are much deeper. These findings prove the importance of macroprudential policy.

2.4 Financial cycle and monetary transmission

In this section we continue the discussion of financial cycles, and give the motivation of why the link between the cycles and monetary transmission may exist. We provide the results of the existing empirical literature that indirectly point to this link, as well as our own arguments why this may be the case.

The recent financial crisis has motivated a new wave of literature on pass-through. Increased cost of short-term financing, pressure on the banks' balance sheets due to dampened profitability and growth prospects, increased counter-party risk – all these factors lead to a decrease in cross-border banking transactions and fragmentation of the common financial market (Al-Eyd & Berkmen, 2013). As a result, the EMU experienced sharp divergence of interest rates across banks and change in the pass-through mechanism (Paries, Moccero, Krylova, & Marchini, 2014).

Al-Eyd and Berkmen (2013) find that the divergence in interest rates is explained by elevated funding costs, increased credit risk and bank leverage. Paries et al. (2014) follow these findings and consider such explanatory variables in the pass-through mechanism as the spread of sovereign bond yields, corporate and household indebtedness (measured by credit-to-GDP ratios), Monetary Financial Institutions interest rate spread (difference between short-term and long-term money market rates).

Holton and d'Acri (2015) also investigate divergence of lending rates during the crisis. The authors find that macroeconomic variables and borrower quality are not sufficient to explain the heterogeneity, and investigate the effect of bank level factors (size, liquidity and capital, credit default swap spreads). The most important factors of pass through (both for individual banks and overall pass-through in the long run) are those that characterize the funding costs of the banks.

The aforementioned papers stress the importance of increased funding costs in explaining pass-through mechanism during the crisis. We propose the following causality that links the crisis environment and the interest rate pass-through: a higher country risk (higher bond yields) and an increased counterparty risk lead to increased funding costs for the retail banks; liquidity in the system drops, so the banks turn to the central bank for marginal financing more often; this way they become more dependent from the main policy rate; hence, their lending rates become more responsive to the changes in the central bank’s rate (since this rate determines the marginal funding costs for banks).

According to the evidence from the empirical literature described in the section 2.2, the reduced volume of credit and decrease in liquidity should both have a positive effect on pass-through. Therefore, we make the following ***hypothesis***: financial cycle should be a significant determinant of pass-through, with crisis having a positive effect on pass-through and expansion of financial markets – a negative effect.

We also want to highlight the difference between financial and business cycles in their effects on monetary transmission. Concerning business cycles our ***hypothesis*** is the following: during economic expansion the lending rates become more responsive to the changes in the main policy rate, whereas during the contractionary period of the cycle the lending rates become stickier (in line with the conclusions of Gigineishvili (2011)).

3. Methodology

3.1 Ingredients of financial cycle

In this section we discuss the variables that can be used to construct the measure of financial cycle and the motivation of the choice of variables in our paper.

It is common in the empirical literature to employ two types of proxies for financial cycles. The first one relies on the fluctuations of different asset markets (property, equity and bond). Although the property prices are considered main indicators of the financial imbalances, equity prices are much more often employed in the analysis (Borio & Lowe, 2002). The explanation for that is the unavailability of the data and incomparability of the datasets of different countries. The second proxy for financial cycle is based on private sector leverage (measured by credit-to-GDP ratio). It represents the vulnerability of the financial system to shocks from the asset markets.

While some papers employ single variable to characterise financial cycle (Claessens et al., 2012; Schularick & Taylor, 2012; Borio et al., 2012; Borio & Lowe, 2004), the others attempt to develop a composite measure (the one that combines several indicators). Borio and Lowe (2004) combine credit and asset prices and claim that jointly they better capture the cyclicality of financial markets. Hiebert et al. (2015) explore financial cycles constructed from the different types of asset prices. They find that residential property prices are more correlated with equity prices and to a lesser extent with bond yields. Hence, a composite cycle, which includes housing and equity price indices, has a higher predicting power than credit-to-GDP ratio.

In addition to traditional ingredients Borio and Lowe (2002) employ the real effective exchange rate as a proxy for financial cycle. They conclude that for industrial countries it is better to use the composite indicator that includes the credit and the equity prices, while for emerging markets the best composite indicator combines the credit with either the asset price index or the exchange rate.

In his composite financial cycle measure Stremmel (2015) incorporates not only credit aggregates and asset price indices, but also different banking sector indicators. However, he finds that they do not add explanatory power. Thus, he ends up with the traditional indicators such as house prices to disposal income ratio, credit growth rate and credit-to-GDP ratio.

Hollo, Kremer and Duka (2012) propose a completely different measure – the Composite Indicator of Systemic Stress (CISS), which aggregates three “raw stress indicators”. They capture the rise in the agents’ uncertainty, investor disagreement and information asymmetries mainly by the changes in the volatilities, risk spreads and cumulative valuation losses. Because it is difficult to track changes in the financial market as a whole, this indicator measures systemic risk through the five main subindices of financial markets. The main distinguishing feature of the indicator is the application of time-varying weights of subindices in the composite measure. Therefore, the simultaneous stress in the several subindices has more weight in the CISS.

Based on the aforementioned analysis of academic literature, we conclude that the composite measure of financial cycle has a higher explanatory power. The set of components that would better explain the cyclical fluctuations of the financial markets depends on country characteristics. Since our sample mostly consists of advanced economies, we use a composite measure developed by Stremmel (2015). This measure includes traditional indicators of financial market cyclicality: credit growth, credit-to-GDP ratio and house price index.

3.2 Methods to extract cyclical information from time series

In this section we continue the methodology on the construction of the financial cycle variable. More specifically we discuss the methods of how the cyclicality can be extracted from the variables that we have discussed before.

There is no consensus in the academic literature concerning the construction of a variable that reflects the fluctuations of a financial cycle. Various authors use different approaches that are usually taken from the literature on the business cycles. There are two main analytical techniques to extract cyclical information from the time series: turning point analysis and frequency-based filters. The first approach uses an algorithm that determines local maxima and minima – turning points of financial cycle time series. To define the absolute maxima and minima, one has to check them through the censoring rules, which set minimal durations of the cycles and phases. We follow the second approach, however, and apply filters, which “isolate fluctuations with different frequencies” (Canova, 1999). The filters eliminate permanent component (the trend) and compute second moments for the residuals (the cycle growth). Two types of filters are commonly used in the literature: band-pass and Hodrick-Prescott (HP). We employ both of them: band-pass for the main regressions and HP for robustness checks.

The band-pass filter is based on the Spectral Representation Theorem: any time series can be decomposed into components with different frequencies. Given auto-covariance function, the properties of the time series are captured by the spectral density of the stationary process. Spectral density takes a Fourier transformation of the auto-covariance, decomposing the variance in terms of frequency.

This filter isolates the components of the time series with the frequencies, which lie in a certain interval. A band-pass filter combines in itself low and high pass moving average filters (it wipes out low and high frequencies). The main advantage of the band-pass filter is that it produces a smother time series comparing to the HP filter; moreover, it generates fewer false alarms compared to turning point analysis (Canova, 1999).

The band pass filter requires infinite time series data, but in practice academics use an approximation. We apply the filter with the approximation developed by Christiano and Fitzgerald (2003). Its advantage is that it penalizes deviations from the ideal filter (the one applied to the infinite time series) more at the frequencies where the spectrum of the time series is large.

The underlying assumption is that the time series follows a random walk. Thus, we test each time series for stationarity with Augmented Dickey-Fuller test and adjust the band-pass filter approximation accordingly. Following Claessens et al. (2012), we allow the financial cycle duration to vary across countries and periods in the interval of 8-20 years (package “mFilter”).

The second filter (HP) is based on a different procedure. HP hybrid decompositions are used to get a smooth time series by penalising the observables for deviations from the trend (Hodrick & Prescott, 1997). These time series are sensitive only to long-term fluctuations giving less weight to the short-term ones (see more details in Appendix A). To apply this filter we have to set a smoothing multiplier. For business cycle, it is recommended to use the multiplier (λ_q) of 1600 for quarterly data. However, we have to alter this number since we construct a financial cycle using monthly data (package “mFilter” in R). Following Ravn and Uhlig (2002), the choice of lambda adjusted (λ_s) depends on:

(1) Frequency of observations. $\lambda_s = s^m * \lambda_q$, where s is the ratio of the frequency of observations compared to quarterly data ($s = 3$ for monthly data) and m lies in the range from 3.8 to 4. Therefore, the lambda for monthly data should be between 104 035 and 129 600. We take the average value in both cases.

(2) Average duration of the cycle. $\lambda_s = n^4 * \lambda_q$, where n is the ratio of the expected duration of the examined cycle to the duration of the business cycle. Following the estimate that financial cycles are three times longer than business cycles, we use smoothing multiplier of 9 462 258 ($\approx 104\ 035 * 3^4$).

To apply the two-sided HP filter, we use ARIMA (autoregressive integrated moving average) model and forecast variables few periods ahead. Keiser and Maravall (1999) claim that application of the series extended with proper ARIMA forecasts can improve performance of the filter. To find the best fitting $ARIMA\ (p, d, q)$ model we implement Hyndman and Khandakar (2008) algorithm. The algorithm includes:

- Augmented Dickey-Fuller test for unit root to define the number of differencing (d);
- the values of p (autoregressive term) and q (moving average term) minimize Akaike information criteria and Maximum Likelihood estimator.

We predict the values for the next four periods with the confidence level of 90-95% based on 5 000 simulations (package “forecast” in R).

We run the filtering for each of three components suggested by Stremmel (2015) (credit-to-GDP ratio, credit growth and the housing price index) and then combine them by taking the average without quantifying the exact relationship between them.

3.3 The common approach for modelling monetary transmission mechanism

In this section we describe the regressions that are commonly used in the empirical studies of monetary transmission. The review of several specific examples of such regressions can be found in Appendix C.

Sander and Kleimeier (2003) develop a common framework to model interest rate pass-through process. They suggest using an error correction model (ECM) to account for non-stationarity and cointegration of interest rates (see the explanation of these terms in Appendix B). ECM is a two-step model that accounts for adjustment to the long-term equilibrium. In our case in equilibrium the retail bank lending rate is equal to the central bank policy rate multiplied by the coefficient of long-term pass-through. So in the first step, the retail bank interest rate (r_t) is regressed on the key policy rate (mr_t):

$$r_t = \alpha_0 + \vartheta mr_t + u_t \tag{2}$$

The regression is run to get the error correction terms (ECT), which are necessary for the second step of ECM:

$$ECT_{t-1} = u_{t-1} \tag{3}$$

$$\Delta r_t = \mu + \underbrace{\sum_{m=1}^{M} \alpha_m \Delta r_{t-m} + \sum_{n=0}^{N} \beta_n \Delta mr_{t-n}}_{a} + \underbrace{\beta_{ECT} ECT_{t-1}}_{b} + \varepsilon_t \tag{4}$$

The advantage of this model (equation (4)) is that it takes into account:

(1) short-term shocks in the current and previous periods (part a);

(2) the adjustment to a long-term equilibrium (part b).

However, we run panel ECM model in one-step following Holton and d'Acri (2015) and in line with Banerjee, Galbraith, and Dolado (1990):

$$\Delta r_t = \mu + \sum_{m=1}^{M} \alpha_m \Delta r_{t-m} + \sum_{n=0}^{N} \beta_n \Delta mr_{t-n} + \\ + \beta_{ECT}(r_{t-1} - \alpha_0 - \vartheta mr_{t-1}) + \varepsilon_t \tag{5}$$

Equation 5 is modified so that:

$$\mu - \beta_{ECT}\alpha_0 = \varphi \tag{6}$$

$$\beta_{ECT}\vartheta = \theta \tag{7}$$

$$\beta_{ECT} = \delta \tag{8}$$

$$\Delta r_t = \varphi + \sum_{m=1}^{M} \alpha_m \Delta r_{t-k} + \sum_{n=0}^{N} \beta_n \Delta mr_{t-n} + \delta r_{t-1} + \theta mr_{t-1} + \varepsilon_t \tag{9}$$

In specification (9) the interpretation of the coefficients is the following:

- the immediate reaction of lending rates to changes in the key policy rate is captured by β_0;
- the coefficient δ determines the speed of adjustment of bank lending rate when it deviates from the equilibrium relationship between r_t and mr_t;
- the overall pass-through is $-\theta/\delta$. In case of complete pass-through (all changes in policy rates are reflected in bank lending rates) this ratio is equal to one.

3.4 Regression specifications in our research

In this section we describe in detail the regression specification that we have used in our study. At the end of the section we introduce the regression that accounts for asymmetric effects in monetary transmission.

To test the influence of financial and business cycles (FC and BC) on monetary transmission we employ panel regression based on the specification (9). The reason we use panel model is to investigate the influence of variation in FC and BC not only across time, but also across countries. This is particularly important for the monetary policy in the EMU since the divergence of FC and BC between countries can be quite significant.

Having reviewed some of the models in the empirical literature (Appendix C), we build up equation (10) in the following way:

- part (a) stays the same as in the regression (9),
- part (b) captures the effect of control variables and FC and BC measures on the immediate pass-through,
- part (c) includes long-term relationship (lagged ECT from the original two-step ECM),
- part (d) consists of the interactions of control variables and FC and BC measures with the long-term transmission terms:

(a) $$\Delta r_{i,t} = \varphi_i + \alpha_n \Delta r_{i,t-1} + \sum_{n=0}^{3} \beta_n \Delta mr_{i,t-n} +$$

(b) $$+ \sum_{n=1}^{5} \beta_n X_n \Delta mr_{i,t} + \beta_6 \Delta FC_{i,t} \Delta mr_{i,t} + \beta_7 \Delta BC_{i,t} \Delta mr_{i,t} +$$

(c) $$+\delta r_{i,t-1} + \theta mr_{i,t-1} +$$

(d) $$+ \sum_{n=1}^{5} \theta_n X_n mr_{i,t-1} + \theta_6 \Delta FC_{i,t} mr_{i,t-1} + \theta_7 \Delta BC_{i,t} mr_{i,t-1} + \varepsilon_{i,t,} \quad (10)$$

where FC is a financial cycle measure; BC is a business cycle measure; X_1:X_5 is a vector of control variables (inflation, competition measure, cost rigidity measure, regulatory quality measure and EMU dummy, which takes the value of one if the country is a member of the EMU in the current month). Financial and business cycle measures are taken in the first differences because in levels these variables do not have a straightaway interpretation. In differences, however, the continuous rise of the variable stands for the period of expansion, and the fall – for contraction of the markets and economies.

We use the cost of borrowing for new short-term loans (with a fixed maturity up to one year) as the retail bank interest rate. As the key policy rate, we take the main refinancing operations rate (MRO) for EMU countries and a similar short-term refinancing rate for non-EMU countries. Currently the ECB and other European central banks face zero lower bound problem, meaning that their interest rates are close to zero or even negative. In this case the monetary policy has limited ability to decrease the lending rates and, thus, it cannot stimulate the economic growth. As an alternative for the key policy rate we could use the central bank's rate with longer maturity, which are currently well above zero. However, these rates are not the closest representation of the key policy rate.

Our sample includes 16 countries and the monetary transmission coefficients are presumably not the same for all of them. There are structural differences in the financial systems of these countries that determine the variation of the coefficients in our panel. To control for these differences, we follow Mojon (2000) and Saborowski and Weber (2013) and include the following control variables:

1) *The monetary policy regime*. Cottarelli and Kourelis (1994) first confirm the significance of monetary regime in explaining pass-through. In this context, monetary regime is characterized by the inflation rate and the volatility of central bank rate. The volatility was not significant in the preliminary regressions, so we include only inflation rate (calculated as the monthly percentage change in Harmonized Index of Consumer Prices (HICP)).
2) *Competition among banks*. The more competitive the loan market is, the faster banks adjust their interest rates towards money market rates (in case of perfect competition the "price" of loans equals the marginal costs of providing them – the money market rate). Mojon (2000) uses Gual index to measure the degree of regulation (the structurally determined level of competition in the banking industry). Leuvensteijn, Sorensen, Bikker, and Rixtel (2008) use Boone indicator as a direct measure of competition. Because of unavailability of these indices, we use a more common measure of market concentration – Herfindahl-Hirschman index (HHI) for the banking industry.
3) *Rigidity of banks' costs*. Mojon (2000) proxies rigidity of banks' costs by measuring the reliance of banks on deposits (the ratio of deposits to total liabilities). Because of the unavailability of this measure for several countries in

our sample, we use a different one – the ratio of overhead costs over total assets (TA). The higher the ratio is, the lower is the share of marginal costs in the cost structure of the banks. Therefore, the pricing of loans is essentially determined by marginal lending rates since overhead costs are fixed. As marginal costs are completely determined by the policy rate of the central bank, a higher overheads-to-TA ratio results in a stronger and faster response of lending rates to the changes in the policy rate.

4) *Regulatory quality*. In a well-functioning regulatory environment the monetary transmission works more efficiently because the uncertainty related to the regulation and its enforcement is minimized. We follow Saborowski and Weber (2013) and use the World Bank regulatory quality index to control for cross-country differences in the regulatory environment. This index reflects the perceptions about the government's ability to implement policies that promote financial development.

5) *Membership in the EMU*. We control for EMU membership for two reasons. Firstly, the monetary union has probably changed the monetary transmission coefficients. Secondly, we need to control for data collection differences before and after the establishment of the EMU (the interest rates for EMU member countries are taken from the ECB, while the data for non-EMU countries are taken from the respective central banks, which use a different methodology to calculate the aggregate retail lending rates).

It is common that an increase and a decrease in the main policy rate have different absolute effects on the retail lending rates. There are two explanations of this asymmetry, which contradict each other. The first one is the consumer behaviour hypothesis (Hannan & Berger, 1991). It predicts that depositors and borrowers possess sufficient knowledge about the financial markets. Thus, banks operating in a highly competitive environment are reluctant to exercise their market power (lending rates are rigid to increase). The second explanation of the asymmetric response is the bank's collusive pricing hypothesis (Hannan & Berger, 1991; Neumark & Sharpe, 1992). It states that when banks can exploit the lack of competition in the market, they are more likely to adjust interest rates to their advantage (lending rates are rigid downwards).

According to Wang and Lee (2009), the models of the pass-through process that do not account for asymmetries in the adjustment process are underestimating the pass-through coefficients. Thus, we run a model that accounts for this asymmetry:

(a) $$\Delta r_{i,t} = \varphi_i + \alpha_n \Delta r_{i,t-1} +$$

$$+ \sum_{n=0}^{2} D_{\Delta mr_{i,t-n}} \beta_n^1 \Delta mr_{i,t-n} + \sum_{n=0}^{5} (1 - D_{\Delta mr_{i,t-n}}) \beta_n^0 \Delta mr_{i,t-n} +$$

(b) $$+ \sum_{n=1}^{5} \beta_n X_n \Delta mr_{i,t} +$$

$$+ \beta_6^1 D_{\Delta FC_{i,t}} \Delta FC_{i,t} \Delta mr_{i,t} + \beta_6^0 \left(1 - D_{\Delta FC_{i,t}}\right) \Delta FC_{i,t} \Delta mr_{i,t} +$$

$$+ \beta_7^1 D_{\Delta BC_{i,t}} \Delta BC_{i,t} \Delta mr_{i,t} + \beta_7^0 \left(1 - D_{\Delta BC_{i,t}}\right) \Delta BC_{i,t} \Delta mr_{i,t} +$$

(c) $$+ \delta r_{i,t-1} + \theta mr_{i,t-1} +$$

(d) $$+ \sum_{n=1}^{5} \theta_n X_n mr_{i,t-1} +$$

$$+ \theta_6^1 D_{\Delta FC_{i,t}} \Delta FC_{i,t} mr_{i,t-1} + \theta_6^0 \left(1 - D_{\Delta FC_{i,t}}\right) \Delta FC_{i,t} mr_{i,t-1} +$$

$$+ \theta_7^1 D_{\Delta BC_{i,t}} \Delta BC_{i,t} mr_{i,t-1} + \theta_7^0 \left(1 - D_{\Delta BC_{i,t}}\right) \Delta BC_{i,t} mr_{i,t-1} + \varepsilon_{i,t} \qquad (11)$$

where $D_{\Delta mr_{i,t-n}}$ is a dummy variable that takes on the value of one when $\Delta mr_{i,t-n}$ is positive (the subscript of the dummy shows the variable which the dummy refers to).

We introduce asymmetric adjustment effects not only to the change in the main policy rate, but also to the change in financial and business cycle variables. This implies that the adjustment coefficient for the expansionary stage of the cycles is different (in absolute value) from the adjustment in contractionary stage.

4. Data description

As we analyse the transmission of ECB monetary policy, we aim to compile our sample with as many EMU countries as possible taking into account the availability of data. Apart from EMU countries, we also include in our sample a group of other EU countries that are not the members of the EMU. We expect financial cycles of the non-EMU countries to be less synchronous than the ones of the EMU countries. Thereby, we have sufficient heterogeneity of financial cycles within our sample, which helps us to capture the effect of this variable on the transmission mechanism.

Our sample consists of 16 countries (Austria, Belgium, the Czech Republic, Germany, Denmark, Spain, Finland, France, Greece, Hungary, Ireland, Italy, the Netherlands, Portugal, Sweden, the United Kingdom). The period we analyse is constrained by the availability of data for control variables. We use the data from January 1996 to December 2014.

4.1 Components of financial cycle

In our analysis, we use a composite cycle measure developed by Stremmel (2015). It consists of three components: credit-to-GDP ratio, credit growth and house-price-to-disposable-income ratio. However, due to the data unavailability of the last variable, we take house price index instead. We extract the data from the Organisation for Economic Cooperation and Development (OECD) and the Bank for International Settlements (BIS) statistics (Table 2).

Table 2. Sources of data for composite financial cycle

Variable	Description	Frequency	Source
Credit-to-GDP	Lending: All sectors Borrowing: Private non-financial sector Adjustment for breaks Percentage of GDP	Quarterly	BIS Credit Database
Credit	Lending: All sectors Borrowing: Private non-financial sector Adjustment for breaks Domestic currency (billions)	Quarterly	BIS Credit Database
Property prices	Price changes of new and existing residential properties, purchased by households	Quarterly	OECD Statisitcs

(created by the authors)

The availability of data poses serious limitations on the number of countries and the periods that we can analyse. The composite cycle measure is computed for the periods when the data for at least one component are available (Appendix D, Table D.1).

4.2 Interest pass-through

The common and standardized statistics for EMU countries are available only from January 2003 despite the fact that the EMU was created in 1999. Therefore, EMU-dummy takes the value of one starting from January 2003.

We use cost of borrowing for new short-term loans (with a fixed maturity up to one year) as the retail bank interest rate. For the EMU countries, we extract the monthly data from the ECB Statistical Data Warehouse. This database provides not only the data for the period of the countries' membership in the EMU, but before the entry (for some countries, Appendix D, Table D.2). Despite the fact that the lending interest rates for the earlier periods are defined differently, this change in the methodology will be captured by the dummy variable indicating EMU membership. For non-EU countries we obtain the interest rate statistics from the central banks' databases. In the absence of the cost of borrowing for new short-term loans, we weight the available interest rates by their volumes to obtain the single interest rate as defined by the ECB. We use the main refinancing operations rate (MRO) as the main policy rate for the EMU countries, and the respective interest rate for non-EMU countries. The descriptive statistics on the interest rates are in Appendix E. There are no extreme values except the lending rate in Greece (21.4%). As the number of observations varies across countries, our panel dataset is unbalanced.

We apply linear interpolation for the control variables (Table 3) to get monthly observations. The descriptive statistics for the variables are in Appendix F. The standard deviation of the control variables is close to zero for the majority of countries, which can be explained by the fact that they capture structural differences across countries, which are rather stable over time. The cross-time stability and cross-country heterogeneity of the control variables is illustrated in Appendix F, which contains plots of observations' means and their 95% confidence interval.

Table 3. The sources of data for the control variables.

Variable	Description	Frequency	Source
HHI	For credit institutions (total assets)	Annually	ECB Statistical Data Warehouse
HICP	Monthly rate of change Index, 1996=100 All-items HICP	Monthly	Eurostat
Bank overhead costs to total assets	Percentage Operating expenses of a bank as a share of the value of all assets held	Annually	The World Bank database
Regualtory quality	Estimate of governance performance From -2.5 (weak) to 2.5 (strong)	Annually	The Worldwide Governance Indicators

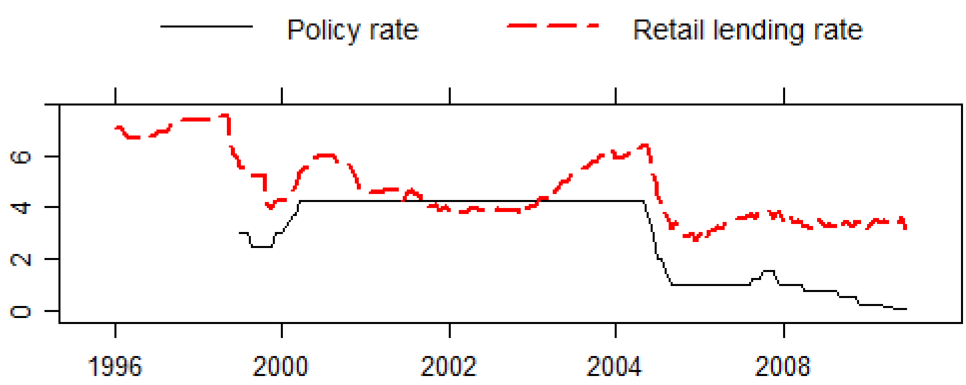
(created by the authors)

5. Results

5.1 Specification diagnostics

In this section, we check whether the assumptions of the chosen model are valid, before proceeding to the ECM model. It is important to check the validity of the underlying econometric assumptions (cointegration of interest rates, independence of time series in panel dataset, no serial correlation in the error terms) because only when they hold the inference is right. Otherwise we need to adjust our model if the assumptions do not hold for our dataset.

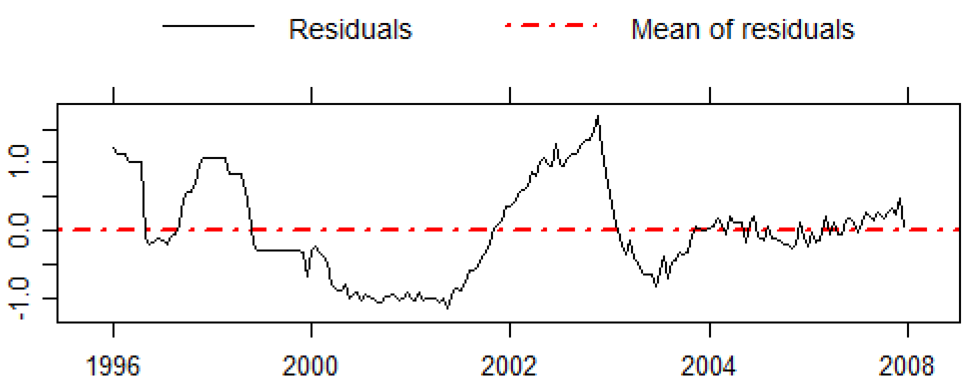
Figure 4. Interest rate time series of Italy



(created by the authors)

First, we test central bank rates and retail lending rates for stationarity (separately for each country). For the majority of time series, we cannot reject the null hypothesis of unit root even at the 10% level (Appendix G, Table G.1). Therefore, we confirm that interest rates represent non-stationary processes. We can make the same conclusion from Figure 4 (the time series are not mean reverting).

Figure 5. Residuals from Engle-Granger test for Italy



(created by the authors)

Secondly, we regress the retail lending interest rates on the central bank rate and test the residuals for stationarity, with Engle-Granger test. For all countries in our sample, we strongly reject the unit root hypothesis (Appendix G, Table G.1). When plotting the residuals (Figure 5), we see that they are fluctuating around the mean, which means that the two time-series are cointergrated.

We use random effects panel model because we intend to make inference about the population of all countries, having only a sample of them. We confirm this choice with Hausman test (Appendix G, Table G.2). To assess the regression specification we also run Wooldridge test for unobserved individual effects: the test confirms the absence of such effects (Appendix G, Table G.2).

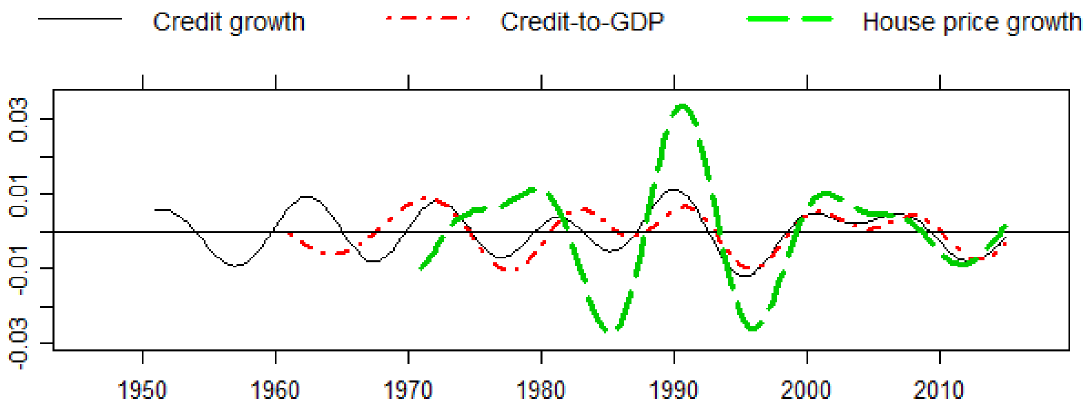
One of the assumptions of panel models is the independence of individual time-series within the sample. However, in our case this assumption does not hold: we run Pesaran test for cross-sectional dependence in panel models and the test confirms the presence of this problem. Another problem that is present in our model is serial correlation of the error terms (tested using Breusch-Godfrey test for panel models). These two problems do not necessarily mean that the coefficients are biased. They rather mean that the standard errors are underestimated. Therefore, we account for these two problems by using double-clustered standard errors (clustered by both country and time) for inference of the results.

5.2 Composite financial cycle measure

Before reporting the results of our main regressions, we describe the financial cycle proxies that we used in the regressions. Since these variables are artificially constructed, they need to be used with caution. We plot these variables to see whether they indeed reflect financial cycles, how homogeneous are they within our sample, and which filters give more informative proxies.

To begin with, we construct a composite financial cycle measure with the band-pass filter. The composite measure is obtained from three components: credit growth, credit-to-GDP ratio and house price index. As an example, we plot the three components for Italy (Figure 6).

Figure 6. Components of the composite financial cycle measure for Italy (band pass)

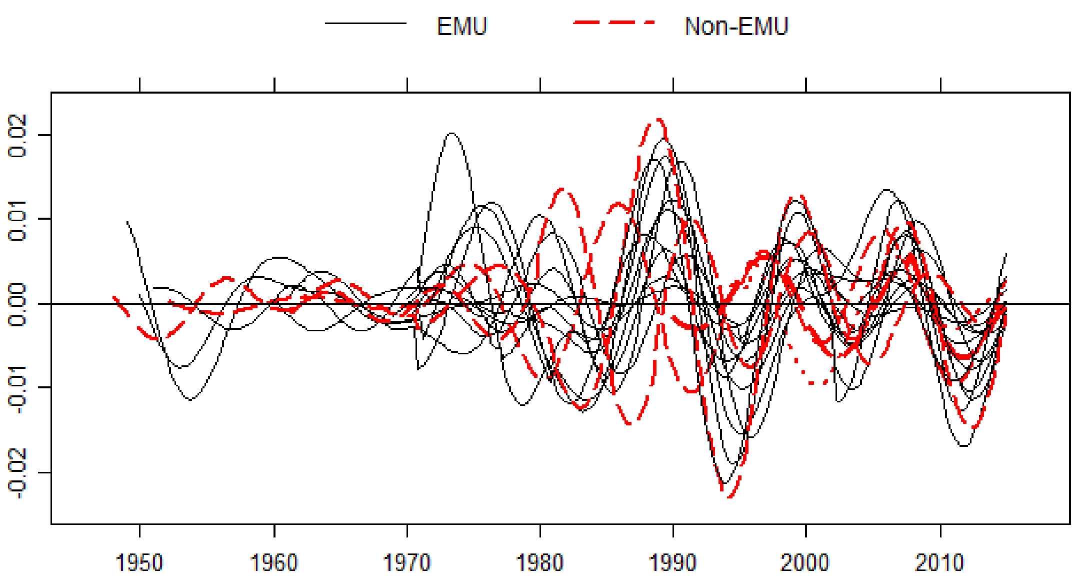


(created by the authors)

The credit growth and credit-to-GDP ratio are very much synchronous, while the house price growth is more volatile than the other two ingredients. The same can be concluded for the majority of other countries (Appendix H).

We construct a composite measure of a financial cycle by averaging the three components. Figure 7 shows the composite measure for all the countries in our sample. Separate graphs of the composite financial cycles for each country are in Appendix I. There was a great divergence of the cyclical movements in the financial market before the EMU was created. After that, some convergence has taken place, however the cycles are still different. We also observe the decrease in the magnitude of the fluctuations since the 1990s, which contradicts the findings of Borio et al. (2012).

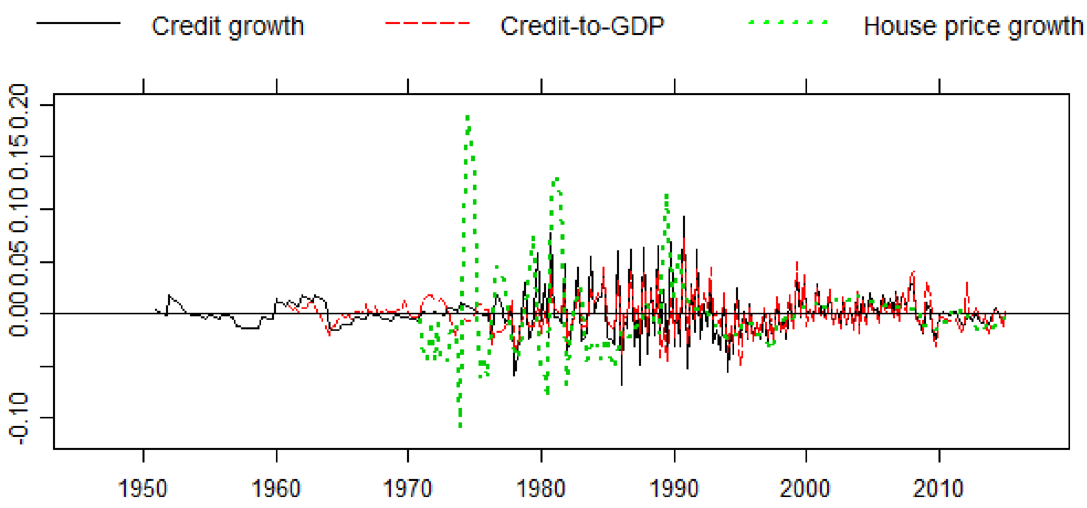
Figure 7. Composite cycle measures for EU countries obtained with band-pass filter



(created by the authors)

The difference between band-pass and HP filters described in the methodology part becomes evident in the Figure 8: the financial cycles obtained with HP filter are less smooth and, thus, less informative for the regression analysis. This has determined our choice of an appropriate filter for the construction of the financial cycle measure.

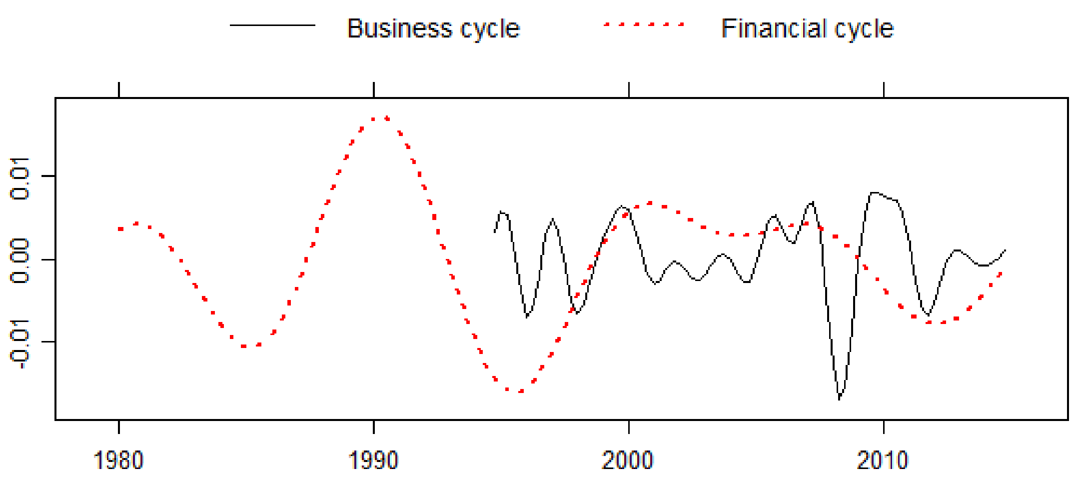
Figure 8. Components of the composite financial cycle measure for Italy (HP filter)



(created by the authors)

Finally, we compare business and financial cycles. As we assumed in section 2.3, business cycles are, on average, three times shorter than their financial counterparts. Moreover, the magnitude of the fluctuations of financial cycles larger (Figure 9).

Figure 9. Comparison of the business and financial cycles for Italy obtained with band-pass filter



(created by the authors)

5.3 Error correction model

In this section we report the coefficients of our main regressions. Table 4 provides the coefficients of pass-through estimated with ECM. Specification 1 includes business cycle measure, specification 2 – financial cycle measure, and specification 3 – both. The error correction terms are significant, as well as the F-statistics, which means that the cointegration relationship is indeed present between $r_{i,t}$ and $mr_{i,t}$ and the model is specified correctly.

Table 4. Results of Error Correction Model

		Dependent variable					
		Short-term lending rate					
		(1)		(2)		(3)	
Immediate pass-through	Constant	0.07	t = 2.93***	0.07	t = 2.87***	0.07	t = 2.92***
	$\Delta r_{i,t-1}$	-0.07	t = -2.08**	-0.07	t = -2.07**	-0.07	t = -2.07**
	$\Delta mr_{i,t}$	0.03	t = 0.22	0.02	t = 0.19	0.03	t = 0.24
	$\Delta mr_{i,t-1}$	0.40	t = 3.98***	0.40	t = 4.04***	0.40	t = 3.96***
	$\Delta mr_{i,t-2}$	0.14	t = 3.13***	0.13	t = 3.00***	0.13	t = 3.05***
	$\Delta mr_{i,t}$ $EZ_{i,t}$	0.06	t = 0.51	0.05	t = 0.45	0.04	t = 0.32
	$\Delta mr_{i,t}$ $inf_{i,t}$	-0.10	t = -4.06***	-0.09	t = -3.40***	-0.10	t = -3.47***
	$\Delta mr_{i,t} hh_{i,t}$	-0.36	t = -0.99	-0.18	t = -0.53	-0.23	t = -0.65
	$\Delta mr_{i,t}$ $rq_{i,t}$	0.16	t = 1.22	0.15	t = 1.29	0.15	t = 1.20
	$\Delta mr_{i,t}$ $overh\_TA_{i,t}$	0.02	t = 5.66***	0.01	t = 5.61***	0.01	t = 5.26***
	$\Delta mr_{i,t}$ $\Delta BC_{i,t}$	6.67	t = 1.42			7.06	t = 1.64
	$\Delta mr_{i,t}$ $\Delta FC_{i,t}$			-82.22	t = -2.15**	-83.05	t = -2.01**
Long-term adjustment	$mr_{i,t-1}$	0.02	t = 1.86*	0.02	t = 1.84*	0.02	t = 1.91*
	$r_{i,t-1}$	-0.02	t = -2.69***	-0.02	t = -2.68***	-0.02	t = -2.67***
	$mr_{i,t-1}$ $EZ_{i,t}$	0.00	t = -0.06	0.00	t = -0.002	0.00	t = -0.08
	$mr_{i,t-1}$ $inf_{i,t}$	0.00	t = 1.87*	0.00	t = 1.71*	0.00	t = 1.69*
	$mr_{i,t-1}$ $hh_{i,t}$	-0.01	t = -0.47	-0.01	t = -0.49	-0.01	t = -0.48
	$mr_{i,t-1}$ $rq_{i,t}$	-0.01	t = -2.44**	-0.01	t = -2.37**	-0.01	t = -2.38**
	$mr_{i,t-1}$ $overh\_TA_{i,t}$	0.00	t = 4.23***	0.00	t = 4.52***	0.00	t = 4.41***
	$mr_{i,t-1}$ $\Delta BC_{i,t}$	-0.21	t = -0.93			-0.20	t = -0.86
	$mr_{i,t-1}$ $\Delta FC_{i,t}$			-0.59	t = -0.30	-0.71	t = -0.35
	Observations	2 825		2 825		2 825	
	R^2	0.23		0.23		0.23	
	Adjusted R^2	0.23		0.23		0.23	
	F Statistic	46.94*** (df = 18; 2806)		47.17*** (df = 18; 2806)		42.604** (df = 20; 2804)	

Note. *p < 0.1; **p < 0.05; ***p < 0.01 *(created by the authors)*

All the three specifications explain 23% of the variability of the retail lending rate around its mean. This can be explained by the fact, that some differences between the countries in our sample are not captured by the model. For example, Sander and Kleimeier (2003) find that legal and cultural differences may be a significant obstacle to the homogeneous monetary transmission.

The coefficient of the immediate pass-through is not significant in any of the specifications; it is significant only when lagged. This indicates that the changes in the policy rates do not transmit within one month, rather they are passed on to the lending rates with at least one-month lag.

Overall pass-through represents the long-term adjustment. The results of our regression indicate a complete pass-through in the long-term (100%), but only if we do not account for interaction terms (which are discussed later).

Another coefficient characterising the monetary transmission mechanism is the speed of adjustment to the long-term equilibrium. Our results indicate the speed of adjustment of only 2%. This means that within one month only 2% of the difference between $r_{i,t}$ and $mr_{i,t}$ is corrected towards the equilibrium.

Out of all the control variables only three are significant across all the specifications: inflation, rigidity of banks' costs and regulatory quality. As expected, the higher overhead costs lead to more flexibility in the retail lending rates. The effect is very small but strongly significant in both immediate and overall pass-through. Regulatory quality affects the interest rate transmission only in the long-term. The estimate is small and negative, meaning that higher ability of government to implement sound policies improves pass-through. In contrast to the predictions from the empirical literature, higher inflation makes the retail lending rates stickier and, thus, worsens the immediate pass-through. The effect of competition measure in the banking industry is not statistically significant in any of the specifications. The coefficient before the EMU dummy is also not significant, which indicates that there is no statistical difference between the pass-through in the EMU member states and other EU countries.

Coming to the analysis of the cycles, it is evident that the business cycles have little to do with the monetary transmission, while the financial cycle is significant in the interaction of immediate pass-through at the 0.05. The coefficient is negative, thus, if the financial market is in expansion (positive change in the variable), pass-through coefficient is lower, while the financial contraction (negative change in the variable) contributes to a higher pass-through. This is consistent with our hypothesis. In the long-term adjustment, we observe no effect of the financial cycle on the pass-through.

5.4 Asymmetric adjustment

Table 5. Results of error correction model with asymmetric adjustment

	Dependent variable					
	Short-term lending rate					
	(1)		(2)		(3)	
Constant	0.07	t = 2.91***	0.07	t = 2.81***	0.07	t = 2.85***
$\Delta r_{i,t-1}$	-0.07	t = -2.02**	-0.07	t = -2.10**	-0.07	t = -2.11**
$\Delta mr_{i,t}\ D\_\Delta mr_{i,t}$	-0.06	t = -0.43	-0.02	t = -0.19	-0.06	t = -0.51
$\Delta mr_{i,t}\ (1 - D\_\Delta mr_{i,t})$	-0.03	t = -0.22	0.03	t = 0.29	-0.02	t = -0.19
$\Delta mr_{i,t-1}\ D\_\Delta mr_{i,t-1}$	0.50	t = 3.54***	0.51	t = 3.54***	0.51	t = 3.59***
$\Delta mr_{i,t-1}\ (1 - D\_\Delta mr_{i,t-1})$	0.28	t = 7.12***	0.28	t = 6.76***	0.27	t = 6.97***
$\Delta mr_{i,t-2}\ D\_\Delta mr_{i,t-2}$	0.11	t = 1.56	0.11	t = 1.64	0.11	t = 1.66*
$\Delta mr_{i,t-2}\ (1 - D\_\Delta mr_{i,t-2})$	0.18	t = 3.39***	0.19	t = 3.61***	0.18	t = 3.50***
$\Delta mr_{i,t}\ EZ_{i,t}$	0.05	t = 0.37	0.05	t = 0.43	0.02	t = 0.16
$\Delta mr_{i,t}\ inf_{i,t}$	-0.10	t = -3.08***	-0.10	t = -2.44**	-0.10	t = -2.58***
$\Delta mr_{i,t} hhi_{i,t}$	-0.50	t = -1.42	-0.25	t = -0.74	-0.40	t = -1.22
$\Delta mr_{i,t}\ rq_{i,t}$	0.19	t = 1.47	0.18	t = 1.53	0.17	t = 1.47
$\Delta mr_{i,t}\ overh\_TA_{i,t}$	0.02	t = 12.25***	0.02	t = 8.61***	0.02	t = 7.34***
$\Delta mr_{i,t}\ \Delta BC_{i,t} D\_\Delta BC_{i,t}$	20.18	t = 2.68***			21.99	t = 2.70***
$\Delta mr_{i,t}\ \Delta BC_{i,t}(1 - D_{\Delta BC_{i,t}})$	-12.81	t = -1.20			-14.18	t = -1.29
$\Delta mr_{i,t}\ \Delta FC_{i,t}\ D\_\Delta FC_{i,t}$			-110.17	t = -1.17	-98.11	t = -1.02
$\Delta mr_{i,t}\ \Delta FC_{i,t}\ (1 - D_{\Delta FC_{i,t}})$			-74.37	t = -1.98**	-86.73	t = -2.28**
$mr_{i,t-1}$	0.03	t = 1.93*	0.02	t = 1.67*	0.02	t = 1.72*
$r_{i,t-1}$	-0.03	t = -2.65***	-0.03	t = -2.61***	-0.03	t = -2.62***
$mr_{i,t-1}\ EZ_{i,t}$	0.00	t = -0.12	0.00	t = 0.08	0.00	t = 0.05
$mr_{i,t-1}\ inf_{i,t}$	0.00	t = 2.21**	0.00	t = 1.97**	0.00	t = 1.87*
$mr_{i,t-1}\ hhi_{i,t}$	-0.01	t = -0.27	-0.01	t = -0.61	-0.01	t = -0.43
$mr_{i,t-1}\ rq_{i,t}$	-0.01	t = -2.54**	-0.01	t = -2.24**	-0.01	t = -2.23**
$mr_{i,t-1}\ overh\_TA_{i,t}$	0.00	t = 3.32***	0.00	t = 2.13**	0.00	t = 1.94*
$mr_{i,t-1}\ \Delta BC_{i,t}\ D\_\Delta BC_{i,t}$	-0.16	t = -0.38			-0.22	t = -0.52
$mr_{i,t-1}\ \Delta BC_{i,t}\ (1 - D\_\Delta BC_{i,t})$	-0.28	t = -1.16			-0.20	t = -0.71
$mr_{i,t-1}\ \Delta FC_{i,t}\ D\_\Delta FC_{i,t}$			4.62	t = 3.07***	4.93	t = 3.10***
$mr_{i,t-1}\ \Delta FC_{i,t}$ (1-$D\_\Delta FC_{i,t}$)			-4.50	t = -2.38**	-4.93	t = -2.33**
Observations	2 825		2 825		2 825	
R^2	0.24		0.24		0.24	
Adjusted R^2	0.24		0.24		0.24	
F Statistic	38.10*** (df = 23; 2801)		38.68*** (df = 23; 2943)		33.31*** (df = 27; 2797	

Note. *p < 0.1; **p < 0.05; ***p < 0.01 *(created by the author*

In this section we report the results of the other type of regressions that we have run: the regression with asymmetric adjustment effects (Table 5). This model accounts for the fact that regression coefficients for some variables can be different depending on the sign of this variable.

In all specifications, the adjusted R-squared is 24%. Again, the coefficient before the immediate pass-through is not significant. Nevertheless, the positive lagged change in the policy rate is transmitted almost two times better than the negative one. This confirms the bank's collusive pricing hypothesis. However, in case of $\Delta mr_{i,t-2}$, we find evidence in favour of the consumer behaviour hypothesis. This is a contradictory and inconclusive result.

In the same regression, we also include dummies for positive and negative changes in the cycles. The positive change in the financial cycle (the capital market is in expansion) is not a significant determinant of the immediate pass-through. While the negative change in the financial cycle variable (financial recession) improves the immediate transmission consistent with our results in the main regression. Concerning the interaction of a financial cycle with the long-term transmission term, both coefficients (negative and positive) are statistically significant, but have the same absolute value and the opposite sign. This is consistent with our results in the main regressions, where the financial cycle has no influence on the long-term transmission coefficient.

As to the business cycle, it is not significant in the long-term adjustment and influences only the immediate pass-through. In case of growth of the real economy, the overall pass-through increases.

6. Discussion of results

6.1 Analysis of the results

In this section we discuss the meaning of the coefficients reported in the previous section in more detail. We also make the arguments to support the idea that our results may hold for a wider range of countries and can be used to make conclusions about the monetary policy in general.

All control variables and cycle measures are included in our regressions in the interaction terms. Therefore, for the interpretation of the coefficients before these terms one needs to assign a value for each control variable. We compute the relevant coefficients using various percentiles of the control variables (5th, 50th and 95th) and the cycle measures (Table 6).

Taking the means of all control variables, the immediate pass-through is equal to 25% in the EMU. This number should be interpreted with caution since not all of the interaction terms are statistically significant in the main regression (specification 3, Table 4). The overall pass-through without the effect of the control variables is almost complete (approximately 98%), but if we account for the interaction terms, we end up with an estimate of 36-72%.

The 5th percentile of inflation improves the short-term transmission by 11%, and decreases long-term pass-through by 5%. This means that a low inflation improves short-term transmission, and worsens long-term transmission (the final transmission in the equilibrium). This result is quite contradictory (because inflation typically has a positive effect on pass-through). We explain this result by the fact that some countries in our sample have negative inflation, which cannot be considered a normal economic condition.

Table 6. Overview of the pass-through process

Significance level	Percentile of the control variable	5	50	95	Significance level	Percentile of the control variable	5	50	95
	Immediate pass-through					*Overall pass-through*			
	β_0	0.03	0.03	0.03	*	θ_0/δ	0.98	0.98	0.98
***	$\beta_1\ inf_{i,t}$	0.06	-0.02	-0.10	*	$\theta_1\ inf_{i,t}/\delta$	-0.06	0.02	0.11
	$\beta_2\ hh_{i,t}$	0.00	-0.02	-0.05		$\theta_2\ hh_{i,t}/\delta$	-0.01	-0.03	-0.08
	$\beta_3\ rq_{i,t}$	0.11	0.21	0.28	**	$\theta_3\ rq_{i,t}/\delta$	-0.29	-0.52	-0.71
***	$\beta_5\ overh\_TA_{i,t}$	0.00	0.02	0.06	***	$\theta_5\ overh\_TA_{i,t}/\delta$	0.01	0.07	0.19
**	$\beta_6\ \Delta FC_{i,t}$	-0.05	0.00	0.05		$\theta_6\ \Delta FC_{i,t}/\delta$	0.05	0.00	-0.05
	$\beta_7\ \Delta BC_{i,t}$	0.14	0.00	-0.13		$\theta_7\ \Delta BC_{i,t}/\delta$	0.06	0.00	-0.05
	Total ($EZ_{i,t} = 0$)	0.29	0.22	0.12		Total ($EZ_{i,t} = 0$)	0.74	0.52	0.39
	Total ($EZ_{i,t} = 1$)	0.32	0.25	0.16		Total ($EZ_{i,t} = 1$)	0.72	0.50	0.36

Note. *p < 0.1; **p < 0.05; ***p < 0.01 *(created by the authors)*

Table 6 also shows the effect of the financial cycle phase even more evidently. The 5th percentile of the variable lowers the immediate transmission by almost 5%, while the 95th percentile improves it by the same amount. This means that during the crisis (or contractual state of the financial markets) the transmission is 10% higher than during the expansionary stage of the cycle.

Neither of the cycles affects the overall pass-through. Overall pass-through is affected only by the structural parameters: regulatory quality, inflation and rigidity of banks' costs (the amount of their fixed costs).

If we account for asymmetric adjustment effects, the only effect that the business cycle has is the improvement of immediate pass-through during up-swings of the economy (in line with our hypothesis). The link between GDP growth and monetary transmission was previously confirmed in other empirical papers. Gigineishvili (2011) finds that GDP per capita has a positive effect on monetary transmission. The business cycle variable that we have constructed based on GDP growth must have captured the same effect: during the expansion of the economy the monetary transmission improves, and this is true not only for variation of business cycles across time, but also on the cross-country basis (countries that have booming economies have better monetary transmission than those with lower GDP growth).

On the contrary, financial cycle improves the immediate pass-through during the contractual phase of the cycle, which is consistent with our hypothesis. There are several explanations why this is the case.

Firstly, during crisis banks may tend to overreact to any changes in the main policy rate. Bondt (2002, p. 13) explains the overshooting of the lending rates with the notion of asymmetric information costs: “If banks increase their lending rates exactly one-for-one with market interest rates they will attract a more risky class of borrowers. Consequently, banks have to increase the lending rate premium charged”. During crises, this effect may be especially pronounced due to an overall decrease of the credit quality of borrowers.

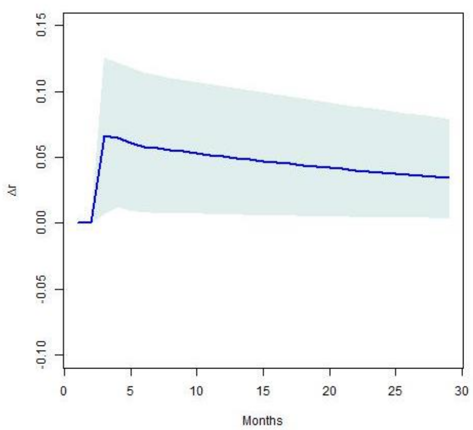
Secondly, in the contractual state of the financial markets the banks are more likely to experience liquidity problems. These problems are usually caused by increased country and counterparty risk, and, as it was the case during the crisis of 2007, increased cost of short term-financing in repo markets. Hence, the banks are more likely to turn to the central bank for marginal borrowing. This means that an increase in the main policy rate is more likely to cause an increase of banks’ costs of financing and, consequently, the costs of providing new loans to the banks’ borrowers. The link between liquidity and pass-through has already been empirically confirmed by Saborowski and Weber (2013).

Thirdly, a reduction of credit volume and real demand during crises also positively affects pass-through, which has been confirmed by Mojon (2000). The explanation of this effect is that banks are not able to preserve their interest rate margin when credit demand drops. As a result, they adjust more quickly to the changes in the main policy rate, which reflect the changes in banks' marginal financing costs.

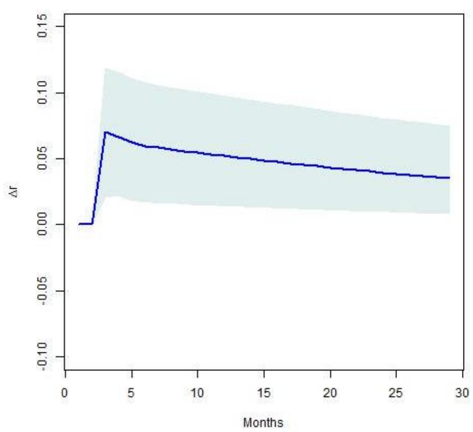
To get a more complete picture of our results we plot impulse response functions (Figure 10). We take the coefficients from the specification 3 (Table 4) and simulate the effect of 0.01% cumulative change in the policy rate on the development of lending rates accounting for interaction only with the financial cycle measure. The plots show that the effect on the financial cycle is small and is present only in the first period (immediate pass-through). In the period of the impulse the difference between expansionary and contractionary stages of the cycle is around 30% of the initial impulse in the main policy rate. In the following 10 periods the difference between the reaction of the lending rates in the two states falls to about 10% of the initial impulse. This is a significant difference, however, since the financial cycle has no effect on the overall pass-through coefficient, its effect is quite limited.

Figure 10. Impulse response functions of $\Delta r_{i,t}$ of a cumulative change in $mr_{i,t}$

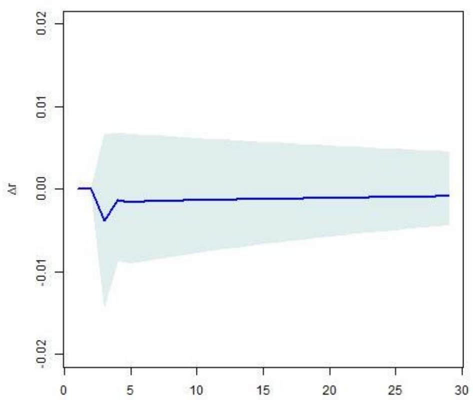
High change in the financial cycle variable (expansiaon of the financial markets)



Low change in the financial cycle variable (contraction of the financial markets)



Difference in the graphs above



Impulse response — Confidence interval 95%

(created by the authors)

6.2 Robustness checks

In this section we describe the results of robustness checks to further support the validity of our results.

We run two types of the robustness checks. Firstly, we run our ECM for three different samples (Table 7).

Table 7. Robustness checks with subsamples

	Dependent variable Short-term lending rate					
	EMU countries		Well-developed financial markets		Less-developed financial markets	
	(1)		(2)		(3)	
Constant	1.69	t = 0.0001	1.39	t = 0.0001	2.27	t = 0.0000
$\Delta r_{i,t-1}$	0.31	t = 6.67***	0.16	t = 3.51***	0.14	t = 2.45**
$\Delta mr_{i,t}$	0.57	t = 2.95***	4.41	t = 22.88***	1.62	t = 3.68***
$\Delta mr_{i,t-1}$	-0.18	t = -3.62***	-0.13	t = -2.65***	-0.01	t = -0.22
$\Delta mr_{i,t-2}$	-0.03	t = -1.06	-0.10	t = -3.81***	0.03	t = 0.65
$mr_{i,t-1}$	0.51	t = 4.33***	2.73	t = 23.42***	1.08	t = 4.45***
$r_{i,t-1}$	-0.55	t = -6.24***	-0.73	t = -8.27***	-0.56	t = -6.46***
$\Delta mr_{i,t}$ $EZ_{i,t}$	-0.44	t = -3.48***	-0.80	t = -6.33***	-0.26	t = -1.93*
$\Delta mr_{i,t}$ $inf_{i,t}$	0.02	t = 0.68	-0.02	t = -0.90	0.04	t = 1.48
$\Delta mr_{i,t} hh_{i,t}$	-1.41	t = -4.08***	0.90	t = 2.60***	-1.26	t = -0.91
$\Delta mr_{i,t}$ $rq_{i,t}$	0.45	t = 4.58***	-1.51	t = -15.32***	-0.78	t = -2.36**
$\Delta mr_{i,t}$ overh_$TA_{i,t}$	0.03	t = 0.58	-0.47	t = -7.86***	0.03	t = 0.33
$\Delta mr_{i,t}$ $\Delta FC_{i,t}$	-6.47	t = -2.37**	12.07	t = 4.42***	0.40	t = 0.07
$mr_{i,t-1}$ $EZ_{i,t}$	-0.23	t = -2.80***	-0.56	t = -6.91***	-0.22	t = -2.32**
$mr_{i,t-1}$ $inf_{i,t}$	0.00	t = -0.22	0.01	t = 0.90	0.01	t = 1.64
$mr_{i,t-1}$ $hh_{i,t}$	0.27	t = 1.13	0.20	t = 0.85	1.13	t = 1.20
$mr_{i,t-1}$ $rq_{i,t}$	-0.10	t = -1.38	-1.06	t = -14.50***	-0.82	t = -21.00***
$mr_{i,t-1}$ overh_$TA_{i,t}$	0.02	t = 1.07	-0.07	t = -4.07***	0.01	t = 0.20
$mr_{i,t-1}$ $\Delta FC_{i,t}$	3.22	t = 1.51	4.57	t = 2.14**	-1.31	t = -0.56
Observations	1 993		686		776	
R^2	0.79		0.78		0.84	
Adjusted R^2	0.78		0.77		0.83	
F Statistic	415.91*** (df = 18; 1974)		239.88*** (df = 18; 667)		327.87*** (df= 18; 757)	

Note. *p < 0.1; **p < 0.05; ***p < 0.01 *(created by the authors)*

In specification 1, we include only countries that belong to the EMU. We track the variables during the same period 1996-2014 and thus we still have the EMU dummy. The immediate pass-through is strongly significant, which means that interest rate transmission goes faster within the EMU. In contrast to the previous results, EMU dummy is significant, indicating that the pass-through has changed since the establishment of the EMU. HHI and regulatory quality also appear to be strong determinants of the pass-through in the EMU countries. The explanatory power of our model goes up to 78%, which is due to more homogeneity of the countries' characteristics in the subsample. Financial cycle in the interaction with the immediate transmission term stays significant at 0.05.

The specification 2 is based on the sample of five most financially developed[2] countries from our main sample (the United Kingdom, the Netherlands, Sweden, Germany, and Denmark). The results show that financial cycle phase is a factor that strongly influences pass-through in both the immediate transmission and the long-term adjustment. Interestingly, the coefficient in the short-term pass-through is opposite to the previous results, meaning that during the financial crisis phase the pass-through is slower. In the adjustment to the equilibrium, the effect goes in the opposite direction. Other coefficients are close to the ones in the specification 1.

The specification 3 is based on the sample of five least financially developed countries from our main sample (Portugal, Italy, the Czech Republic, Hungary, and Greece). The results show that financial cycle is not significant, which is consistent with the idea that fluctuations in the capital markets are less important in the countries where those markets are not sufficiently developed. Moreover, the majority of control variables are not significant in contrast to the previous specification. Thus, we conclude that the structural determinants of the pass-through differ with the level of the financial development of the country.

In the second group of robustness checks, we test our results with four alternative explanatory variables (Table 8). Many papers on pass-through study not the transmission from the policy rate to the retail lending rates (as we do in this paper), but from the interbank rate to the retail lending rates. In specification 1, we take 3-month interbank rate (Euribor for EMU countries and the respective interbank rates for other countries) instead of the main policy rate. In this case, we have more observations, but lower R-squared. The pass-through coefficients are different from the main results. Almost none of the control variables are significant. But even in this case, we confirm that financial cycle is a determinant of the pass-through.

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[2] The selection is done according to the index of financial development developed by the World Economic Forum (2012).

Table 8. Robustness checks with alternative variables

	Dependent variable Short-term lending rate							
	Interbank rate (1)		HP filter for both cycles (2)		FC as credit growth (3)		FC as house index (4)	
Constant	0.05	t = 2.97***	0.07	t = 2.92***	0.07	t = 2.86***	0.06	t = 2.88***
$\Delta r_{i,t-1}$	-0.05	t = -1.05	-0.07	t = -2.12**	-0.07	t = -2.05**	-0.07	t = -2.07**
$\Delta mr_{i,t}$	0.21	t = 1.02	-0.01	t = -0.10	0.02	t = 0.20	0.03	t = 0.26
$\Delta mr_{i,t-1}$	0.05	t = 0.77	0.40	t = 3.93***	0.40	t = 4.04***	0.40	t = 4.09***
$\Delta mr_{i,t-2}$	0.11	t = 1.51	0.14	t = 3.43***	0.14	t = 3.02***	0.14	t = 3.09***
$\Delta mr_{i,t}\ EZ_{i,t}$	0.21	t = 2.56**	0.09	t = 0.80	0.06	t = 0.53	0.06	t = 0.56
$\Delta mr_{i,t}\ inf_{i,t}$	-0.03	t = -0.57	-0.11	t = -3.31***	-0.09	t = -3.07***	-0.10	t = -4.16***
$\Delta mr_{i,t} hh_{i,t}$	0.47	t = 1.32	-0.28	t = -0.87	-0.26	t = -0.73	-0.25	t = -0.79
$\Delta mr_{i,t}\ rq_{i,t}$	0.10	t = 0.96	0.16	t = 1.38	0.15	t = 1.25	0.16	t = 1.24
$\Delta mr_{i,t}\ overh\_TA_{i,t}$	-0.01	t = -1.32	0.02	t = 5.59***	0.01	t = 5.40***	0.01	t = 4.03***
$\Delta mr_{i,t}\ \Delta FC_{i,t}$	-87.03	t = -1.67*	-3.57	t = -1.69*	-64.60	t = -2.19**	-15.91	t = -0.61
$mr_{i,t-1}$	0.03	t = 1.89*	0.02	t = 1.81*	0.02	t = 1.84*	0.02	t = 1.82*
$r_{i,t-1}$	-0.02	t = -3.00***	-0.02	t = -2.69***	-0.02	t = -2.67***	-0.02	t = -2.62***
$mr_{i,t-1}\ EZ_{i,t}$	0.00	t = -0.24	0.00	t = -0.04	0.00	t = -0.02	0.00	t = -0.03
$mr_{i,t-1}\ inf_{i,t}$	0.00	t = 1.07	0.00	t = 1.65*	0.00	t = 1.67*	0.00	t = 1.87*
$mr_{i,t-1}\ hh_{i,t}$	0.01	t = 0.19	-0.01	t = -0.46	-0.01	t = -0.47	-0.01	t = -0.50
$mr_{i,t-1}\ rq_{i,t}$	-0.01	t = -1.47	-0.01	t = -2.38**	-0.01	t = -2.35**	-0.01	t = -2.40**
$mr_{i,t-1}\ overh\_TA_{i,t}$	0.00	t = 6.28***	0.00	t = 4.08***	0.00	t = 4.74***	0.00	t = 5.23***
$mr_{i,t-1}\ \Delta FC_{i,t}$	-3.81	t = -1.35	-0.01	t = -0.03	-0.96	t = -0.61	0.62	t = 0.32
Observations	3 055		2 825		2 825		2 825	
R^2	0.20		0.23		0.23		0.23	
Adjusted R^2	0.20		0.23		0.23		0.23	
F Statistic	42.70*** (df = 18; 3036)		46.96*** (df = 18; 2806)		47.14*** (df = 18; 2806)		42.82*** (df = 18; 2806)	

Note. *p < 0.1; **p < 0.05; ***p < 0.01 *(created by the authors)*

Specification 2 contains financial and business cycles constructed with HP filter. The estimates are similar to the ones in the main analysis. The financial cycle measure is again significant in the interaction with the short-term pass-through term. The coefficient is larger, but still negative. This might be due to the high volatility of series produced by the HP filter. In specification 3, we use a financial cycle measure based on a single macro variable – credit growth. Financial cycle is a significant determinant of the immediate pass-through, but does affect the long-term adjustment. Specification 4 includes financial cycle measured based on the house price index. We do not get any significant coefficients before the interaction terms with the financial cycle. This can be explained by the fact that cycle constructed from house price index is much more volatile than the one constructed from credit growth.

Summing up, our results are robust to the choice of filter applied for the construction of financial cycle. However, they might be sensitive to the choice of the cycle measure (house price index, credit growth, or a composite measure). The composite measure that we use in our main analysis is the most informative and comprehensive measure known so far (Stremmel, 2015). While the financial cycle definitely determines the pass-through in the countries with highly developed capital markets, it may be of lower importance for less financially developed ones. Other structural determinants may also differ between these two classes of countries.

6.3 Limitations

In this section we discuss the limitations of our study and suggest the areas for further research on this topic. It is important to recognise the possible bias introduced by our methodology to enable the reader critically assess our results.

Bodoev and Bruno (2012) point out to the possibility of aggregation bias in the studies of pass-through that use the interest rates aggregated at the country level. While aggregated data are based on the observations of the individuals, those individuals may adjust their lending rates with different speed and to a different extent. As this heterogeneity in behaviour is repressed in the aggregated data, the estimates of the coefficients are likely to be biased. However, we cannot use bank-level data due to their unavailability.

We also admit that our results may suffer from omitted variable bias, meaning that factors other than the policy rate may explain the changes in the retail lending rate.

We try to overcome this bias by including control variables that capture all main structural determinants of the pass-through process.

In addition, there are some limitations of the model that we use:

(1) We have a single equation, with one dependent variable and several explanatory variables, which are assumed to be weakly exogenous[3]. However, in reality, this assumption may not hold: when central bank sets its interest rate, its decision is sometimes influenced by the current lending rate of the retail banks. Vector error correction model solves this problem by treating all the variables as endogenous. Nevertheless, we make the exogeneity assumption, since it is actually close to reality.

(2) ECM is based on two-steps. However, it is impossible to assess the validity of the estimates in the first-step regression since OLS estimates for cointergrated series do not follow a normal distribution.

(3) Our model does not allow the coefficients of the pass-through to vary across countries and across time. It may lead to some biases as long as our control variables do not explain completely the differences in the pass-through process across countries.

In addition, there are some measurement errors in the data on the interest rates. Some of the interest rates are given as of the end of each month, while others represent the average for the whole month. We tried to harmonize retail interest rate statistics computed by the national central banks (based on classifications, which vary across countries). The difference in aggregation methods of the central banks may still take place, but since we take first differences this effect is minimized.

Moreover, our sample size as well as the number of observations for each country is limited by the data availability. More countries in the sample would allow us to get a higher heterogeneity of the financial cycles and other control variables and thus make our findings on the structural determinants of pass-through more generalizable. The period we analyse may be too short to capture the impact of the cyclicality in the

[3] An independent variable is weakly exogenous if its determinants are independent from the determinants of the dependent variable, while this independent variable is determined by only lagged values of the dependent variable.

financial markets on the interest rate pass-through. While we have a period of 19 years and the average duration of the financial cycle is 11 years, so we observe (the maximum) only 1.5 financial cycles.

Finally, our analysis shows that financial crisis is associated with the stregthened pass-through, but it does not prove the causal relationship between two. While academics agree that it is almost impossible to drow the causal inferences from empirical data, the only way we can solve the problem is to base these inferences on the theoretical hypotheses. We propose three explanations of how the causal direction goes from financial cycle to the pass-through.

Taking into account the limitations of our paper, further research is needed. Our suggestions would be to extend the period of study, the number of countries in the sample, and use a more advanced model that would produce smoother impulse response functions, and relax the exogeneity assumption.

7. Conclusion

The primary objective of this paper is to explore the interest rate pass-through in the EMU over the different stages of the financial cycle. We confirm that a composite financial cycle measure is a determinant of the immediate pass-through: the periods of financial crisis are characterized by the better interest rate transmission. The estimate of its influence is statistically significant, but small. This effect is stronger in the countries with highly developed financial markets. The overall pass-through is not affected by financial cycles, and it is determined only by structural economic variables (regulatory quality, inflation and rigidity of bank's costs). We conclude that heterogeneity of the financial cycles in the EMU countries can explain the different impact of the common monetary policy on the local economies.

While there are papers that find a strong link between business cycle phase and monetary transmission, the financial cycle has not been considered as a determinant of the transmission so far. However, with the growing importance of the financial markets in the global economy, we cannot ignore it anymore. Although the identified effect of financial cycle is small, the tendency of the European economies to be relied on and interconnected with the financial system may amplify this effect in the future.

Our paper is also of value for the policy makers. The existence of financial cycle is out of their control: they can hardly reduce the amplitude of cyclical fluctuations in financial markets. However, the policy makers can make efforts to reduce the divergence of these cycles between the countries in the EMU. The current policy developments in the creation of the Banking Union of the EMU countries is exactly the step towards the reduction of this divergence, and according to our results, the Banking Union will make the transmission of the ECB policy more homogeneous for all countries.

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9. Appendices

Appendix A. Detailed explanation of HP filter

HP filter has two main assumptions: trend and cycle are uncorrelated; trend can change over time but these changes should not be sharp. Given that,

$$y_t = \tau_t + c_t + \varepsilon_t,$$

where y_t is a logarithm of the observed time series y at the period t ($t = 1,2,\dots,T$), τ_t is the trend of this series and c_t is its cyclical component, to calculate the trend the following minimization problem has to be solved:

$$\min_{\tau}\left(\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda\sum_{t=2}^{T}((\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1}))^2\right)$$

where λ is multiplier that allows to adjust the sensitivity of the time series to short-term fluctuations or, in other words, the smoothness of the trend. As $\lambda \to \infty$, the penalty is larger and the trend becomes linear.

This filter is appropriate only if there is a trend in the time series and noise follows normal distribution. Moreover, the problem arises with the usage of the same λ for different countries as the duration of financial cycles may vary across countries

Appendix B. Stationarity and cointegration

Non-stationary time series has mean, variance and covariance that vary across time. In contrast to stationary time series when variable fluctuates around the constant mean, non-stationary process is unpredictable. It can consist of deterministic and stochastic trends with drifts (so-called random walks or unit root processes) or the combination of two. Deterministic trend is defined as follows: $x_t = \beta * t + \varepsilon_t$, where ε_t is i.i.d. $(0, \sigma^2)$, "white noise". Random walk with the drift is $x_t = \alpha + x_{t-1} + \varepsilon_t$ (α represents a drift).

To introduce the concept of integration order, one has to be familiar with autoregressive moving average (ARMA) process. ARMA (p, q) has p order of the autoregressive part and q order of the moving average part:

$$X_t = \alpha + \underbrace{\sum_{i=1}^{p}\theta X_{t-1}}_{AR} + \underbrace{\varepsilon_t + \sum_{i=1}^{q}\varphi\varepsilon_{t-1}}_{MA}$$

where α is a constant, θ and φ are coefficients.

Non-stationary time series is integrated of order d (I(d)) if it can be represented by stationary ARMA process after differencing d times. The order of zero means that time series is stationary. The random walk process is an example of I(1) series:

$$X_t - X_{t-1} = \alpha + \varepsilon_t$$

Definition of cointergrated processes can be formulated as follows: vector of variables integrated of order one x_t is cointergrated of rank 1 if there exists vector β_1 s.t. $\beta_1' x_t$ is has stationary (I(0)) ARMA representation.

As it was already stated before, if the process has unit root, it is non-stationary. Assume we have an autoregressive process $x_t = \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \cdots + \alpha_p x_{t-p} + \varepsilon_t$. Time series has unit root or is integrated of order one if $m = 1$ is the root of the following equation: $m^p - \alpha_1 m^{p-1} - \cdots - \alpha_p = 0$.

To test some process x_t ($x_t = \rho x_{t-1} + \varepsilon_t$) for stationarity or unit root, we can apply the Dickey-Fuller test. In the case of non-stationarity, the change in the series does not depend on in the current level. So we have $x_t - x_{t-1} = (\rho - 1)x_{t-1} + \varepsilon_t$ or $\Delta x_t = \pi x_{t-1} + \varepsilon_t$, where $\pi = (\rho - 1)$. Under the null hypothesis $\rho = 1$ so that $x_t = x_{t-1} + \varepsilon_t$ and $\Delta x_t = \varepsilon_t$, meaning that x_t process has unit root. We can compare the t-statistics with the Dickey-Fuller distribution. If $t < DF$, we reject the null hypothesis.

Once, the considered processes are defined as being non-stationary, we can perform Engle-Granger test for cointegration. Suppose we have two non-stationary processes X_t and Y_t. We run the OLS regression $Y_t = \bar{\alpha} + \bar{\beta} X_t + \bar{u}_t$ and calculate the estimated residuals. Then, we test the residuals for stationarity.

Appendix C. Examples of regression specifications from the empirical literature

There is a common approach to model monetary transmission (Error Correction Model). However, the specifications of regressions in the empirical literature differ a lot. They vary in many ways depending on the scope of data and additional factors considered as determinants of pass-through. Here we make three examples of regressions that have determined our methodology choice.

The first model is developed by Holton and d'Acri (2014) who consider in their analysis bank-level characteristics. As the authors have data from several EZ countries, they first control for changes in country-specific macro-economic variables:

$$\Delta r_{i,t} = \mu_i + \sum_{j=1}^{M} \alpha_j \Delta r_{i,t-j} + \sum_{j=0}^{N} \beta_j \Delta mr_{t-j} + \delta\left(r_{i,t-1} - mr_{t-1}\right) + \eta mr_{t-1} + \sum_{j=0}^{J} \gamma_j \Delta X_{k,t-j} + \varepsilon_t$$

where i is an individual bank, k k is country index, $r_{i,t}$ is bank lending rate, mr_t is money market rate, $\Delta X_{k,t}$ is a vector of changes in structural macro variables of country k, $\varepsilon_t$is an error term. Here changes in bank lending interest rate ($\Delta r_{i,t}$) depend on changes in policy rate (Δmr_{t-j}) and the correction of the "error" from the previous perioud $\left(r_{i,t-1} - mr_{t-1}\right)$. The term mr_{t-1} is entered to allow the relationship between $r_{i,t-1}$ and mr_{t-1} to deviate from one-to-one (Holton & Rodrigez d'Acri, 2014).

Equation is futher modified so that $\theta = \eta - \delta$:

$$\Delta r_{i,t} = \mu_i + \sum_{j=1}^{M} \alpha_j \Delta r_{i,t-j} + \sum_{j=0}^{N} \beta_j \Delta mr_{t-j} + \delta r_{i,t-1} + \theta mr_{t-1} + $$
$$+ \sum_{j=0}^{J} \gamma_j \Delta X_{k,t-j} + \varepsilon_t$$

Then the authors introduce the bank-level characteristics ($Z_{i,t-1}$) both as a separate explanatory variable and an interaction term with changes in the market rate and retail interest rate:

$$\Delta r_{i,t} = \mu_0 + \sum_{j=1}^{M} \alpha_j \Delta r_{i,t-j} + \sum_{j=0}^{N} (\beta_j + \beta_j^* Z_{i,t-1}) \Delta mr_{t-j} +$$
$$+\lambda Z_{i,t-1} + \left(\delta + \delta^* Z_{i,t-1}\right) r_{i,t-1} + \left(\theta + \theta^* Z_{i,t-1}\right) mr_{t-1} + \sum_{j=0}^{J} \gamma_j \Delta X_{k,t-j} + \varepsilon_t$$

As a result the economic interpretation of the coefficients is the following:

- Overall pass-through $-(\theta + \theta^* \hat{Z}_{i,t-1})/(\delta + \delta^* \hat{Z}_{i,t-1})$
- Immediate pass-through $\beta_0 + \beta_0^* \hat{Z}_{i,t-1}$
- Adjustment to long-term equilibrium $\delta_0 + \delta^* \hat{Z}_{i,t-1}$

where $\hat{Z}_{i,t-1}$ denotes the mean of each specific bank characteristic in different percentiles, starting from the 10^{th} up until the 90^{th}.With this specification, the authors are able to can explore the extent to which different bank characteristics affect pass-through. For instance, they can see whether banks pass on more of the overall changes in money market rates, have faster adjustment or a bigger immediate reaction depending on the level of certain characteristics (i.e. liquidity, capital) and they can test whether the differences in pass-through between different types of banks are significant (Holton & Rodrigez d'Acri, 2014).

Another specification is suggested by Al-Eyd and Berkmen (2013):

$$\Delta r_t = \varphi + \sum_{j=1}^{N} \alpha_j \Delta r_{t-j} + \sum_{j=0}^{M} \beta_j \Delta mr_{t-j} + \sum_{j=1}^{J} \gamma_j \Delta X_{t-j} +$$
$$+\delta(r_{t-1} - \beta_1^* mr_{t-1} - \beta_2^* X_{t-1} + k) + \varepsilon_t$$

where r_t is country-level bank lending lending rate, $mr_t$is market rate, X is vector of credit channel measures, k stands for "all other factors, apart from the market rate, that determine the level of the bank rate, such as bank market power and efficiency, credit and interest rate risk, cross-subsidisation effects, etc." (Al-Eyd, & Berkmen, 2013).

The authors also use ECM but estimate it separately for 5 countries in the EZ (not as a panel regression). Al-Eyd and Berkmen (2013) introduce additional variables that characterize credit channel of interest rate pass through (the variables are put into vector X and measure such factors as funding costs, leverage, credit risk and economic uncertainty). In contrast to the previous specification, these factors are not introduced in interaction with change in market rate.

The third model specification that also introduces additional factors to a standard pass-through estimation was presented by Paries et al. (2014). To determine the factors explaining fragmentation of interest rates during the financial crisis, the authors add variables measuring demand and supply risk factors of the lending process:

$$\Delta r_t = \sum_{j=1}^{J} \alpha_k r_{t-j} + \sum_{k=0}^{K} \beta_k \Delta mr_{t-k} + \sum_{n=1}^{N} \gamma_{k,n} \Delta k_{t-n} + \sum_{m=1}^{M} \gamma_{p,n} \Delta p_{t-m} + \sum_{n=1}^{N} \gamma_{s,n} \Delta s_{t-n} + \gamma (r_{t-1} - \beta_1^* mr_{t-1} - \beta_2^* k_{t-1} - \beta_3^* p_{t-1} - \beta_4^* s_{t-1} - \mu) + u_t$$

where s s is yield of sovereign bond, k and p are risk factors demand and supply-side of lending process. Supply-side factors include bank's expected default frequencies, capital to asset ratio, liquidity to asset ratio, cost of equity for financial corporations, spread between BBB and AAA corporate bond yields for financial corporations. Demand-side factors include probabilities of default of non-financial corporations and households, their expected default frequencies, unemployment rate (and expectations of it), aggregate cost of equity, spread between BBB and AAA corporate bond yields for non-financial corporations.

Appendix D. Data description

Table D.1. Periods of the data availability for the financial cycle compoments

Country	**Credit growth**		**Credit-to-GDP**		**House prices**		**Synthetic cycle**	
	Start date	*End date*	*Start date*	*End date*	*Start date*	*End date*	*Start date*	*End date*
AT	1950-Q1	2015-Q1	1995-Q4	2015-Q1	1996-Q1	2015-Q1	1950-Q1	2015-Q1
BE	1971-Q1	2015-Q1	1994-Q4	2015-Q1	1981-Q1	2015-Q1	1971-Q1	2015-Q1
CZ*	1993-Q2	2015-Q1	1994-Q4	2015-Q1	1996-Q1	2015-Q1	1993-Q2	2015-Q1
DE	1949-Q1	2015-Q1	1991-Q1	2015-Q1	1971-Q1	2015-Q1	1949-Q1	2015-Q1
DK*	1952-Q1	2015-Q1	1994-Q4	2015-Q1	1995-Q1	2015-Q1	1952-Q1	2015-Q1
ES	1970-Q2	2015-Q1	1995-Q1	2015-Q1	1981-Q1	2015-Q1	1970-Q2	2015-Q1
FI	1971-Q1	2015-Q1	1990-Q1	2015-Q1	1971-Q1	2015-Q1	1971-Q1	2015-Q1
FR	1970-Q1	2015-Q1	1980-Q1	2015-Q1	1978-Q1	2015-Q1	1970-Q1	2015-Q1
GR	1960-Q2	2015-Q1	1994-Q4	2015-Q1	1995-Q1	2015-Q1	1960-Q2	2015-Q1
HU*	1990-Q1	2015-Q1	1994-Q4	2015-Q1	1990-Q1	2015-Q1	1990-Q1	2015-Q1
IE	1971-Q3	2015-Q1	1997-Q1	2015-Q1	2002-Q2	2015-Q1	1971-Q3	2015-Q1
IT	1951-Q1	2015-Q1	1994-Q4	2015-Q1	1961-Q1	2015-Q1	1951-Q1	2015-Q1
NL	1961-Q2	2015-Q1	1994-Q4	2015-Q1	1991-Q1	2015-Q1	1961-Q2	2015-Q1
PT	1948-Q1	2015-Q1	1994-Q4	2015-Q1	1980-Q1	2015-Q1	1948-Q1	2015-Q1
SE*	1961-Q2	2015-Q1	1992-Q4	2015-Q1	1981-Q1	2015-Q1	1961-Q2	2015-Q1
UK*	1977-Q2	2015-Q1	1963-Q2	2015-Q1	1976-Q2	2015-Q1	1963-Q2	2015-Q1

Note. * indicates non-EZ countries *(created by the authors)*

Table D.2. List of the time series of retail lending rates

Country	**Name of the time series**
ECB	Loans including lending for house purchase (up to 1 year calculated by weighting the volumes with a moving average). New business coverage
AT	Loans to enterprises (up to one year)
BE	Term loan to non-financial corporations (up to one year)
ES	Short-term loans to enterprises: variable rate; monthly reviewable
FI	Lending to enterprises (total maturity)
FR	Discount, overdrafts and other short-term loans up to one year, non-financial corporations
GR	Short-term loans to enterprises
IE	Variable mortgage lending to households
IT	Interest rate on loans up to 18 months - all customers
NL	Mortgage loans from credit institutions, lending for house purchase to households
PT	Loans to private non-fin. enterprises with 91 to 180 days maturity
SE	Loans to corporations with collateral > EUR 25M & up to EUR 1M, up to one year

(created by the authors)

Appendix E. Descriptive statistics

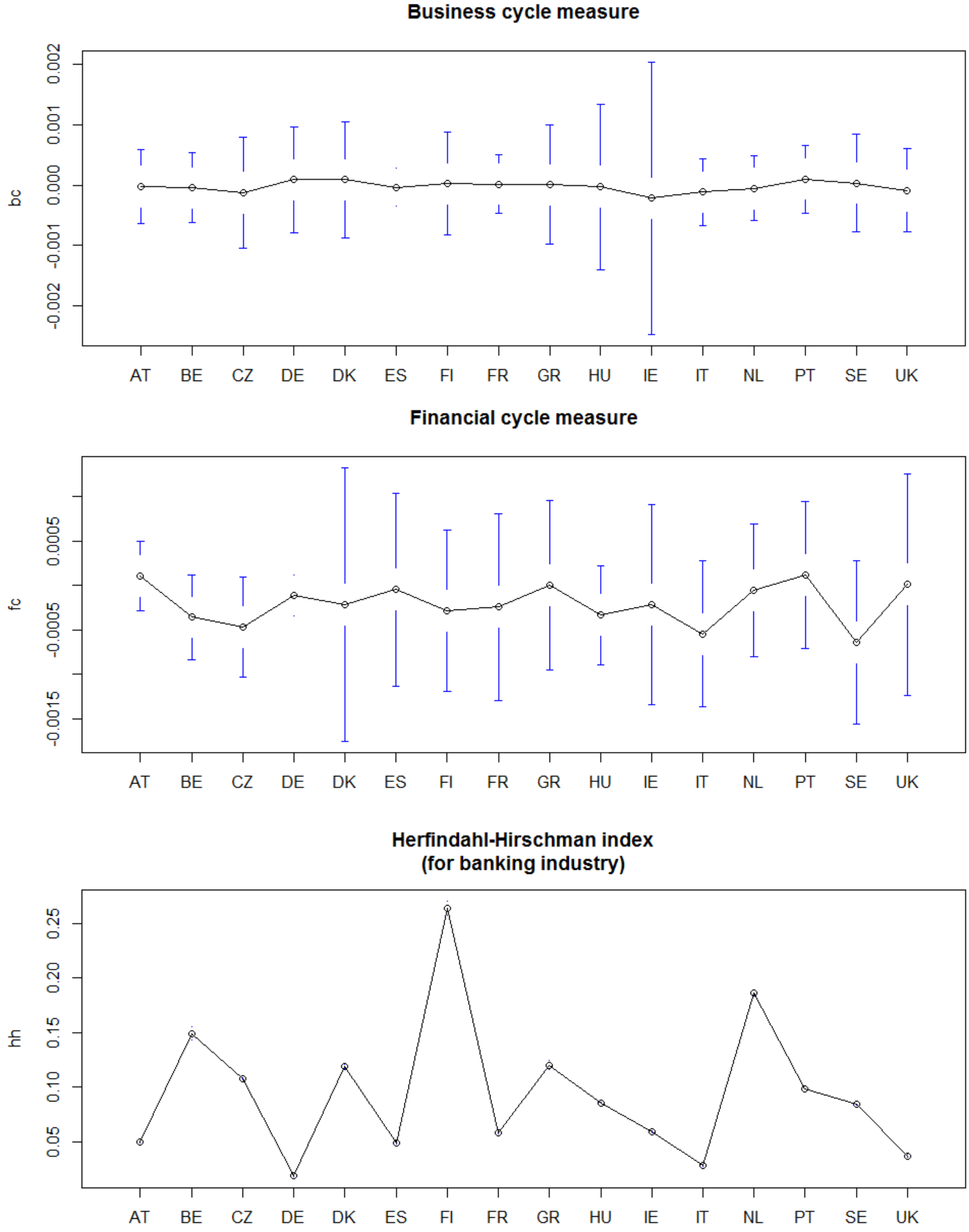
Table E.1. Descriptive statistics of the dependent and explanatory variables

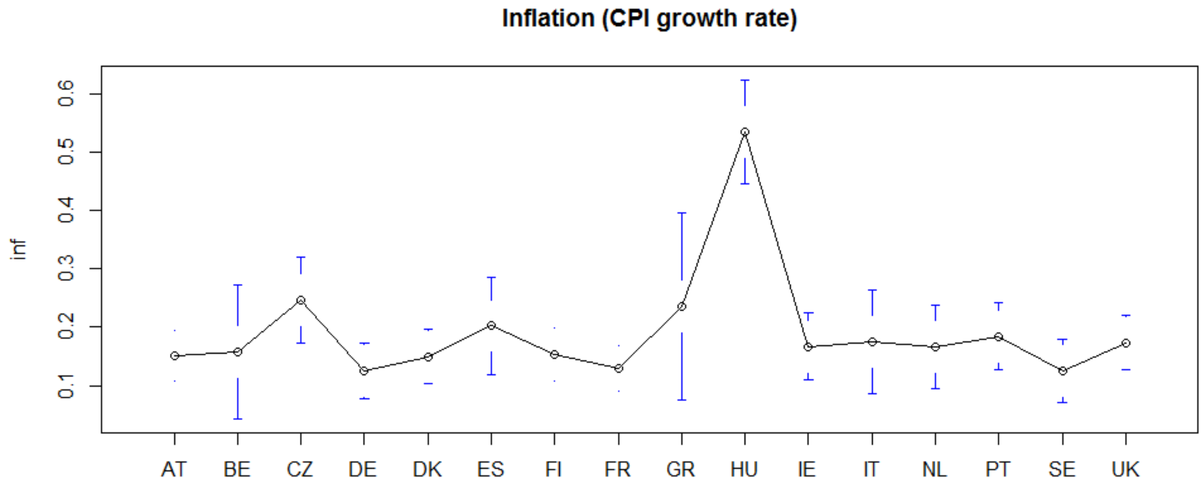
Country	*Obs*	*Mean*	*St. Dev.*	*Min*	*Max*	*Obs*	*Mean*	*St. Dev.*	*Min*	*Max*	*Obs*	*Mean*	*St. Dev.*	*Min*	*Max*
	Retail lending rate					**Key policy rate**					**HHI**				
AT	228	4.44	1.77	1.81	7.63	182	3.05	1.87	0.05	6.00	19	0.05	0.01	0.04	0.06
BE	228	3.76	1.10	2.05	5.97	182	2.85	1.67	0.05	4.25	19	0.15	0.05	0.07	0.21
CZ	132	4.14	0.92	2.61	5.95	182	2.22	1.66	0.05	5.50	19	0.11	0.01	0.09	0.13
DE	228	5.42	2.22	2.28	9.12	182	2.85	1.67	0.05	4.25	19	0.02	0.01	0.01	0.03
DK	130	2.16	0.70	1.07	4.71	182	2.41	1.59	0.20	5.60	19	0.12	0.02	0.09	0.15
ES	228	4.41	1.42	2.42	10.03	182	2.85	1.67	0.05	4.25	19	0.05	0.01	0.03	0.08
FI	228	3.68	1.25	1.60	5.99	182	2.85	1.67	0.05	4.25	19	0.27	0.05	0.20	0.37
FR	228	3.99	1.57	1.75	7.82	182	2.79	1.65	0.05	4.75	19	0.06	0.01	0.04	0.07
GR	228	8.91	5.27	4.30	21.4	182	3.17	2.18	0.05	10.25	19	0.12	0.04	0.09	0.22
HU	144	9.20	2.38	3.85	14.4	157	7.16	2.44	2.10	12.5	19	0.09	0.00	0.08	0.09
IE	228	4.75	1.34	2.74	7.5	192	2.84	1.62	0.05	4.25	19	0.06	0.01	0.05	0.07
IT	228	5.52	2.27	2.73	12.82	182	2.79	1.65	0.05	4.75	19	0.03	0.01	0.02	0.04
NL	228	4.32	1.53	1.76	6.65	182	2.85	1.67	0.05	4.25	19	0.19	0.02	0.17	0.22
PT	228	5.89	1.85	3.79	12.9	192	2.84	1.62	0.05	4.25	19	0.10	0.02	0.06	0.12
SE	52	4.05	0.66	2.62	5.02	182	3.03	1.37	0.75	5.42	19	0.08	0.01	0.08	0.10
UK	132	4.84	2.28	2.42	10.17	182	3.08	2.17	0.50	6.00	19	0.04	0.01	0.02	0.05
	Overheads-to-total assets					**Regulatory quality**					**HICP**				
AT	19	2.12	0.66	1.01	3.02	16	1.52	0.09	1.34	1.70	228	0.15	0.34	-1.1	1.2
BE	19	1.39	0.39	0.95	2.01	16	1.26	0.10	1.02	1.41	228	0.16	0.88	-1.9	2.5
CZ	19	1.73	0.69	0.91	2.69	16	1.09	0.14	0.73	1.32	228	0.25	0.57	-0.8	3.6
DE	19	1.95	0.58	1.52	3.52	16	1.51	0.10	1.22	1.70	228	0.12	0.37	-0.8	1.2
DK	19	2.85	0.97	1.44	4.36	16	1.80	0.07	1.67	1.92	228	0.15	0.36	-0.7	1.1
ES	19	1.38	0.33	0.63	1.89	16	1.16	0.16	0.78	1.35	228	0.20	0.63	-1.9	2.4
FI	19	1.99	2.41	0.15	11.68	16	1.76	0.13	1.48	1.9	228	0.15	0.35	-0.8	1.2
FR	19	2.09	0.55	1.33	3.10	16	1.13	0.15	0.81	1.31	228	0.13	0.30	-0.6	0.9
GR	17	2.12	1.10	1.00	4.59	16	0.74	0.19	0.34	1.00	228	0.24	1.23	-2.1	3.4
HU	19	6.20	4.75	3.01	19.45	16	1.06	0.14	0.77	1.31	228	0.54	0.68	-0.8	3.8
IE	19	0.38	0.48	0.04	1.47	16	1.69	0.12	1.54	1.92	228	0.17	0.44	-1.0	1.2
IT	19	2.39	0.87	1.19	4.86	16	0.87	0.13	0.66	1.09	228	0.18	0.68	-2.1	2.5
NL	19	0.87	0.37	0.24	1.96	16	1.79	0.10	1.67	2.08	228	0.17	0.55	-1.6	1.5
PT	19	2.04	1.34	0.02	5.23	16	1.02	0.22	0.63	1.29	228	0.18	0.44	-1.4	1.7
SE	19	3.26	1.36	1.73	6.23	16	1.61	0.21	1.19	1.91	228	0.12	0.41	-1.2	1.3
UK	19	2.01	0.44	1.41	3.15	16	1.77	0.13	1.59	2.02	228	0.17	0.36	-0.9	1.0

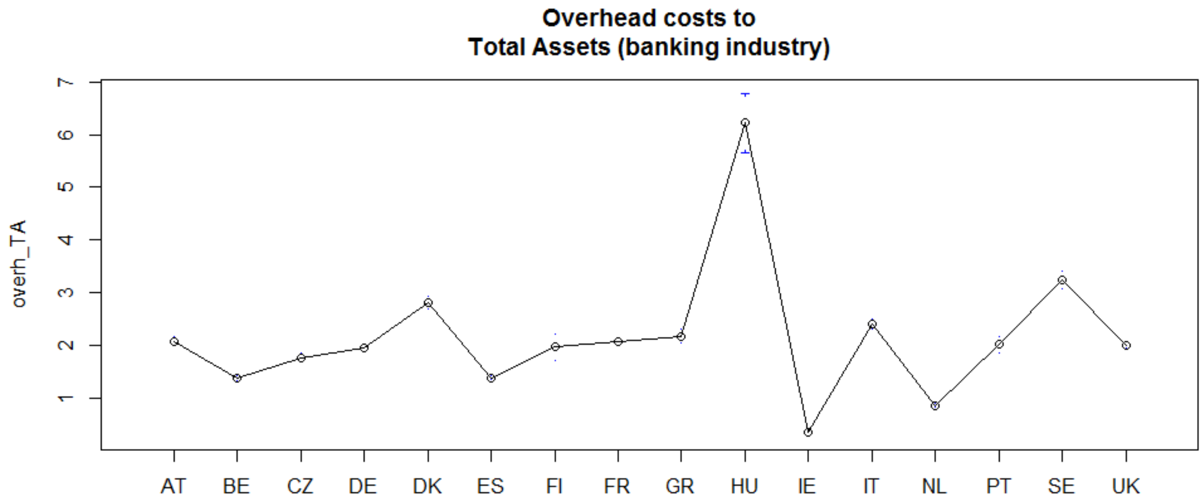
(created by the authors)

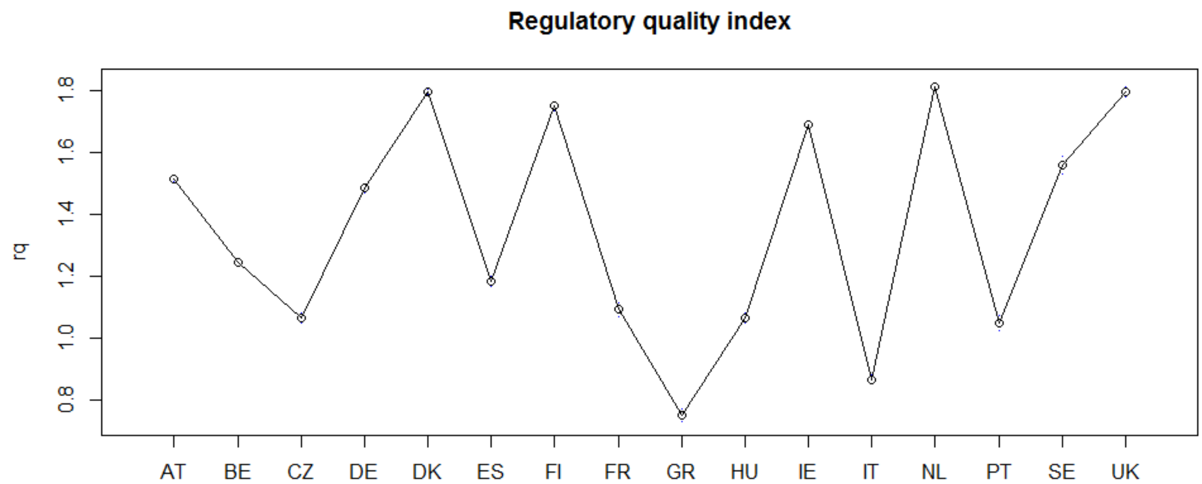
Appendix F. Heterogeneity of the control variables

Figure F.1. Plots of the heterogeneity of the control variables across countries




Inflation (CPI growth rate)
inf
0.1
0.2
0.3
0.4
0.5
0.6
AT BE CZ DE DK ES FI FR GR HU IE IT NL PT SE UK


Overhead costs to
Total Assets (banking industry)
overh_TA
1
2
3
4
5
6
7
AT BE CZ DE DK ES FI FR GR HU IE IT NL PT SE UK


Regulatory quality index
rq
0.8
1.0
1.2
1.4
1.6
1.8
AT BE CZ DE DK ES FI FR GR HU IE IT NL PT SE UK

Appendix G. Tests for the panel regression

Table G.1. Stationarity tests with augmented Dickey-Fuller test

Country	**Lending rates**		**Policy rate**		**Residuals**	
	Statistic	*Cannot reject at the level*	*Statistic*	*Cannot reject at the level*	*Statistic*	*Reject at the level*
AT	-2.11	10%	-1.97	10%	-25.67	1%
BE	-2.14	10%	-2.02	10%	-29.67	1%
CZ	-1.81	10%	2.69	10%	-42.19	1%
DE	-2.09	10%	-1.25	10%	-24.81	1%
DK	-3.66	1%	-1.94	10%	-55.65	1%
ES	-3.87	1%	-2.02	10%	-28.76	1%
FI	-2.21	10%	-1.29	10%	-36.47	1%
FR	-2.26	10%	-2.02	10%	-30.19	1%
GR	-1.33	10%	1.41	10%	-21.22	1%
HU	-2.48	10%	-2.18	10%	-69.77	1%
IE	-2.18	10%	-2.02	10%	-33.17	1%
IT	-3.21	5%	-2.48	10%	-23.46	1%
NL	-2.27	10%	-1.22	10%	-28.55	1%
PT	-3.88	1%	-2.02	10%	-36.20	1%
SE	-3.59	1%	4.33	10%	-21.05	1%
UK	-2.06	10%	-2.45	10%	-45.06	1%

Note. H0: time series has a unit root. *(created by the authors)*

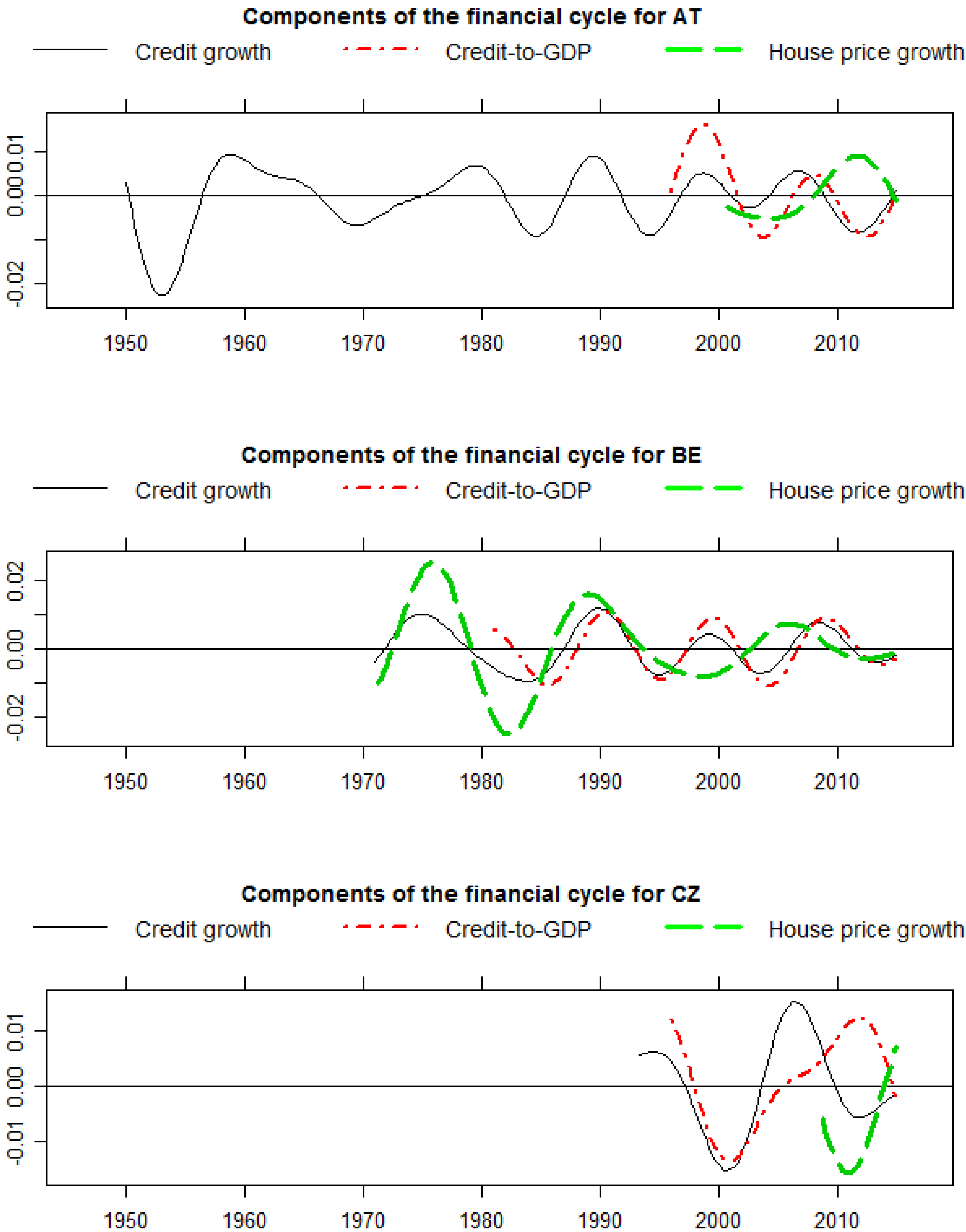
Table G.2. Diagnostics

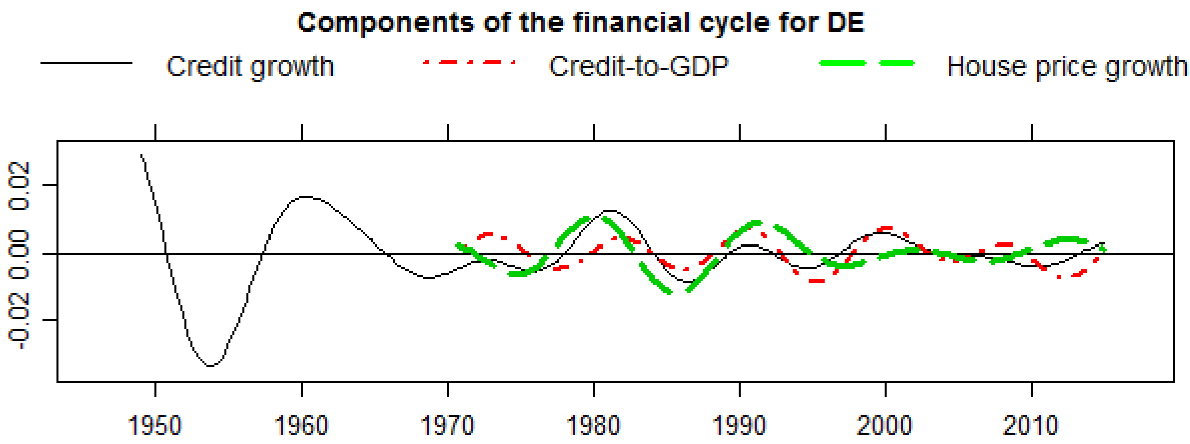
Perasan CD test for cross-sectional dependence in panels		
z = 18.857		p-value < 2.2E-16
Alternative hypothesis:	cross-sectional dependence	
Breusch-Godfrey/Wooldridge test for serial correlation in panel models		
Chi-squared = 117.31	degrees of freedom = 50	p-value = 2.475E-07
Alternative hypothesis:	serial correlation in idiosyncratic errors	
Wooldridge test for unobserved individual effects		
z =-1.5605		p-value = 0.1186
Alternative hypothesis:	unobserved effect	
Hausman test		
Chi-squared = 8.1897	degrees of freedom = 20	p-value = 0.9905
Null hypothesis:	random effects estimator is consistent and efficient fixed effects estimator is consistent and inefficient	
Alternative hypothesis:	random effects estimator is inconsistent fixed effects estimator is consistent	

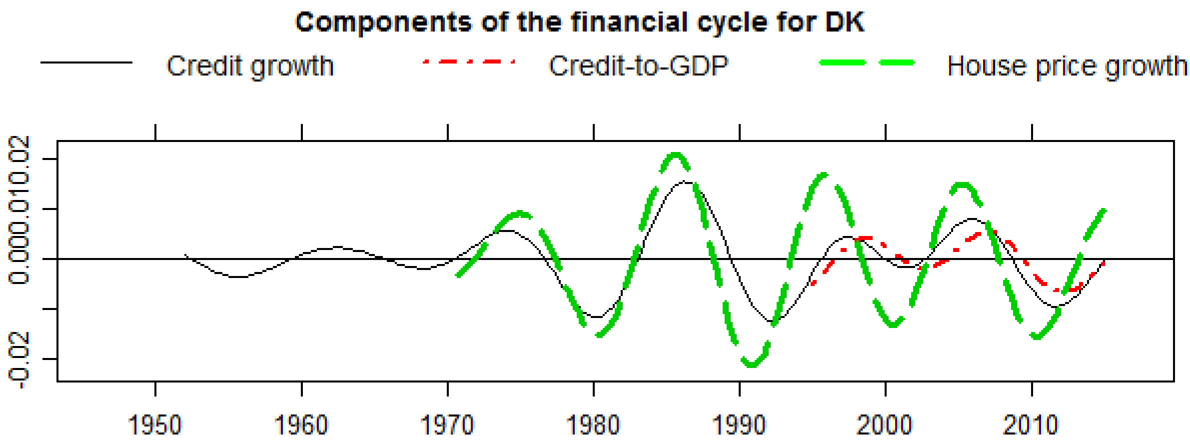
(created by the authors)

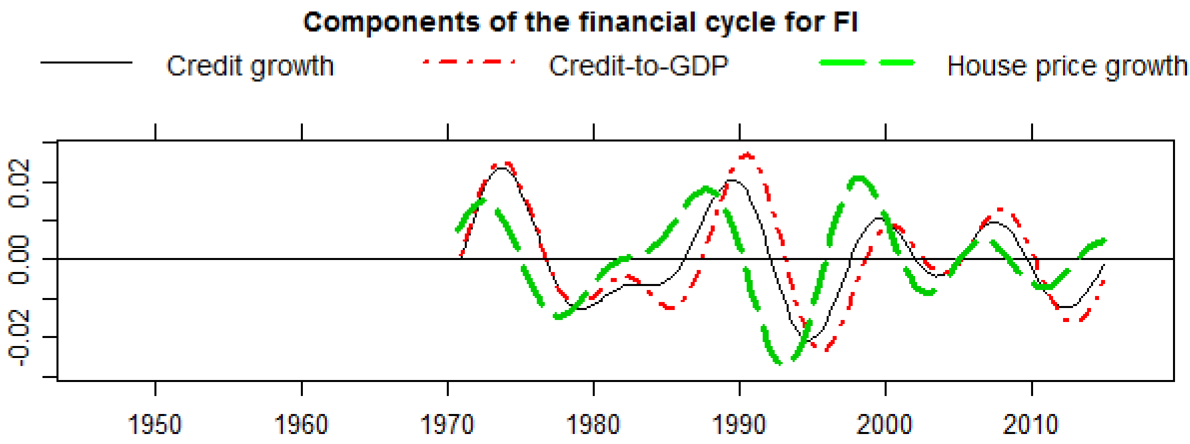
Appendix H. Plots of the components of the financial cycle

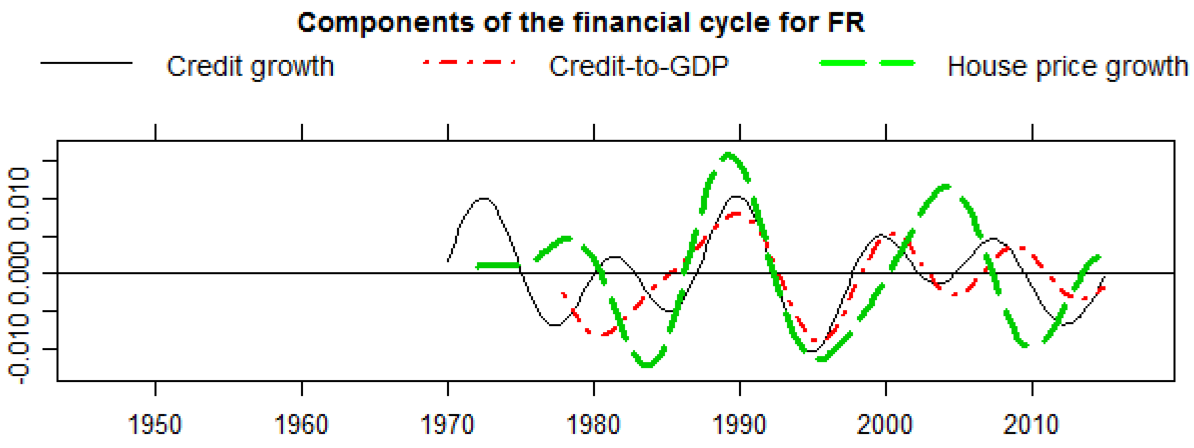
Figure H.1. Plots of the components of the financial cycle for all the countries in the sample obtained with band-pass filter

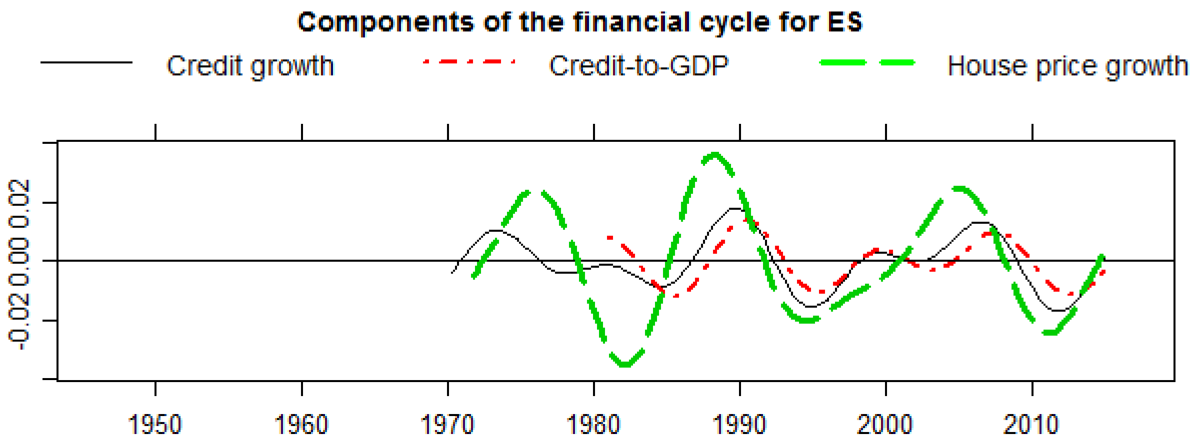



Components of the financial cycle for DE
Credit growth
Credit-to-GDP
House price growth
-0.02
0.00
0.02
1950
1960
1970
1980
1990
2000
2010

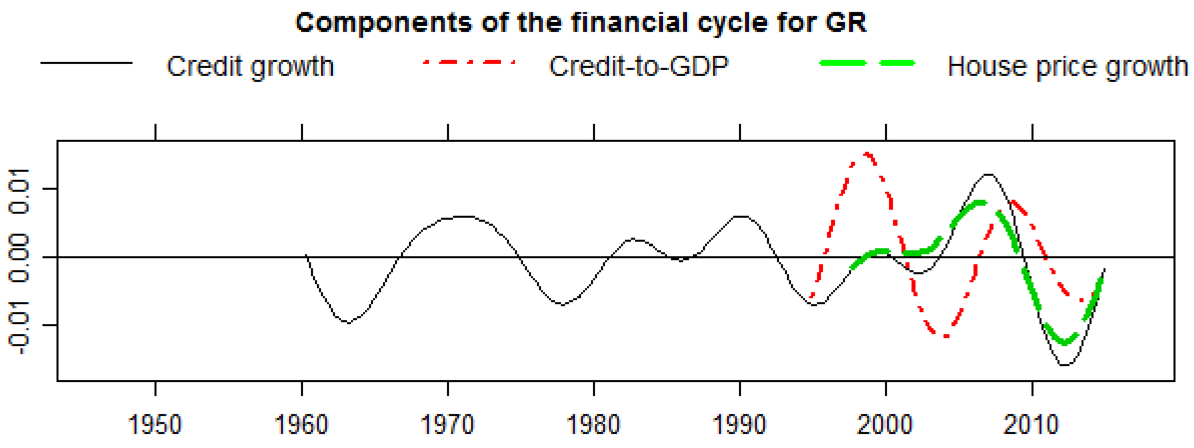

Components of the financial cycle for DK
Credit growth
Credit-to-GDP
House price growth
-0.02
0.00
0.01
0.02
1950
1960
1970
1980
1990
2000
2010

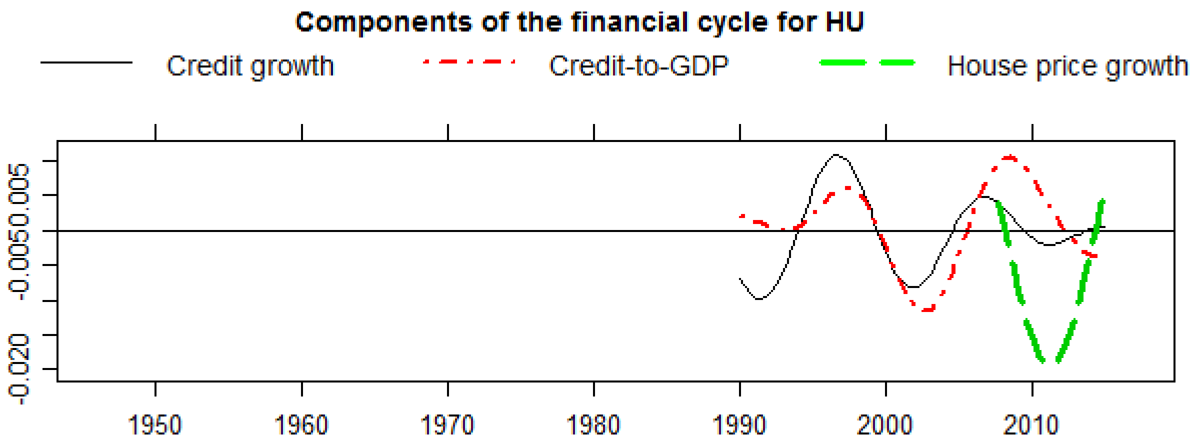

Components of the financial cycle for FI
Credit growth
Credit-to-GDP
House price growth
-0.02
0.00
0.02
1950
1960
1970
1980
1990
2000
2010

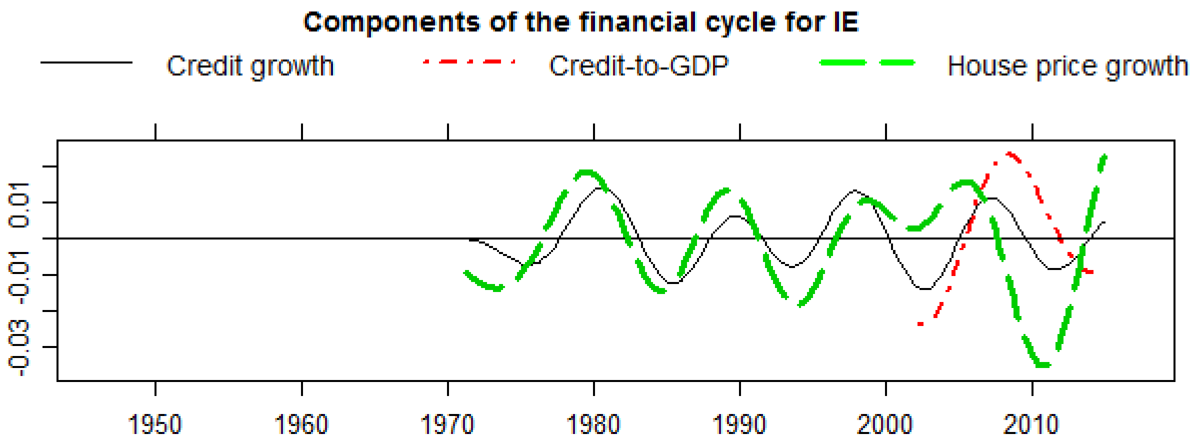


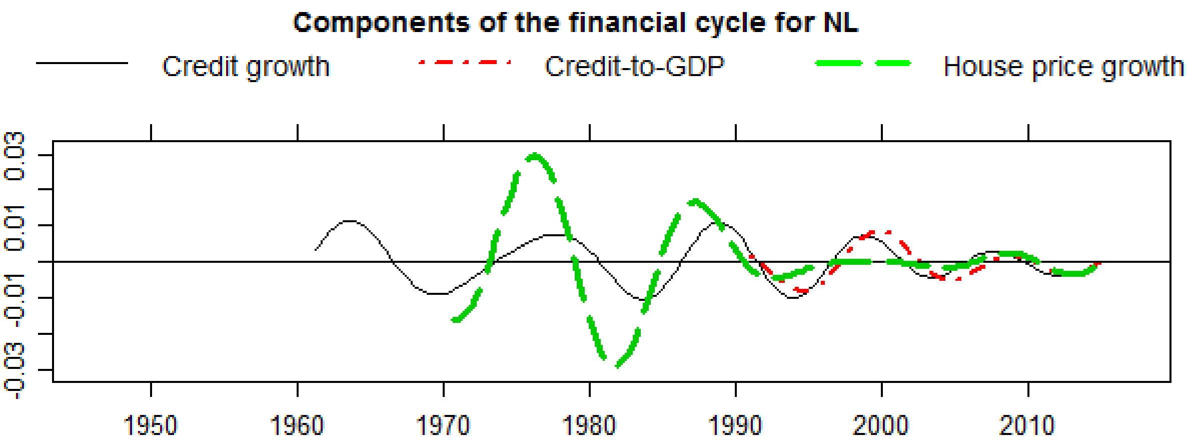


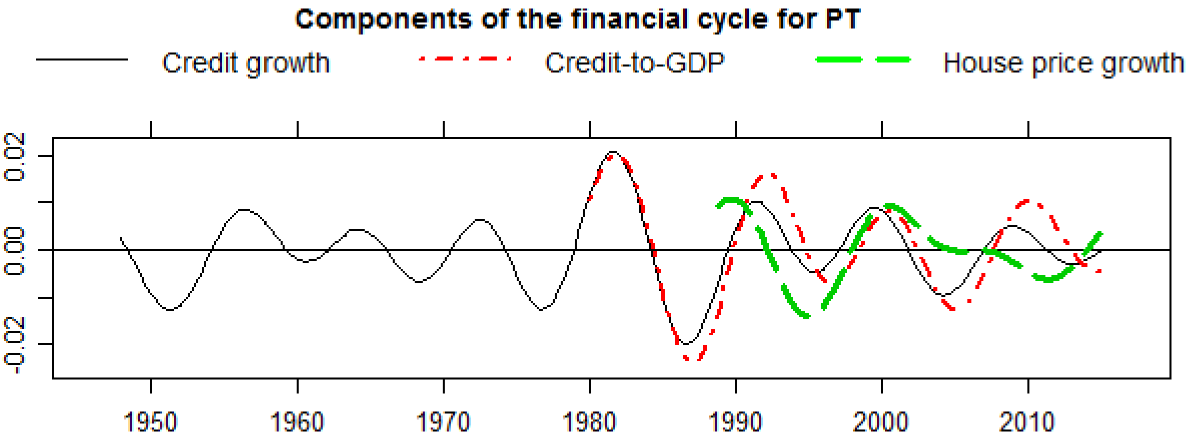
(created by the authors)

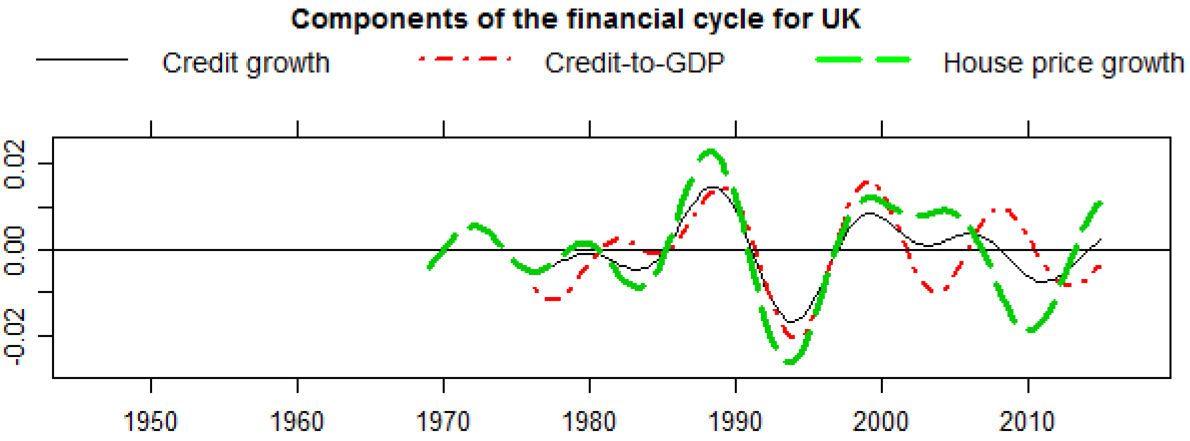

Components of the financial cycle for GR
Credit growth
Credit-to-GDP
House price growth
-0.01 0.00 0.01
1950 1960 1970 1980 1990 2000 2010


Components of the financial cycle for HU
Credit growth
Credit-to-GDP
House price growth
-0.020 -0.005 0.005
1950 1960 1970 1980 1990 2000 2010


Components of the financial cycle for IE
Credit growth
Credit-to-GDP
House price growth
-0.03 -0.01 0.01
1950 1960 1970 1980 1990 2000 2010

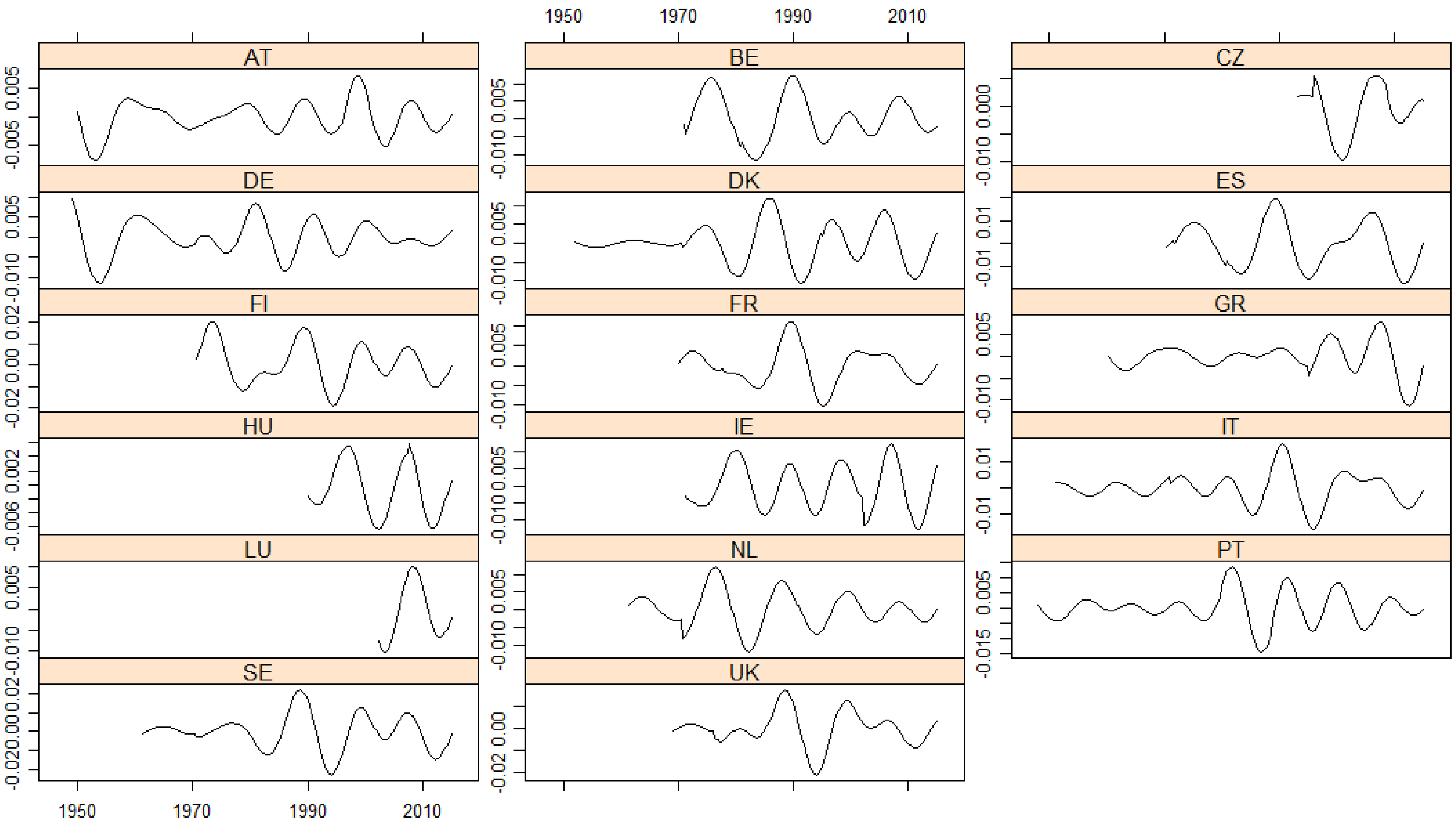

Components of the financial cycle for NL
Credit growth
Credit-to-GDP
House price growth
-0.03
-0.01
0.01
0.03
1950
1960
1970
1980
1990
2000
2010


Components of the financial cycle for PT
Credit growth
Credit-to-GDP
House price growth
-0.02
0.00
0.02
1950
1960
1970
1980
1990
2000
2010


Components of the financial cycle for UK
Credit growth
Credit-to-GDP
House price growth
-0.02
0.00
0.02
1950
1960
1970
1980
1990
2000
2010

Appendix I. Composite financial cycles

Table. I.1 Composite financial cycles obtained from band-pass filter



(created by the authors)