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Credit market concentration and systemic risk in Europe

Merike Kukk, Alari Paulus and Nicolas Reigl*

Abstract

We assess empirically the relationship between credit market concentration and a novel country-level systemic risk indicator that has been developed at the European Central Bank. We find a weakly U-shaped relationship between market concentration and systemic risk for Western European countries, where very low and high levels of market concentration are associated with higher systemic risk. Cumulative estimates with dynamic models show that systemic risk has a persistent negative response to an increase in market concentration from low and median levels of concentration. Local projection estimates for the period preceding the global financial crisis also suggest that an increase in market concentration may have further added to systemic risk at a time when it was building up in countries with high banking concentration, demonstrating the complexity of the relationship between systemic risk and market concentration.

JEL codes: G10, G21, E58, C22, C54

Keywords: systemic risk, financial stability, credit institutions, credit growth, market concentration

The views expressed in this paper are personal and do not necessarily represent the official views of Eesti Pank or the Eurosystem.

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Non-technical summary

Many European countries experienced a marked increase in financial risks before the global financial crisis, though the degree of increase differed, suggesting that both common and country-specific factors contributed to it. Financial stability and systemic risks may be among those affected by market concentration and competition intensity in the financial sector, which vary substantially across Europe. Central and Eastern European countries tend to have greater credit market concentration than Western European countries, and the market in Estonia has been one of the most concentrated. The financial sector in Estonia was also hit hard by the global financial crisis, raising the question of whether and how credit market concentration is related to systemic risks in the financial sector.

The literature on bank competition and financial stability offers different views on the relationship between them. Theoretical arguments point to bank competition having both stabilising and destabilising aspects, and the empirical evidence remains similarly mixed, as it has provided support for both positive and negative relationships.

The concepts of competition and financial stability have also been interpreted in various ways. The main measures of competition primarily show how sensitive the profits or revenues of individual banks are, rather than showing competition intensity itself. Empirical studies have often used indexes of market concentration as proxies for competition, though these are related but distinct concepts, and typical measures of risk reflect the riskiness of individual banks rather than broader financial stability or systemic risks. There is a notable gap in research using indicators of systemic risk that are specifically designed to identify instability at the country level.

Our paper addresses that gap and studies the relationship between systemic risk and the structure of the credit market. We use a novel composite systemic risk indicator (Lang et al., 2019) for European countries that captures the risks that arise from domestic credit cycles, real estate market developments, asset prices and external developments, and we assess the potential influences from market concentration indicators with it.

We estimate various panel data models using quarterly data on 20 European countries from the fourth quarter of 1997 to the first quarter of 2020. As well as estimating models for the whole period and across all countries, we also estimate models separately for the periods before and after the global financial crisis of 2007-08 and for two regions, separating Western European countries from Central and Eastern European countries.

We find evidence for a weakly U-shaped relationship between the systemic risk indicator and the credit market concentration index in Western Europe. This means that very low and very high levels of market concentration are associated with higher levels of systemic risk. Cumulative estimates with dynamic models show that systemic risk has a persistent negative response over a longer period to an increase in market concentration from low and median levels of concentration. The overall effect of market concentration on systemic risk is limited as the negative relationship is mainly found in the post-crisis period. We also find weak evidence that a rise in market concentration had a slowly emerging positive effect on the build-up of systemic risk before the financial crisis in cases where the market was already highly concentrated. The positive effect is more clearly seen for the bank credit-to-GDP ratio, which is the debt-related subcomponent of the systemic risk index.

Our results suggest that the regulators in charge of monitoring the banking industry and developments in systemic risk need to pay attention to changes in the structure of the banking sector. Increased banking sector concentration can be cautiously promoted in most Western European countries as it seems to reduce systemic risks rather than increasing them. At the same time, mergers and acquisitions need to be monitored and possibly prevented in highly concentrated banking markets, at least for the largest banks.

Contents

1 Introduction

It is difficult to overemphasise how important it is for financial stability to be protected and maintained, especially since the global financial crisis (GFC) of 2007-2008. The GFC underlined the need for systemic risks in the financial sector to be better understood and tackled, and it led to the development of several new indicators to gauge such broader risks.

The GFC also caused structural changes in the banking sector. Most countries saw a decline in the number of banks in the following decade, especially large advanced economies (Buch & Dages, 2018), though for some countries this appears to have been a continuation of the consolidation process that had started earlier. European countries accumulated systemic risk in different ways before the GFC, with the build-up more pronounced in Central and Eastern European countries than in Western European countries. There were also marked differences between the strucutres of the banking market in the two regions (Uhde & Heimeshoff, 2009). Central and Eastern European countries started out in the beginning of the 1990s with a highly concentrated banking market and market concentration has remained higher than in Western European countries despite the entry of foreign banks. Estonia stands out for its high banking concentration, and its banking sector was hit hard by the GFC.

The evidence of high levels of systemic risk in countries where the banking market is highly concentrated has raised concern about whether market structure might affect banking sector stability. Basic industrial organisation theory assumes that competition is beneficial for efficiency and innovation, as only the most efficient firms can survive in a competitive market. Furthermore, strong competition tends to reduce the prices paid by consumers. Credit institutions are however not the same as other economic actors since fierce competition can not only cause specific problems in their own sector but can also lead to wider financial instabilities. The main channel through which market structure affects financial stability is the credit risk channel.

There is a substantial body of research that has focused specifically on whether and how financial stability could be affected by bank competition and the concentration of the financial sector, but it has not been able to offer conclusive theoretical and empirical insights. Whereas earlier studies have mainly focused on indicators of risk and market power at the level of individual banks, we investigate the relationship between overall financial stability and credit market structure at the country level. We use a novel composite systemic risk indicator (Lang et al., 2019) for European countries, referred to as d-SRI, that captures the risks that arise from domestic credit cycles, real estate market developments, asset prices and external developments, and we assess potential influences from market concentration indicators such as the Herfindahl-Hirschman index and the concentration ratio.

We find evidence for a weakly U-shaped relationship between the systemic risk indicator and the credit market concentration index in Western Europe. This means that very low and very high levels of market concentration are associated with higher levels of systemic risk. Cumulative estimates with dynamic models show that systemic risk has a persistent negative response over a longer period to an increase in market concentration from low and median levels of concentration, while there is no such negative relationship when the level of concentration is already high. The overall effect of market concentration on systemic risk is limited as the negative relationship is mainly present for the period after the GFC.

Further to this, we find weak evidence that an increase in market concentration had a slowly emerging positive effect on the build-up of systemic risk before the financial crisis in cases where the market was already highly concentrated. The positive effect is more clearly seen for the bank credit-to-GDP ratio, which is the debt-related subcomponent of the systemic risk index.

The paper is organised as follows. Section 2 provides a summary of the literature and presents the indicators for systemic risk and market concentration. Section 3 shows some stylised facts about the relationship between credit market concentration and the systemic risk indicator. In Section 4 we describe the empirical models. Section 5 presents the results. The final section concludes.

2 Related literature

2.1 Competition and financial stability

The links that may exist between financial stability and competition have attracted the attention of researchers for a long time, and a large theoretical and empirical literature has sought to address them. See Badarau and Lapteacru (2020) for a recent brief overview. The theoretical literature offers two main opposing views. The conventional competition-fragility view, which dates back at least to Keeley (1990), Marcus (1984), and Smith (1984), argues that managers in highly competitive environments have incentives to take on high-risk operations or to reduce lending standards to acquire more costumers. Banks operating in environments of weak competition meanwhile can afford higher capital buffers and less aggressive operations, and reduced risk-taking in conjunction with higher capital buffers enhances the stability of the banking sector overall.

In contrast, the more recent competition-stability view (e.g. Boyd & De Nicoló, 2005) notes that banks have greater market power when there are fewer competitors, and so they can set higher margins on loan interest rates. Clients are then faced with higher borrowing costs and so are more likely to default on their loans. Large credit institutions are also subject to moral hazard effects, where a few systemically important banks may believe that they are too big to fail and assume that the authorities will bail them out if problems arise. Some models have also generated ambiguous results (Allen & Gale, 2004; Caminal & Matutes, 2002) or suggested a U-shaped relationship between competition and risk (e.g. Martinez-Miera & Repullo, 2010).

A number of studies have assessed empirically whether highly concentrated banking markets can affect financial stability. It is helpful to distinguish here between three strands of empirical research, that can be separated by the nature of instability and the market power considered. First are the studies that use bank-level data for a single country or multiple countries to investigate the relationship between the risk of individual banks and the market power of banks. Cuestas et al. (2020) survey recent examples of this and carry out an analysis for the Baltic countries. They focus on the distance to default (the z-score) and loss reserves as measures of risk indicators on one side and the Lerner index and market shares as measures of market powers on the other side, and they similarly find a U-shaped relationship between risk and competition.

The second strand also uses bank-level data, employing it to analyse how individual banks contribute to systemic risk as well as looking at the risk of individual banks.[1] Anginer et al. (2014) and Leroy and Lucotte (2017) both show that competition between banks enhances systemic stability, but arrive at different conclusions about the relationship between bank competition and the risk of individual banks.

The third strand is the most relevant to our paper as it studies competition and systemic risk at the country level, using historic episodes of banking crises (Beck et al., 2006; Schaeck et al., 2009) or traditional bank risk indicators applied to aggregate data (IJtsma et al., 2017; Uhde & Heimeshoff, 2009) as measures of systemic risk at the country level. There is a notable gap, however, in research using systemic risk indicators, which are specifically designed to identify instability at the country level.

The results across these three strands are far from conclusive. Zigraiova and Havranek (2016) conducted a meta-analysis of 31 studies published between 2003 and 2014, and found no evidence for any robust relationship between banking sector

[1] Dissem and Lobez (2020) discuss and compare three such measures (marginal expected shortfall, the systemic risk measure, the delta conditional value at risk).

concentration and financial stability. Their analysis does however indicate that the choice of countries, measures of financial stability and bank competition, and method of estimation can systematically influence the results. It also suggests that the level of analysis, whether individual bank or country, does not have much relevance after controlling the measures of stability and competition are controlled for. This finding is in line with IJtsma et al. (2017), who estimated and explicitly contrasted bank-level and country-level results for European banks.

2.2 Systemic risk indicators

The existing literature on competition and financial stability uses a range measures of individual bank risk such as the share of non-performing loans, loan loss reserves, volatility, or the probability of bankruptcy, or uses stability measures that are inversely related to the level of risk such the z-score, ROA/ROE level, capital adequacy ratio, or distance-to-default, but these do not necessarily reflect broader financial stability or systemic risks, even if they are aggregated across individual banks. The literature has also used macro-level information such as indicator variables for financial crises or bank failures, but their binary nature means that these offer limited insights and they are not good enough for considering systemic risks on a continuous scale.

A number of systemic risk measures have been proposed in the literature on economics and finance that have varying aims, properties and data requirements; see Bisias et al. (2012) for a comprehensive review, alternative taxonomies and discussion. There is no single common definition of what systemic risk actually is. ECB (2009, p. 134) broadly characterises it as 'the risk that financial instability becomes so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially.' A thorough discussion of the concept of systemic risk together with a review of theoretical models and empirical evidence can be found in De Bandt et al. (2010), while Silva et al. (2017) further provide an extensive collection of studies on systemic financial risk.

Our analysis requires a country-level index of systemic risk in the financial sector with a sufficiently long time series for European countries. Following the global financial crisis, which exposed the need for systemic risks to be understood and monitored, several new indicators were developed at the ECB. Most of them involve two steps, where a financial stress index (FSI) is first constructed, and then employed to identify episodes of systemic crisis. It is generally not sufficient to identify such episodes simply as periods when the FSI is at high levels, as not all of those periods are necessarily associated with substantial and prolonged negative effects on the real economy, or any such effects that there were could in some cases have been prevented by appropriate policy action, so this then introduces a potential selection bias.

Lo Duca and Peltonen (2013) was one of the earlier attempts. They constructed a country-specific, composite, quarterly financial stress index for 28 emerging market and advanced economies. It covered several segments of the domestic financial market and aggregated five components in a relatively simple fashion, using the average of each component's quartile rank. They then defined systemic events as those episodes where the extreme level of financial stress was typically followed by negative economic developments.

Holló et al. (2012) developed another financial stress index called the *Composite Indicator of Systemic Stress* (CISS) for the euro area as a whole. It measures the current state of financial instability with an emphasis on accrued systemic risks and comprises 15 mostly market-based measures of financial stress for the five market segments of financial intermediation, money, equities, bonds and foreign exchange, deriving them mainly from financial asset prices on a weekly basis. Its main novelty was its application of standard portfolio theory to the aggregation of the subindexes for market segments, allowing it to take account of their time-varying cross-correlations. As such, the CISS captures how widespread instabilities are across the financial system, reflecting their systemic nature. To determine critical levels finally for the index and to evaluate whether these are indeed associated with a large negative impact on economic activity, the authors employed two econometric regime-switching models, which were the autoregressive Markov switching model, and the threshold vector autoregression model.

Following the same strategy, Duprey et al. (2015) created the *Country-Level Index of Financial Stress* (CLIFS). This uses six financial stress measures for the three market segments of equities, bonds and foreign exchange, and so it has a narrower scope than the CISS but is available for each EU country at a monthly interval, with the longest time series starting from the mid-1960s. Also similar to Holló et al. (2012), it uses a Markov switching model with a TVAR model as a robustness check to identify endogenously periods with high stress levels. As a further additional step, an algorithm was employed to check which of these episodes were associated with a sustained negative impact on the real economy and so were systemic in their nature. Lo Duca et al. (2017) draw on Duprey et al. (2015) and combine their algorithmic approach with a qualitative approach that involves feedback from national authorities to create the ECB/ESRB financial crises database.

Most recently, Lang et al. (2019) developed the *domestic Systemic Risk Indicator* (d-SRI) for the EU countries. This was designed to signal financial vulnerabilities, as identified in Lo Duca et al. (2017), four to five years ahead on a quarterly basis, and

Table 1: The components of d-SRI

ESRB risk category: measures of ...	Indicator	Weight
(a) overvaluation of property prices	3-year change in RRE price-to-income ratio, p.p.	17%
(b) credit developments	2-year change in the bank credit-to-GDP ratio, p.p.	36%
(b) credit developments	2-year growth rate of real total credit (CPI deflated), %	5%
(c) external imbalances	Current account-to-GDP ratio, %	20%
(e) private sector debt burden	2-year change in the debt-service-ratio (DSR), p.p.	5%
(f) potential mispricing of risk	3-year growth rate of real equity prices (CPI deflated), %	17%

Source: Lang et al., 2019, p. 8.

it is also highly correlated with GDP growth three to four years ahead. The early warning properties of the indicator allow policy makers to set macro-prudential policies well before a crisis manifests. The d-SRI is constructed as the optimal weighted average of six standardised early warning indicators, with higher values signalling higher levels of systemic risk.[2]

The selection of the sub-indicators used to construct the d-SRI balances institutional requirements for monitoring systemic risk and for signalling performance. Table 1 shows the link between the European Systemic Risk Board (ESRB) risk categories, the d-SRI components and the weights of the components. The sub-indicators are measured in either two-year or three-year differences, which have been found to provide the best early warning properties. The largest weight is attached to the two-year change in the bank credit-to-GDP ratio, while the minimum weight is capped at 5% for the two-year change in the debt-service-ratio and the two-year growth rate of real total credit (Lang et al., 2019). We retain the original weighting scheme for the d-SRI, even though we use a subset of countries because of data limitations.[3]

Our primary interest lies in the novel d-SRI, but we will also use the CLIFS as an alternative measure for robustness checks. The reason why the CISS is not well suited for our purposes is because it is available only for a very limited set of countries, known as the new CISS, in addition to the original measure for the euro area as a whole.

[2]The sub-indicators are standardised by subtracting the median and dividing the result by the standard deviation of the pooled distribution across countries. Using the pooled distribution for standardisation allows a degree of cross-country heterogeneity to be exploited, making the d-SRI more robust to extraordinary domestic shocks while at the same time accounting for shocks that are common across the euro area sample countries.

[3]We refrain from calculating the d-SRI from our restricted sample and use the d-SRI provided by the authors. We reason that under the assumption that the d-SRI is an appropriate proxy for systemic risk for the full sample, it is also the appropriate proxy in a sample that is restricted due to the availability of banking sector concentration measures.

2.3 Market concentration indicators

The earlier literature has focused on bank-level indicators for market structure, as it did with risk measures. These typically characterise prevailing competition conditions by quantifying the sensitivity of the profits or revenues of individual banks to their marginal cost, like for example the Lerner index, the Panzar-Rosse index, and the Boone index do. While the profitability of market participants is clearly affected by the market structure, it is not a simple one-to-one relationship and there are other important determinants. There could also be significant differences between market participants, and so the same index could imply a very different degree of competition for participants in that market.

To match systemic risk indicators at the country level, our interest is in broader measures that characterise the structure of the market as a whole. We therefore turn to structural measures that reflect market allocation between the market participants. As a primary indicator we use the *Herfindahl-Hirschman index* (HHI):

$$HHI = \sum_{i=1}^{N} s_i^2 \tag{1}$$

which measures market concentration by taking the sum of the squared terms of the market shares of individual firms indexed with i, $s_i \in [0, 1]$. The market shares of domestic credit institutions refer to their shares in aggregate assets. The HHI ranges from $1/N$ for perfect competition to one for monopoly. It is also common in the literature to denote s_i in percentages, $s_i \in [0, 100]$, in which case the HHI can range from 0 to 10,000. There is also a normalised version of the HHI, that takes account of the size of the market and ranges from 0 to 1. It is calculated as $H^\star = \frac{H-(1/N)}{1-(1/N)}$ for $N \geq 1$. We use the standard HHI in our main analysis, but we obtained very similar qualitative results with the normalised HHI.

As an alternative measure for robustness checks, we use the *concentration ratio*,

$$CRn = \sum_{j=1}^{n} s_j \tag{2}$$

which shows the combined market share of the n largest firms by their total assets, with j ranking firms by their market share in descending order. The ratio ranges from n/N for perfect competition to one for monopoly. We specifically consider the total market share of the five largest credit institutions, $CR5$.

3 Data

We obtained the d-SRI data series from the authors of Lang et al. (2019), while all the other data series used here are available on the ECB website. The combined dataset is an unbalanced panel of 20 European countries, where the selection of countries was based on data availability and country specific considerations. We had to exclude Denmark for example, because its time series for the Herfindahl-Hirschman index of credit institutions is too short.

The dataset contains countries from Western Europe and Central and Eastern Europe. As well as differing in their market structure (Uhde & Heimeshoff, 2009), countries from the two regions also differ for their systemic risk and data availability. The Baltic countries in the Central and Eastern European sample for instance are textbook examples of highly concentrated credit markets. Therefore we analyse the two country groups jointly but also split them up to understand the sample-specific dynamics.

The data span from the fourth quarter of 1997 to the first quarter of 2020. The build-up of systemic risk in the run-up to the global financial crisis was a unique event in our dataset. In the post-crisis market environment, strategic realignments and changes in the regulatory framework had an impact on the market structure of credit institutions. To see whether the market structure changed after the financial crisis as bank mergers and changes in regulations led to market consolidation, we split the sample into two subperiods. We analyse the full dataset first, but then proceed by analysing the pre-crisis and post-crisis periods separately. The first part, labelled pre-crisis, contains observations from the fourth quarter of 1997 to the fourth quarter of 2007, capturing the dynamics before the GFC. We limit this sample to Western European (WE) countries only as there are very few observations available for the Central and Eastern European (CEE) countries in this period. The second part, labelled post-crisis, contains observations from the first quarter of 2008 to the first quarter of 2020 and covers both WE and CEE countries. Country-level data coverage for our core variables can be found in Table A.1 in Appendix A.

The top panel of Figure 1 shows the regional averages for the Systemic Risk Indicator (SRI) and the Country-Level Index of Financial Stress (CLIFS). The build-up of systemic risk is clearly visible in both samples, though the increase in systemic risk was much larger in the Central and Eastern European countries. The mean level of systemic risk started to increase three to four years before the onset of the GFC. Even though we do not observe data for the CEE countries before 2008, we can see that the systemic risk that was measured was at least twice as large in the CEE sample as it was in the WE sample at the start of the second subperiod. The

CLIFS as a financial stress indicator peaks in the fourth quarter of 2008 to the second quarter of 2009, making it a lagging indicator for that crisis episode. The unwinding of credit, the real estate market, and current account balances led to a rapid decline in the SRI indicator, in both WE and CEE alike.

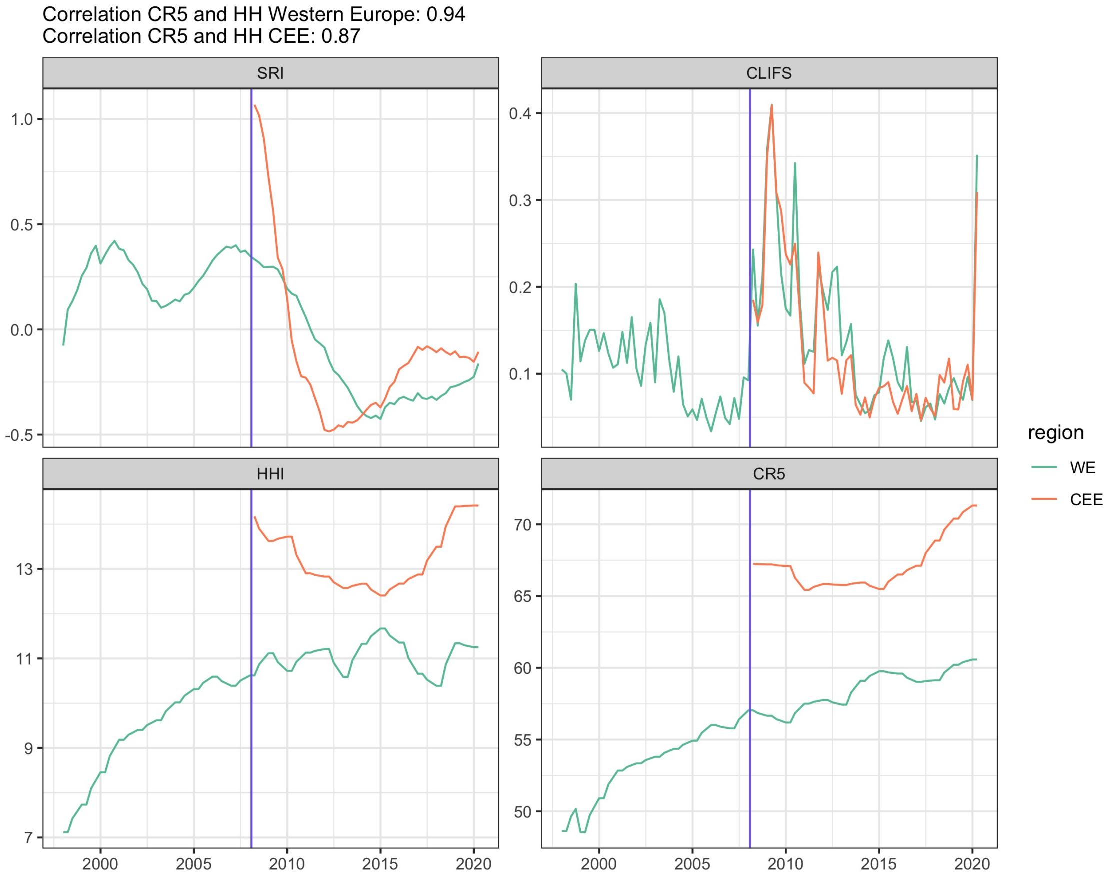

Figure 1: Risk and concentration indexes: regional averages

The bottom panels of Figure 1 show the evolution of the Herfindahl-Hirschman index[4] and the concentration ratio of the five largest banks (CR5). The HHI in the sample of Western European countries increased gradually until 2008 and then settled at around 11. At least for our sample, there was no massive consolidation during the recovery phase of the financial crisis that would have caused the Herfindahl-Hirschman index to rise. The bottom right panel shows that the ratio of asset concentration increased during the sample period. Market concentration, measured by either the HHI or the CR5, has always been higher in Central and Eastern European countries, and highest in Estonia. The slight decrease that followed the crisis ended in 2015 and market concentration has been increasing in Central and

[4]In the following sections, we always refer to HHI values scaled by 100.

Eastern European countries from then to the end of our sample period.

The summary statistics also show that the concentration of credit institutions varies greatly across Western European countries. Some countries, such as Germany, have very low values for market concentration, indicated by a minimum HHI value of 1.14 in the pre-crisis period. Other countries, such as Finland, have a relatively concentrated banking sector.

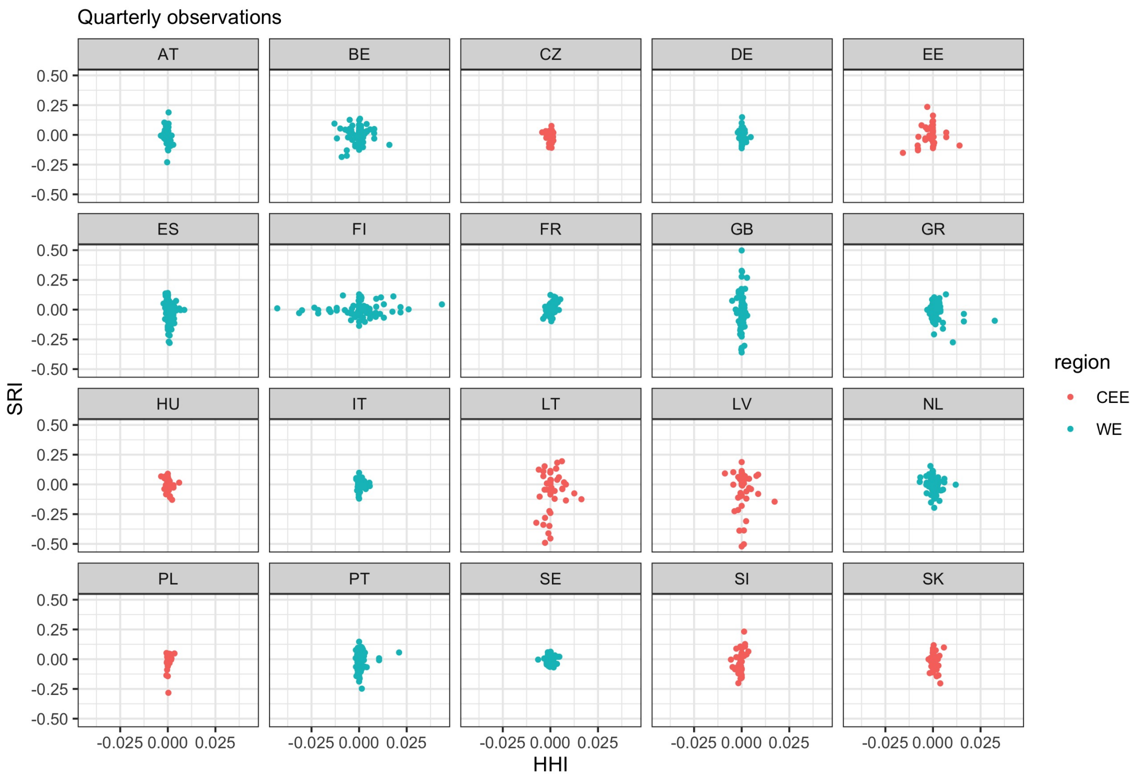

Figure 2: Relationship between SRI and HHI: quarterly changes

Notes: The reference period is the full period for WE countries and the post-crisis period for CEE countries.

The HHI is a slow-moving variable. To visualise changes over time we plot the first difference of the HHI and the first difference of the SRI. Figure 2 shows that market concentration measured by the HHI has hardly changed over time in most countries. One notable exception is Finland where there were larger structural changes in the banking sector. Most of the values in the scatterplot are centred around the zero intercept, which makes it more complicated to identify the possible effects that market structure may have on systemic risk.

Figure 3 shows the quarterly changes of the HHI and the SRI separately for the two subperiods. The left panel shows the results for the pre-crisis period for Western Europe. While the SRI shows some variation in the run-up to the financial crisis, there is little change in the market structure. The sample for the post-crisis period sample in the right panel, covers both Western European countries and Central and

Eastern European countries. More variation is visible for the HHI in the post-crisis sample. Note also that changes in the market structure might be endogenous, so any relationship that there may be could be non-causal. It is still difficult to detect a linear or potentially non-linear relationship between the HHI and the SRI, so we test formally the presence of the relationship by estimating an econometric model.

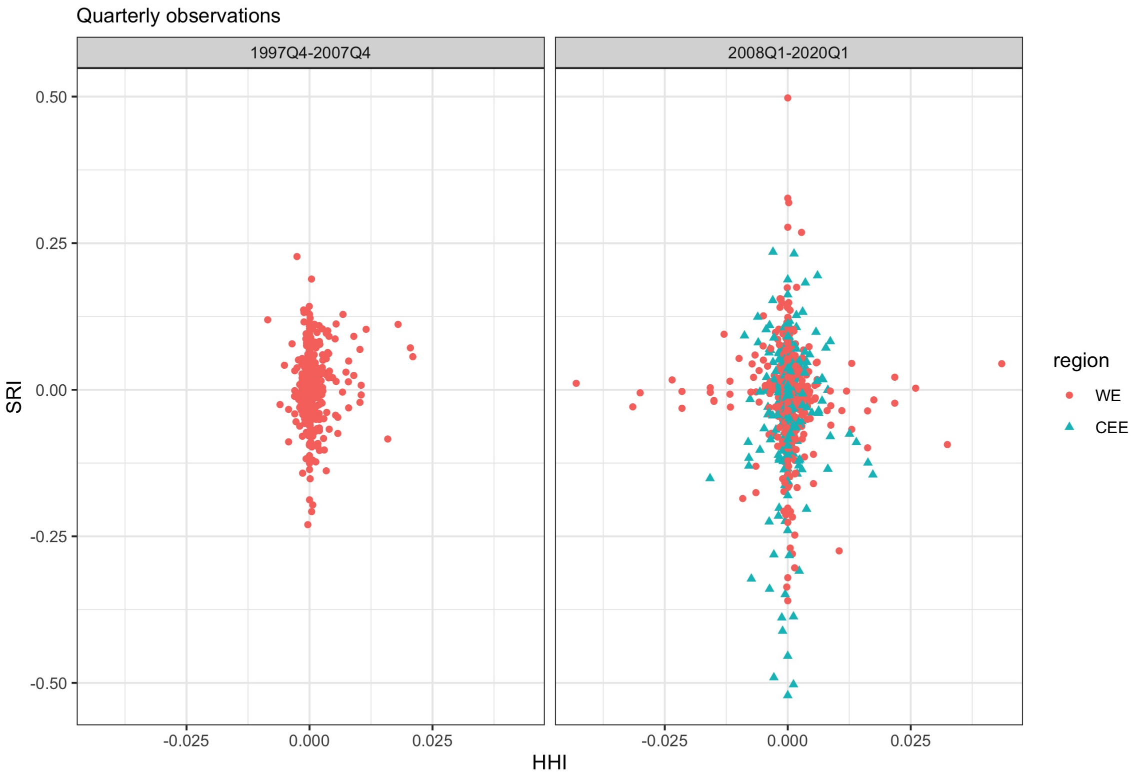

Figure 3: Relationship between SRI and HHI: quarterly changes in the pre-crisis and post-crisis periods

Tables A.2 and A.3 in Appendix A provide further summary statistics separately for Western European and Central and Eastern European countries.

4 Estimation methods

To assess whether market concentration may influence systemic risk we use two types of empirical approach with static panel data models and local projection models.

4.1 Static panel data model

Several papers analyse the potential trade-off between market concentration and financial stability using a non-linear specification. Martinez-Miera and Repullo (2010) point out that nonlinear effects between the banking sector market structure may exist, particularly for market entry conditions and financial risk in the banking sector. Following those micro-theoretical predictions, we construct an empirical model that takes a potential nonlinear relationship between a country-specific banking sector and country-specific system risk into account.

We start with a simple model specification and estimate the following fixed-effects model:

$$SysRisk_{it} = \beta_1 Conc_{it-1} + \beta_2 Conc^2_{it-1} + \beta_3 \Delta RGDP_{it-1} + \mu_i + \tau_y + \epsilon_{it} \qquad (3)$$

where i denotes the country and t indicates the time period from the fourth quarter of 1997 to the first quarter of 2020. $SysRisk_{it}$ denotes the measure or components of systemic risk. In the first specification, we use the composite d-SRI, and subsequently consider its standardised subcomponents separately. As a robustness exercise we also regress an alternative systemic risk indicator (CLIFS) on the explanatory variables. The variable $Conc_{it-1}$ represents a credit market concentration measure, either the Herfindahl-Hirschman Index (HHI) or the asset concentration ratio (CR5). We control for the business cycle by including the annual growth rate of real GDP, denoted by $\Delta RGDP_{it-1}$. μ_i denotes country fixed effects, which capture time invariant country-specific dynamics. τ_y denote yearly dummies that capture unobserved aggregate shocks that are common to all the countries in the sample, among others the macro-prudential policies that have affected all sample countries. To determine the appropriate lag length in the baseline specification, we use model comparisons based on the information criterion.

4.2 Local projection method

As the effects of changes in market concentration are expected to evolve over time, their dynamics cannot be captured by static panel data models. This means that the FE model only allows us to capture the short-term effects. In consequence, we complement the analysis using the local project method (LPM) introduced by Jordà (2005) and employed in many research papers.

The LPM allows us to estimate the cumulative response of systemic risk to a rise in the market concentration over a longer time span. We estimate the following model:

$$\begin{aligned}\Delta_h SysRisk_{it+h} =& \sum_{l=0}^{L} \Gamma_{h,l} Conc_{it-l} + \sum_{l=0}^{L} \Lambda_{h,l} Conc^2_{it-l} + \\ &+ \sum_{l=1}^{L} P_{h,l} SysRisk_{it-l} + \sum_{l=0}^{L} \Pi_{h,l} X_{it-l} + \mu_{h,i} + \tau_{h,y} + u_{it+h}\end{aligned} \tag{4}$$

where $\Delta_h SysRisk_{it+h} = SysRisk_{it+h} - SysRisk_{it}$ denotes the cumulative response of systemic risk with the projection horizon $h = 1, .., H$ up to 16 quarters. The model includes contemporaneous regressors and their lags $l = 1, .., L$ for four quarters. As the SRI is an indicator constructed from growth rates or changes in subcomponents (see Table 1) and it fluctuates around zero, the systemic risk indicator is in levels on the right hand side of the equation.[5] This implies that we control for the previous *levels* of systemic risk when estimating the response for market concentration.[6]

Market concentration ($Conc$) is a slow-moving variable and we are interested in the response of systemic risk to a rise in concentration, which is why the variable is in levels in eq. 4. Like in the FE model, the power term of concentration ($Conc^2$) allows a non-linear relationship between market concentration and systemic risk. As an additional control variable (X) we use the real GDP growth rate. Both yearly and country fixed-effects are included in the model. We estimate the response of the SRI to a rise in the HHI or in the CR5. We also estimate the model using an alternative risk indicator (CLIFS) as a dependent variable and compare the results.

The local projection impulse responses are computed from the sequence of coefficients $\{\Gamma_h,\ \Lambda_h\}$ that are obtained from the regressions for each time horizon $h = 1, 2..., 16$. The LPM is a parsimonious alternative to unrestricted VAR models as only one equation with the focus variable for systemic risk is estimated, instead of a system of equations. As shocks from a concentration measure are not explicitly identified, the model does not estimate the causal effects of market concentration on systemic risk. The estimations show how systemic risk evolves after a rise in market concentration when the previous movements of systemic risk, market concentration and the economic cycle are taken into account.

[5] Similarly, the CLIFS is a composite measure of standardized subindicators and it is computed as a stationary variable (Duprey et al., 2015).

[6] An alternative model to estimate is a model with the dependant variable in levels $SysRisk_{it+h}$ while the contemporaneous $SysRisk_{it}$ is added as a regressor. The IRFs of the two models are very similar.

Table 2: Fixed effects estimates with SRI and HHI

	Full sample		Pre-crisis	Post-crisis		
	WE + CEE	WE	WE	WE + CEE	WE	CEE
HH_Lag1	−0.176***	−0.199***	−0.077	−0.110*	−0.153**	0.239
	(0.043)	(0.041)	(0.071)	(0.050)	(0.045)	(0.127)
HHsq_Lag1	0.003**	0.004***	0.002	0.002	0.003**	−0.006
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
GDP	−0.287	0.899	0.612	−0.966	−0.133	−0.528
	(0.717)	(1.472)	(2.170)	(0.554)	(1.021)	(0.701)
Num.Obs.	1380	1012	424	956	588	368
R2	0.585	0.638	0.759	0.542	0.643	0.644
R2 Adj.	0.571	0.625	0.745	0.525	0.626	0.622
R2 Within	0.198	0.309	0.032	0.095	0.242	0.107
FE: Country & Time	X	X	X	X	X	X

Pre-crisis: 1997Q4-2007Q4; Post-crisis: 2008Q1-2020Q1
Std. Error in parenthesis | Robust Std. Errors
CEE: CZ, EE, HU, LV, LT, PL, SK, SI
WE: AT, BE, DE, ES, FI, FR, GB, GR, IT, NL, PT, SE
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5 Results

5.1 Fixed effects estimates

We present the estimates from the fixed effects model first. The main focus is on the effect of the Herfindahl-Hirschman index (HHI) on systemic risk by sample period and region. We focus on the HHI as it captures broader market structures than the CR5, though the correlation between them is strong, as shown in Figure 1.

Table 2 shows the results for the specification where the HHI is used as a measure of market concentration. The first column shows the results for the full period from the fourth quarter of 1997 to the first quarter of 2020, including observations for both Western Europe and Central and Eastern Europe. As the observations for Central and Eastern Europe are only available for the later sub-period, the second column also shows the results for the full period for Western Europe alone.

As discussed in Section 3, we observe only one extreme systemic risk event in our dataset, with the SRI peaking before the crisis. We have also argued that changes in the market structure might be endogenous in the post-crisis period. Furthermore, there might be different mechanisms at work in the WE and CEE countries given their different average levels of market concentration and the different levels of the systemic risk indicator. In consequence, we split the sample between the pre-crisis and post-crisis periods and further between Western European and Central and Eastern European countries.

There is evidence of a U-shaped relationship in the full sample period and in the post-crisis period for Western Europe, though the size of the effect for the quadratic term is small. This result is in line with the existing literature. The estimated coefficient of -0.199 for HHI and 0.004 for HHI^2 imply that an increase of one standard deviation in the HHI from its mean value is associated with a decline in systemic risk of around 0.32 units in the full sample of Western European countries.[7] In the post-crisis period, a similar rise in the HHI is associated with a decline of around 0.25 in systemic risk.

This means that market concentration enhances systemic stability, up to a certain turning point. For Western Europe this turning point is around $HHI = 30$ in the post-crisis period.[8] Most countries in Western Europe have a market concentration far below that level in the post-crisis sample.[9] Only Finland has an average value for the HHI that exceeds that level in the post-crisis period, meaning that a reduction in its market concentration would lower systemic risk in Finland. For all the other countries, an increase in the HHI would on average lower systemic risk.

Figure 4 illustrates the non-linear relationship between systemic risk and market concentration, showing the predicted values of the SRI at different levels of the HHI.[10] We focus on the Western European sample as it allows the pre- and post-crisis period to be compared. The vertical dashed black line in the figure shows the mean HHI value in the Western European sample.

The left panel of Figure 4 shows that the U-shaped relationship is not statistically significant in the pre-crisis period, as the predicted values of the SRI for different values of the concentration index are approximately linear. The right panel shows there to be a U-shaped relationship between systemic risk and market concentration in the post-crisis period, but the uncertainty around the point estimates is quite large. The systemic risk is highest at very low levels of market concentration, then decreases until a concentration level of approximately 30. After that point the marginal effect of the HHI turns positive, meaning that concentration increasing beyond that point starts to increase the systemic risk again.

To provide local context, the range of the HHI in Estonia is between 24 and 41, and its average value of 32 is the highest in the whole sample. The country with the highest concentration in the WE sample is Finland, with an HHI of 38-39

[7] The within standard deviation is 2.775 and the mean HHI is 10.3.

[8] The 95% confidence interval for the turning point ranges from 26 to 33. The interval for Western Europe in the whole period ranges from 25 to 30, while the turning point is estimated with very low precision in the pre-crisis period.

[9] Large countries in Western Europe in particular have very low concentration in the banking sector, with average HHI values ranging from only 2 in Germany to 6 in France.

[10] The predictions are estimated at the sample means of the control variables, implying that the differences in the predictions of the SRI across HHI levels originate only from different levels of market concentration.

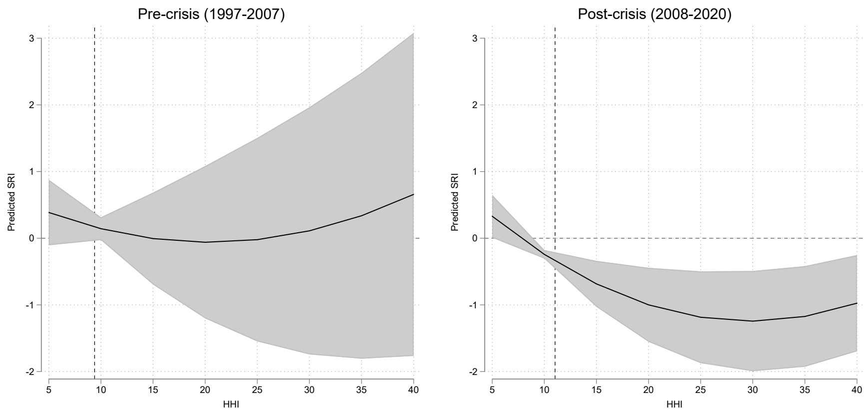

Figure 4: *The predicted values of SRI at different concentration levels*

Notes: The predictions are calculated from the model in column 3 and column 5 in Table 2 . For the prediction mean values of other control variables are used.

between the fourth quarter of 2010 and the first quarter of 2012. This means that credit market concentration in Estonia exceeds the upper tail of the WE sample and assessing the effect of market concentration using the estimates for WE countries would imply that having lower concentration should lower systemic risk.

Comparing the regression results for the Western European sample with the results for all the countries and for the CEE countries shows that the WE countries drive the U-shaped relationship. The U-shaped relationship is stronger for Western Europe both in the full period and in the post-crisis period. We do not obtain statistically significant results for Western Europe in the pre-crisis period though.

The results for the Western European sample in the post-crisis period are not too far away from the results for Western Europe in the full period, but this might be partly because most of the observations come from the post-crisis period. The dynamics seem therefore to be driven by the post-crisis period. It may be noted however that the specification for the post-crisis period might suffer from some endogeneity bias, as the systemic risk episodes of the financial crisis might have initiated changes in the structure of the banking sector.

Only the post-crisis data are considered in the empirical estimation for the Central and Eastern European sample. We do not find a statistically significant relationship between the HHI and the SRI.

Table 3 shows the results with the CR5 ratio used as a proxy for the market structure. We find no evidence of a relationship between the CR5 indicator and the SRI in any of the periods or subsamples. There are various possible explanations for why the results using the HHI differ from those with the CR5 index. Even though the two indicators are highly correlated, it is possible that they capture market structures in different ways.

Table 3: Fixed effects estimates with SRI and CR5

	Full sample		Pre-crisis	Post-crisis		
	WE + CEE	WE	WE	WE + CEE	WE	CEE
CR5_Lag1	−0.010	−0.013	0.005	0.001	−0.007	−0.035
	(0.025)	(0.025)	(0.051)	(0.032)	(0.026)	(0.064)
CR5sq_Lag1	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP growth	−0.286	0.811	0.424	−0.703	0.437	−1.251
	(0.709)	(1.499)	(2.375)	(0.486)	(1.025)	(0.552)
Num.Obs.	1376	1008	420	956	588	368
R2	0.596	0.642	0.767	0.559	0.654	0.607
R2 Adj.	0.583	0.629	0.754	0.543	0.638	0.582
R2 Within	0.217	0.312	0.056	0.128	0.265	0.014
FE: Country & Time	X	X	X	X	X	X

Pre-crisis: 1997Q4-2007Q4; Post-crisis: 2008Q1-2020Q1
Std. Error in parenthesis | Robust Std. Errors
CEE: CZ, EE, HU, LV, LT, PL, SK, SI
WE: AT, BE, DE, ES, FI, FR, GB, GR, IT, NL, PT, SE
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The SRI indicator is constructed from six subcomponents, and credit market concentration is expected to be closer to the credit related subcomponents that are directly affected by the business operations of banks. Therefore we regress the credit-related subcomponents of the SRI on the explanatory variables. The focus is on Western Europe in the full sample period.[11] Table 4 shows the results, with the first column repeating the results for the SRI aggregate measure for ease of comparison.

The estimated model points to statistically significant U-shaped relationships for the credit variables. This is in line with the empirical observation that changes in the structure of the banking sector affect the ability of banks to perform their core function of credit intermediation. There is a strong linear relationship between the lagged HHI and the two-year change in the bank credit-to-GDP ratio. Larger growth in credit in the economy is commonly perceived to be one of the leading indicators of financial instability.

The results for the two-year growth rate of the real total credit sub-index further support the finding that market concentration improves financial stability. This sub-index also reacts inversely to changes in the lagged HHI, indicating that higher market concentration slows down the growth of real total credit. Note that, especially in the post-crisis period, a combination of factors such as macroeconomic

[11] Detailed estimates for all the subcomponents in each subperiod are available upon request.

Table 4: Fixed effects results with SRI subcomponents and HHI for Western Europe

	SRI	BCred_GDP_d8	TotCred_g8	Debt_Serv_d8
HH_Lag1	−0.199***	−0.352**	−0.302**	−0.197**
	(0.041)	(0.093)	(0.085)	(0.052)
HHsq_Lag1	0.004***	0.006**	0.006**	0.004**
	(0.001)	(0.002)	(0.001)	(0.001)
GDP growth	0.899	−1.434	12.685**	−7.304*
	(1.472)	(3.718)	(3.568)	(2.610)
Num.Obs.	1012	1068	1068	1068
R2	0.638	0.553	0.676	0.542
R2 Adj.	0.625	0.538	0.665	0.526
R2 Within	0.309	0.229	0.291	0.106
FE: Country & Time	X	X	X	X

Std. Error in parenthesis | Clustered Std. Errors

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes:

[1] BCred_GDP_d8=two-year change in the bank credit-to-GDP ratio; TotCred_g8=two-year growth rate of real total credit; Debt_Serv_d8=two year growth rate in the debt-service ratio;

[2] Standardised subcomponents: $\tilde{x}^j_{i,t} = (x^j_{i,t} - x^j_M)/x^j_{SD}$.

uncertainty, the stock of non-performing loans, and the adoption of global regulatory reforms affected the credit supply too, and it is not straightforward to isolate individual effects.

Finally, the two-year growth rate in the debt-service ratio is also negatively related to the lagged HHI. As well as moderating debt increases, in both relative and absolute terms, higher market concentration also reduces the increases in the relative interest burden. While this primarily and directly follows from the dynamics in aggregate debt levels, there could also be additional secondary effects because of market concentration potentially influencing the interest environment in the commercial banking sector.

We perform a range of robustness tests. We first use the normalised Herfindahl-Hirschman index in all the regressions. The results are similar to our baseline results with the standard HHI. We also use the CLIFS as an alternative indicator for systemic risk, and the results with the HHI are shown in Table B.1 and those with the CR5 in Table B.2. The CLIFS does not seem to be affected by either measure of credit market concentration, as we find almost no significant results for most specifications and the effect size of the banking concentration treatment is very small. It may be recalled that the CLIFS is based on six measures of financial stress that are mainly market-based, and it is unlikely that those fast moving financial sector variables are closely related to the slow moving measures of credit market concentration.

5.2 Local projections estimates

We further investigate the possible dynamic effects of the market concentration on systemic risk. If the effect is slow and appears over a longer time horizon, the FE model is not able to capture those relationships fully. We estimate impulse response functions (IRFs) with the local projection method that is given in eq. 4. The IRFs show the cumulative response of systemic risk to an increase of one standard deviation in market concentration, controlling for the changes in market concentration in the previous four quarters.[12]

The LPM requires a relatively long sample period to estimate robust IRFs up to 16 quarters forward, so we estimate the model using the full sample from the fourth quarter of 1997 to the first quarter of 2020. However, as we are interested in how credit market concentration contributed to the accumulation of systemic risk, we also provide results for the pre-crisis period. The sample of CEE countries is considerably shorter and covers only the post-crisis period, when the market restructuring might have been induced by the global financial crisis. We therefore focus on the WE countries.

The IRFs at the median concentration level are shown in Figure 5. The median values of the HHI and CR5 are 7.85 and 54.8, and the median HHI corresponds to the concentration level in Sweden between the fourth quarter of 2018 and the first quarter of 2019.

A negative response from systemic risk to a rise in the HHI is found with the full period sample in the upper left panel, while the CR5 provides less clear results, confirming the FE results from the previous subsection. The decline in systemic risk is quite persistent, showing no signs of fading out in four years after an increase in market concentration, and staying at the new level.[13]

The response seems to be positive but imprecisely estimated for the pre-crisis period, shown in the lower panel of Figure 5. This suggests that the negative effect for the full period might be driven by the dynamics after the GFC, as was also suggested by the FE results in the previous subsection. Additional estimations for the second sub-period from the first quarter of 2008 to the first quarter of 2020 show the SRI to have a negative response, but the results are not statistically significant and not reported here. One apparent reason for the estimates being imprecise is

[12] We also estimated models with more lags and their IRFs were very similar.

[13] We obtain very similar results when we estimate the alternative specification of the model as explained in Section 4.2, confirming that the results are robust to the alternative specifications.

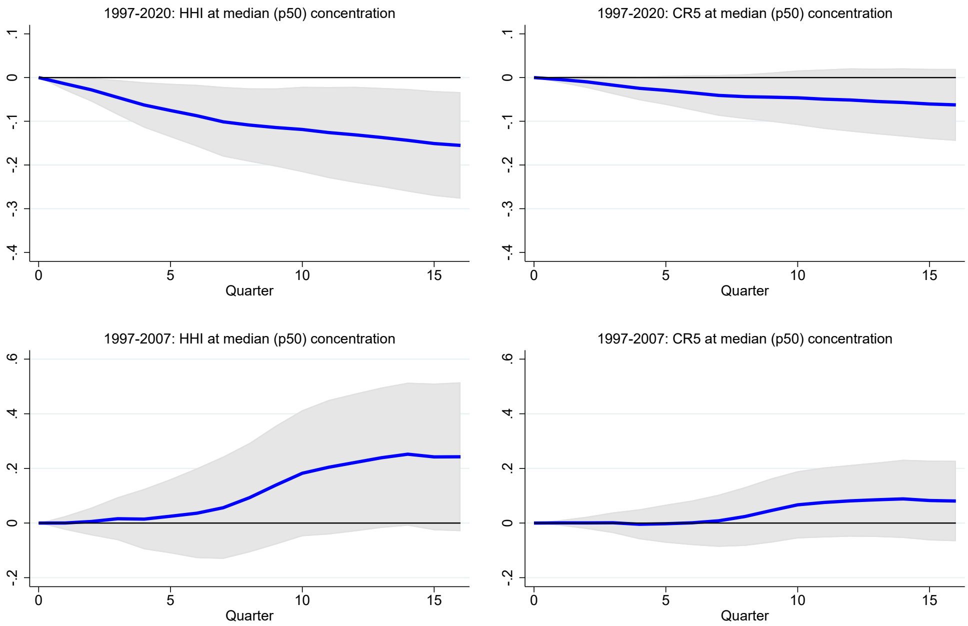

Figure 5: *LPM estimates for Western Europe: response of SRI to a 1SD change in market concentration*

Notes: The model includes GDP growth and yearly time dummies as control variables, lag length of four quarters, 90% confidence intervals are shown.

that the time period is short. Robust results would need longer time series with additional accumulation and de-accumulation episodes of systemic risk.

When the CLIFS is used to measure systemic risk, the general pattern in the response of CLIFS to a rise in market concentration is similar to the response of SRI, as the response is negative in the full period, as shown in the upper panel of Figure 6, and is positive in the pre-crisis period, shown in the lower panel of Figure 6. However, the results are imprecisely estimated except for the response of the CLIFS to a rise in the CR5 in the pre-crisis period, which is clearly positive after five quarters. It is possible that the FE results did not identify any relationship between the CLIFS and market concentration, as the significant effect seems to appear only after quite a few quarters.

As already mentioned in the previous subsection, the HHI apparently contains more information about the SRI than the CR5 does, though we might expect that aggregate systemic risk would depend more on the largest credit institutions. Rapid digitalisation in the past decade has however made it easier for fintechs to enter the banking market (Feyen et al., 2021). Even if the newcomers are small, they may become key players in a specific market segment that may increase systemic risk.

As the dynamics may vary at different levels of concentration, we compare the responses of the SRI at the low and high levels of market concentration observed for

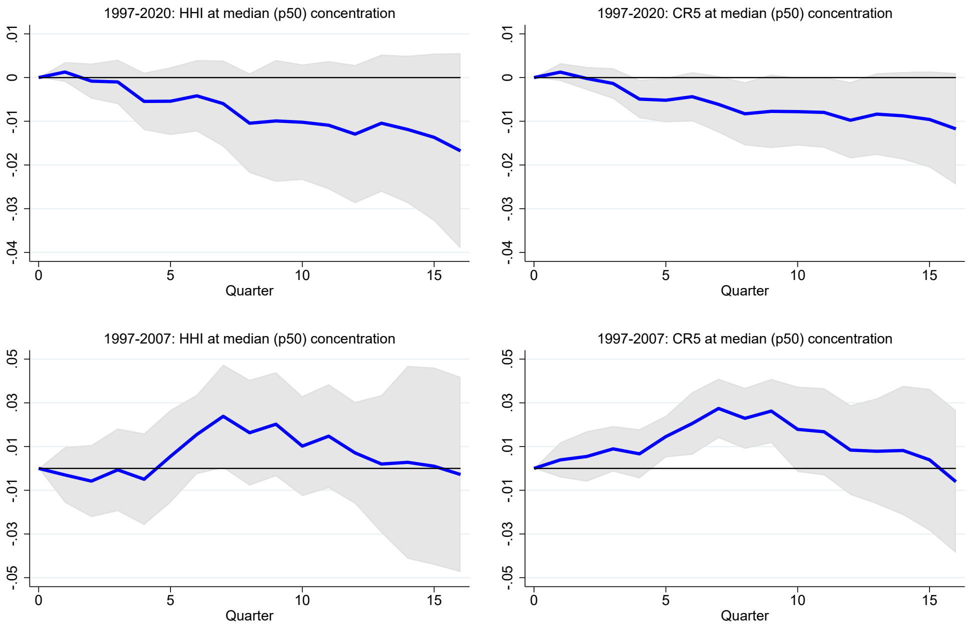

Figure 6: *LPM estimates for Western Europe: response of CLIFS to a 1SD change in market concentration*

Notes: The model includes GDP growth and yearly time dummies as control variables, lag length of four quarters, 90% confidence intervals are shown.

the WE countries. The low level is set at the 10th percentile, equal to 2.65, which corresponds to the market concentration in Great Britain from the fourth quarter of 2000 to the first quarter of 2001 and in Italy in the second quarter of 2002, and the high level is set at the 90th percentile, equal to 21.5, which corresponds to the concentration level in Finland from the fourth quarter of 1997 to the first quarter of 1998 and in the Netherlands in the third quarter of 2012.

The response of the SRI to a rise in the HHI when market concentration is low is shown in the left panel of Figure 7 and the response when the concentration is high is in the right panel of the same figure. The IRFs reveal that the negative response from the SRI is found only at the low level of market concentration, while there is no statistically significant response when the concentration is high. For the pre-crisis period, when market concentration was already at high levels, there seems to be a slowly emerging positive response from the SRI to a rise in market concentration, as the 90% confidence intervals are above the zero level after 13 quarters.

The normalised HHI, which takes the number of credit institutions in the market into account, provides very similar results to those from the standard HHI. We also investigated whether the effect is different during periods of high systemic by estimating IRFs with quantile regressions, but the estimations did not provide any additional robust insights.

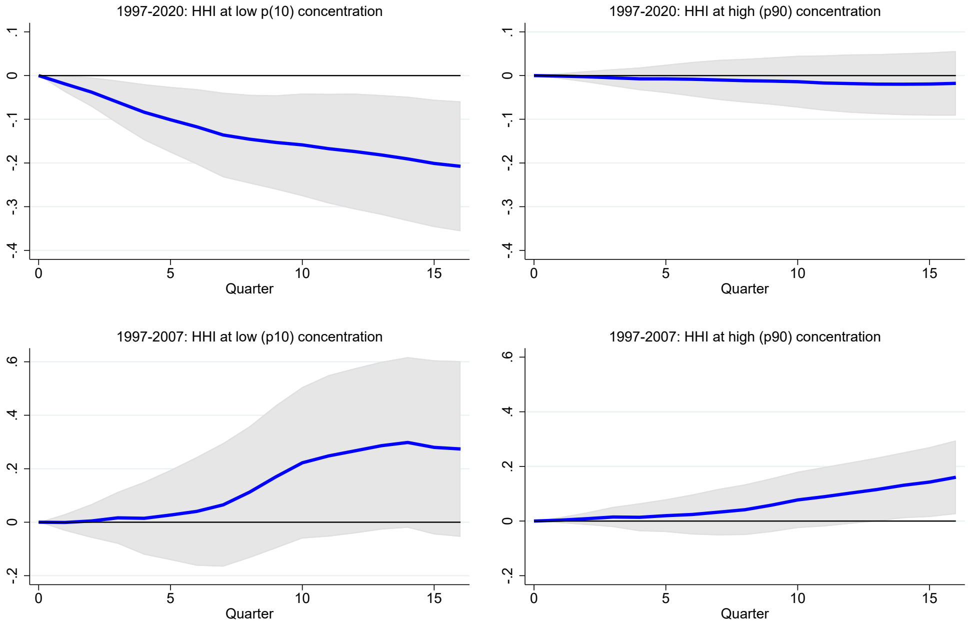

Figure 7: *LPM estimates for Western Europe at different concentration levels: response of SRI to a 1SD change in market concentration*

Notes: The model includes GDP growth and yearly time dummies as control variables, lag length of four quarters, 90% confidence intervals are shown.

Like we did with the FE estimations, we take an additional look at the credit-related subcomponents of the SRI. As we are interested in the period when systemic risk was accumulating, and as the estimations with the SRI hinted that the effect might be positive, we look at the dynamics of the standardised SRI subcomponents from the fourth quarter of 1997 to the foruth quarter of 2007. The responses of the subcomponents are estimated with eq. 4, with the SRI replaced by each subcomponent in turn.

In Figure 8 we show the estimated effect of the credit-to-GDP ratio, of credit growth, and of the debt-service-ratio to a rise in the level of market concentration. The credit-to-GDP ratio shows a clear positive response 10 quarters after a rise in market concentration, reaching its peak after 14 quarters. This implies that higher concentration is only followed by higher indebtedness after two-three years, and the effect is not present earlier. This subcomponent has the largest weight of the composite SRI at 36%. That the responses of the other credit-related subcomponents are not significant explains why the response of the composite SRI is not as clear as that of the credit-to-GDP subcomponent.

The upshot of the LPM estimations is that the response of systemic risk evolves over time as the HHI is a slow moving variable and the SRI is constructed from growth rates over two or three years or from changes in the subcomponents. The

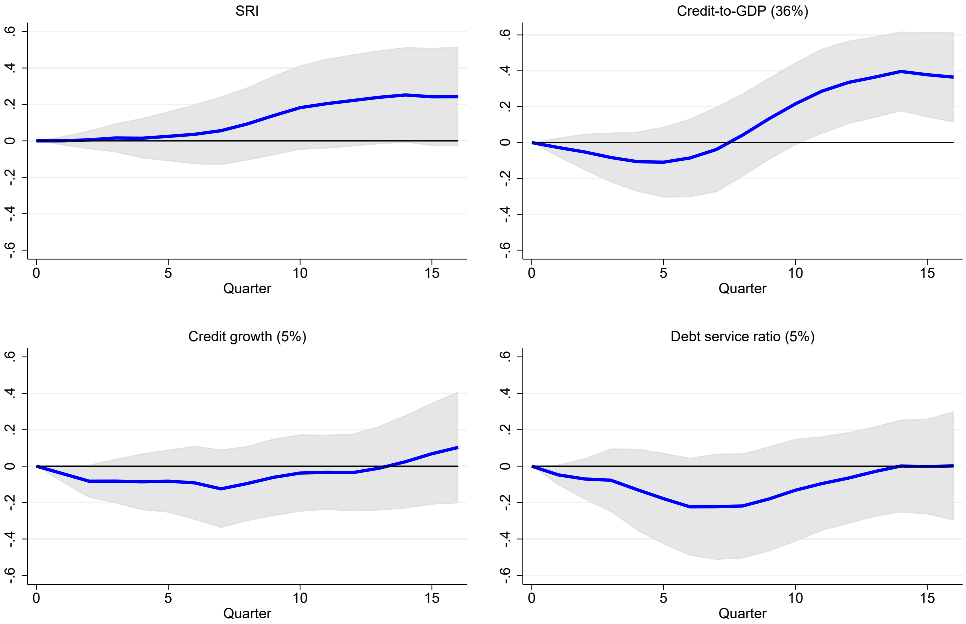

Figure 8: *LPM estimates with SRI subcomponents for Western Europe in the pre-crisis period at median (p50) concentration level.*

Notes: The model includes GDP growth and yearly time dummies as control variables, lag length of four quarters, 90% confidence intervals are shown.

relationship between systemic risk and market concentration seems to be different in the period of risk accumulation and in the aftermath of the crisis. This makes it challenging to provide any robust answer about the relationship between market concentration and systemic risk when only one extreme episode of risk accumulation and de-accumulation is covered. The initial estimations suggest that although a rise in market concentration is followed by a decline in systemic risk over a longer period, market concentration might have supported the accumulation of risks through the rise in the credit-to-GDP ratio in the pre-crisis period.

6 Conclusions

A number of studies have investigated the relationship between banking sector concentration or competition and financial risk at the level of banks. This paper is the first attempt to assess empirically the relationship between the market concentration of credit institutions and country-level systemic risk, using a novel domestic systemic risk indicator, or d-SRI, from the European Central Bank for a set of European countries. We consider two alternative measures of credit market concentration, the Herfindahl-Hirschman index (HHI) and the share of total assets held by the five largest credit institutions (CR5).

We first estimate a static fixed-effects model to gauge how the level of banking concentration affects systemic risk in the short term. We then estimate the dynamic relationship between an index of market concentration and the systemic risk indicator over a longer period using the local projections method. Both estimation strategies contain a nonlinear component to capture possible U-shaped relationships.

The empirical results from the fixed-effects model show a weakly U-shaped relationship between the HHI and the systemic risk indicator, but no link between the CR5 and the SRI. We observe a statistically significant effect for the full period sample from the fourth quarter of 1997 to the first quarter of 2020 and for the post-crisis period since 2008, but not for the pre-crisis period up to 2007. At low levels of market concentration with a HHI of up to around 25, an increase in market concentration reduces systemic risk, while at higher levels the relationship between the HHI and the systemic risk indicator turns negative again. Cumulative estimates with the local projection method reveal that the negative response of the SRI to a rise in market concentration is persistent and does not fade out in four years, and that the negative response is only significant at low or median levels of market concentration.

These results hold mostly for the post-crisis period, and we do not find a stable relationship in the pre-crisis period. It may be noted that the relationship between market concentration and systemic risk in the post-crisis period might be subject to some endogenous effects. Local impulse responses for the pre-crisis period show that an increase in the HHI has a slowly emerging positive effect on systemic risk at high levels of concentration, as it only appears after three years.

Additionally, the fixed-effects estimates show a statistically significant relationship between the lagged HHI and credit-related subcomponents of the SRI in the full sample period. Nonlinear effects are again present, but weak, hinting that an increase in market concentration has a positive effect on financial stability by restricting credit growth. The LPM estimations reveal that when systemic risk was building up during the pre-crisis period, a rise in market concentration supported a rise in the credit-to-GDP ratio, which is the largest subcomponent of the SRI at 36% of it.

Our results suggest that the regulators in charge of monitoring the banking industry and developments in systemic risk need to pay attention to changes in the structure of the banking sector. Increased banking sector concentration can be cautiously promoted in most Western European countries as it seems to reduce systemic risks rather than increasing them. At the same time, mergers and acquisitions need to be monitored and possibly prevented in highly concentrated banking markets, at least for the largest banks.

The analysis for Central and Eastern Europe was constrained by data limitations. Future research could focus on that set of countries, given that banking is more concentrated in CEE countries. Understanding the relationship between market concentration and systemic risk is especially important for the Baltic countries, given their high degree of banking sector concentration and their rapid accumulation of systemic risk before the global financial crisis.

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Appendixes

Appendix A Sample and descriptive statistics

Table A.1: The start of data series by country

Country	SRI	HHI	CR5	CLIFS
AT	2002.1	1997.4	1997.4	1997.1
BE	2000.4	1997.4	1997.4	1997.1
DE	1997.1	1997.4	1997.4	1997.1
ES	1997.1	1997.4	1997.4	1997.1
FI	1997.1	1997.4	1997.4	1997.1
FR	1999.4	1997.4	1997.4	1997.1
GB	1999.4	1997.4	1997.4	1997.1
GR	2000.1	1997.4	1997.4	1997.1
IT	1997.1	1997.4	1998.4	1997.1
NL	1997.1	1997.4	1997.4	1997.1
PT	1998.1	1997.4	1997.4	1997.1
SE	1999.4	1997.4	1997.4	1997.1
CZ	2008.1	2008.1	2008.1	2008.1
EE	2010.1	2008.1	2008.1	2008.1
HU	2008.1	2008.1	2008.1	2008.1
LT	2008.1	2008.1	2008.1	2008.1
LV	2008.1	2008.1	2008.1	2008.1
PL	2009.3	2008.1	2008.1	2008.1
SI	2008.1	2008.1	2008.1	2008.1
SK	2008.1	2008.1	2008.1	2008.1

Table A.2: Summary statistics for Western European countries

		Mean		SD		Min		Max		Missing (%)	
Variable	Mean	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
HH	10.304	9.422	11.043	7.51	8.56	1.14	1.83	31.30	38.80	6.82	0.00
CR5	56.169	53.368	58.493	21.50	20.25	16.68	22.00	90.99	97.35	7.58	0.00
SRI	0.021	0.253	−0.155	0.48	0.44	−0.66	−1.25	1.92	1.55	15.91	0.00
CLIFS	0.124	0.103	0.143	0.07	0.11	0.01	0.02	0.54	0.62	0.00	0.00
BCred_GDP_d8	1.102	2.928	−0.537	3.50	4.43	−3.68	−12.35	17.61	14.46	0.00	0.00
TotCred_g8	3.868	6.720	1.307	4.65	3.66	−2.86	−8.07	20.16	15.92	0.00	0.00
Debt_Serv_d8	0.002	0.004	−0.001	0.01	0.01	−0.02	−0.03	0.04	0.04	0.00	0.00
Prop_Inc_d12	1.224	2.340	0.290	3.74	3.42	−7.00	−9.67	12.00	10.67	6.82	0.00
Equity_g12	−0.092	−0.088	−0.095	0.01	0.00	−0.10	−0.10	−0.02	−0.08	0.00	0.00
CAB	0.263	−0.315	0.724	5.09	4.86	−15.19	−15.61	9.09	10.84	11.17	0.00

Notes:
[1] BCred_GDP_d8=two-year change in the bank credit-to-GDP ratio; TotCred_g8=two-year growth rate of real total credit; Debt_Serv_d8=two year growth rate in the debt-service ratio; Prop_Inc_d12=three-year change in the residential real estate (RRE) price to income ratio; Equity_g12=three-year growth rate of real equity prices; CAB=current account balance.
[2] Pre-crisis from 1997Q4 until 2007Q4; Post-crisis from 2008Q1 until 2020Q1

Table A.3: Summary statistics for Central and Eastern European countries

		Mean	SD	Min	Max	Missing (%)
Variable	Mean	Post	Post	Post	Post	Post
HH	13.230	13.230	6.35	5.59	34.10	0.00
CR5	67.184	67.184	14.81	43.37	95.75	0.00
CLIFS	0.129	0.129	0.12	0.01	0.80	0.00
SRI	−0.135	−0.135	0.49	−1.38	2.24	4.59
BCred_GDP_d8	−0.593	−0.593	4.30	−15.68	11.06	2.04
TotCred_g8	2.663	2.663	6.35	−11.99	35.77	0.00
Debt_Serv_d8	−0.001	−0.001	0.01	−0.03	0.05	1.02
Prop_Inc_d12	−1.087	−1.087	7.30	−27.00	26.67	1.53
Equity_g12	−0.094	−0.094	0.01	−0.10	−0.08	0.00
CAB	−0.849	−0.849	3.91	−19.05	9.38	0.00

Notes:
[1] BCred_GDP_d8=two-year change in the bank credit-to-GDP ratio; TotCred_g8=two-year growth rate of real total credit; Debt_Serv_d8=two year growth rate in the debt-service ratio; Prop_Inc_d12=three-year change in the residential real estate (RRE) price to income ratio; Equity_g12=three-year growth rate of real equity prices; CAB=current account balance.
[2] Pre-crisis from 1997Q4 until 2007Q4; Post-crisis from 2008Q1 until 2020Q1

Appendix B Estimations

Table B.1: Fixed effects estimates with CLIFS and HHI

	Full sample		Pre-crisis	Post-crisis		
	WE + CEE	WE	WE	WE + CEE	WE	CEE
HH_Lag1	0.007*	0.005	0.004	0.005	0.002	0.038**
	(0.003)	(0.003)	(0.004)	(0.005)	(0.004)	(0.010)
HHsq_Lag1	0.000	0.000	0.000*	0.000	0.000	−0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP growth	−0.948***	−1.267***	−1.093*	−0.876***	−1.231***	−0.723*
	(0.171)	(0.193)	(0.403)	(0.187)	(0.244)	(0.235)
Num.Obs.	1452	1068	480	972	588	384
R2	0.481	0.499	0.367	0.508	0.551	0.492
R2 Adj.	0.465	0.482	0.335	0.490	0.530	0.461
R2 Within	0.071	0.080	0.056	0.063	0.068	0.086
FE: Country & Time	X	X	X	X	X	X

Pre-crisis: 1997Q4-2007Q4; Post-crisis: 2008Q1-2020Q1
Std. Error in parenthesis | Robust Std. Errors
CEE: CZ, EE, HU, LV, LT, PL, SK, SI
WE: AT, BE, DE, ES, FI, FR, GB, GR, IT, NL, PT, SE
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.2: Fixed effects estimates with CLIFS and CR5

	Full sample		Pre-crisis	Post-crisis		
	WE + CEE	WE	WE	WE + CEE	WE	CEE
CR5_Lag1	0.001	0.001	0.004	0.001	−0.001	0.028
	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)	(0.013)
CR5sq_Lag1	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP growth	−0.931***	−1.258***	−1.049*	−0.869***	−1.233***	−0.597
	(0.185)	(0.199)	(0.428)	(0.199)	(0.256)	(0.279)
Num.Obs.	1448	1064	476	972	588	384
R2	0.481	0.500	0.359	0.508	0.551	0.488
R2 Adj.	0.464	0.482	0.326	0.490	0.530	0.457
R2 Within	0.070	0.081	0.042	0.062	0.068	0.078
FE: Country & Time	X	X	X	X	X	X

Pre-crisis: 1997Q4-2007Q4; Post-crisis: 2008Q1-2020Q1
Std. Error in parenthesis | Robust Std. Errors
CEE: CZ, EE, HU, LV, LT, PL, SK, SI
WE: AT, BE, DE, ES, FI, FR, GB, GR, IT, NL, PT, SE
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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