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Banking Integration, Bank Stability, and Regulation

Introduction to a Special Issue of the International Journal of Central Banking

The link between banking integration and financial stability has taken center stage in the wake of the current financial crisis. To what extent is the banking system in Europe integrated? What role has the introduction of the common currency played in this context? Are integrated banking markets more vulnerable to contagion and financial instability? Does the fragmented regulatory framework in Europe pose special problems in resolving bank failures? What policy reforms may become necessary? These questions are of considerable policy interest as evidenced by the extensive discussions surrounding the design and implementation of a new regulatory regime and by the increasing attention coming from academia.

This special issue presents five papers that attempt to address these questions from different angles. The papers were presented at the 2nd ZEW Conference on Bank Regulation—Integration and Financial Stability that took place on October 29–30, 2007, at the Centre for European Economic Research (ZEW) in Mannheim, Germany. The conference was organized by Claudia Buch (University of Tübingen), Reint Gropp (European Business School), and Michael Schroeder (ZEW).

In the lead-off paper Massimiliano Affinitọ and Fabio Farabullinị take another look at one possible measure of banking integration: the law of one price. The paper highlights that for tests of the law to be meaningful, one has to carefully control for the characteristics of the bank products under investigation. The paper finds that banking markets continue to be segmented within Europe. The authors attempt to disentangle supply factors in the lack of integration (such as lack of contestability across borders) from demand differences across countries. Only if supply factors were the main reason for the observed violations of the law of one price would there be room for further policy initiatives to foster integration. The results suggest that supply factors continue to be important, although Affinito and Farabullini also find that products with a higher elasticity of demand exhibit less variation in rates across countries.

Matthias Köhler emphasizes national political resistance as an explanation for the relatively low number of cross-border bank mergers in Europe. There is ample anecdotal evidence that political influence may constitute a barrier to the integration of European banking markets, as suggested by numerous recent cases in, for example, Italy and France. Köhler constructs, based on a survey of supervisors in the EU, an index of the transparency of the process governing the approval process for cross-border bank mergers. He finds that the probability that a credit institution will be taken over by a foreign bank is significantly lower if the regulatory process is less transparent, controlling for a host of bank and country characteristics. Interestingly, particularly large banks seem to be less likely to be taken over by foreign credit institutions if merger control lacks procedural transparency, which lends further credence to his results.

Wolf Wagner analyzes from a theoretical viewpoint the question of financial integration and stability, with particular reference to the overall efficiency of bank portfolios from a welfare perspective. The paper emphasizes the role of regulation in a financial system in which the costs of financial stress at institutions are interdependent. The paper shows that there may be externalities arising from banks' portfolio choices. The assets a bank holds on its balance sheet determine not only its own default probability but the default probability of all other banks as well. As banks fail to take this externality sufficiently into account, the equilibrium portfolio allocations in the economy are typically not efficient. Wagner concludes that regulation should explicitly take the correlation of one bank's portfolio with all other banks into account.

The likelihood of cross-border bank contagion within Europe is analyzed in the paper by Reint Gropp, Marco Lo Duca, and Jukka Vesala. The paper employs a new method to estimate the effect of a large decline in the distance to default of banks in one country on the probability of large declines in the distance to default in other countries. The paper finds evidence of significant cross-border contagion among large European banks and no contagion among smaller European banks. This is consistent with a tiered cross-border interbank structure. The results also suggest that contagion increased after the introduction of the euro, suggesting some banking system integration within Europe at least at the level of large listed banks.

The final paper of the issue focuses on the difficulties arising from the particular institutional structure of bank supervision in the EU in the context of the potential recapitalization of a large cross-border bank. Starting from the notion that a recapitalization is efficient if the social benefits exceed the costs, Charles Goodhart and Dirk Schoenmaker argue that in a cross-border setting ex post negotiations on burden sharing lead to an underprovision of recapitalizations. Cross-border externalities of failing banks are not incorporated in the decision-making process. The authors then turn to ex ante burden-sharing mechanisms to overcome the coordination failure. Based on a calibration with data on large cross-border banks in Europe, the paper argues that a scheme relating the burden to the location of the assets of the bank to be recapitalized (specific burden sharing) may be able to overcome the coordination failure.

As a whole, the papers in this volume offer a useful and timely perspective on the interplay between institutional arrangements and financial sector stability. Much remains to be done on this important theme, but the papers in this volume will be a timely source of reference in the continuing research.

Hyun Shin
Princeton University

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European Business School

Does the Law of One Price Hold in Euro-Area Retail Banking? An Empirical Analysis of Interest Rate Differentials across the Monetary Union*

Massimiliano Affinito and Fabio Farabullini
Bank of Italy

To measure integration, economic theory provides a clear background regarding price convergence: the law of one price. This paper is the first test of this law in euro-area retail banking. Since the law can be verified only on similar assets, we use recent harmonized data and a methodology that renders banking products homogeneous across countries, controlling for national factors. Econometric results signal that rates differ, and that markets are still segmented, because banking services are differentiated. Since supply factors play a driving role, there is room for improved integration. Moreover, where bank customers are stronger, rates are more homogeneous.

JEL Codes: E43, E44, G21.

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1. Introduction

Euro-area financial integration is an important issue, since both economic theory and empirical findings suggest that the integration of financial markets contributes to the smooth functioning of the single monetary policy, to financial stability, and to economic growth (e.g., Artis, Weber, and Hennessy 2000; Danthine, Giavazzi, and von Thadden 2001; Gaspar, Hartmann, and Sleijpen 2003; Guiso et al. 2004; and European Central Bank 2007). To date, some segments of euro-area financial markets have made great progress in terms of integration, while there is little evidence of similar integration having taken place in retail banking. However, the general process of European integration is expected to bring more homogeneous banking systems as well. In fact, euro-area banking convergence is pursued as a goal by European supranational organizations, since the euro-zone countries are banking oriented and the common monetary policy is implemented mainly through the banks.

In relation to this process, a large stream of literature is monitoring the convergence of European credit markets and measuring banking integration with several indicators: the number and value of cross-border transactions and mergers and acquisitions (M&As), the number of foreign banks, and the share of assets held by foreign banks.[1] This literature regards financial convergence primarily as a purely empirical question. From this standpoint, our paper joins in the current debate by analyzing the convergence of an important indicator: banking interest rates.

On the other hand, just regarding price convergence, a theoretical background seems to exist—the law of one price—and a clear benchmark—full convergence—once returns and risks are taken into account. On the basis of the law of one price (hereinafter simply the Law), in a single market, prices should converge thanks to arbitrage.

[1]See, e.g., Centeno and Mello (1999); European Central Bank (1999); Kleimeier and Sander (2000); Byrne and Davis (2002); Cabral, Dierick, and Vesala (2002); Hartmann, Maddaloni, and Manganelli (2003); European Banking Federation (2004); European Central Bank–Center for Financial Studies (2004); Gual (2004); Manna (2004); Murinde, Agung, and Mullineux (2004); Barros et al. (2005); European Commission (2005); European Parliament (2005); Walkner and Raes (2005); European Central Bank (2007).

If the Law holds, there should be no market segmentation, while persistent differences in price levels may signal that barriers remain. As far as we know, after a partial test pioneered by Adam et al. (2002), this paper is the first empirical attempt to verify the validity of the Law in all the main euro-area retail banking activities.

In reality, the Law has been criticized on various grounds, and the test of its validity is particularly complex in banking markets. One the one hand, arbitrage is generally easier in financial markets than in goods markets, since there are no transportation costs and the Law can be expected to hold almost instantaneously.[2] On the other hand, several banking products are not fungible, in the sense that they cannot be substituted either by other products or by the same services provided by other banks; accordingly, they cannot have the same price. Hence the Law may not hold within countries, even if the market is integrated.

Nonetheless, we refer to the law of one price because it remains a useful theoretical reference when one analyzes price convergence. First, financial theorists have used the Law as an uncontroversial minimal condition, and upon it they have built the edifice of modern financial theory, including the Modigliani-Miller capital structure propositions and the Black-Scholes option-pricing formula (e.g., Lamont and Thaler 2003). Second, the European Central Bank (ECB) considers the Law a natural way to assess the state of European financial integration (e.g., Trichet 2006). Third, several scholars indicate that, even with its imperfections, the Law is the sole theory for measuring integration (Adam et al. 2002; Adjaouté and Danthine 2003; Baele et al. 2004; Dermine 2006; Sørensen and Lichtenberger 2007; Gropp and Kashyap 2008).

In any case, when we refer to the Law, we use it not as a dogma, but as a methodological expedient. For us, the Law is a theoretical benchmark that guides the reading of the progressive steps of our analysis. In particular, we propose a specific interpretation of the Law, which seems the only one feasible to us and makes it possible to handle the nonfungibility of banking products. In fact, since the Law calls for "identical prices for identical goods," we stress the fact that goods must be identical and, since banking services are often

[2] Analyses of the Law in the European goods markets are, for example, in European Commission (2001) and De Grauwe (2003).

not uniform, that we can correctly verify the validity of the Law only if we somehow render them homogeneous. In an econometric exercise, it is possible to homogenize national banking services by controlling for the factors differentiating them across countries. Our idea is that, once controlled for both the demand and supply determinants of their differences, the products become homogeneous, so that, if the price is no longer dispersed, the Law holds. Needless to say, as long as national peculiarities continue to prevail, the Law remains only a theoretical benchmark.

This manner of proceeding acknowledges the criticism of the Law suggested by part of the industrial organization theory (e.g., Salop and Stiglitz 1982). According to this line of research, market equilibrium may be characterized by price dispersion for seemingly homogeneous commodities owing to consumer or producer heterogeneity.[3] Our interpretation is precisely that the Law can be verified only if these heterogeneities are taken into account. In the banking case, for example, if loan applicants are different because they do not belong to the same credit-risk class, the underlying loans are not identical; consequently, the corresponding prices are not identical and the Law does not hold. On the contrary, once the risk profile of borrowers has been controlled for, if the interest rates are similar, we can say the Law holds.

Even recent literature, although it admits the Law as the sole theory for measuring integration, emphasizes that it can be verified only on similar assets. Adjaouté and Danthine (2003) and Baele et al. (2004) grant that in order to verify the Law, if assets are not sufficiently homogeneous, which is relatively easy for bonds or in the money market but difficult in retail banking, differences in systematic risk factors and other important characteristics must be taken into account. Likewise, Gropp and Kashyap (2008) argue that the Law will not send a clear message regarding the state of integration "unless one accurately controls for those factors, which may

[3]This large body of research dating back to the 1970s studied price dispersion in contrast with Walrasian theory. Price dispersion can result, for instance, when consumers have different search costs (e.g., Salop 1977; Stiglitz 1987); if consumers receive a different number of price offers (e.g., Butters 1977); if consumers have different valuations for the good (e.g., Shilony 1977; Varian 1985); or if the environment is inflationary and price adjustments are costly (e.g., Bénabou 1992) and so on.

very likely systematically differ across countries." They highlight that if the observed violation of the Law is due to unobserved heterogeneity in demand, which may be a function of "differences in preferences, risk characteristics, or other demand characteristics" in different markets and countries, the price differences would have nothing to do with the failure of integration. We therefore control for differences in preferences, risk characteristics, and other demand characteristics.

We deal with other problems raised by the previous literature. Dermine (2006) signals that empirical tests of the Law could be misleading because if customers buy a bundle of financial services from their bank, the Law should hold for the entire package. We tackle this argument by analyzing not a single or a few banking products, but fourteen different interest rate categories representative of all the main retail banking activities. Adam et al. (2002) highlight that in order to assess the extent to which the Law holds in euro-area banking markets, new and more accurate data were required. We have the advantage of being able to exploit recent harmonized data on euro-area bank interest rates, making a consistent cross-country comparison possible for the first time.

Since integration is not an absolute concept, another element of our analysis is the use of a single country, Italy, as the empirical benchmark for assessing the level of euro-area integration. The idea is that the level of integration reached within a country represents an upper bound to the level euro-area banking markets can reach (Guiso, Sapienza, and Zingales 2004).

Our paper finds three main results: First, the law of one price does not hold for the raw interest rate data, and the euro-area retail banking markets appear still segmented. Second, euro-area bank interest rates differ because national products are differentiated by national factors; once these have been controlled for, many differences disappear and the Law starts to hold. Moreover, since supply factors play an important role in rate heterogeneity, there is scope for further interest rate convergence. And third, when instruments are sophisticated or the market power of bank customers counts, prices are more homogeneous.

The rest of the paper is organized as follows. The next section presents our methodology, based on two econometric approaches and three steps of analysis. The third section introduces the new

euro-area harmonized data on bank interest rates and our data set. The fourth section presents the results of the unconditional tests (the first step of our analysis). The fifth section provides regressions carried out using national determinants of bank interest rates (our second step). The sixth section describes the final outcomes of the conditional tests, i.e., controlling for national peculiarities (our third step). The final section summarizes our findings.

2. Methodology

Our purpose is to assess whether, in the sense argued in the previous section, the law of one price holds in the euro-area credit market. Our focus is twofold, on interest rate categories and on countries. In other words, we want to find out which interest rate categories are more uniform across Europe and which countries are more "similar" in a pairwise and/or multicountry sense.

The new harmonized and still relatively short data series, which we have the advantage of using, do not make it possible to assess the long-run process of convergence. However, since European banking markets have undergone a significant process of integration in the last few decades, the current level of bank interest rates should reflect this convergence. We therefore verify the degree of similarity reached between national rates, the so-called convergence hypothesis (e.g., Harvey and Carvalho 2002; Busetti and Harvey 2003).

In the first step of our analysis, we use two methodological approaches: stationarity tests and statistical tests of equality of country coefficients.

According to the strategy proposed by Harvey and Carvalho (2002, 2005), our first methodological approach is based both on the ADF (augmented Dickey-Fuller) test and on the KPSS (Kwiatkowski-Phillips-Schmidt-Shin) test.[4] These stationarity tests are standard methods used in the empirical literature to evaluate convergence processes—with reference, for instance, to interest rates, as in our case (e.g., Siklos and Wohar 1997), real GDP growth rates (e.g., Bernard and Durlauf 1996), and inflation rates (e.g., Busetti

[4]See, e.g., Dickey and Fuller (1981); Bell, Dickey, and Miller (1985); Hall, Robertson, and Wickens (1992); Kwiatkowski et al. (1992); and Hobjin and Franses (2000).

et al. 2007). We apply the two tests to the bilateral differentials δ_t^{ij} between the bank interest rates of each pair of countries:

$$\delta_t^{ij} = r_{i,t} - r_{j,t}, \tag{1a}$$

where $r_{i,t}$ and $r_{j,t}$ are the fourteen different types of interest rates, specific to each test, for countries i and j ($i \neq j$; $i, j = 1, 2, \ldots, n$ countries) in month $t = 1, 2, \ldots, T$ months.

Two countries can be said to have homogeneous interest rates (occurred convergence) when the interest differential δ_t^{ij} between them is a zero-mean stationary process. The ADF test preliminarily verifies whether the differentials δ_t^{ij} are nonstationary processes. Then the KPSS test verifies the zero-mean stationarity of stationary δ_t^{ij}, rejecting the null hypothesis (zero-mean stationarity) for a large value of ζ statistic:

$$\zeta = \frac{\sum_1^{27} \left(\sum_1^t \delta^{ij} \right)^2}{27^2 \, \widehat{\sigma}_{LR}^2}, \tag{1b}$$

where $\widehat{\sigma}_{LR}^2$ is a nonparametric estimator, robust to autocorrelation and to heteroskedasticity, of the long-run variance of δ_t^{ij}. The two tests are repeated for the fourteen types of bank interest rates and for all pairwise differentials among the euro-area countries, at the 5 percent level of statistical significance.

Our second methodological approach uses the same fourteen bank interest rates as dependent variables in as many regressions. We carry out statistical tests of equality of the country coefficients estimated in the regressions (e.g., Jackson 1992; Levy and Panetta 1993). In formal terms, we adopt the following general specification:

$$r_{i,t} = \alpha_t' \, T_{i,t} + \beta_i' \, C_{i,t} + \gamma' \, D_{i,t} + \delta' \, S_{i,t} + \varepsilon_{i,t}, \tag{2a}$$

where $r_{i,t}$ is defined as in equation (1a); $T_{i,t}$ is a matrix ($nt \times t$) of time (monthly) dummies; $C_{i,t}$ is a matrix ($nt \times i$) of country dummies; α, β, γ, and δ are vectors ($nt \times 1$) of coefficients; $D_{i,t}$ is a matrix ($nt \times g$) of demand-side regressors; $S_{i,t}$ is a matrix ($nt \times h$) of supply-side regressors; g and h indicate the number of regressors, different in each regression in, respectively, matrix $D_{i,t}$ and matrix $S_{i,t}$; and $\varepsilon_{i,t}$ is the idiosyncratic error $\sim$ i.i.d. $(0, \sigma_\varepsilon^2)$.

The estimated coefficients β_i are used in each interest rate category for Wald tests on the statistical significance of bilateral differences for $i \neq j$:

$$H_0\text{: } \beta_i = \beta_j. \tag{2b}$$

When the data do not reject the equality of coefficients, on the basis of the $F[1, Tn - (i + g + h)]$ statistic at the 5 percent significance level, we say that the bilateral interest rate differentials are not significant and therefore the interest rates for the pair of countries are similar or homogeneous. In the first step we use only time $T_{i,t}$ and binary country $C_{i,t}$ dummies as independent variables; in the second step we first add the matrix $D_{i,t}$, which contains factors influencing interest rates on the basis of the characteristics of bank depositors and borrowers, and then the matrix $S_{i,t}$, which contains the determinants of rates that depend on banking-system characteristics.

In the second and third steps of our analysis, we use only our second approach. The reason is that the first approach can only be used on the raw data (unconditional test). On the contrary, our second approach allows us to "clean up" the data using the matrices $D_{i,t}$ and $S_{i,t}$ in sequence (second step) and then to repeat the initial test of homogeneity on the cleaned-up data (conditional test—third step). This data cleaning renders homogeneous euro-area banking services and allows us to really verify the validity of the Law.

There are at least two reasons to distinguish the demand regressors' effect from the overall effect. First, since our aim is to homogenize banking services, and economic theory does not specify what defines a product, it is disputable whether all regressors in matrices $D_{i,t}$ and $S_{i,t}$ contribute to defining banking products. Following the example of credit-risk classes, only if we take into account the riskiness of borrowers (a demand-side characteristic) can we consider the underlying loans as similar goods and expect their prices to be similar. Likewise, market power (a supply-side characteristic) differentiates the perception of goods and therefore might be taken into account as well. Second, the ongoing euro-area process of integration could reduce the differences in the supply factors, but it would be difficult for it to render bank customers more similar. The point stressed by Gropp and Kashyap (2008) is that even in a perfectly integrated (national) market, we should find dispersion due to

demand factors. If this is true, one could view demand-side characteristics as "good" reasons for dispersion and supply-side factors as "bad" reasons. In any case, it is appropriate to keep the two effects distinct.

3. Data

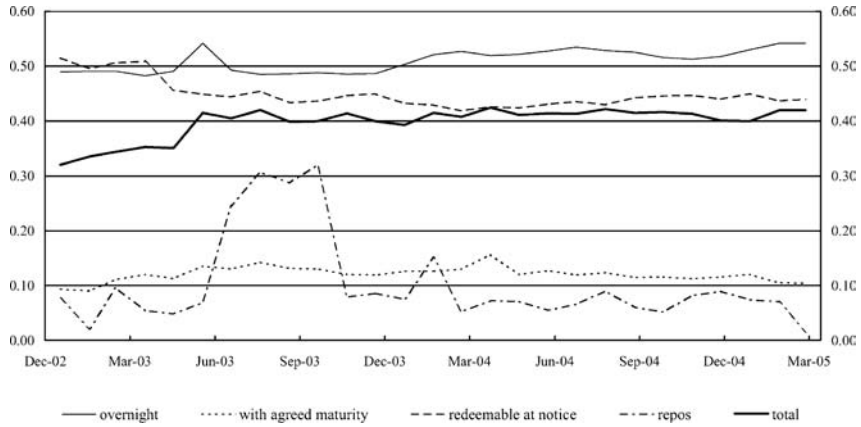
Five out of the fourteen bank interest rate categories regard deposits: interest rates on total deposits, on overnight deposits, on deposits with agreed maturity, on deposits redeemable at notice, and on repos. Five categories regard lending interest rates to households: interest rates on total loans to households, on bank overdrafts, on loans for house purchase, on consumer credit, and on loans for other purposes. Four categories regard lending interest rates to nonfinancial corporations: interest rates on total loans to firms, on bank overdrafts, on loans up to €1 million (loans to small firms), and on loans over €1 million (loans to large firms).[5]

We have the advantage of using recent harmonized monthly data on the bank interest rates in the euro-area countries, collected by the Eurosystem since January 2003 (see European Central Bank 2003). All the fourteen interest rates selected refer to new business for the period January 2003–March 2005 ($T = 27$). The number of observations is 324 (twelve countries and twenty-seven periods) when the interest rate exists in each euro-area country in our sample, and smaller otherwise.[6] We excluded interest rates on outstanding amounts because these suffer from national pre-euro effects, while those on new business reflect the current post-euro situation.

[5] We chose to carry out our analysis on product-specific rate levels. The empirical literature highlights that the analyses of margin and level differences provide similar indications. Moreover, the analysis of product-specific rates may show different degrees of homogeneity in some markets, which could pass unnoticed in the margin analysis. In any case, for the sake of completeness, we extended the analysis to two spreads: the first between the average rate on total loans to households and that on total deposits, and the second between the average rate on total loans to firms and that on total deposits.

[6] In our sample period, twelve European countries adopted the euro: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. The observations are 297 for deposits redeemable at notice (excluding Greece) and 162 for repos (the instrument is not used in Finland, Germany, Ireland, Luxembourg, the Netherlands, or Portugal).

Figure 1. Dispersion of Interest Rates on Deposits of Households



Figures 1–3 list the fourteen interest rate categories and provide the cross-country dispersion of each category in our sample period.

As explained in the previous section, in the second and third steps of our exercise, we add in the estimations of equation (2a) the matrices $D_{i,t}$ and then $S_{i,t}$. The two matrices include a different set of regressors for deposit rates, for lending rates to households,

Figure 2. Dispersion of Interest Rates on Loans to Households

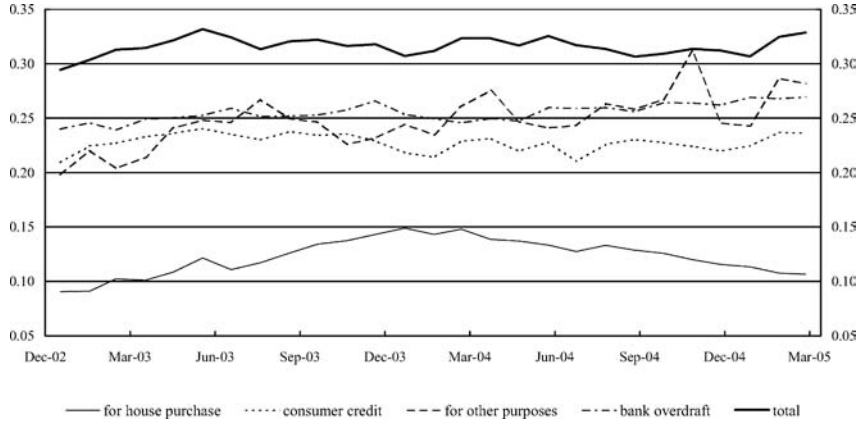
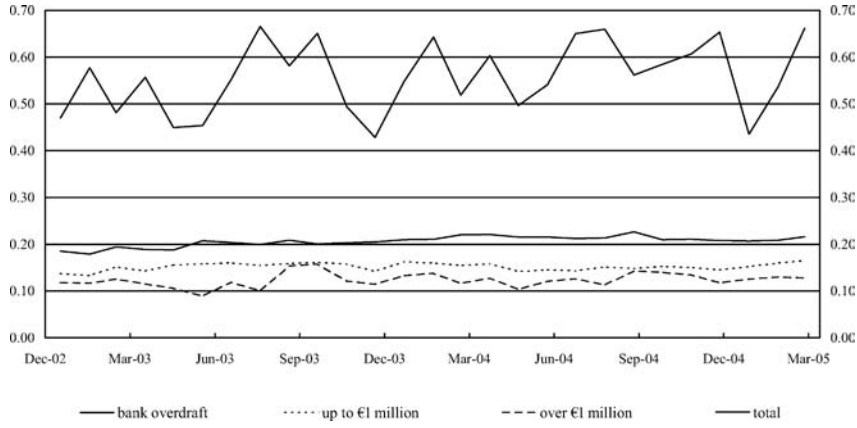


Figure 3. Dispersion of Interest Rates on Loans to Nonfinancial Corporations



and for lending rates to nonfinancial corporations. The regressors are rates of change or ratios between variables. Table 1 contains the complete list of covariates, their description and the effect they proxy, their division between demand and supply factors, the indication of the interest rate equations in which they are included, data sources, and summary statistics. An element of the paper worthy of mention is the large use of European harmonized data collected by the European System of Central Banks (ESCB).

4. First Step: Unconditional Test of Cross-Country Interest Rate Homogeneity

The results of the first step of our analysis are reported in table 2 (instrument-by-instrument analysis) and in table 3 (country-by-country analysis).

The first column of table 2 reports the fourteen categories of bank interest rates. The second column counts the total number of cross-country bilateral differentials for each type of interest rate: $n(n-1)/2$. It is equal to 66 when the interest rate category exists in all the countries; it is equal to 55 for deposits redeemable at notice and to 15 for repos. The third column shows the results of our first methodological approach: the number of stationary bilateral

Table 1. Description of Variables

Type	Covariates	Description	In Equation of	Data Sources	Mean	Std. Dev.	Min.	Max.
Demand-Side Regressors $D_{i,t}$	Real GDP growth	Real GDP growth rate	All rate categories	Eurostat	0.194	0.681	−1.84	3.04
	Disposable income	Total disposable income on number of households	Deposit and lending rates to households	Eurostat	28.442	7.539	10.504	38.706
	Alternative forms of saving	Government bonds as a ratio of GDP	Deposit rates	ESCB–Eurostat	2.55	1.43	0.07	5.87
	Alternative financial sources	Firms' market capitalization on bank loans	Lending rates to nonfinancial corporations	ESCB–Eurostat	1.348	1.194	0.243	5.382
	Risk exposure	Ratio between bank loss provisions and total loans	Lending rates	ESCB–Banksk.	0.442	0.330	0.0	1.13
	Firms' average size	Firms' value added on number of firms	Lending rates to nonfinancial corporations	Eurostat	1.611	0.35	0.734	2.395
Supply-Side Regressors $S_{i,t}$	Bank operating costs	Operating expenses/average balance-sheet total	All rate categories	OECD	1.648	0.490	0.54	2.68
	Bank non-interest income	Non-interest income/average balance-sheet total	All rate categories	OECD	1.204	0.578	0.54	3.74
	Bank liquidity	(Cash + holdings of gov. bonds)/total assets	All rate categories	ESCB	0.043	0.041	0.0	0.191
	Bank capitalization	Capital and reserves as a ratio of total assets	All rate categories	ESCB	0.063	0.017	0.035	0.104
	Bank liability structure	Total deposits as a ratio of total liabilities	Deposit rates	ESCB	0.286	0.103	0.063	0.491
	Bank asset structure	Long-term loans on total loans	Lending rates	ESCB	1.854	0.495	0.965	2.746
	Banks' international presence	Market share of branches and subsidiaries of nondomestic banks as a percentage of the total assets	All rate categories	ECB	23.730	24.767	4.74	94.56
	Banking market concentration	Five largest credit institutions' share of total assets	All rate categories	ECB	52.99	20.891	20.454	84.261
	Bank average size	Total assets on number of banks	All rate categories	ESCB–ECB	3,905	2,586	502.8	12,007
	Bank M&As	Number of domestic bank mergers and acquisitions on total number of domestic banks	All rate categories	ECB	0.022	0.02	0.0	0.09

Table 2. Statistical Tests of the Significance of Bilateral Differentials between National Bank Interest Rates: Outline by Type of Instrument

Interest Rate Categories	Total Number of Bilateral Differentials	Total Number of Statistically Similar Bilateral Differentials			
		First Step		Third Step	
		First Approach: ADF and KPSS Test	Second Approach: With Only Time and Country Dummies (a)	Second Approach: (a) + Demand-Side Regressors (b)	Second Approach: (b) + Supply-Side Regressors (c)
Deposits	**66**	**1**	**2**	**15**	**34**
of which: overnight	66	0	4	19	31
with agreed maturity	66	7	3	27	35
redeemable at notice	55	2	5	11	27
repos	15	0	11	4	8
Loans—Households	**66**	**4**	**1**	**12**	**23**
of which: bank overdrafts	66	3	1	12	22
for house purchase	66	4	3	7	31
consumer credit	66	6	4	13	32
for other purposes	66	6	5	22	45
Loans—Nonfinancial Corps.	**66**	**3**	**4**	**7**	**16**
of which: bank overdrafts	66	2	8	26	42
up to €1 million	66	5	7	14	33
over €1 million	66	21	8	23	47

combinations resulting from the ADF and KPSS tests. The fourth column reports the results of our second methodological approach: the number of cases in which the bilateral differentials are not significant and the interest rates are subsequently similar. The results are partially different under the two approaches only for repos and loans to firms over €1 million. However, both approaches clearly suggest that the data do not appear to fit with the idea of the law of one price holding in the European banking industry.

Table 3 summarizes the main results concerning the bilateral equality of coefficients for each pair of countries.[7] Panel A reports the total number of bilateral differentials, equal to 11 when all rate categories exist for that pair of countries.[8] Panel B shows the number of cases in which the bilateral differentials are nonsignificant in the first step of our analysis. Symmetrically with respect to the instrument-by-instrument analysis, the number of similar interest rates is low for all pairs of countries. Panel C shows the number of nonsignificant bilateral differentials in the third step of our analysis, after controlling both for demand-side and supply-side regressors. We return to it later on (section 6).

As highlighted, a further element of our analysis is the comparison between the degree of integration in the euro area and in a single country. To this purpose, we adopted the same econometric specification of equation (2a) for bank interest rates within Italian regions. We used twenty region dummies (one for each Italian administrative region instead of for the twelve euro-area countries) and ten quarterly time dummies (instead of the twenty-seven monthly dummies of the euro-area equation).[9] Figure 4 shows that the percentage

[7]To improve the fluency of the paper, we report the country-by-country analysis only for the second approach, because the outcomes of the two approaches are substantially similar and the second approach is used in the rest of the paper.

[8]The three aggregate rates (total deposits of households, total loans to households, and total loans to nonfinancial corporations) are excluded from this exercise.

[9]The test was carried out using quarterly data on six interest rates from the Italian Central Credit Register. To enhance the comparison between the data for Italian regions and euro-area countries, we selected six aggregate rates (three for lending and three for borrowing) that are defined similarly in the national Central Credit Register and in Eurosystem statistics. The data from the Italian Central Credit Register are only available on a quarterly basis. The Italian time series are longer than the euro-area ones, but we selected ten quarters (from September

(Continued on page 21)

Table 3. Significance of Bilateral Differentials between National Bank Interest Rates: Cross-Country Analysis

A. Total Number of Bilateral Differentials

	AUS	BEL	FIN	FRA	GER	GRE	IRL	ITA	LUX	NET	POR	SPA
AUS	—											
BEL	11	—										
FIN	10	10	—									
FRA	11	11	10	—								
GER	10	10	10	10	—							
GRE	10	10	9	10	9	—						
IRL	10	10	10	10	10	9	—					
ITA	11	11	10	11	10	10	10	—				
LUX	10	10	10	10	10	9	10	10	—			
NET	10	10	10	10	10	9	10	10	10	—		
POR	10	10	10	10	10	9	10	10	10	9	—	
SPA	11	11	10	11	10	10	10	11	10	9	10	—
Total	114	114	109	114	109	104	109	114	109	109	109	114

B. Number of Similar Interest Rates: Second Approach with Only Time and Country Dummies (a)

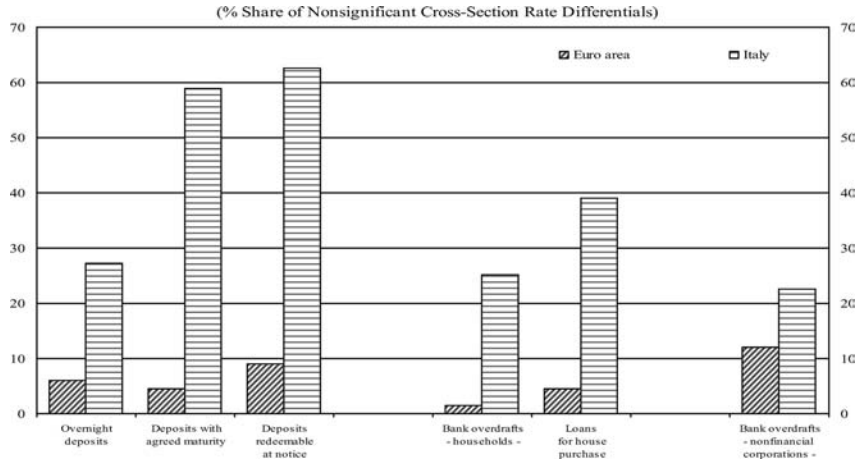
	AUS	BEL	FIN	FRA	GER	GRE	IRL	ITA	LUX	NET	POR	SPA
AUS	—											
BEL	4	—										
FIN	1	0	—									
FRA	0	3	1	—								
GER	2	2	0	0	—							
GRE	2	2	0	0	0	—						
IRL	0	1	0	2	1	1	—					
ITA	2	1	1	0	0	1	0	—				
LUX	2	1	3	0	0	0	2	0	—			
NET	2	2	0	1	0	0	1	1	1	—		
POR	1	0	2	1	0	0	0	1	2	0	—	
SPA	1	3	1	1	0	1	0	1	0	1	0	—
Total	17	19	9	9	5	7	8	8	11	9	7	9

(continued)

Table 3. (Continued)

C. Number of Similar Interest Rates: Second Approach with (a) + Demand- and Supply-Side Regressors												
	AUS	**BEL**	**FIN**	**FRA**	**GER**	**GRE**	**IRL**	**ITA**	**LUX**	**NET**	**POR**	**SPA**
AUS	—											
BEL	6	—										
FIN	7	6	—									
FRA	4	6	7	—								
GER	2	5	5	3	—							
GRE	4	6	4	5	5	—						
IRL	7	6	8	6	7	4	—					
ITA	4	9	5	6	4	7	7	—				
LUX	9	8	6	8	8	5	4	8	—			
NET	6	7	4	6	4	4	6	7	8	—		
POR	2	3	4	3	7	5	6	4	5	1	—	
SPA	5	4	5	3	5	4	7	5	7	2	3	—
Total	56	66	61	57	55	53	68	66	76	55	43	50

Figure 4. Percentage Shares of Statistically Similar Bank Interest Rates: Euro-Area Countries versus Italian Regions (first step of our analysis)



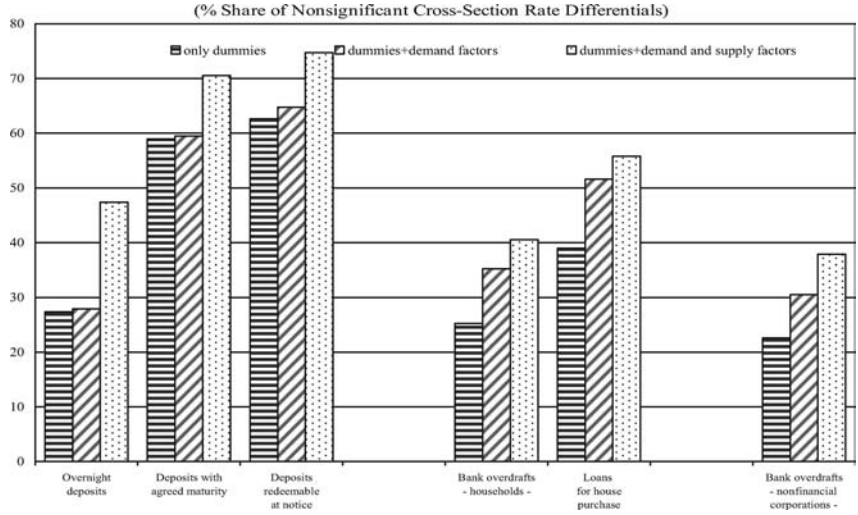
share of similar interest rates—namely, the number of similar interest rates on the total number of bilateral combinations—is much larger for Italian regions than for euro-area countries.[10] In any case, it is worth noting that the homogeneity of interest rates is not full even at the national level, and that the homogeneity of deposits, consistently with other analyses, is higher than that of loans.

Since this heterogeneity may be due to cross-region differences, we repeated the same test after adding three regressors influencing bank rates. The regressors are defined at the regional level as well. Two regressors capture the effect on interest rates of demand factors: regional borrowers' riskiness (the ratio between bad loans and total loans, only in the lending rate regressions) and the growth rate of regional GDP. The third regressor captures the effect of supply

(Continued from page 18)
2001 to December 2003) in order to compare samples of similar length. To check the robustness of the results, we repeated the exercise for Italian regions over a long-period horizon (twenty quarters, from January 1999 to December 2003), and the results remained substantially stable.

[10]Symmetrically, we used the first approach based on the ADF and KPSS tests for the Italian regions as well. The comparison of the outcomes for the Italian regions and the euro-area countries produced similar differences under both approaches.

Figure 5. Percentage Shares of Statistically Similar Bank Interest Rates across the Twenty Italian Administrative Regions (with and without control variables)



factors: regional banking market concentration (Herfindahl indexes of loans and deposits, alternatively).

Figure 5 shows that these determinants explain the rate differences among Italian regions, and once they have been allowed for, the percentage share of similar interest rates increases significantly. This result corroborates what we argued from the beginning. When we control for the factors affecting bank interest rates, we make banking products uniform, and the degree of cross-section homogeneity improves. At the same time, figure 5 shows that even within a country, though integration is higher than across countries, both demand and supply factors matter. Therefore, even in an integrated market, banking characteristics may continue to constitute a bad factor hampering further integration. This is the argument of the second and third steps of our analysis.

5. Second Step: The Determinants of Differences in Bank Interest Rates

Once we have empirically tested that the Law does not hold in the euro area on the raw data and that the intercountry dispersion is

greater than the intracountry dispersion, in this section we pick out the determinants of national differences. Since many channels may influence banks' pricing behavior, we use an eclectic approach, by including regressors representative of the main effects proposed in the literature.[11]

We carried out fourteen regressions, i.e., as many as the interest rate categories subjected to our analysis. For the sake of brevity, the main econometric outcomes are summarized in table 4, where the signs of the coefficients are reported when they are uniform for all the categories belonging to the same class of bank rate: deposits, loans to households, and loans to nonfinancial corporations.[12] Subsections 5.1 (demand-side explanatory variables) and 5.2 (supply-side explanatory variables) examine the correspondences between our results and the effects proposed in the literature; subsection 5.3 summarizes some robustness checks.

5.1 Demand-Side Explanatory Variables

Real GDP Growth. Economic theory suggests that interest rates on loans are positively influenced by real GDP growth, because better economic conditions improve the number of projects becoming profitable, thus increasing credit demand (e.g., Melitz and Pardue 1973; Kashyap and Stein 1995). But the effect is partially ambiguous since only increases in permanent income have a positive influence on credit demand, while the transitory component of GDP is associated with a self-financing effect that reduces recourse to bank loans (Friedman and Kuttner 1993). Symmetrically, the interest rates on deposits are negatively influenced by increases in the transitory component of real GDP. In our estimates, the real GDP growth rate is not significant for interest rates on deposits or on loans

[11] On the other hand, we do not allow for the decreasing official rates set by the Eurosystem in our sample time. First, official rates are country invariant in the euro area and thus not able to add clear explanations for national differences. Second, although the official rates are time variant, the adjustment of national banking rates to monetary policy inputs occurs in the same months, and therefore the effect is captured by the time dummies included in our regressions.

[12] Our results on bank interest-rate-setting behavior can be viewed as an independent part of the analysis, but they are mainly used to verify the validity of the Law in a stricter way.

Table 4. The Determinants of National Differences in Euro-Area Bank Interest Rates: Summary Econometric Results (second step of our analysis)

Explanatory Variables		Effect on Interest Rates on		
		Deposits	Loans to Households	Loans to Nonfinancial Corporations
Demand-Side Explanatory Variables $D_{i,t}$	GDP growth rate	n.s.	+	n.s.
	Disposable income	+	–	n.a.
	Risk exposure	n.a.	n.u.	+
	Alternative financing sources	n.a.	n.a.	+
	Alternative forms of saving	+	n.a.	n.a.
	Firms' average size	n.a.	n.a.	–
Bank Balance-Sheet Characteristics $S_{i,t}$	Bank operating costs	n.u.	n.u.	+
	Bank non-interest income	+	–	n.s.
	Bank liquidity	n.u.	+	–
	Bank capitalization	+	–	–
	Bank liability structure	n.u.	n.a.	n.a.
	Bank asset structure	n.a.	–	–
Banking System Structural Characteristics $S_{i,t}$	Banks' international presence	+	–	+
	Banking market concentration	n.s.	+	+
	Bank average size	–	n.u.	–
	Bank M&As	–	+	n.s.

Note: For the sake of brevity, we do not report the analytical results of all fourteen regressions and their different specifications; they are available from the authors upon request. The symbols ± indicate the signs of the coefficients when the effect of regressors on the dependent variable is significant at the 5 percent level and uniform across interest rate categories, respectively for all kinds of deposit rates, and for all kinds of interest rates on loans to households and to nonfinancial corporations; n.s. means nonsignificant coefficient; n.u. means non-uniform effect of variable, for each instrument category; n.a. means non-applicable variable.

to nonfinancial corporations, while it is positive and significant for interest rates on loans to households.

Disposable Income. While the GDP growth rate is an indicator of general macroeconomic conditions, household disposable income (total disposable income divided by the number of households) is an indicator of households' spending (saving) capacity.

Therefore, there are no problems of collinearity.[13] The effect of disposable income on deposit interest rates is likely to be negative if it implies an increasing supply of deposits, or positive, as in our results, if it implies a decreasing supply of deposits or a stronger bargaining power of savers. Its expected effect on interest rates on loans to households is negative, as we find, because it both decreases the demand for credit and increases households' bargaining power (de Bondt 2002; Gambacorta 2008).

Risk Exposure. Banks investing in riskier projects ask for a higher interest rate return because lending rates include a risk component (the risk of default).[14] We used, as a standard proxy of the riskiness of loan applicants, the ratio between banks' total loss provisions and total loans. The idea is that where banks have larger loss provisions, the borrowers are riskier.[15] Our results show a positive effect on the interest rates of nonfinancial corporations.

Alternative Financing Sources. Where borrowers have direct financing at their disposal, since this is less expensive than intermediated financing, bank loan applicants are only agents unable to

[13]According to standard consumer theory, spending (and saving) decisions depend on households' income and wealth. The measures of households' financial wealth in the national financial accounts are not available for all the euro-area countries.

[14]Economic theory suggests contrasting views about the link between interest rates, risk, collateral, and relationship banking. Credit institutions do not necessarily adjust the interest rate with rising risk, if they choose to ration the credit supply in order to avoid adverse selection and moral hazard (Stiglitz and Weiss 1981). Moreover, the provision of collateral or relationship banking might decrease lending rates by reducing the problem of asymmetric information (e.g., Petersen and Rajan 1994). On the other hand, some authors (Manove, Padilla, and Pagano 2000) have argued that collateral may have a perverse effect on banks' risk because it may reduce the screening and monitoring of debtors. Similarly, relationship banking may result in higher interest rates (Angelini, Di Salvio, and Ferri 1998), which can be attributed to a lock-in effect on borrowers and banks' stronger bargaining power.

[15]The ratio of loss provisions to total loans could also act as a proxy for the ability of the legal system to safeguard lenders' rights. When banks are forced to make larger loss provisions, it is because the legal system is less efficient. Actually, in some specifications we used another variable, the usual duration of enforcement proceedings for mortgage loans, as a proxy of the (in)efficiency of the legal and judiciary system. The results confirm that lending rates tend to increase where the time taken for proceedings is longer. The inclusion of this regressor did not distort the other results of the estimates, but we eliminated it because the available data are time invariant.

obtain direct debt and thus forced to pay higher interest rates (e.g., Diamond 1991; Holmström and Tirole 1997). As a proxy of direct finance, we used the ratio of firms' market capitalization to their bank loans. As expected, the effect of the variable is significantly positive.

Alternative Forms of Saving. Likewise, where savers have more financial instruments at their disposal, the supply of deposits decreases, and therefore banks are likely to set higher deposit rates (e.g., Green 1998). We used the ratio between government bonds and GDP as a proxy of an alternative financial investment. As expected, the effect on deposit interest rates is positive.

Firms' Average Size. Larger firms, where size is measured by nonfinancial corporations' value added divided by the number of firms, are usually less opaque and have a greater bargaining power, so that banks quote lower lending interest rates (e.g., Berger and Udell 2006). Our econometric exercises corroborate this idea.

5.2 Supply-Side Explanatory Variables

Bank Operating Costs. Since banks apply a mark-up and a mark-down on a refinancing rate and on management costs, operating costs have a positive effect on lending rates and a negative effect on deposit rates (e.g., Klein 1971; Monti 1972). Our estimates confirm the expected signs for all interest rate categories on loans to nonfinancial corporations, for total deposits, and for total loans to households.

Bank Non-Interest Income. In the past few decades, because of falling net interest spreads, banks have been shifting their focus away from interest-generating activities, such as deposit taking and lending, toward more profitable fee-generating services (e.g., DeYoung and Roland 2001). Our results show that in countries where the share of non-interest income in bank income statements is higher, banks set higher interest rates on deposits and lower interest rates on loans to households.

Bank Liquidity and Capitalization. According to bank lending channel theory, when policy rates decrease or in any case are low (as in our sample period), well-capitalized and liquid banks let interest rates on loans fall and those on deposits increase (Bernanke and Blinder 1988; Bernanke and Gertler 1995; Kashyap and Stein 1995,

2000). These predictions are confirmed in our estimates: highly capitalized banking systems (capital and reserves as a share of total assets) have lower lending rates and higher deposit rates; highly liquid banking systems (cash plus holdings of government bonds as a share of total assets) have lower lending rates to nonfinancial corporations, but higher rates to households.

Bank Liability Structure. Banks that finance themselves mainly through bonds, rather than deposits, should set higher deposit rates because their liabilities are more affected by market movements (Berlin and Mester 1999). Accordingly, in our estimates, banking systems in which deposits account for a larger share of liabilities set lower rates on all deposit categories but repos.

Bank Asset Structure. Banks that have a higher proportion of long-term loans should set lower lending rates—first, because they are expected to care more for credit relationships (Berger and Udell 1992), and second, as part of an implicit risk-sharing agreement, based on the risk aversion of their better borrowers (Fried and Howitt 1980). Consistently, in our estimates, the asset structure indicator (the ratio of long-term loans to total loans) is inversely correlated with lending rates.

Banks' International Presence. The share of foreign banks in a market is an indicator of competitive pressure, and, according to theory, increasing competition leads to lower lending rates and higher deposit rates (e.g., Guiso et al. 2004). Moreover, a larger international presence is accompanied by an increase in cross-border activity, which might homogenize banking behavior. In our exercises, a larger presence of foreign banks, measured by market share as a percentage of total assets, affects the level of interest rates on deposits positively, the lending rates to households negatively, and the lending rates to nonfinancial corporations positively.

Banking Market Concentration, Bank Average Size, and Bank M&As. Banking literature underlines two possible impacts of concentration on the pricing behavior of banks. Following the class of models applying the structure-conduct-performance approach to banking activity (e.g., Berger and Hannan 1989), as market power increases, banks set lower deposit rates and higher lending rates. By contrast, the so-called efficient-structure approach (e.g., Demsetz 1973) suggests that concentration is due to more-efficient banks

taking over less-efficient counterparts; therefore, more-concentrated markets are associated with increased efficiency, lower management costs, and hence lower spreads. We tested three kinds of variables concerning the banking system structure: market concentration (the five largest credit institutions' share of total assets), bank average size (the ratio of total assets to number of banks), and banking M&As (the ratio of the number of domestic bank mergers and acquisitions to the total number of domestic banks). Our results provide evidence in favor of the structure-conduct-performance hypothesis. At the same time, it is interesting that banking systems with larger banks on average set lower lending rates to firms.

5.3 Robustness Checks

Although bank interest rate setting is not the first topic of our paper, we made some checks to evaluate the robustness of previous results. The first robustness check lies in the fact that we conducted regressions on fourteen interest rate categories.

A way to check the robustness of our results was to introduce the additional explanatory variables progressively in order to control for the possible presence of endogeneity. In the first specification, we used only demand-side factors in each equation; then we introduced bank balance-sheet characteristics and finally banking-system structural characteristics as well. The explanatory power of the estimations remained noteworthy. The signs of the significant coefficients always remained the same, although the significance level changed.

The further robustness check was to modify the whole specification by introducing interaction terms instead of using the single variables. There was no change in the sense of all the results.

Another way to check the robustness of results involved substituting the single regressors with similar variables. As a proxy of the riskiness of loan applicants, we replaced the figures on bank loss provisions with the statistics on write-offs/write-downs of loans collected by the ECB. These series, while harmonized and relative to the entire population of banks, are less long and not available for all countries. In any case, the use of these data confirmed that risk exposure affects lending rates positively. In a similar way, we used the Herfindahl indexes instead of the share of the five largest credit institutions. In the indicator of alternative financing sources,

we added the securities issued by nonfinancial firms to market capitalization. The results remained stable, but the data on securities issued are not available for all countries. Finally, we substituted the denominator of some regressors represented by ratios: the number of households with GDP in the indicator of disposable income, and bank loans both with GDP and with the number of firms in the indicator of alternative financing sources. The results remained stable every time.

6. Third Step: Conditional Test of Cross-Country Interest Rate Homogeneity

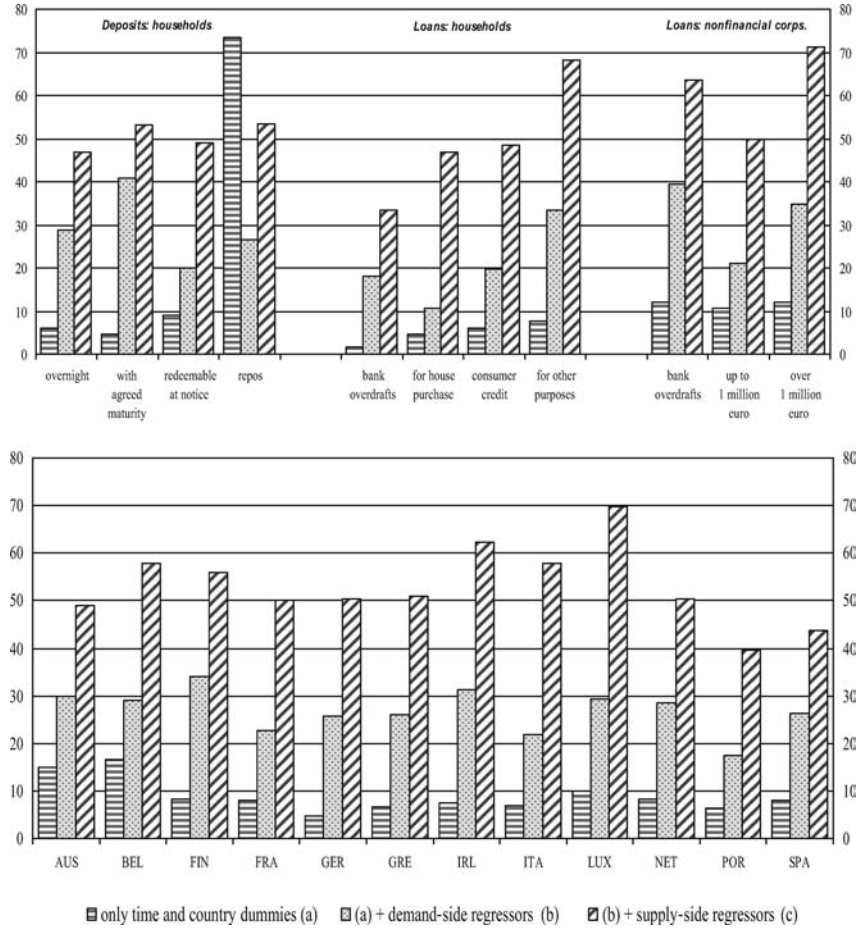
The last two columns of table 2 report the results of Wald tests on the significance of bilateral differentials after controlling for, respectively, the demand-side regressors and the overall effect of both demand and supply factors. Figure 6 shows the percentage shares of statistically similar interest rates. As expected, the similarities progressively increase, moving from the tests based on only time and country dummies to those based on demand regressors up to those based on all the covariates.[16]

Looking at the instrument-by-instrument results (figure 6, upper panel), after allowing for all the consumer and producer heterogeneities, the share of nonsignificant differentials is over 60 percent for four instruments and over or close to 50 percent for six instruments. In one case the homogeneity remains quite low (bank overdrafts granted to households).[17] The results suggest that the more sophisticated instruments, and those where the market power of bank customers counts, are characterized by more homogeneous

[16] In one case only (repos) did the regressors not have any explanatory power and was the level of homogeneity higher before controlling for national characteristics. However, it should be noted that, compared with other deposit products, repos are more sophisticated and less widespread in euro-area countries. This may have influenced their atypical result.

[17] The improvement in the results is confirmed for the two spreads to which we extended the analysis (see footnote 5). For the spread between the average rate on total loans to households and that on total deposits, the number of similarities progressively grows from one out of sixty-six in the first step, to thirteen in the second, and to thirty in the third; for the spread between the average rate on total loans to firms and that on total deposits, it grows from two out of sixty-six, to seven, and then to seventeen.

Figure 6. Percentage Shares of Statistically Similar Bank Interest Rates across Euro-Area Countries (first and third step of our analysis)



prices: repos versus overnight deposits, interest rates for enterprises versus those for households, and interest rates for large corporations (i.e., loans over €1 million) versus those for small firms (i.e., loans up to €1 million).[18]

[18]Our exercise does not consider the effect of fiscal framework. The taxation on bank products can influence the behavior of both banks and their customers

Turning to the country-by-country results (figure 6, lower panel), the percentage share of nonsignificant differentials progressively grows for all countries. After controlling for the overall effect of the regressors, the percentage share is close to or exceeds 50 percent in ten out of twelve countries. On the other hand, geographical proximity and similar cultural characteristics do not seem to explain the statistical similarity between interest rates: the number of nonsignificant differentials grows between the Benelux countries but remains low between Spain and Portugal and between Germany and Austria (table 3, panel C).

Both instrument and country analyses show that supply factors play a driving role in generating rate heterogeneity. Ceteris paribus, their effect is much more important across countries than within Italy. Empirically, this shows that if supply factors ease, there will be considerable room for an improvement in integration.

7. Concluding Remarks

Prima facie, the law of one price does not hold in the euro-area retail banking markets. The econometric analysis, comparing the bank rate differentials in the twenty Italian regions with those of twelve euro-area countries, shows that the degree of integration in a national banking market is much higher than in the euro area.

However, if we take into account demand-side regressors and supply-side regressors, many differences disappear and the Law starts to hold. In particular, econometric results suggest that where the bank customer is likely to be stronger, because of greater market power or better information, interest rates tend to be more homogeneous across Europe. This is the case of corporations compared with households, and large corporations compared with small firms. By contrast, geographical proximity does not influence the similarity of interest rates as much as one might have expected.

Our methodology and empirical findings show that, on the basis of our interpretation, the Law is an empirically testable theory. We show that the euro-area prices appear different, because national

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and hence interest rates. The lack of harmonized data as well as the difficulty of finding good information or building a good proxy put us off including this effect in the exercise. However, its inclusion would probably strengthen our results.

bank products appear different or because they are differentiated by national factors. In particular, since great dispersion is due to supply factors, the degree of integration will improve if the ongoing euro-area process of convergence makes European banks more similar.

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Transparency of Regulation and Cross-Border Bank Mergers*

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There is ample anecdotal evidence that political influence might constitute a barrier to the integration of European banking markets. Based on a data set on the transparency of the supervisory review process of bank mergers in the EU, we estimate the probability that a credit institution will be taken over as a function of bank and country characteristics and the transparency of merger control. The results indicate that a credit institution is systematically more likely to be taken over by foreign banks if the regulatory process is transparent. In particular, large banks seem to be less likely to be taken over by foreign credit institutions if merger control lacks procedural transparency.

JEL Codes: G21, G28, G34.

"Every time there is an attack on the banking system, every government in Europe is active, they intervene. . . . France is just like the others."

(Close advisor of French President Nicolas Sarkozy, after Société Générale announced trading losses of almost €5 billion)

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1. Introduction

Although the EU has removed barriers to cross-border banking through the harmonization of banking regulations, the number of cross-border mergers and acquisitions (M&As) in the EU banking sector is still low compared with domestic and cross-border M&As in other sectors (European Commission 2005). This paper shows that a lack of procedural transparency of merger control might constitute a systematic barrier to cross-border consolidation in the banking sector if politicians and supervisors use the intransparency to block cross-border M&As for nationalistic feelings.

The fact that interference by politicians and supervisors constitutes a barrier to banking market integration in the EU was recently demonstrated in France when the French government made clear that it would protect Société Générale from being taken over by foreign credit institutions. "Every time there is an attack on the banking system, every government in Europe is active, they intervene. . . . France is just like the others," said a close advisor of French President Nicolas Sarkozy. This was not the first time that French politicians intervened in the acquisition of domestic banks. The case of Crédit Lyonnais is another example. Crédit Lyonnais was privatized in 1999, with the state retaining 10 percent of ownership shares until the end of 2000. This made the takeover of Crédit Lyonnais by foreign banks more difficult, since government officials repeatedly stated they would oppose the acquisition of the bank by a foreign credit institution. The importance of the political dimension for bank acquisitions is also reflected by a statement of the former chairman of Lloyds TSB. In an interview, he said that Lloyds TSB would like to buy Crédit Lyonnais but was put off by the regulatory and political climate in France. This explains why Lloyds never made an official takeover bid for Crédit Lyonnais, although it frequently expressed its interest in the French bank.[1] The political dimension of bank mergers seems to be important in other member countries as well. In Italy, the acquisition of Banca Antonveneta (BA) and

[1]Political influence also played a role in the bidding war for Crédit Industriel et Commercial (CIC) (Boot 1999). Although ABN AMRO was favored because of its excellent track record vis-à-vis competing French bidders, CIC was sold in 1998 to Crédit Mutuel.

Banca Nazionale de Lavoro (BNL) by the Dutch ABN AMRO and the Spanish Banco Bilbao Vizcaya Argentaria (BBVA) was blocked by the Bank of Italy in 2005 for prudential reasons and formal errors. Because it later became public that the deals were not blocked for prudential reasons, but to protect Banca Antonveneta and Banca Nazionale de Lavoro from foreign ownership, the EU Commission brought actions against Italy for infringement of the principle of the free movement of capital.[2] To improve the legal certainty, clarity, and transparency of the merger control process, the Commission furthermore proposed changes of the EU Banking Directive to increase the transparency of merger control in the banking sector (European Commission 2006).

Although these examples demonstrate that political interference makes cross-border takeovers in the banking sector more difficult, systematic empirical evidence on the role of politicians and supervisors as a barrier to cross-border consolidation is missing. This paper aims to fill this gap. It relies on a unique database on the transparency of merger control in the banking sector. To our knowledge, this is the first paper to examine the difference between domestic and cross-border acquisitions as a function of bank characteristics, country characteristics, and the transparency of merger control in the banking sector. The paper is organized as follows. After a literature survey on the determinants of domestic and cross-border acquisition in the banking sector, we estimate the probability that a bank will be taken over by domestic and foreign credit institutions. We find that the likelihood of a takeover depends not only on the characteristics of the acquired bank and the country where it is located but also on the degree of transparency of merger control in the banking sector. The results indicate that cross-border takeovers are systematically more likely if merger control is more transparent. In particular, large banks seem to be less likely to be taken over if merger control lacks transparency. This supports the hypothesis that politicians might

[2] Another example where cross-border takeovers were blocked for opaque concerns is the proposed acquisition of the Portuguese financial group Champlinaud by the Spanish Banco Santander Central Hispanio (BSCH) in 1999. The acquisition was vetoed by the Portuguese Minister of Finance. The grounds for opposing the deal included not only "late and incomplete notification" and the "absence of a transparent structure" in the new group but also the "necessity to protect the national interest" (European Commission 1999).

use merger control to block cross-border acquisitions if they want to protect national flagships. Domestic takeovers are not affected. The results suggest that merger control might constitute a barrier to cross-border consolidation and that further integration of EU banking markets requires a higher degree of procedural transparency of merger control.

2. Literature

European banking markets are still not integrated. One indicator for this lack of integration is that domestic bank mergers still outnumber cross-border M&As in the EU banking sector (Cabral, Dierick, and Vesala 2002).[3] This indicates that there are barriers to consolidation that are larger for foreign banks than for domestic banks. These barriers might be differentiated into market entry and efficiency barriers.

Berger, De Young, and Udell (2001) argue that one reason for the small number of cross-border M&As in the banking sector is efficiency barriers. Differences in banking regulation and supervision are one example of these kinds of barriers. Since foreign banks have to comply with regulations both at home and abroad, domestic credit institutions have cost advantages because complying with two different sets of regulations imposes additional costs on foreign banks. Different regulations furthermore reduce the amount of overlapping fixed costs. This decreases the potential to reap benefits from economies of scale and scope and makes the acquisition of foreign banks less attractive. Efficiency barriers might also arise from cultural diversity, different languages, and corporate cultures. Cultural diversity and different languages raise information costs and make an efficient restructuring and reorganization of the acquired institution more difficult. This reduces the potential to increase X-efficiency. X-efficiency gains arise if the acquiring institution is more efficient ex ante and brings the efficiency of the target bank up to its own level (Berger et al. 2000). The expectation is that more efficient banks

[3] Adam et al. (2002) and Affinito and Farabullini (2006) measure the degree of banking market integration based on the law of one price. Another indicator for banking market integration has recently been proposed by Gropp and Kashyap (2009). They look at the rate of convergence of bank return on assets to measure banking market integration. Both measures of integration indicate that EU banking markets are still fragmented along national lines.

will restructure and transfer their managerial expertise, policies, and procedures to the acquired institution in order to increase efficiency. Since efficiency barriers are assumed to be higher for foreign banks than for domestic banks, the potential to raise X-efficiency appears to be lower for cross-border takeovers than for domestic takeovers. This might reduce the incentive to take over or merge with credit institutions in other countries. Consolidation across borders is therefore likely to be limited as long as barriers exist that prevent foreign banks from taking full advantage of potential efficiency gains from this consolidation (Berger, DeYoung, and Udell 2001).

The empirical literature on the efficiency effects of M&As in the banking sector suggests that efficiency barriers exist. Vander Vennet (1998), for example, finds that in Europe some acquisitions tended to improve cost efficiency, whereas other types tended to decrease cost efficiency.[4] Studies that compare the efficiency of foreign and domestic banks also do not find much evidence for efficiency gains through cross-border consolidation. Vander Vennet (1996) concludes that foreign banks in Europe had about the same cost efficiency as domestic credit institutions. In contrast, Bonin, Hasan, and Wachtel (2005) find that they are more cost efficient than domestic banks in ten Central and Eastern European countries. In contrast, Kraft and Tirtiroglu (1998) for Croatia and Matousek and Taci (2002) for the Czech Republic find no evidence of greater efficiency of foreign banks. These results suggest that in some countries substantial efficiency barriers exist that offset most of any potential efficiency gains from cross-border takeovers. Since only the most efficient banks are able to overcome these barriers, efficiency barriers constitute an obstacle to the integration of banking markets.

Cross-border consolidation in the EU banking sector is also restricted by market entry barriers. Entry barriers make it harder or even impossible for banks to take over or merge with foreign banks. Ownership limits for foreign investors are one example of

[4]Studies on U.S. bank mergers also find on average only little or no cost X-efficiency improvements through M&As (Berger and Humphrey 1992; Peristiani 1997; Berger 1998; Rhoades 1998; Cummins, Tennyson, and Weiss 1999; De Young 1999; and Fried, Knox Lovell, and Yaisawarng 1999). The evidence on cost X-efficiency in Europe is mixed as well. Vander Vennet (1996, 1998) finds that some groups of M&As, particularly cross-border M&As, tend to improve, whereas other types tend to decrease, cost efficiency.

such barriers. Market entry barriers also arise from political interference. Boot (1999) argues that central banks, ministries of finance, and domestic banks operate in close concert to block cross-border takeovers and promote domestic takeovers because they want the largest institution in the country to be domestically owned. Since ownership limits on foreign shareholdings are prohibited by the EC Treaty, politicians have to look for other ways to block foreign investment in the EU banking sector. One way is to block cross-border acquisitions and to promote domestic acquisitions during merger control. The fact that merger control might constitute a barrier to cross-border consolidation has been demonstrated in Italy, where the central bank blocked the acquisition of BA and BNL by the Dutch ABN AMRO and the Spanish BBVA in 2005.

Market entry barriers only constitute a barrier to integration if banks want to take over a foreign credit institution. Efficiency barriers always constitute a barrier to integration, since they reduce the incentive of banks to take over a foreign credit institution. Since efficiency barriers lower the potential to generate X-efficiency gains from mergers, only the most efficient banks are expected to take over foreign credit institutions. This is consistent with Foccarelli and Pozzolo (2001). They find that banks are more likely to take over foreign credit institutions if they are large and efficient. Banks with a larger share of non-interest income are also more likely to have foreign shareholdings. The size of the banking sector and the average national return on assets in the country where the acquiring bank is located are positively correlated, and the size of the stock market is negatively correlated, with the probability that a bank will take over a foreign credit institution. This suggests that the takeover decision depends not only on bank-specific but also on location-specific determinants.

This paper differs from Foccarelli and Pozzolo (2001) in two important dimensions. While we also analyze the determinants of cross-border bank takeovers, we do not focus on the acquiring bank and the country where the acquiring bank is located, but rather on the acquired banks and on the characteristics of the country where the acquired bank is located. This distinction is necessary, since we want to find out if political interference constitutes a barrier to cross-border consolidation. This cannot be analyzed if we focus on the acquiring bank, because the likelihood that a bank will be

taken over depends not only on whether a bank is willing to acquire foreign credit institutions, but also on whether it is able to do so or whether cross-border takeovers are blocked by politicians or supervisors. Since the scope to block cross-border M&As and promote domestic M&As in the banking sector is larger if merger control lacks transparency, we use three indices that measure the degree of political independence of the supervisor and procedural transparency of merger control. To account for the fact that politicians and supervisory authorities might block cross-border acquisitions and promote domestic acquisitions, we estimate the determinants of acquisitions in the EU banking sector for domestic and cross-border takeovers separately in a multinomial logit framework.

3. Merger Control as Barrier to Integration

Political interference has been identified by Boot (1999) as a barrier to cross-border consolidation in the EU banking sector. This has recently been confirmed by a survey of the EU Commission on the barriers to cross-border banking in Europe. It indicates that political interference and the misuse of supervisory powers is one of the main barriers to the integration of EU banking markets (European Commission 2005).

The survey was initiated by the Economics and Finance Ministers of the EU after the acquisition of BA and BNL by the Dutch ABN AMRO and the Spanish BBVA had been blocked by the Bank of Italy in 2005 for prudential reasons and formal errors.[5] The central bank simultaneously promoted takeover bids from domestic financial institutions for the same targets. Because it later became public that both deals were blocked by the supervisor to protect BA and BNL from foreign ownership, the EU Commission has brought actions against Italy for infringement of the principle of the free movement of capital. The Commission complained that the merger control process of the Bank of Italy lacks procedural transparency and can create legal uncertainty. This could lead to a situation in which the supervisors can refuse authorization based on opaque

[5]For more information on these two cases and the EU directive proposal to improve the legal certainty, clarity, and transparency of the merger control process, see Köhler (2007).

concerns (European Commission 2005). The Commission, furthermore, initiated changes of the EU banking directive to increase the transparency of merger control in the EU banking sector.

To find out if merger control lacks procedural transparency in EU member countries, Köhler (2007) sent out a questionnaire to supervisory authorities of the twenty-five EU member countries between November 2006 and March 2007. The aim of the questionnaire was to find out how transparent merger control in the EU is. Based on information from this questionnaire and additional sources, he has constructed two indices for twenty EU countries that measure the degree of procedural transparency of merger control in the banking sector. Both indices are based on the idea that merger control is more transparent if the criteria according to which supervisors assess the suitability of potential investors is known. The difference between these indices is that they concentrate on different criteria that are used to assess potential investors. The General Criteria Index (GCI) measures the general criteria supervisors use to assess the suitability of potential investors. Takeovers are generally assessed based on a prudential and competition assessment. Merger control is assumed to be intransparent if the general criteria used to assess the suitability of potential investors is not known. While the GCI looks at whether prudential criteria are used by supervisors at all to assess the suitability of potential investors, the Prudential Criteria Index (PCI) focuses on the specific criteria that are used by supervisors for the prudential assessment of potential investors. Possible criteria for the prudential assessment are the reputation and financial soundness of the proposed investor as well as the experience of the future management. Merger control is assumed to be more transparent, the larger the number of criteria is that are known to potential investors and the public. The idea is that supervisors and politicians should have less scope to block cross-border takeovers if the prudential assessment is based on a closed list of official criteria.[6]

Table 1 indicates that the proportion of cross-border takeovers to the total number of takeovers in the banking sector is positively correlated with the average degree of procedural transparency of

[6]The twenty EU countries for which index values are available are Austria, the Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Luxembourg, Malta, the Netherlands, Poland, Portugal, the Slovak Republic, Slovenia, Spain, and Sweden.

Table 1. Correlation Analysis

	Index of Political Independence	General Criteria Index	Prudential Criteria Index	Domestic M&As to the Total Number of M&As in the Banking Sector	Cross-Border M&As to the Total Number of M&As in the Banking Sector
Index of Political Independence	1.00				
General Criteria Index	−0.23	1.00			
Prudential Criteria Index	0.75	−0.36	1.00		
Domestic M&As to the Total Number of M&As in the Banking Sector	−0.14	0.20	−0.40	1.00	
Cross-Border M&As to the Total Number of M&As in the Banking Sector	0.14	−0.20	0.40	−1.00	1.00

Source: Köhler (2007), Bankscope (2008), and Zephyr (2008).

merger control between 1997 and 2006. This is in line with the hypothesis that politicians and supervisors have less scope to block cross-border acquisitions and to promote domestic takeovers if the supervisory review process of bank mergers is transparent. The correlation seems to be stronger for the PCI than for the GCI. Cross-border takeovers also seem to be more frequent in countries where the supervisor is more politically independent. The degree of political independence of the supervisor is measured by the Index of Political Independence (IPI) (Köhler 2007). This index measures which authority approves bank mergers and how the head of this institution is appointed. The idea is that the scope for political interference is larger if a government body approves mergers or if the head of the institution that assesses the suitability of potential investors in the banking sector is appointed by the government.

4. Empirical Model

Since we assume that the scope for political interference is larger if merger control lacks procedural transparency, we expect that the

probability that a bank will become the target of a cross-border takeover is smaller and the likelihood that a credit institution will be taken over by a domestic bank is larger if the supervisory review process of bank mergers is intransparent and politicians want banks in domestic ownership.

This makes it necessary to estimate the probability that a bank will be taken over by a domestic and a foreign credit institution separately. Hence, we use a multinomial logit framework that allows multiple choices and which is standard in this context (see, for example, Pasiouras, Tanna, and Gaganis 2007). The model can then be described as follows:

$$\text{Prob}\,(Y_i = j) = \frac{\exp(x_i\beta_{1j} + z_i\beta_{2j})}{\sum_{j=1}^{J}\exp(x_i\beta_{1j} + z_i\beta_{2j})},$$

where $i = 1, 2, 3, \ldots$ represent the individual bank and $j = 1, 2, 3, \ldots$ the possible outcomes (1 = not taken over, 2 = taken over by a domestic bank, and 3 = taken over by a foreign bank), x = vector of bank-specific determinants, and z = vector of location-specific determinants. To remove the indeterminacy associated with this model, we define $j = 1$ as the base category. This gives the following probability for each outcome:

$$\text{Prob}\,(Y_i = j) = \frac{\exp(x_i\beta_{1j} + z_i\beta_{2j})}{1 + \sum_{j=2}^{J}\exp(x_i\beta_{1j} + z_i\beta_{2j})},$$

and for the reference category:

$$\text{Prob}\,(Y_i = 1) = \frac{1}{1 + \sum_{j=2}^{J}\exp(x_i\beta_{1j} + z_i\beta_{2j})}.$$

All coefficients are estimated relative to this base and express the probability that a bank will be taken over by domestic or foreign credit institutions relative to the probability that a bank will not be taken over.

5. Data

5.1 Bank Sample

To estimate our model, we have constructed a data set on M&As in the banking sector of the twenty-five EU member countries for

the period between 1997 and 2006. Information on M&As comes from the Zephyr database. Deals are considered M&As if investors buy more than 50 percent of ownership shares or increase a majority shareholding. Minority shareholdings are not included. Balance-sheet data has been taken from BankScope. We use consolidated balance sheets whenever possible and concentrate on commercial banks only. Coverage by BankScope is very comprehensive in most countries, with banks included accounting for 90 percent of the assets of all banks. The final data set includes 415 deals, of which 184 were cross-border and 231 were domestic. Since some banks were taken over more than once, the number of deals is larger than the number of acquired credit institutions. The reference group consists of all commercial banks that were not taken over in the twenty-five EU member countries between 1997 and 2006. Together with the acquired banks, the final data set includes 1,934 credit institutions. This gives us 7,734 bank-year observations.

The distribution of banks in the sample is reported in table 2. The largest number of banks comes from France (302), Germany (274), and Italy (218). The United Kingdom has 204, Luxembourg 140, and Spain 113 banks. All other countries report fewer than 100 credit institutions. France, Germany, and Italy also record the largest number of deals in the banking sector. While domestic deals outnumber cross-border deals in the larger EU countries, the number of cross-border deals is larger in the smaller EU countries. Cross-border deals are particularly important in the new member states. In all of these countries, the number of cross-border deals exceeded the number of domestic deals. One reason for the large number of cross-border deals in the new member states is the liberalization and privatization of the banking sector. Many Central and Eastern European countries have opened their banking sectors to foreign investors after having experienced banking crises in the nineties.

5.2 Variables

5.2.1 Bank-Specific Variables

One motive for the acquisition of or the merger with a bank in the same or in a foreign country is to transfer the managerial expertise and organization of the acquiring bank on the acquired credit

Table 2. Bank Sample

A. Banks and Deals by Country

	Banks	Bank M&As	of which: Domestic M&As	of which: Cross-Border M&As
Austria	85	6	2	4
Belgium	64	16	9	7
Cyprus	22	0	0	0
Czech Republic	33	22	5	17
Denmark	63	6	5	1
Estonia	11	13	0	13
Finland	10	1	1	0
France	302	52	37	15
Germany	274	44	32	12
Greece	27	7	5	2
Hungary	33	23	6	17
Ireland	45	2	1	1
Italy	218	73	66	7
Lithuania	13	8	2	6
Luxembourg	140	23	11	12
Latvia	28	17	1	16
Malta	14	1	0	1
Netherlands	64	4	0	4
Poland	62	34	14	20
Portugal	32	9	8	1
Slovak Republic	22	12	2	10
Slovenia	28	6	3	3
Spain	113	26	14	12
Sweden	27	2	2	0
United Kingdom	204	8	5	3
Total	1,934	415	231	184

B. Deals by Year

Year	Bank M&As	of which: Domestic M&As	of which: Cross-Border M&As
1997	11	6	5
1998	26	15	11
1999	40	22	18
2000	58	35	23
2001	53	32	21
2002	58	35	23
2003	43	25	18
2004	37	21	16
2005	51	22	29
2006	38	18	20
Total	415	231	184

Source: Zepyhr (2008).

institution to generate X-efficiency gains from a better management. To control for this motive, we use the cost-income ratio (CIR) as a measure of cost and the return on assets (ROA) as a measure of profit efficiency. Since X-efficiency gains are more likely to be achieved if the acquired credit institution is less efficient, we expect the CIR to be positively correlated and the ROA to be negatively correlated with the probability of a takeover (Berger and Humphrey 1992 and Berger et al. 2000).

Another motive of acquisitions in the banking sector is economies of scale and scope. To control for this motive, we use bank assets (SIZE). Cost economies of scale occur if the average costs of production decrease as the size of the institution increases. Revenue scale economies might arise because some customers might need or prefer the services of larger institutions (Berger et al. 2000). Economies of scope might originate on the cost and revenue side as well. Cost economies of scope might arise among others from sharing physical inputs (Berger et al. 2000). Revenue scope economies might emerge from the cross-selling of financial products through different distribution channels (Berger et al. 2000). Since larger banks have a larger market share, SIZE also controls for the motive to obtain market power. If banks are taken over to generate economies of scale and to get market power, SIZE and the probability of a takeover are positively correlated. But the effect of SIZE on the probability that a bank is acquired might also be the opposite. If larger banks are more difficult to integrate and to restructure owing to increased organizational complexity, diseconomies of scale arise and SIZE is expected to be negatively correlated with the probability of being acquired. The acquisition of smaller banks is also less likely to raise problems with the antitrust authority.

To control for the business orientation of banks, we use the ratio of net interest to total revenue (NIREV). The importance of interest-earning activities to total business activities might be relevant for banks that take over other credit institutions to get access to local retail-banking markets. Retail banking has become more attractive in recent years because it provides a more stable source of income than non-interest-earning activities. Non-interest-earning activities are, however, considered as having a larger growth potential than interest-earning activities. Because of that, NIREV is often regarded as measuring bank *in*efficiency as well (see, for example, Foccarelli

and Pozzolo 2001). Banks with a larger proportion of interest income to total income, hence, not only have a stronger business focus on retail-banking activities, but are also expected to be less efficient. Both suggest that NIREV and the probability of being taken over are positively correlated.

To find out if the probability of a takeover depends on the degree of capitalization and liquidity of the acquired bank, we include the ratio of equity to assets (CAP) and the ratio of liquid assets to customer and short-term funding (LIQ). The effect of CAP on the probability of a takeover is not obvious a priori (Hannan and Rhoades 1987 and Hannan and Pilloff 2006). CAP is positively correlated with the probability that a credit institution is acquired if a high level of capital indicates that a bank is less diversified. Such banks are attractive for acquirers that are more diversified, since the latter can free capital if they transfer their knowledge of risk diversification to the acquired credit institution. Banks might also take over a well-capitalized credit institution if they face pressure by the regulator to increase their level of capital. The effect of CAP on the probability of a takeover might, however, also be the opposite. If a higher level of capital indicates better management skills and organization, well-capitalized credit institutions are less attractive to potential investors, since potential X-efficiency gains from better management are expected to be smaller. Acquisitions are also more likely to occur if a bank's capitalization is so low that it is in danger of default. CAP is then expected to be negatively correlated with the probability of being taken over. The relationship between LIQ and the probability of a takeover is not obvious a priori as well. On the one hand, the likelihood that a credit institution will be taken over is larger if it is close to illiquidity. On the other hand, a high level of liquidity might indicate a lack of investment opportunities or managerial inefficiency in allocating liquid funds. Both make banks more attractive takeover targets.

Table 4 presents descriptive statistics on these bank characteristics.[7] Correlation coefficients are reported in table 5. To eliminate outliers, all observations below the 1st and above the 99th percentile of the respective variable are winsorized. In order to minimize the

[7] A list of bank- and location-specific variables used in this paper is provided in table 3 in the appendix.

Table 4. Descriptive Statistics

Domestic and Cross-Border Targets (EU-25)	**Mean**	**Median**	**Std. Dev.**
Bank Assets (in USD)	18.800.000	1.486.587	65.300.000
Equity to Total Assets	11.05	8.00	12.20
Liquid Assets to Customer and Short-Term Funding	26.50	17.84	31.41
Cost-Income Ratio	77.17	71.58	32.63
Return on Assets	0.60	0.64	2.22
Net Interest Revenue to Total Revenue	34.74	34.88	15.23
Customer Deposits to Total Assets	52.88	57.76	24.52
Customer Loans to Total Assets	49.41	51.85	23.47
Domestic Targets (EU-25)	**Mean**	**Median**	**Std. Dev.**
Bank Assets (in USD)	21.300.000	1.253.906	73.600.000
Equity to Total Assets	12.35	7.92	15.62
Liquid Assets to Customer and Short-Term Funding	25.77	21.63	22.05
Cost-Income Ratio	83.14	75.13	39.67
Return on Assets	0.45	0.42	2.44
Net Interest Revenue to Total Revenue	33.57	32.59	15.63
Customer Deposits to Total Assets	50.26	50.15	25.16
Customer Loans to Total Assets	49.90	50.59	24.23
Cross-Border Targets (EU-25)	**Mean**	**Median**	**Std. Dev.**
Bank Assets (in USD)	16.800.000	1.543.445	58.000.000
Equity to Total Assets	9.94	8.06	8.09
Liquid Assets to Customer and Short-Term Funding	27.12	14.19	37.63
Cost-Income Ratio	72.02	68.43	24.08
Return on Assets	0.72	0.89	2.01
Net Interest Revenue to Total Revenue	35.77	36.11	14.87
Customer Deposits to Total Assets	55.17	62.23	23.82
Customer Loans to Total Assets	48.97	52.74	22.89
Non-Targets (EU-25)	**Mean**	**Median**	**Std. Dev.**
Bank Assets (in USD)	9.233.282	738.065	44.000.000
Equity to Total Assets	12.71	7.99	15.10
Liquid Assets to Customer and Short-Term Funding	38.53	25.02	43.00
Cost-Income Ratio	68.55	64.36	35.29
Return on Assets	0.73	0.58	1.87
Net Interest Revenue to Total Revenue	30.25	29.02	18.80
Customer Deposits to Total Assets	46.83	50.40	29.41
Customer Loans to Total Assets	43.39	43.20	28.90

Source: Bankscope (2008). To eliminate the influence of outliers, observations below the 1st percentile and above the 99th percentile have been winsorized.

Table 5. Correlation Analysis

	SIZE	CIR	ROA	NIREV	CAP	LIQ	DEP	LOAN
SIZE	1.00							
CIR	−0.04	1.00						
ROA	−0.02*	−0.53*	1.00					
NIREV	−0.11*	−0.04*	0.08*	1.00				
CAP	−0.12*	0.07*	0.19*	0.22*	1.00			
LIQ	−0.10*	0.09*	−0.02*	−0.15*	0.38*	1.00		
DEP	−0.10*	0.08*	−0.01	0.15*	−0.26*	−0.01	1.00	
LOAN	0.00	−0.08*	0.03*	0.41*	−0.16*	−0.51*	0.06*	1.00

Source: Bankscope (2008) and own calculations. Correlation coefficients have been calculated for winsorized data. * indicates significance at the 5 percent level.

effects of particular events, all data on bank characteristics are averages for the period between 1997 and 2006. The numbers are broadly consistent with the hypotheses put forward. Large banks are more likely to be taken over than small credit institutions. This is in line with the hypothesis that banks are taken over to obtain market power and to generate economies of scale and scope. Measured by CIR and ROA, targets are less efficient than banks that were not taken over. This supports the hypothesis that banks tend to take over less efficient credit institutions to spread managerial expertise and operating procedures to generate X-efficiency gains from better management. In particular, domestic acquisitions seem to be driven by the motive to increase X-efficiency. Banks that were not involved in merger activity are, on average, better capitalized and more liquid. This is consistent with the hypothesis that less capitalized and less liquid banks are more likely to be acquired. The relative importance of retail-banking business is reflected by the proportion of net-interest revenue to total revenue (NIREV), which is higher for targets than for banks that were not acquired. This supports the hypothesis that banks take over credit institutions to get access to local retail-banking markets. That targets are more active in retail banking than banks that were not taken over is also reflected by the ratio of customer deposits to total assets (DEP) and customer loans to total assets (LOAN). DEP and LOAN are both higher for targets than for banks that were not taken over. The correlation analysis suggests that there is no link between bank efficiency and the proportion of interest earnings to total earnings.

5.2.2 Location-Specific Variables

The probability of a takeover depends not only on bank characteristics but also on the characteristics of the country where potential targets are located. For this reason, we have to control for location-specific determinants as well. The first location-specific determinant is the real gross domestic product (GDP). It measures the market potential in the host country. GDP has been found to be relevant for multinational banking (Berger et al. 2004 and Buch and DeLong 2004). GDP seems to be particularly relevant for banks that follow a market-seeking strategy, while the degree of trade openness is expected to be particularly relevant for credit institutions that take over or merge with foreign banks to provide services to customers from the home country that make business in the country where the potential target is located. This follow-your-customer strategy has been confirmed by Heinkel and Levi (1992), Ter Wengel (1995), and Yamori (1998). To control for this strategy, we use the ratio of aggregate imports to GDP (IMGDP) to measure trade integration.

Besides the market potential and the degree of trade openness, the structure of the banking system also matters. For this reason, we include the market share of the three largest banks (C3) to measure banking market concentration. The effect of C3 on the probability of being acquired is not obvious a priori (Hannan and Rhoades 1987 and Hannan and Pilloff 2006). On the one hand, a higher level of concentration might make acquisitions more likely by banks that operate in the same market as the potential target, since market power could be enhanced by the acquisition. On the other hand, since antitrust authorities are designed to prevent takeovers from reducing competition, domestic acquisitions are less likely to occur if the degree of market concentration is high. Cross-border takeovers are less likely to be challenged for antitrust reasons. This suggests that the effect of market concentration on the probability that a bank will be taken over by a domestic and foreign credit institution is different. The size of the banking sector (BSSIZE) might also affect the decision to take over or merge with a domestic or foreign bank. BSSIZE is expected to be positively correlated with the probability of being acquired, since a larger banking sector offers greater opportunities to generate economies of scale and scope (Buch and DeLong 2004). BSSIZE might, however, also have a negative impact

on the probability of a takeover if bank profitability is lower in a larger banking sector (Demirgüc-Kunt and Huizinga 1999 and Buch and DeLong 2004).

To control for bank regulation and the supervisory framework, we construct an index on banking and financial freedom (BFFREE) based on data from the Heritage Foundation (2008). BFFREE measures restrictions on capital inflows and banking activity as well as government ownership in the banking sector. A larger value of BFFREE indicates a lower degree of banking and financial freedom. Since cross-border acquisitions are more likely if foreign capital inflows are not restricted and government ownership is low, we expect BFFREE to be negatively correlated with the probability of being taken over by a foreign credit institution. Domestic takeovers should not be affected. We also include an index that measures government intervention in the economy (GOVINT). GOVINT is also based on data from the Heritage Foundation (2008). It measures government intervention by the share of revenues from state-owned enterprises and property. Another variable that controls for the institutional environment in the host country is EMU. EMU is a dummy variable that is set equal to 1 for countries that are members of the European Monetary Union (EMU) and zero otherwise. EMU membership should increase the probability of being acquired by a foreign investor, since the introduction of a common currency facilitates cross-border bank entry. If banks are afraid of being taken over by foreign investors, it might also raise the pressure for domestic consolidation. This suggests that EMU might be positively correlated not only with the likelihood that a bank will be taken over by a foreign credit institution, but also with the likelihood that it will be taken over by a domestic credit institution.

Since it is more difficult for banks to generate X-efficiency gains if languages and cultures are different, we include a variable that measures the distance between the capital of the country where potential targets are located and the center of Europe (DIST). The idea is that efficiency barriers that arise from differences in cultures and language are expected to be larger the farther away countries are from the center. DIST also controls for omitted variables that are correlated with distance. Berger et al. (2004), for example, argue that agency costs associated with monitoring the management of the acquired bank increase with geographical distance. For this reason,

we expect distance to be negatively correlated with the probability of a cross-border takeover (Berger et al. 2004 and Buch and DeLong 2004). Domestic takeovers should not be affected.

6. Results

The blocked cross-border acquisitions of Banca Antonveneta and Banca Nazionale de Lavoro by the Dutch ABN AMRO and the Spanish Banco Bilbao Vizcaya Argentaria have demonstrated that a lack of transparency of merger control in the banking sector could lead to a situation in which the supervisors can refuse authorization based on opaque concerns. To find out if EU banks are systematically more likely to be taken over by foreign credit institutions, controlling for bank- and location-specific characteristics, we perform a multinomial logit analysis. In the first step of the analysis, we examine which bank- and location-specific characteristics make it more likely that a bank will be taken over relative to a bank that will not be taken over. In the second step, we add the indices presented in section 3 to find out if the probability that a bank will be taken over by a domestic or foreign investor is larger if the supervisor is more politically independent and merger control more transparent.

Since we are only interested in the bank- and location-specific characteristics of acquired banks at the time when the deal takes place, observations for targets are dropped after the deal has been completed. The results of the regressions are presented in table 6. The regression coefficients reported are to be interpreted as affecting the odds ratio with respect to the baseline case and not as marginal probability. To control for heteroskedasticity and serial correlation, we use robust standard errors clustered on the bank level.

6.1 Bank- and Location-Specific Determinants

The first step in the regression analysis is to estimate the effect of bank-specific and location-specific variables on the probability of a takeover separately. To check the robustness of our results, we then put both groups of variables together in a single regression. The results are reported in table 6.

The results suggest that bank size is an important determinant for domestic and cross-border M&As in the EU banking sector. The

Table 6. Regression Results

	Model 1		Model 2		Model 3		Model 4	
	Domestic M&As	Cross-Border M&As	Domestic M&As	Cross-Border M&As	Domestic M&As	Cross-Border M&As	Domestic M&As	Cross-Border M&As
WLNSIZE	**0.243*** **	**0.241*** **			**0.279*** **	**0.492*** **	**0.3*** **	**0.519*** **
	(0.057)	(0.063)			(0.065)	(0.083)	(0.068)	(0.083)
WCIR	**0.121*** **	**0.008*** **			**0.01*** **	**0.007*** **	**0.01*** **	**0.006** **
	(0.002)	(0.002)			(0.002)	(0.002)	(0.002)	(0.003)
WNIREV	**0.13** **	**0.027*** **			0.008	**0.029*** **	0.005	**0.024** **
	(0.007)	(0.007)			(0.007)	(0.010)	(0.007)	(0.011)
WCAP2	0.01	0.001			0.012	0.005	0.015	0.01
	(0.014)	(0.010)			(0.014)	(0.012)	(0.014)	(0.013)
WLIQ1	**−0.009*** **	**−0.008** **			**−0.006***	0.001	−0.004	0.004
	(0.003)	(0.004)			(0.003)	(0.004)	(0.003)	(0.004)
LNGDP			**0.341** **	−0.036	0.36	−0.242	0.4	−0.004
			(0.137)	(0.128)	(0.221)	(0.168)	(0.274)	(0.302)
IMGDP			**3.047*** **	**4.043*** **	**3.218** **	**4.955*** **	**3.189***	**5.843*** **
			(1.044)	(0.983)	(1.609)	(1.210)	(1.787)	(1.645)
BSASSTOGDP			**−1.165*** **	**−1.507*** **	**−1.611*** **	**−1.296*** **	**−1.522** **	**−1.63** **
			(0.346)	(0.414)	(0.562)	(0.475)	(0.708)	(0.716)
INDIST			**0.767*** **	0.23	**0.615***	0.33	**0.767** **	0.048
			(0.267)	(0.351)	(0.370)	(0.364)	(0.387)	(0.432)
EMU			**0.861*** **	0.053	**0.782*** **	0.08	**0.675** **	0.488
			(0.190)	(0.257)	(0.267)	(0.378)	(0.285)	(0.476)
C3			**−1.477** **	−1.044	−0.612	−0.655	−0.812	0.668
			(0.640)	(0.751)	(0.910)	(0.821)	(1.052)	(1.006)
Index of Political Independence							−0.805	0.23
							(0.704)	(0.654)
General Criteria Index							0.45	0.43
							(0.981)	(0.640)
Prudential Criteria Index							1.236	**1.205***
							(1.002)	(0.660)
Observations	7,743		13,666		6,022		4,753	
Pseudo-R^2	0.044		0.071		0.16		0.176	

(continued)

Table 6. (Continued)

	Model 5		Model 6		Model 7	
	Domestic M&As	Cross-Border M&As	Domestic M&As	Cross-Border M&As	Domestic M&As	Cross-Border M&As
WLNSIZE	**0.294*** **	**0.501*** **	**0.298*** **	**0.501*** **	**0.299*** **	**0.516*** **
	(0.068)	(0.085)	(0.680)	(0.084)	(0.068)	(0.083)
WCIR	**0.01*** **	**0.005***	**0.01*** **	0.005*	**0.01*** **	**0.006** **
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
WNIREV	0.005	**0.028** **	0.005	**0.024** **	0.005	**0.024** **
	(0.007)	(0.011)	(0.007)	(0.011)	(0.007)	(0.011)
WCAP2	0.014	0.007	0.014	0.007	0.015	0.01
	(0.014)	(0.013)	(0.014)	(0.013)	(0.014)	(0.013)
WLIQ1	−0.004	0.004	−0.004	0.004	−0.004	0.004
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
LNGDP	0.303	−0.098	0.378	−0.254	0.461	−0.045
	(0.265)	(0.286)	(0.256)	(0.198)	(0.286)	(0.215)
IMGDP	**3.397***	**6.174*** **	**4.137** **	**6.332*** **	**3.515***	**5.221*** **
	(1.864)	(1.567)	(1.923)	(1.539)	(1.886)	(1.545)
BSASSTOGDP	**−1.39** **	**−1.508** **	**−1.534** **	**−1.342** **	**−1.477** **	**−1.557** **
	(0.628)	(0.717)	(0.685)	(0.606)	(0.657)	(0.680)
INDIST	**0.73***	0.182	**0.798** **	0.291	**0.801** **	−0.007
	(0.373)	(0.410)	(0.377)	(0.397)	(0.388)	(0.435)
EMU	**0.73** **	0.559	**0.702** **	0.495	**0.691** **	0.537
	(0.291)	(0.469)	(0.292)	(0.451)	(0.292)	(0.474)
C3	−1.033	0.279	−0.78	0.113	−0.826	0.543
	(0.975)	(0.971)	(1.024)	(0.915)	(0.965)	(0.887)
Index of Political Independence	−0.268	0.658				
	(0.702)	(0.682)				
General Criteria Index			0.695	1.139		
			(0.865)	(0.441)		
Prudential Criteria Index					0.847	**1.496*** **
					(0.832)	(0.477)
Observations	4,753		4,753		4,753	
Pseudo-R^2	0.1693		0.172		0.175	

(continued)

Table 6. (Continued)

	Model 8		Model 9		Model 10		Model 11	
	Domestic M&As	**Cross-Border M&As**	**Domestic M&As**	**Cross-Border M&As**	**Domestic M&As**	**Cross-Border M&As**	**Domestic M&As**	**Cross-Border M&As**
WLNSIZE	**0.298*** **	**0.494*** **	**0.354*** **	**0.542*** **	**0.349*** **	**0.568*** **	**0.305*** **	**0.515*** **
	(0.069)	(0.089)	(0.073)	(0.073)	(0.074)	(0.093)	(0.068)	(0.082)
WCIR	**0.01*** **	**0.006** **	**0.01*** **	**0.007** **	**0.011*** **	**0.007** **	**0.01*** **	**0.006** **
	(0.002)	(0.003)	(0.003)	(0.073)	(0.003)	(0.003)	(0.002)	(0.003)
WNIREV	0.005	**0.023** **	0.006	**0.027** **	0.005	**0.029** **	0.003	**0.023** **
	(0.007)	(0.011)	(0.008)	(0.073)	(0.009)	(0.012)	(0.008)	(0.011)
WCAP2	0.016	0.01	0.017	0.011	0.017	0.01	0.016	0.009
	(0.014)	(0.014)	(0.014)	(0.073)	(0.015)	(0.013)	(0.014)	(0.013)
WLIQ1	−0.004	0.004	−0.005	0.003	**−0.007** **	0.004	**−0.006** *	0.004
	(0.003)	(0.004)	(0.003)	(0.073)	(0.003)	(0.004)	(0.003)	(0.004)
LNGDP	0.45	−0.053	0.643	−0.046	−0.126	−1.418	0.347	−0.146
	(0.283)	(0.214)	(0.392)	(0.073)	(1.013)	(3.026)	(0.282)	(0.242)
IMGDP	**3.44** *	**5.033*** **	1.141	**4.476*** **	−2.314	1.381	0.896	**4.333** **
	(1.912)	(1.504)	(2.180)	(0.073)	(10.136)	(3.853)	(2.261)	(1.682)
BSASSTOGDP	**−1.47** **	**−1.538** **	−0.673	**−1.446** **	0.482	−1.458	**−2.175*** **	**−1.683** **
	(0.666)	(0.683)	(0.571)	(0.073)	(2.634)	(2.267)	(0.762)	(0.681)
INDIST	**0.804** **	−0.018	**1.115** **	0.036	1.61	**24.229** *	0.162	−0.254
	(0.389)	(0.433)	(0.435)	(0.073)	(6.873)	(13.606)	(0.483)	(0.456)
EMU	**0.696** **	0.542	**−1.156** **	0.117	**−21.343*** **	−0.647	**0.966*** **	0.675
	(0.292)	(0.476)	(0.531)	(0.073)	(6.361)	(0.966)	(0.328)	(0.479)
C3	−0.791	0.565	−1.426	0.664	0.77	0.211	0.104	0.524
	(0.963)	(0.903)	(0.965)	(0.073)	(3.382)	(3.606)	(0.953)	(0.890)

(continued)

Table 6. (Continued)

	Model 8		Model 9		Model 10		Model 11	
	Domestic M&As	**Cross-Border M&As**	**Domestic M&As**	**Cross-Border M&As**	**Domestic M&As**	**Cross-Border M&As**	**Domestic M&As**	**Cross-Border M&As**
PCI SMALL	0.162	**1.363***						
	(0.985)	(0.734)						
PCI MED	1.343	**1.49*****						
	(0.887)	(0.531)						
PCI LARGE	−0.806	**1.873*****						
	(2.618)	(0.680)						
PRUDENTIAL			1.115	**1.519*****	21.43	**1.621****	0.86	**1.359*****
CRITERIA INDEX			(0.978)	(0.073)		0.824	(0.799)	(0.515)
FREEDOM							−0.496	−0.239
							(0.400)	(0.301)
GOVINT							**−0.357****	−0.139
							(0.150)	(0.168)
Observations	4,753		4,753		4,753		4,753	
Pseudo-R^2	0.177		0.203		0.225		0.182	

Source: Own calculations. */**/*** indicate significance at the 10/5/1 percent level. Estimates have been calculated by multinomial logit estimation with cluster robust standard errors.

coefficient for SIZE is positive and highly significant, indicating that larger banks are more likely to be taken over than small banks. That confirms our hypothesis that banks are acquired to reap benefits from economies of scale and scope and to obtain market power. The results are in line with Lanine and Vander Vennet (2007) and Pasiouras, Tanna, and Gaganis (2007). Lanine and Vander Vennet analyze the determinants of cross-border acquisition of banks from Central and Eastern Europe by banks from Western Europe for the period between 1995 and 2002. They also find that bank size is positive and highly significant for acquisitions in Central and Eastern Europe. Pasiouras, Tanna, and Gaganis get the same results for a sample of commercial banks from the EU-15 for the period between 1997 and 2002.[8]

Domestic and cross-border takeovers are also more likely to happen if banks are cost inefficient. The coefficient for CIR is positive and significant for domestic and cross-border targets. To test if profit efficiency determines the probability of a takeover, we replace CIR with the return on assets (ROA). The coefficient for ROA is negative and significant for domestic and cross-border acquisitions. This indicates that less efficient banks are more likely to be acquired. Both results are consistent with the hypothesis that banks are taken over to transfer the managerial expertise from the acquiring bank to the acquired bank in order to generate X-efficiency gains from better management.[9]

To control for the overall risk profile of the acquired bank, we include the ratio of equity to total assets (CAP). CAP is insignificant for domestic and cross-border targets.[10] A low level of liquidity

[8]Hannan and Pilloff (2006) find out for a sample of U.S. banks that larger banks are more likely to be taken over than smaller credit institutions.

[9]We do not include CIR and ROA together in a single regression because both variables are correlated. The regression results with CIR and ROA are in line with Lanine and Vander Vennet (2007) and Pasiouras, Tanna, and Gaganis (2007). Hannan and Pilloff (2006) get the same results for a sample of U.S. banks. The results for the regression with ROA are not reported, but are available from the author upon request.

[10]This contrasts with Lanine and Vander Vennet (2007) and Pasiouras, Tanna, and Gaganis (2007). Both find a significant and negative relationship between the size of the capital buffer and the probability of being acquired for a sample of banks from the EU-15. Hannan and Pilloff (2006) get mixed evidence for the role of capital for their sample of U.S. banks.

does not seem to increase the likelihood that a bank will be taken over by foreign banks either. LIQ is insignificant for cross-border acquisitions. This suggests that neither the level of bank risk nor the degree of liquidity is an important determinant of cross-border takeovers in the EU banking sector. There is, however, weak evidence that liquidity matters for domestic consolidation. LIQ is negative and significant in some regressions for domestic acquisitions. This indicates that banks that face liquidity difficulties are more likely to be acquired by domestic credit institutions.[11]

To control for the business orientation of banks, we use the proportion of interest income to total income (NIREV). NIREV is insignificant for domestic acquisitions, but significant and positive for cross-border targets. This suggests that banks are taken over by foreign credit institutions to get access to local retail-banking markets. Retail banking has become more attractive in recent years because it provides a more stable source of income than non-interest-earning activities.

Location-specific determinants also matter for acquisitions in the banking sector. IMGDP is positive and significant for cross-border targets. This is consistent with the follow-your-customer strategy, according to which banks expand into countries where customers from the home country are located in order to provide services related to their business. IMGDP is mostly significant and positive for domestic acquisitions as well. Since countries that are more open to trade might also be more open to foreign investment, the pressure for domestic consolidation might be higher in countries where the degree of trade openness is high. Pressure for domestic consolidation might also explain why EMU membership seems to matter for domestic takeovers. The positive and significant coefficient for EMU in the equation for domestic acquisitions might reflect the domestic consolidation process that has taken place in the larger Western European countries, which might have been triggered by the introduction of a common currency that has made cross-border takeovers of banks within the EMU easier. There is no evidence that the euro has had a significant impact on cross-border takeovers. The

[11] This is partly in line with Pasiouras, Tanna, and Gaganis (2007). They get a significant and negative coefficient for LIQ for both domestic and cross-border acquisitions.

primary response to the introduction of the euro thus seems to be defensive. This result is consistent with Boot (1999). He argues that the liberating EU directives have so far only had a positive effect on domestic mergers but not on cross-border takeovers because mergers among domestic credit institutions have generally been encouraged to protect national internets.

While GDP does not seem to matter for M&As in the banking sector, the size of the banking system (BSSIZE) does. BSSIZE is significant and negative for both domestic and cross-border takeovers.[12] This suggests that banks do not invest in countries that have a large banking sector. One reason might be that countries with a larger banking system have a more competitive banking sector where margins are smaller and banks are less profitable than countries with smaller banking systems (Demirgüc-Kunt and Huizinga 1999). Since profitability is one of the main reasons for multinational banking, foreign bank expansion in countries with more competitive banking markets is less attractive. Domestic takeovers are also less likely if banking markets are large. Since banks in countries with smaller banking markets are considered less competitive than banks in countries where banking markets are large and where competition is high, credit institutions in countries with smaller banking sectors might be under pressure to merge among themselves in order to increase their level of competitiveness and to prevent being taken over by more efficient banks from countries with larger banking markets.[13] This is also in line with the result that less efficient banks are more likely to be taken over than efficient banks. In particular, domestic acquisitions seem to be driven by the motive to increase X-efficiency (see table 4). One reason is that X-efficiency gains are more likely to be achieved in domestic takeovers because efficiency barriers are lower for domestic banks than for foreign banks. Another reason is that domestic consolidation is often regarded as a precondition

[12]Pasiouras, Tanna, and Gaganis (2007) also find banking sector development to be negatively correlated with the likelihood of an acquisition.

[13]This is supported by Focarelli and Pozzolo (2001) and Buch and DeLong (2004). Both find that banks from countries with large banking markets are more often involved in cross-border acquisition than banks from small banking markets because banks from countries with a more developed banking market are more likely to have a competitive advantage over their competitors in countries with smaller banking systems.

for cross-border consolidation, since a strong position in the home market is believed to be crucial for a successful expansion in foreign markets (Boot 1999).

Domestic consolidation is possible because mergers among domestic banks do not seem to raise antitrust concerns. This is indicated by C3, which is insignificant for cross-border acquisitions and mostly insignificant for domestic acquisitions. To test if this result is robust, we replace C3 with the Herfindahl Index (HHI). HHI measures market concentration based on the sum of the squared market shares of all banks in the country and, thus, takes account of the structure of the whole banking system. C3 measures market concentration only based on the market share of the three largest banks. The regressions with HHI provide further evidence that banking market concentration does not matter for cross-border takeovers. HHI is insignificant for cross-border acquisitions. This is what we have expected, since cross-border takeovers are less likely to raise antitrust concerns. Domestic acquisitions do not seem to raise antitrust concerns as well.[14] DIST is insignificant for cross-border acquisitions. This suggests that efficiency barriers that might arise from distance do not determine the decision to take over or merge with foreign credit institutions. The probability of domestic takeovers, in turn, is positively related to distance. This might indicate that domestic consolidation is more intense in countries that are farther away from the geographical center of Europe.

6.2 The Role of Merger Control

The next step of the regression analysis is to analyze if the probability of a takeover depends on the degree of transparency of merger

[14]Hannan and Pilloff (2006) do not find any significant evidence that banking market concentration measured by HHI matters for acquisitions in the U.S. banking sector. Pasiouras, Tanna, and Gaganis (2007) get a significant and negative correlation between the degree of banking market concentration measured by the market share of the five largest banks (C5) for a sample French, German, Italian, Spanish, and British bank. For the sample of the remaining ten EU member countries, they get a significant and positive coefficient for C5. The results for the regression with HHI are not reported, but are available from the author upon request.

control. For that reason, we add the merger control indices presented in section 3 to the regression. Since a higher index value indicates a higher degree of transparency of merger control and political independence of the supervisory authority, we expect the indices to be positively correlated with the probability that a bank will be taken over by a foreign credit institution if politicians and supervisors use merger control to block cross-border acquisitions in the banking sector.

The first step is to put all indices together into a single regression. The results are presented in column 4 of table 6. All indices are insignificant. Only the Prudential Criteria Index (PCI), which measures how transparent the prudential assessment of potential investors is, is highly significant. Since some of the indices are correlated, we ran separate regressions for all indices to prevent multicollinearity. The results of these regressions are presented in columns 5, 6, and 7 of table 6. All indices are insignificant in the regression for domestic acquisition, but significant in the regression for cross-border takeovers. The positive sign for all coefficients indicates that acquisitions of domestic banks by foreign credit institutions are more likely if supervisors are more politically independent and merger control is more transparent. This is in line with the hypothesis that merger control might constitute a barrier to cross-border consolidation in the EU banking sector if politicians and supervisors use the intransparency of the regulatory process to block cross-border takeovers for other than prudential reasons. Since the coefficients for domestic targets are insignificant, politicians and supervisors do not seem to have used their powers to promote mergers between domestic banks.

Interference by politicians and supervisors seems to be particularly likely if foreign banks are interested in large domestic banks. This is also reflected by the comments of the French government to speculations that Société Générale might be taken over by foreign investors. Société Générale is the second largest bank in France, measured by assets, and Crédit Lyonnais was one of the largest banks as it was taken over by Crédit Agricole. To find out if the political dimension is particularly important for the takeover of large banks, we have created three dummy variables, each representing a different bank size. Banks are considered small if their assets are smaller than the 25th percentile, middle-sized if their assets lie within the

25th and 75th percentile, and large if their assets exceed the 75th percentile. The results of the regression with these dummies are presented in column 8 of table 6. Since we multiply the size dummies with PCI, each coefficient measures the effect of merger control on the probability of a takeover for a different size of banks. The results suggest that large banks are more likely to be taken over by foreign credit institutions if merger control is transparent. Although all interaction terms are significant in the equation for cross-border targets, the coefficient is higher for large banks than it is for small banks. This supports the hypothesis that the acquisition of large banks by foreign credit institutions is less likely if merger control lacks procedural transparency. The results are also in line with Boot (1999). He argues that the political dimension of bank mergers is particularly important if politicians want to protect national flagships.

6.3 Robustness Tests

To find out if our results are biased by omitted variables, we did several robustness tests. The first test is to add time dummies to the baseline regression with PCI (column 9 of table 6). Time dummies control for shocks that occurred in a given year and had the same effect on all countries in our sample. We, furthermore, estimate a model that includes both time and country dummies (column 10 of table 6). While time dummies control for common shocks in a given year, country dummies control for omitted variables that do not vary over time and that are specific to each country. Examples for such time-invariant variables are culture and language. Country dummies also control for the attitude of the government toward foreign investment in the banking sector as long as it does not change over time. Time and country dummies, hence, control for a lot of determinants of multinational banking that cannot be controlled for with the variables in the baseline regressions. However, even if we control for such omitted variables, the results of the baseline regressions do not change. PCI remains significant and keeps its positive sign.

Another problem of the baseline regression might be that PCI only varies for the Central and Eastern European countries. To test if this has caused the significance of the PCI, we run a separate

regression for the new member states. This regression also controls for the fact that many countries in Central and Eastern Europe opened their banking sectors to foreign investors after they experienced banking crises in the nineties. This might have led to an overestimation of the effect PCI has on the likelihood that a bank will be taken over. The results of the separate regression indicate that overestimation has not caused our results. PCI remains positive and significant. This suggests that our results are not driven by differences between new and old EU member countries, but rather by country-by-country differences in the degree of transparency of merger control.

A third robustness check is to estimate the baseline regression with PCI together with indices that measure the quality of the institutional environment in the country where the target is located. The results of the regression with BFFREE and GOVINT are reported in column 11 of table 6. BFFREE measures restrictions on capital inflows and banking activity as well as government ownership in the banking sector. GOVINT measures government influence in the economy. Both are based on data from the Heritage Foundation (2008). Since both indices should reflect the attitude of politicians and supervisors toward foreign investment in the banking sector, they might capture what PCI measures. BFFREE and GOVINT have the expected negative sign, which indicates that acquisitions are less likely in countries where restrictions on foreign investment are higher and government intervention is more intense. Both indices are, however, not significant. They, furthermore, do not change the sign and the significance of PCI. This suggests that barriers that might arise from a lack of transparency of merger control cannot be measured by BFFREE and GOVINT.

7. Conclusions

Domestic M&As still outnumber cross-border acquisitions in the EU banking market (Cabral, Dierick, and Vesala 2002). We argue that a lack of procedural transparency of merger control might constitute a barrier to cross-border consolidation, since this could lead to a situation in which the supervisors can refuse authorization based on opaque concerns. The fact that merger control might constitute a barrier to cross-border takeovers in the EU banking

sector was demonstrated in 2005 when the Bank of Italy blocked the acquisition of Banca Antonveneta and Banca Nazionale de Lavoro by ABN AMRO and Banco Bilbao Vizcaya Argentaria. To find out if merger control is a systematic barrier to cross-border consolidation in other EU member countries, we estimate the probability of a takeover as a function of bank and country characteristics and the degree of transparency of the regulatory process.

We find that the likelihood that a bank will be taken over by a foreign credit institution is larger if merger control is transparent. In particular, large banks are less likely to be taken over by foreign credit institutions if merger control lacks transparency. This suggests that governments might block cross-border takeovers and promote domestic takeovers because they want the largest institution in the country to be domestically owned. Domestic takeovers are not affected.

Besides the transparency of merger control, bank characteristics also matter for the probability of a takeover. We find that larger banks are more likely to be acquired, which is consistent with the hypothesis that M&As are driven by economies of scale and scope. Acquirers also seem to be driven by the motive to generate X-efficiency gains from better management because less efficient banks are more likely to be acquired. Cross-border acquisitions also seem to be used to gain access to local retail-banking markets. Banks with a stronger focus on interest-earning activities are more likely to be taken over.

Country characteristics determine in which countries potential targets are taken over. We find that cross-border mergers are more likely if a country's degree of trade integration is high. This suggests that banks follow their customers abroad in order to provide them banking services in foreign countries. Cross-border acquisitions are also more likely if the banking sector where the target is located is small. The euro does not seem to have increased the probability that a bank will be taken over by a foreign credit institution. There is, however, evidence that it has a positive impact on domestic takeovers. Trade openness is also positively related to domestic consolidation. Together, these findings suggest that domestic takeovers might be a defensive reaction to prevent foreign investors from buying majority shareholdings.

Appendix

Table 3. Variables

SIZE	Log (Total Bank Assets)
MS	Total Bank Assets/Total Banking Sector Assets
ROA	Pre-Tax Profits/Total Assets
CIR	Total Expenses/Total Income
CAP	Total Equity/Total Assets
LIQ	Liquid Assets to Customer and Short-Term Funding
NIREV	Net Interest Income to Total Income
DEP	Customer Deposits to Total Bank Assets
LOAN	Customer Loans to Total Bank Assets
GDP	Log (Gross Domestic Product)
IMGDP	Total Imports to GDP
DIST	Log (Distance)
C3	Market Share of the Three Largest Banks
BFFREE	Average (Banking and Investment Freedom Index)
GOVINT	Government Intervention Index
HHI	Herfindahl Index
EMU	Dummy Variable for EMU Membership
IPI	Index of Political Independence
GCI	General Criteria Index
PCI	Prudential Criteria Index

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Efficient Asset Allocations in the Banking Sector and Financial Regulation*

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The failure of a bank or the case of a bank experiencing a crisis usually has negative spillovers for other banks in the economy, such as through informational contagion or an increased cost of borrowing. Such spillovers are likely to be higher when the other banks are close to failure as well. This paper shows that this gives rise to externalities among banks which arise from their portfolio choices. The reason is that the assets a bank holds on its balance sheet determine the situations in which a bank will be in a crisis, and thus whether this will be at a time when other banks are in a crisis as well. As a result, the equilibrium portfolio allocations in the economy are typically not efficient. Some banks may choose too-correlated portfolios, but others may choose too-heterogeneous portfolios. The optimal regulatory treatment of banks is typically heterogeneous and may involve encouraging more correlation at already highly correlated banks but lowering correlation at other banks. Additional inefficiencies arise when bank failures also have implications outside the banking sector. Overall, the paper highlights a role for regulation in a financial system in which the costs of financial stress at institutions are interdependent.

JEL Codes: G21, G28.

1. Introduction

The failure of a bank often induces negative spillover effects for other banks. Such spillovers may be of an informational nature.

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Depositors, having observed the failure of one bank, may conclude that other banks are also in trouble and may start running on them as well. The other banks may also suffer from higher borrowing costs because lenders generally update their beliefs about the riskiness of banks. There may also be direct costs arising from the failure of a bank—for example, from defaulting interbank loans. Another channel of spillovers is through asset prices. The liquidation of assets following the failure of a bank may depress asset prices and hurt other banks that have the same assets on their balance sheets.

The overall impact of such spillovers is likely to depend on the general health of the other banks. A bank that is already on the brink of failure may particularly suffer from such spillovers and may even fail itself as a consequence. And when many banks fail at the same time (a systemic crisis), there may be additional costs for society as a whole, because it then becomes more difficult for firms to obtain financing. By contrast, the impact of such spillovers on healthy banks is likely to be limited. Healthy banks may even benefit from a crisis of their competitors, either because it enables them to capture a higher market share or because it allows them to purchase their competitors' assets at discounted prices.

The main idea of this paper is as follows. When the externalities from a bank's failure depend on whether other banks are in trouble at the same time, then a bank's portfolio choice will have welfare implications beyond the traditional risk-liquidity trade-off. The reason is that the assets a bank holds on its balance sheet determine the situations in which the bank will be in a crisis, and thus whether this will be at times when other banks are in trouble as well. For example, if a bank invests in the same portfolio as most of the other banks, it would tend to fail at a time when other banks are failing as well, thus potentially maximizing the negative spillovers. By contrast, a bank that holds a portfolio very different from other banks, even if it is very risky itself, may overall pose very few externalities, since it will tend to fail at a time when other banks are in good shape (and when those other banks can potentially purchase its assets).

We consider a setup where there are interbank externalities due to liquidation costs. They arise because a bank's failure depresses asset prices, which negatively affects all other banks that are in trouble at the same time, since these banks also have to liquidate. There are many banks in our economy, each of which decides the

combination of risky assets it wants to hold in its portfolio. We show that the equilibrium in this economy is typically not efficient due to the presence of externalities. Suppose a bank invests more in an asset. It then makes itself more similar to all banks that are relatively exposed to this asset. This is costly for the latter, since it now becomes more likely that these banks will have to liquidate jointly with the aforementioned bank if it fails. But there is also a counteracting externality. When a bank invests in the asset, it also makes itself less similar to all banks that are less exposed to this asset. This benefits these banks by reducing their likelihood of joint liquidation.

We show that the net effect of these externalities is ambiguous. As a result of this, a bank may either be too close to the average portfolio in the banking system (too correlated) or too far away (too heterogeneous). We also show that, typically, some banks are always too little correlated with the average portfolio, while at the same time others are too much correlated. Optimal financial regulation should thus treat banks heterogeneously. In particular, we show that, perhaps paradoxically, correlation at already correlated banks should be further encouraged, while correlation at less correlated banks should be discouraged.

The reason for this result is as follows. Consider a bank that is relatively specialized (that is, not very correlated with the other banks in the banking system). If this bank gets closer to the average portfolio in the economy, it will become more similar to most other banks in the system, which will impose an overall large externality. It is true that it will also increase differences with the banks that are even more specialized in the asset this bank is invested in. However, these are only a few banks. Thus, the negative externality is relatively large compared with the positive one, and hence this bank may correlate more than what is optimal. For a bank that is already fairly correlated, the opposite reasoning can be applied.

These considerations concern the impact a bank's portfolio choice has on other banks. However, the effects of a bank's failure are not limited to the banking sector. The bank's failure will also affect the returns of the agents who may purchase the assets in a liquidation (in our model, these are located outside the banking sector). Furthermore, there may be effects in the wider economy. For example, when there are many failures at the same time (a systemic crisis),

this may induce social costs in the form of a credit crunch. We show that the overall efficiency implications of banks' portfolio choices depend crucially on how these effects materialize. In the limit case when there are no losses from transferring assets to outsiders and there are no social externalities, the equilibrium is always efficient. In the case where the transfer of an asset to outsiders incurs a deadweight loss which increases in the total amount of assets liquidated, we find that banks tend to correlate too little. However, when there are social costs from a joint failure of banks, there is a tendency for too much correlation in the financial system.

Concluding, the analysis in this paper suggests that the consequences of banks' portfolio choices for the financial system are complex and go beyond the classical risk-liquidity trade-off. This is because in a financial system in which there are various interlinkages across banks, the social cost of risk at a bank is determined not only by its likelihood of failure but also by the situations in which it is likely to fail. In particular, banks that invest in idiosyncratic portfolios are relatively more likely to fail at times when other banks are in good health, and their failure is hence less likely to pose large externalities. By contrast, the externalities of banks whose investment is closer to the average portfolio in the economy may be larger. Financial regulation that operates from a systemic viewpoint should strive to take this into account.

The paper proceeds as follows. The next section discusses related literature. Section 3 sets up the model. Section 4 analyzes the efficient allocation of portfolios in the economy. In section 5 the implications for the optimal regulatory treatment of bank portfolios are discussed. The final section concludes.

2. Related Literature

There is a rapidly growing literature that analyzes banks' portfolio choices. Several papers in particular have considered the implications for banks' incentives to hold liquidity in the presence of fire sales of assets.[1] Gorton and Huang (2004) present a model in which financing

[1]Allen and Gale (2004), by contrast, consider the impact on the incentives of outsiders to provide liquidity.

is restricted by agency problems at the level of the firm, as in Holmström and Tirole (1998). Banks supply liquidity in order to be able to buy up assets cheaply in a crisis. This is socially inefficient because a private provision of liquidity implies less investment in risky, high-return assets. In Wagner (2007) banks also hold liquidity in order to profit from fire sales. Purchasing banks, however, are inferior users of the assets compared with the originating bank. Because of this, they do not perceive the full social value of providing liquidity and, as a result, liquidity is underprovided in equilibrium. Acharya, Shin, and Yorulmazer (2007) show that liquidity can be either under- or overprovided in the presence of fire sales. The reason is that risky assets—the alternative to holding liquidity—can be used as well to purchase assets in a crisis because they serve as a collateral. The relative incentives to hold liquidity, as opposed to investing in the risky asset, depend then on the pledgeability of assets. If the latter is high, liquidity is underprovided in equilibrium.[2]

This paper differs from these papers in that it analyzes banks' choices between two risky assets, rather than between a risky and a safe asset. Such a choice is also considered in various papers by Acharya and Yorulmazer. In their papers, banks have incentives to choose overly correlated assets. In Acharya (2001) and Acharya and Yorulmazer (2005), this is because bank owners invest in correlated assets because they do not internalize the costs of a joint failure due to limited liability. In Acharya and Yorulmazer (2006) and Acharya and Yorulmazer (2007), banks want to increase the likelihood of failing simultaneously in order to induce a regulator to bail them out, which again causes them to correlate too much.

A difference to these papers is that in our setup banks dislike being correlated with each other due to the higher costs of failure this implies. Still, a failure that takes place when many other banks fail as well imposes greater externalities than if only a few other banks are failing. Interestingly, however, and in contrast to the above papers, this does not imply that banks choose too-correlated portfolios. The reason is that in our setting banks can hold a mix of assets

[2]Perotti and Suarez (2002) present a model where banks also gain from the failure of their competitors. They do this not through fire sales, but by capturing a higher market share. This is shown to make banks more prudent in their lending behavior (the analog to holding more liquidity in the former papers).

(while in the papers by Acharya and Yorulmazer the investment decision is an "either-or" choice). Consider a bank that is invested in two assets, X and Y, but more so in asset X. If the bank chooses a more correlated portfolio by investing more in Y (correlated in the sense of choosing a portfolio that is closer to the average portfolio in the banking sector, which is the portfolio that combines X and Y equally in the case that portfolio allocations in the banking sector are symmetric), the bank becomes more similar to all banks invested more heavily in Y. However, it also becomes less similar to all banks that are even less invested in Y. As we show in the paper, this makes the overall externalities that arise from moving closer to the average portfolio ambiguous. As a result, banks may either correlate too much or too little in equilibrium.

While in the present paper, and in the papers by Acharya and Yorulmazer, a higher correlation among banks is undesirable, Wagner (2008) presents a model where this is not the case. The reason is that when banks are more correlated, their liquidity positions in a crisis will be more homogeneous. There is then less need to reallocate liquidity through the interbank market, which improves welfare since the interbank market may not work perfectly in times of crisis. Moreover, a higher homogeneity of banks also reduces the need to regulate banks. This is because when banks are more homogeneous, they can rely less on interbank risk sharing. This in turn reduces any externalities that arise from such risk sharing. A downside of the homogenization, however, is that it also lowers banks' incentives to hold liquidity and increases their incentives to invest in risky assets (while the total amount invested in risky assets stays constant in the present paper).

3. The Model

The economy is inhabited by a continuum of banks of mass 1 that are indexed by i. Each bank has collected one unit of funds from investors, of which a share d is in the form of deposits and $1 - d$ is equity. Shareholders and depositors are both risk neutral.

There are three dates. At date 1 banks can divide their funds between two assets, X and Y. We denote with $\alpha_i \in [0, 1]$ the share invested by bank i in asset Y. $1 - \alpha_i$ is then the share invested in $\dot{X}$. The assets mature at date 3. We denote with x and y the

date 3 returns on asset X and Y, respectively. These returns are identically and independently distributed on $[0, \infty)$ according to a density $\phi(.)$.

At date 2, the date 3 returns x and y become known. The fundamental value of bank i is then given by

$$v_i = (1 - \alpha_i)x + \alpha_i y. \tag{1}$$

Following this, a bank run occurs at a bank if the (fundamental) value of its assets falls below the value of deposits. That is, bank i experiences a run if $v_i < d$ (we thus rule out panic runs). The bank then has to sell its entire portfolio to investors that are located outside the banking system.[3] We assume that the portfolio can only be sold at a discount $C(.) \geq 0$ to its date 3 value. $C(.)$ is strictly and smoothly increasing in the number of portfolios that are liquidated at the same time. We also assume that $C(0) = 0$; that is, if the mass of other selling banks is zero, the portfolio can be sold without a loss.

The increasing discount may stem from several sources. First, there may be fire-sale prices due to *cash-in-the-market pricing* (e.g., Allen and Gale 2004, Gorton and Huang 2004, and Schnabel and Shin 2004): when the total supply of liquidity by outsiders is limited, all available liquidity may have to be used to purchase assets. This then necessarily implies that if more portfolios are sold, the price per portfolio has to decline, which naturally gives rise to the above cost function. Alternatively, the purchasers of the portfolios may require a higher compensation when they have to hold more assets (e.g., because they are risk averse), also implying that the price per portfolio is declining in the amount of portfolios sold.

The crucial assumption here is that C, which represents a bank's cost of failure, is higher when other banks face stress at the same time. Besides fire sales, this may be for a variety of other reasons. For example, there may be informational spillovers from the failure of a bank, driving up the cost of borrowing at other banks. Such a spillover is likely to hurt a bank more when it is close to failure itself.

[3]Banks themselves cannot purchase assets, as they do not hold liquidity. The impact of fire sales on their incentives for holding liquidity has, for example, been emphasized in Acharya, Shin, and Yorulmazer (2007).

Or, there may be network externalities (such as from the failure of the settlement system), which will also tend to hurt banks more when they are weak.

Finally, at date 3, assets mature and shareholders and depositors consume their respective returns. Since both shareholders and depositors are risk neutral, each bank's value is maximized when its overall expected return is maximized. The latter can be split into the expected fundamental value of a bank's portfolio (v_i) minus the expected liquidation costs due to the asset discount. Since both assets are identically distributed, a bank's portfolio allocation α_i does not influence its expected fundamental value v_i. Hence, a bank's value is simply maximized when its expected liquidation costs are minimized (which we derive below).

4. Efficient Portfolio Allocations in the Banking Sector

An allocation in this economy can be summarized by a density function $f(\alpha)$ on $[0, 1]$, which gives the density of all banks playing the portfolio α. Alternatively, the allocation can be represented by the corresponding mass function $F(\alpha)$, which represents the mass of banks playing α or less. In this section we analyze the $F(\alpha)$ that is efficient for the banking sector—that is, the $F(\alpha)$ that minimizes the total expected liquidation costs in the banking sector. We denote this mass function with $F^e(\alpha)$.[4]

We first derive a single bank's expected liquidation costs from playing α. Recall that a bank has to sell its portfolio if the fundamental value of its assets is less than the deposits. From rearranging (1), we have that the bank has to liquidate if $y < \widehat{y}(x)$, where $\widehat{y}(x)$ is given by

$$\widehat{y}(x, \alpha) = \frac{d}{\alpha} - \frac{1 - \alpha}{\alpha} x. \tag{2}$$

$\widehat{y}(x)$ gives us the critical return of asset Y for which the bank just survives if asset X pays x.

[4]We only characterize the efficient aggregate allocation $F^e(\alpha)$, which completely suffices for our purpose. A bank's individual allocation α_i at the efficient solution cannot, in fact, be uniquely determined, as will become clear soon.

Suppose now that we have $y < \widehat{y}(x)$; that is, the bank has to liquidate. What are the costs the bank will incur? This will depend on how many other banks are failing at the same time. Consider first $x > y$; that is, asset X has a higher return than asset Y. In such a situation, banks with low α (banks that have not invested much in Y) will survive, but banks with high α will fail. It follows that there is a critical value $\widehat{\alpha} = \widehat{\alpha}(x, y)$, such that all banks with $\alpha > \widehat{\alpha}(x, y)$ fail, while all banks with $\alpha \leq \widehat{\alpha}$ survive. From (1) we have that $\widehat{\alpha}$ is implicitly defined by $v = (1 - \widehat{\alpha})x + \widehat{\alpha}y = d$. Rearranging for $\widehat{\alpha}$ we get

$$\widehat{\alpha}(x, y) = \frac{d - x}{y - x}. \tag{3}$$

Since all banks with $\alpha > \widehat{\alpha}(x, y)$ fail, the mass of failing banks is $1 - F(\widehat{\alpha}(x, y))$ and the liquidation costs are consequently $C(1 - F(\widehat{\alpha}(x, y)))$. Consider next $x < y$. Now all banks that are more exposed to X will fail—that is, banks with $\alpha < \widehat{\alpha}$. The liquidation costs in this case are hence $C(F(\widehat{\alpha}(x, y)))$.

The liquidation costs that arise for a return realization (x, y) can thus be summarized as follows:

- If $y \geq \widehat{y}(x)$, there are no liquidation costs.
- If $y < \widehat{y}(x)$ and $x > y$, liquidation costs are $C(1 - F(\widehat{\alpha}(x, y)))$.
- If $y < \widehat{y}(x)$ and $x < y$, liquidation costs are $C(F(\widehat{\alpha}(x, y)))$.

A bank's total expected liquidation costs can then be found by integrating over the liquidation costs for each return realization (x, y) weighted by its density $\phi(x)\phi(y)$. The total expected liquidation costs in the banking sector are then obtained by integrating over the expected liquidation costs of all banks.

Appendix 1 makes assumptions on the distribution function ϕ. These assumptions ensure that (i) more investment in one asset increases the likelihood of failure if this asset performs worse than the other one but reduces the likelihood of failure when it performs better, (ii) moving the portfolio toward $\alpha = 1/2$ always reduces the likelihood of failure, and (iii) the marginal gains from doing so (in terms of reducing the likelihood of failure) are declining the closer we get to $\alpha = 1/2$.

Proposition 1. *The efficient portfolio allocation $F^e(\alpha)$ is strictly increasing in α.*

Proof. See appendix 2.

Since the mass function is strictly increasing, it follows that the efficient allocation requires that all portfolio allocations are played by at least some banks. In particular, we also have banks that play $\alpha = 0$ and $\alpha = 1$; that is, some banks hold completely polarized portfolios.

What is the intuition behind this result? Since the liquidation costs are increasing in the number of banks failing, it is not optimal to have many banks playing the same allocation. The reason is that banks would then tend to liquidate together, which would incur substantial liquidation costs. Since one wants to avoid pooling many banks in a liquidation, it is efficient to spread banks as widely as possible on the continuum $[0, 1]$.

5. Implications for Financial Regulation

Proposition 1 has shown that it is optimal for the banking sector as a whole that all possible portfolios are played by the banks. There is no guarantee, however, that banks themselves will choose the optimal allocation. The equilibrium may in fact be inefficient, and thus gives rise to a role for financial regulation. Let us first consider efficiency within the banking system and ignore the impact banking failures and fire sales may have in other parts of the economy. This *interbank* aspect of efficiency can be analyzed by studying whether there are any externalities among banks. Clearly, in the absence of such externalities, the equilibrium would be efficient within the banking sector.

To this end, consider the impact of bank i becoming more correlated on the other banks in the economy. For this we presume that the aggregate portfolio holdings in the economy are symmetric (that is, we have $f(\alpha) = f(1 - \alpha)$). The average portfolio in the banking sector consists then of equal parts of X and Y. Getting more correlated for a bank thus implies moving closer toward $\alpha = 1/2$. Suppose, in particular, that bank i slightly increases its α_i, starting from an α_i of less than $1/2$. That is, the bank gets more correlated by investing more in asset Y. When it does so, it tends to

fail more often when $x > y$ and less often when $x < y$. In the situations where the bank now fails (although it did not do so previously), the (per portfolio) liquidation costs in the banking sector rise marginally. This is because C is increasing in the mass of failing banks. This poses a negative externality on all banks that fail at the same time. These are all the banks that are even more exposed to Y—that is, all banks that play an α higher than α_i. The total externality from this on the other banks' liquidation costs can be shown to be (second part of equation (16) in appendix 2):

$$C'(1 - F(\alpha_i))B'(\alpha_i)(1 - F(\alpha_i)) > 0. \tag{4}$$

The externality is thus the product of the impact of more liquidations on the liquidation costs, $C'(1 - F(\alpha_i))$; the probability of the area where more liquidations take place, $B'(\alpha_i)$ ($B'(\alpha_i) > 0$; see appendix 1); and the mass of banks that play an α higher than α_i, $1 - F(\alpha_i)$.

Conversely, liquidation costs are lower in the situations where the bank now survives. This induces a positive externality on all banks with $\alpha < \alpha_i$ since such situations occur when $x < y$. The total externality from this is (first part of equation (16) in appendix 2):

$$C'(F(\alpha_i))A'(\alpha_i)F(\alpha_i) < 0. \tag{5}$$

This externality now depends on the mass of banks that play a higher α and is positive because it reduces the expected liquidation costs ($A'(\alpha) < 0$; see appendix 1).

It can be easily seen that the net effect from these externalities cannot be generally determined. This is because their relative magnitude depends crucially on how many of the other banks play a higher α and how many play a lower α (which in turn depends on the α_i played by bank i and the α's of all other banks). Suppose, for example, that all banks play a higher α than bank i. We then have $F(\alpha_i) = 0$. Then, there is obviously no positive externality, and the negative externality prevails. In such a situation, bank i is too much correlated from an efficiency perspective.[5] However, when many banks play a lower α, $F(\alpha_i)$ is large. Additionally, we have that

[5] A similar result is obtained in the various papers by Acharya and Yorulmazer. They show (in a two-bank setup) that investing in the same asset as the (single)

$|A'(\alpha_i)| > B'(\alpha_i)$ because moving more toward the fully diversified portfolio reduces the overall probability of the bank being liquidated (see assumption (ii) in appendix 1). The positive externality may then prevail. In such situations, regulators should optimally encourage correlation at this bank. This suggests that regulators should, perhaps paradoxically, discourage correlation at uncorrelated banks (low α_i relative to other banks). At more-correlated banks, by contrast, the positive externality is also present. It may hence be optimal to further encourage their correlation.

Note that, in our setup, being more similar and being more diversified is the same thing. This is because when banks are symmetrically distributed around $\alpha = 1/2$ ($f(\alpha) = f(1-\alpha)$), the consolidated portfolio in the banking sector is the fully diversified portfolio, regardless of whether banks are individually diversified or not. We can thus rephrase the last sentence as saying that diversification should be encouraged at relatively diversified banks (thus making them even more diversified), while it may be optimal to discourage diversification at banks that are already close to the fully polarized portfolio.

Let us next consider overall efficiency, thus also taking into account the effect of bank correlation on other parts of the economy and, in particular, on the purchasers of the assets. As we will see, the results will depend crucially on how these effects materialize.

Suppose first that the outsiders who purchase the assets are risk neutral as well and that their (exogenous) supply of liquidity leads to cash-in-the-market pricing, CITMP. CITMP refers to situations where the total amount of liquidity provided by outsiders is less than the combined fundamental value of all portfolios that have to be liquidated. Assume that the transfer of assets to the outsiders does not result in any efficiency losses; that is, outsiders can extract their full fundamental value. Moreover, assume that there are no other deadweight losses from banking failures, which may realize either at banks themselves (e.g., due to bankruptcy costs) or in other parts of the economy (e.g., because of a credit crunch).

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other bank increases the likelihood of joint failure of the two banks, which in turn may impose negative externalities on society. Thus, banks correlate ("herd" in their papers) too much.

Under CITMP, banks will make a loss from the liquidation of their assets. However, this loss is then exactly offset by the gains to the outsiders since there is no overall efficiency loss from transferring assets: fire sales are a zero-sum game. It follows that, conditional on the liquidity supplied by outsiders, all portfolio allocations are efficient. Thus, there is no rationale for regulation in this case.

Suppose next that there is an efficiency loss from selling assets to outsiders in the form of a constant loss $\delta > 0$ per portfolio transferred. This loss may occur because outsiders, who do not have the specialized knowledge of banks, are less efficient users of the asset. In this case the total efficiency losses in the economy are proportional to the number of portfolios that are liquidated. Welfare hence decreases in the number of banks that have to liquidate. Since higher correlation minimizes the likelihood of liquidation at each bank (since it implies a more diversified portfolio), it follows that full correlation (or a complete homogeneity of banks) is the socially efficient outcome. Banks themselves, however, will not find it optimal to play all the full correlated outcome. The reason for this is the same as for proposition 1, which showed that a heterogeneity of portfolios is optimal for the banking sector. If banks were indeed all holding the same portfolio, they would need to liquidate at the same time, which would be very costly for them.[6] In this case, too little correlation is the likely outcome for the banking sector.

Finally, consider a different scenario. Assume that there are no efficiency losses from transferring assets ($\delta = 0$ in the notation of the previous paragraph). However, there are social costs of a systemic crisis: when more than a certain number of banks fail at the same time, there are costs $C_S > 0$ outside the banking sector (this may be, for example, because there is then a credit crunch, which causes losses to the wider economy). More specifically, assume that a systemic crisis arises when the mass of failing banks is larger than F_S ($F_S < 1/2$). Also assume that the social costs increase in the mass of failing banks ($C_S'(.) > 0$) and that the marginal social costs are constant $C_S'(.) = \overline{C}_S'$.

[6]Note that the assumption that a bank's liquidation costs are increasing in the number of banks failing at the same time (which is required for proposition 1) is still fulfilled in this context, since δ is a constant and CITMP itself implies increasing costs.

A bank that plays α_i then always fails in a systemic crisis (and thus always amplifies the systemic costs when it fails) when both $F^e(\alpha_i) \geq F_S$ and $1 - F^e(\alpha_i) \geq F_S$. This is because if the bank fails when $x < y$, it fails together with $F^e(\alpha_i)$ banks, while if it fails when $x > y$, it fails together with $1 - F^e(\alpha_i)$ banks. Defining with $F^{e-1}(.)$ the inverse of $F^e(.)$, this happens when the bank's α_i fulfills $F^{e-1}(F_S) \leq \alpha_i \leq F^{e-1}(1 - F_S)$, that is, when the bank is relatively correlated. For α_i outside this range, the bank does not contribute to a systemic crisis if either $x > y$ or $x < y$.

Since the systemic costs occur outside the banking system, they are not internalized by banks. They hence do not affect the equilibrium amount of correlation in the banking sector. Suppose that, starting from an equilibrium, we reduce correlation at a relatively correlated bank. In particular, we lower correlation at a bank with $\alpha_i = F^{E-1}(F_S)$ to $\alpha_i = 0$. In the situations of additional failures (which occur when $x < y$), the bank then fails without a systemic crisis, since the number of other banks failing at the same time is less than F_S. In the situations of avoided failures (which arise when $x > y$), the bank previously failed in a systemic crisis. Hence, the bank overall contributes less to systemic crises. Therefore, the negative externality (in terms of amplifying systemic crises) posed by the bank declines and efficiency increases. Thus, in this scenario banks may be too similar in equilibrium. Encouraging heterogeneity in the banking system may then improve welfare.

6. Concluding Remarks

This paper has considered the efficiency of banks' portfolio choices when the externalities from a bank's failure depend on the general health of the banking sector. We have shown that there are interesting implications for financial regulation. For example, encouraging less correlation at banks is not necessarily desirable for the financial system. There are plausible scenarios under which banks may either choose too much or too little correlation in equilibrium.

Our analysis has also shown that the welfare implications of a change in an individual bank's portfolio depend crucially on how the bank's portfolio relates to the portfolios of the other banks in the financial system. This is because when a bank invests more in an asset, this has a negative effect on all banks that are even more

invested in this asset, but it has a positive effect on all banks that are less invested in the asset. The net effect then depends on the relative size of these two groups of banks and thus on the portfolio allocation of the bank itself. Since banks will typically hold different portfolios in equilibrium, their regulatory treatment should hence not be the same. Indeed, as we have shown, it may be optimal to encourage correlation at some banks, while discouraging it at others.

Appendix 1. The Assumptions on the Distribution Function ϕ

It is useful to define with

$$A(\alpha) := \int_0^d \left(\int_x^{\widehat{y}(x,\alpha)} \phi(x)\phi(y)dy \right) dx \tag{6}$$

the probability that a bank that plays α fails when there is $x < y$, and with

$$\begin{aligned} B(\alpha) : = & \int_0^d \left(\int_0^x \phi(x)\phi(y)dy \right) dx \\ & + \int_d^{\widehat{x}(0,\alpha)} \left(\int_0^{\widehat{y}(x,\alpha)} \phi(x)\phi(y)dy \right) dx \end{aligned} \tag{7}$$

the probability that the bank fails when $x > y$. $\widehat{x}(0)$ is the x at which $\widehat{y}(x)$ becomes zero. $\widehat{x}(0)$ is obtained by setting $\widehat{y}(x) = 0$ and solving for x:

$$\widehat{x}(0,\alpha) = \frac{d}{1-\alpha}. \tag{8}$$

$A(\alpha) + B(\alpha)$ then gives us the overall probability of failure when α is played.

The assumptions on ϕ are as follows:

(i) The density is smooth and has full support on $[0, \infty)$; that is, we have $\phi(z) > 0$ for $z \in [0, \infty)$. From this, it follows that $A'(\alpha) < 0$ and $B'(\alpha) > 0$; that is, more investment in Y makes it less likely that the bank fails if $x < y$ and more likely if $x > y$.

(ii) We have $A'(\alpha)+B'(\alpha) < 0$ for $\alpha < 1/2$ and $A'(\alpha)+B'(\alpha) > 0$ for $\alpha > 1/2$. This guarantees that more diversification (that is, moving toward $\alpha = 1/2$ from either side) always reduces the overall probability of failure.

(iii) We have $A''(\alpha) > 0$ and $B''(\alpha) > 0$. This ensures that the marginal impact of diversification $(A'(\alpha)+B'(\alpha))$ is declining in the amount of diversification.

Appendix 2. Proof of Proposition 1

We first derive the total expected liquidation costs in the banking sector. Integrating over all liquidation outcomes, we get that the liquidation costs for a bank that plays α are

$$\begin{aligned} K(\alpha) = &\int_0^d \left(\int_x^{\widehat{y}(x,\alpha)} (\phi(x)\phi(y)C(F(\widehat{\alpha}(x,y))))dy \right) dx \\ &+ \int_0^d \left(\int_0^x (\phi(x)\phi(y)C(1-F(\widehat{\alpha}(x,y))))dy \right) dx \\ &+ \int_d^{\widehat{x}(0,\alpha)} \left(\int_0^{\widehat{y}(x,\alpha)} (\phi(x)\phi(y)C(1-F(\widehat{\alpha}(x,y))))dy \right) dx. \end{aligned} \tag{9}$$

The first integral in (9) refers to liquidations when $x < y$, while the second and the third integrals refer to liquidations that arise when $x > y$. $\widehat{x}(0,\alpha)$ is the x at which $\widehat{y}(x,\alpha)$ becomes zero and is given by equation (8) in appendix 1. The total expected liquidation costs in the banking sector are then obtained by integrating over all banks:

$$\begin{aligned} TK &= \int_0^1 K(\alpha) f(\alpha) d\alpha \\ &= \int_0^1 \left(\begin{array}{l} \int_0^d \left(\int_x^{\widehat{y}(x,\alpha)} (\phi(x)\phi(y)C(F(\widehat{\alpha}(x,y))))dy \right) dx \\ + \int_0^d \left(\int_0^x (\phi(x)\phi(y)C(1-F(\widehat{\alpha}(x,y))))dy \right) dx \\ + \int_d^{\widehat{x}(0,\alpha)} \left(\int_0^{\widehat{y}(x,\alpha)} (\phi(x)\phi(y) \right. \\ \quad \left. C(1-F(\widehat{\alpha}(x,y))))dy \right) dx \end{array} \right) f(\alpha) d\alpha. \end{aligned} \tag{10}$$

The efficient $F^e(\alpha)$ is the $F(\alpha)$ that minimizes the above expression.

We show next that F^e is strictly increasing at each $\alpha \in [0,1]$. For this we first show that there is positive density around $\alpha = 0$ and $\alpha = 1$. Without loss of generalization, focus on $\alpha = 0$. Suppose, to the contrary, that there is an interval to the right of 0 without density. We can then extend this interval until we reach the first α with positive density. Denote this α with α_1. We hence have that $F(\alpha) = 0$ for $\alpha < \alpha_1$ but that at least one bank plays α_1.

Suppose now that this bank plays $\alpha = 0$ instead. This has a potential impact on the bank itself, but also on other banks in the economy. Consider first the impact on the bank itself. The difference in its expected losses between playing α_1 and 0 are given by

$$\begin{aligned}
&\int_0^d \left(\int_x^{\widehat{y}(x,\alpha_1)} (\phi(x)\phi(y)C(F(\widehat{\alpha}(x,y))))dy \right) dx \\
&\quad + \int_0^d \left(\int_0^x (\phi(x)\phi(y)C(1 - F(\widehat{\alpha}(x,y))))dy \right) dx \\
&\quad + \int_d^{\widehat{x}(0,\alpha_1)} \left(\int_0^{\widehat{y}(x,\alpha_1)} (\phi(x)\phi(y)C(1 - F(\widehat{\alpha}(x,y))))dy \right) dx \\
&\quad - \int_0^d \left(\int_x^{\infty} (\phi(x)\phi(y)C(F(\widehat{\alpha}(x,y))))dy \right) dx \\
&\quad - \int_0^d \left(\int_0^x (\phi(x)\phi(y)C(1 - F(\widehat{\alpha}(x,y))))dy \right) dx. \qquad (11)
\end{aligned}$$

This simplifies to

$$\begin{aligned}
&\int_d^{\widehat{x}(0,\alpha_1)} \left(\int_0^{\widehat{y}(x,\alpha_1)} (\phi(x)\phi(y)C(1 - F(\widehat{\alpha}(x,y))))dy \right) dx \\
&\quad - \int_0^d \left(\int_{\widehat{y}(x,\alpha_1)}^{\infty} (\phi(x)\phi(y)C(F(\widehat{\alpha}(x,y))))dy \right) dx. \qquad (12)
\end{aligned}$$

Note that $\widehat{\alpha}(x,y)$ in the integrals only varies between 0 and α_1. Hence, we have $F(\widehat{\alpha}(x,y)) = 0$ in the integrals. It follows that (12) can be simplified to

$$C(1)\int_d^{\widehat{x}(0,\alpha_1)}\left(\int_0^{\widehat{y}(x,\alpha_1)}\phi(x)\phi(y)dy\right)dx$$

$$-C(0)\int_0^d\left(\int_{\widehat{y}(x,\alpha_1)}^{\infty}\phi(x)\phi(y)dy\right)dx$$

$$=C(1)\int_d^{\widehat{x}(0,\alpha_1)}\left(\int_0^{\widehat{y}(x,\alpha_1)}\phi(x)\phi(y)dy\right)dx>0. \qquad (13)$$

Thus the change to $\alpha_1 = 0$ lowers the bank's expected liquidation costs.

Consider next the impact on other banks in the economy. Due to the move to $\alpha = 0$, the bank now fails for $x < y$ when $0 \leq \widehat{\alpha}(x,y) < \alpha_1$, while it previously survived for these outcomes. No other bank fails in these situations since they all play at least α_1. Hence, these additional failures do not have an impact on the other banks in the economy. The bank, however, now also survives when $x > y$ and $0 \leq \widehat{\alpha}(x,y) < \alpha_1$, while it previously failed for such outcomes. This reduces the liquidation discount $C(.)$, which may, if anything, have a positive impact on other banks. It follows that the overall impact on the other banks cannot be negative. Since we have shown that the move to $\alpha = 0$ increases the bank's payoff, we thus conclude that the original allocation did not maximize welfare.

Thus, we know that there has to be a positive mass around 0 and 1 for an efficient solution. We show next that there cannot be an interval without mass on $(0,1)$. From this, it follows that there is positive mass everywhere (and F strictly increasing). Suppose, to the contrary, that there is such an interval. We can then extend this interval until we reach the first α (on each side) played by some banks. This is possible since we have shown that there is mass on both sides of the boundaries of the interval. Let us call the α's on the lower and upper end of this interval $\underline{\alpha}$ and $\overline{\alpha}$ (with $\underline{\alpha} < \overline{\alpha}$).

We thus have that $f(\alpha) = 0$ for $\alpha \in (\underline{\alpha}, \overline{\alpha})$ and $f(\underline{\alpha}), f(\overline{\alpha}) > 0$. At $\underline{\alpha}$, the expected liquidation costs in the banking sector should be nondecreasing in α, since otherwise welfare could be improved by increasing α at a bank that plays $\underline{\alpha}$ a bit.

Next, we derive the impact of an increase in α at a bank on the expected liquidation costs in the banking sector. For this we consider first the impact on the bank itself. The derivative of a bank's expected liquidation costs with regard to its own α is

$$K'(\alpha) = \int_0^d \left(\phi(x)\phi(\widehat{y}(x))C(1 - F(\widehat{\alpha}(x, \widehat{y}(x))))\frac{\partial \widehat{y}(x)}{\partial \alpha} \right) dx + \int_d^{\widehat{x}(0)} \left(\phi(x)\phi(\widehat{y}(x))C(F(\widehat{\alpha}(x, \widehat{y}(x))))\frac{\partial \widehat{y}(x)}{\partial \alpha} \right) dx. \quad (14)$$

Substituting in $A'(\alpha)$ and $B'(\alpha)$ (which can be obtained from equations (6) and (7) in appendix 1) and using $\widehat{\alpha}(x, \widehat{y}(x)) = \alpha$, we get the following equation:

$$C(F(\alpha))A'(\alpha) + C(1 - F(\alpha))B'(\alpha). \quad (15)$$

In a similar fashion, the impact on the other banks in the economy can be derived from (10) to be

$$C'(F(\alpha))F(\alpha)A'(\alpha) + C'(1 - F(\alpha))(1 - F(\alpha))B'(\alpha). \quad (16)$$

Thus the total impact of a change in α at the bank on the expected liquidation costs is

$$C(F(\alpha))A'(\alpha) + C(1 - F(\alpha))B'(\alpha) + C'(F(\alpha))F(\alpha)A'(\alpha) + C'(1 - F(\alpha))(1 - F(\alpha))B'(\alpha). \quad (17)$$

Using this condition, we can now write down the condition that increasing α at a bank that plays $\underline{\alpha}$ does not lower the expected liquidation costs in the economy:

$$C(F(\underline{\alpha}))A'(\underline{\alpha}) + C(1 - F(\underline{\alpha}))B'(\underline{\alpha}) + C'(F(\underline{\alpha}))F(\underline{\alpha})A'(\underline{\alpha}) + C'(1 - F(\underline{\alpha}))(1 - F(\underline{\alpha}))B'(\underline{\alpha}) \geq 0. \quad (18)$$

Likewise, reducing α at a bank that plays $\overline{\alpha}$ should also not reduce the total liquidation costs. This condition writes

$$C(F(\overline{\alpha}))A'(\overline{\alpha}) + C(1 - F(\overline{\alpha}))B'(\overline{\alpha}) + C'(F(\overline{\alpha}))F(\overline{\alpha})A'(\overline{\alpha}) + C'(1 - F(\overline{\alpha}))(1 - F(\overline{\alpha}))B'(\overline{\alpha}) \leq 0. \quad (19)$$

Noting that $F(\underline{\alpha}) = F(\overline{\alpha})$ (since there is no density on $(\underline{\alpha}, \overline{\alpha})$), we can combine these equations to

$$\frac{A'(\underline{\alpha})}{A'(\overline{\alpha})} \geq \frac{-B'(\underline{\alpha})}{-B'(\overline{\alpha})}. \quad (20)$$

Since $A'' > 0$ and $B'' > 0$, we have $A'(\overline{\alpha}) > A'(\underline{\alpha})$ and $B'(\overline{\alpha}) > B'(\underline{\alpha})$. Thus (20) is not fulfilled, and there is a contradiction. It follows that there cannot be an interval without mass on $(0, 1)$.

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Cross-Border Bank Contagion in Europe*

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We analyze cross-border contagion among European banks in the period from January 1994 to January 2003. We use a multinomial logit model to estimate, in a given country, the number of banks that experience a large shock on the same day ("coexceedances") as a function of common shocks and lagged coexceedances in other countries. Large shocks are measured by the bottom 95th percentile of the distribution of the daily percentage change in distance to default of banks. We find evidence of significant cross-border contagion among large European banks, which is consistent with a tiered cross-border interbank structure. The results also suggest that contagion increased after the introduction of the euro.

JEL Codes: G21, F36, G15.

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1. Introduction

Contagion is widely perceived to be an important element of banking crises and systemic risk. For example, the private-sector rescue operation of LTCM in 1998, coordinated by the Federal Reserve Bank of New York, was justified by the risk of contagion among financial institutions and to markets. Similarly, contagion transmitted through the interbank market played a major role in the failure of a number of Japanese securities houses in the early 1990s (Padoa-Schioppa 2004). Most recently, the crisis that originated with the subprime mortgage market in the United States quickly spread to European banks.

In this paper, we use the distance to default (KMV Corporation 2002) as a measure of the soundness of a bank. Similar to Bae, Karolyi, and Stulz (2003) and Gropp and Moermann (2004), we focus on the behavior of the tail of the distribution of the change in the distance to default. For each country, we construct "coexceedances" by counting the number of banks that experience a large shock in the distance to default on a given day. Large shocks are measured by large negative percentage changes in the daily distance to default of a bank. We then estimate the probability of several banks simultaneously experiencing a large shock in one country as a function of lagged coexceedances in other countries, controlling for common shocks.

We find evidence of significant cross-border contagion for large listed banks during the period of January 1994 to January 2003. There is no evidence of cross-border contagion for smaller banks. Finally, the estimates suggest that the prevalence of cross-border contagion may have increased since the introduction of the euro in 1999.

What are the mechanisms of contagion consistent with these findings? Because the distance to default is derived from equity price data, our approach captures contagion as perceived by banks' equity holders. Market-price-based indicators of bank fragility, such as the distance to default, summarize all available information about a given bank. Hence, our measurement of contagion could be viewed as covering all possible transmission channels of contagion. It does not rely on accurately measuring one particular channel. We consider this to be an advantage.

Nevertheless, the results do suggest that some channels are more likely than others. First, we can exclude "domino effects" due to a chain of bank defaults as an explanation of our findings, as no bank in our sample defaulted on any of its obligations.[1] Second, we find that only large banks exhibit cross-border contagion. This would suggest that cross-border interbank exposures among large banks ("money-center banks") may be important, since small banks tend to only operate in a very limited way across borders in the tiered interbank market structure in the euro area, in which only large banks are active in cross-border interbank markets (Degryse and Nguyen 2007; Freixas and Holthausen 2005). The evidence is consistent with Allen and Gale (2000), who show that, in a Diamond and Dybvig (1983) liquidity framework, an "incomplete" market structure with only unilateral exposure among banks may exhibit contagion; and it is consistent with Freixas, Parigi, and Rochet (2000), who show that a tiered structure with money-center banks is also vulnerable. In both papers, contagion transmits via liquidity problems, i.e., banks withdrawing interbank deposits at other institutions (like in the recent case of Bear Stearns).[2]

Alternatively, our evidence may support a notion of contagion due to asset sales by one bank, resulting in declining market valuations and increased counterparty risks. The results may reflect that large banks hold similar assets, such as structured instruments or credit derivatives, which are not typically intermediated by smaller banks. Hence, our evidence is also consistent with a channel of contagion via market valuations and counterparty risks as in Cifuentes,

[1] This distinguishes this paper from Calomiris and Mason (2000), who find evidence of contagion within specific regions of the United States during the Great Depression, or Iyer and Peydró-Alcalde (2005b), who estimate the contagion of the failure of one large regional bank in India. In addition, a number of papers have used actual or estimated interbank links to simulate domino effects in interbank markets (Furfine 2003 for the United States, Sheldon and Maurer 1998 for Switzerland, Upper and Worms 2004 for Germany, and Degryse and Nguyen 2007 for Belgium).

[2] Iyer and Peydró-Alcalde (2005a) model the mechanism of contagion through the money market and show how the reactions of banks initially unaffected by the shock can result in an endogenous reduction in liquidity, which in turn results in further stress on the banking system.

Ferrucci, and Shin (2004).[3] This contagion effect is different from the one captured by our common-shock variables, as it is an endogenous result of the behavior of other banks, i.e., extraordinarily large asset sales. Finally, one could view the results as evidence in favor of a "run" by equity holders, even in the absence of explicit financial links or common exposures. In the presence of asymmetric information, difficulties in one bank may be perceived as a signal of possible difficulties in others, especially if banks' assets are opaque and balance-sheet data and other publicly available information are uninformative (Morgan 2002) or stale (Gropp and Kadareja 2006).[4] In Freixas, Parigi, and Rochet (2000), if a liquidity shock hits one bank, depositors may run on other banks as well, even if they are perfectly solvent, if they fear that there may be insufficient liquid assets in the banking system.

The paper also suggests a new methodology for the measurement of international bank contagion in the absence of accurate and comparable data on interbank and asset-side exposures of banks. The approach is related to Hartmann, Straetmans, and de Vries (2006), who use multivariate extreme-value theory to estimate contagion in Europe and the United States. They find that contagion may have increased from the mid-1990s onward both in Europe and the United States.[5]

The remainder of the paper is organized as follows. In the next section, we describe the data used in the paper and give some descriptive statistics. Section 3 explains our primary econometric

[3]In Cifuentes, Ferrucci, and Shin (2004), contagion arises through fire sales of illiquid assets as banks are subject to regulatory solvency constraints. If banks use fair-value accounting to value at least some of their illiquid assets at imputed market prices and the demand for illiquid assets is less than perfectly elastic, sales by distressed institutions depress the market prices of such assets. Prices fall, inducing a further round of sales. Ultimately, banks may have difficulties meeting solvency requirements. In their model, relatively small shocks can result in contagious failures in the banking system.

[4]An example of an extreme version of a reaction by equity holders was the "run" on European life insurance companies in the summer of 2002. For recent evidence that banks may not be more opaque than nonfinancial firms, see Flannery, Kwan, and Nimalendran (2004).

[5]Gropp and Moerman (2004) use the distance to default to identify systemically important banks using the same sample as this paper.

approach. Section 4 presents the econometric results. Section 5 discusses the robustness of our findings. Finally, section 6 concludes the paper.

2. Sample, Definition of Variables, and Descriptive Statistics

In our sample selection, we started with all banks in France, Germany, Italy, the Netherlands, Spain, and the United Kingdom that are listed at a stock exchange and whose stock price and total debt are available from Datastream during January 1994 to January 2003 (fifty banks). Almost all large, internationally active European banks are headquartered in these countries (see table 1). We deleted all banks that had trading volume below 1,000 shares in more than 30 percent of the trading days and banks that had less than 100 weeks of stock data available (seven banks). We deleted three additional banks where we had serious concerns about data quality.[6] For those banks where the distance to default could not be calculated for the entire period under review due to missing data (five banks), we imputed a total of 342 missing values, using linear interpolation and random numbers (for details, see the notes to table 2). Doing that ensures that the "coexceedances" (see below) for each country are built using the same banks during the entire period under analysis. This yields a complete data set for forty banks. For each bank, the sample contains 2,263 daily observations, i.e., a total of 94,520 observations.

The banks in the sample are generally quite large relative to the population of banks in the European Union (EU) (table 1). On average, their total assets amount to €178 billion (median: €132 billion). The relatively large average size is an outcome of the requirement that the bank must be traded at a stock exchange. Nevertheless, the size variation is considerable within the sample. For example, the largest bank, Deutsche Bank, is more than 300 times the size of the smallest bank. The degree of coverage in each country depends on the number of banks traded at a stock exchange and on the structure of the banking system, but despite the relatively low number

[6]The banks showed zero equity returns on a high number of trading days.

Table 1. Sample Banks (Sorted by Total Assets in 2000, Millions of Euro)

1	Deutsche Bank AG	DE	927,900
2	Bayerische Hypo- und Vereinsbank	DE	694,300
3	BNP Paribas	FR	693,053
4	ABN AMRO Bank N.V.	NL	543,200
5	Barclays	UK	486,936
6	Societe Generale	FR	455,881
7	Commerzbank	DE	454,500
8	ING Bank NV	NL	406,393
9	Banco Santander Central Hispano	ES	347,288
10	Banca Intesa	IT	331,364
11	Abbey National plc	UK	293,395
12	Banco Bilbao Vizcaya Argentaria	ES	292,557
13	HSBC	UK	288,339
14	Royal Bank of Scotland	UK	206,176
15	Bankgesellschaft Berlin	DE	203,534
16	UniCredito Italiano	IT	202,649
17	Sanpaolo IMI	IT	171,046
18	Standard Chartered	UK	161,934
19	DePfa Group	DE	156,446
20	Banca di Roma	IT	132,729
21	Natexis Banques Populaires	FR	113,131
22	BHF-BANK	DE	53,863
23	Banco Espanol de Credito	ES	44,381
24	Banca Pop Bergamo	IT	37,670
25	IKB Deutsche Industriebank	DE	32,359
26	Banco Popular Espanol	ES	31,288
27	Banca Popolare di Milano	IT	28,282
28	Banca Lombarda	IT	26,816
29	Banca Popolare di Novara	IT	20,959
30	Credito Emiliano	IT	15,148
31	Banca Agricola Mantovana	IT	10,190
32	Banco Pastor	ES	9,404
33	Credito Valtellinese	IT	7,416
34	Banco Guipuzcoano	ES	5,518
35	Kas-Associatie N.V.	NL	5,417
36	Banco Zaragozano	ES	5,175
37	Schroders	UK	4,180
38	Banca Popolare di Intra	IT	3,929
39	Close Brothers	UK	3,241
40	Singer & Friedlander Group	UK	2,792

Table 2. Variable Definitions and Summary Statistics

Variable	Definition	n	Mean	Median	Std. Dev.	Min.	Max.
Bank-Specific Variables							
dd_{it}	Distance to default of bank i in week t (see appendix 1)	94,520	4.13	3.73	1.73	0.55	16.59
$\Delta dd_{it}/\lvert dd_{it-1}\rvert$	Percentage change in the distance to default (of which missing values replaced)[a]	94,520 343	0.00 —	0 —	0.01 —	−0.77 —	0.69 —
tail	Takes value 1 if bank i is in 95th percentile negative tail of distribution of $\Delta dd_{it}/dd_{it-1}$	94,520	0.05	0	0.22	0	1
Country-Specific Variables							
Coexceedances DE	No. of banks in 95th percentile negative tail of $\Delta dd_{it}/dd_{it-1}$in DE	2,363	0.34	0	0.75	0	7
Coexceedances ES	No. of banks in 95th percentile negative tail of $\Delta dd_{it}/dd_{it-1}$in ES	2,363	0.34	0	0.71	0	6
Coexceedances FR	No. of banks in 95th percentile negative tail of $\Delta dd_{it}/dd_{it-1}$in FR	2,363	0.16	0	0.48	0	3
Coexceedances IT	No. of banks in 95th percentile negative tail of $\Delta dd_{it}/dd_{it-1}$in IT	2,363	0.56	0	1.12	0	11
Coexceedances NL	No. of banks in 95th percentile negative tail of $\Delta dd_{it}/dd_{it-1}$in NL	2,363	0.16	0	0.47	0	3
Coexceedances UK	No. of banks in 95th percentile negative tail of $\Delta dd_{it}/dd_{it-1}$in UK	2,363	0.48	0	0.90	0	7
Systemic Risk DE	No. of markets in 95th percentile negative tail among US, emerging, Europe, and DE	2,363	0.2014	0	0.6104	0	4
Systemic Risk ES	No. of markets in 95th percentile negative tail among US, emerging, Europe, and ES	2,363	0.2014	0	0.6034	0	4
Systemic Risk FR	No. of markets in 95th percentile negative tail among US, emerging, Europe, and FR	2,363	0.2014	0	0.6146	0	4

(continued)

Table 2. (Continued)

Variable	Definition	n	Mean	Median	Std. Dev.	Min.	Max.
Country-Specific Variables							
Systemic Risk IT	No. of markets in 95th percentile negative tail among US, emerging, Europe, and IT	2,363	0.2014	0	0.5935	0	4
Systemic Risk NL	No. of markets in 95th percentile negative tail among US, emerging, Europe, and NL	2,363	0.2014	0	0.6062	0	4
Systemic Risk UK	No. of markets in 95th percentile negative tail among US, emerging, Europe, and UK	2,363	0.2014	0	0.6048	0	4
Yield Curve DE	Change in slope of yield curve in DE	2,363	0.0004	0.0000	0.0385	−0.1900	0.3800
Yield Curve ES	Change in slope of yield curve in ES	2,363	0.0006	−0.0020	0.0682	−0.5400	0.4840
Yield Curve FR	Change in slope of yield curve in FR	2,363	0.0006	−0.0046	0.0645	−0.8000	0.3198
Yield Curve IT	Change in slope of yield curve in IT	2,363	0.0002	−0.0010	0.1511	−2.5580	2.5960
Yield Curve NL	Change in slope of yield curve in NL	2,363	0.0003	0.0000	0.0512	−0.3000	0.3210
Yield Curve UK	Change in slope of yield curve in UK	2,363	0.0013	0.0000	0.0814	−0.8740	0.5460
*Volatility DE**	Change in volatility of stock market in DE	2,362	0.0072	−0.3141	3.0809	−10.5551	47.7505
*Volatility ES**	Change in volatility of stock market in ES	2,362	0.0011	−0.3486	2.4996	−9.2267	32.1450
*Volatility FR**	Change in volatility of stock market in FR	2,362	0.0044	−0.2951	1.9286	−4.8973	47.0638
*Volatility IT**	Change in volatility of stock market in IT	2,362	0.0045	−0.6004	4.1482	−15.1464	63.3724
*Volatility NL**	Change in volatility of stock market in NL	2,362	0.0060	−0.2482	2.8988	−10.9020	32.1924
*Volatility UK**	Change in volatility of stock market in UK	2,362	0.0045	−0.1762	1.5277	−6.5127	21.0707
*Volatility US**	Change in volatility of stock market in US	2,362	0.0054	−0.2353	2.1676	−5.2696	34.7094
Memo Items							
Cutoff point of the 95th percentile of $\Delta dd_{it}/\lvert dd_{it-1}\rvert$		−0.0085					

[a]Number of observations imputed by linear interpolation: Close Brothers (20 observations), ING (1 observation), Natexis (1 observation). Number of observations added with random number generator: BHF (113 observations), BNP (208 observations).
*This variable has been multiplied by 1,000.

of banks, the coverage is quite high. The fraction of the total assets of commercial banks covered in our data varies from 36 percent for France to 68 percent for Spain.[7]

The distance to default is defined as the difference between the current market value of assets of a firm and its estimated default point, divided by the volatility of assets (KMV Corporation 2002). The value of equity is modeled as a call option on the assets of the company. The level and the volatility of assets are calculated with the Black/Scholes model using the observed market value and volatility of equity and the balance-sheet data on debt. A detailed description of the method used to compute the distance to default is in appendix 1. The distance to default increases when the values of assets increase and/or when the volatility of assets declines. An increase in the distance to default means that the firm is moving away from the default point and that bankruptcy becomes less likely. Gropp, Vesala, and Vulpes (2004, 2006) argue that the distance to default may be a particularly suitable and all-encompassing measure of default risk for banks. In particular, its ability to measure default risk correctly is not affected by the potential incentives of the stockholders to prefer increased risk taking (unlike, e.g., in the case of unadjusted equity returns) or by the presence of explicit or implicit safety nets (unlike, e.g., subordinated debt spreads). Further, it combines information about stock returns with leverage and volatility information, thus encompassing the most important determinants of default risk (unlike, e.g., unadjusted stock returns).

In order to obtain our dependent variable, we calculated the distance to default for each bank in the sample and for each day, t. Following the approach of Bae, Karolyi, and Stulz (2003) and Gropp and Moermann (2004), we then arbitrarily defined as large shocks those observations falling in the negative 95th percentile of the common distribution of the percentage change in distance to default ($\Delta dd_{it}/dd_{it-1}$) across all banks.[8] Choosing the bottom 95th percentile is a compromise between the need for "large" shocks in the

[7]The total assets of commercial banks in a country were taken from the OECD's Bank Profitability data.

[8]This definition relies on the assumption that the stochastic process governing the distance to default at different banks is the same. This assumption turns out

spirit of extreme-value theory (Straetmans 2000) and maintaining adequate sample size for the estimation. Finally, we counted the number of banks in a given country that were simultaneously in the tail, which we, following Bae, Karolyi, and Stulz (2003), labeled "coexceedances."

Gropp and Moerman (2004) use the coincidence of large shocks to banks' distance to default to examine systemically important banks. They employ Monte Carlo simulations to show that standard distributional assumptions (multivariate normal, Student t) cannot replicate the patterns observed in tails of the data. This implies not only that the distribution of distances to default of individual banks exhibits fat tails, but also that the correlation among banks' distances to default is substantially higher for larger shocks. Bae, Karolyi, and Stulz (2003) do the same for emerging-market stock returns. Both papers suggest that it is necessary to examine the tails of the distribution of returns or the distance to default separately from the overall distribution.

In order to control for common shocks, we rely on the existing literature on financial crises and contagion (Forbes and Rigobon 2002; Rigobon 2003). In total, we use four control variables, which take into account (i) the occurrence of shocks in stock markets, (ii) movements of the yield curve, and the level of volatility in (iii) domestic and (iv) international markets.

The first common factor, which we label "systemic risk," is an indicator measuring the number of stock markets that are experiencing a large shock at time t. We construct this variable similarly to modeling large shocks to banks. We use indicator variables that we set equal to 1 if the stock market of a given country experienced a shock large enough to be in the bottom 95th percentile of the distribution of daily returns. Equivalently, we calculate indicator variables for a euro-area stock market index and the U.S. and emerging-market stock indices. We use total market indices as provided by Datastream and, for emerging markets, the MSCI Emerging

to be reasonable, however, as redoing the analysis reported below with bank-specific tail occurrences yields quantitatively very similar results. A further alternative would have been to estimate 95th percentiles separately for tranquil and volatile periods. The 95th percentile in this paper is higher (lower) for tranquil periods (volatile periods) than it would be using only data from the tranquil period.

Market Index. "Systemic risk" is then the sum of the indicator variables measuring whether or not the domestic stock market, the U.S. stock market, the euro-area market index, and the emerging-market index are in the tail on a given day. Hence, it ranges from 0 to 4.[9] We also include a domestic shock, measured as the domestic conditional stock market volatility (see below). "Systemic risk" should be positively related to the number of coexceedances.

The second factor ("yield curve") is the daily change in absolute value of the slope of the yield curve. The slope is defined as the difference between the yield of the ten-year government bond and the yield of the one-year note in a given country.[10] This variable is a commonly used measure of expectations on economic growth and monetary policy. One view of banks suggests that they transform short-term liabilities (deposits) into long-term assets (loans). A flattening of the yield curve results in an increase of the interest rate banks have to pay on their short-term liabilities without a corresponding increase in the rates they can charge on their loans. We would, thus, expect this variable to be positively related to the number of coexceedances.

The third factor ("volatility own") is the daily change in the volatility of the domestic stock market. In Bae, Karolyi, and Stulz (2003), this variable is particularly important for explaining emerging-market coexceedances. We estimate stock market volatility using a GARCH (1,1) model of the form

$$\sigma_{tc}^2 = \alpha + \beta_1 \varepsilon_{c,t-1}^2 + \beta_2 \sigma_{c,t-1}^2 \tag{1}$$

using maximum likelihood, where σ_{tc}^2 represents the conditional variance of the stock market index in country c in period t, and ε represents stock market returns in that market. The estimated parameters are reported in appendix 2. We obtain, depending on the country, values of between 0.06 and 0.11 for β_1 and between 0.89 and 0.93 for β_2. While we are interested in contagion among European banks,

[9] We also experimented with including the indicator variables for each market separately. However, their correlation is generally above 0.5 within the EU and around 0.2 and 0.3 with the U.S. and emerging markets, respectively.

[10] If the yield of the one-year Treasury note was not available, we used the interbank rate for the same maturity. The sources of the data are Datastream and the Bank for International Settlements.

Table 3. Description of the Sample by Countries

	Number of Observations	Number of Banks	Percentage of Total Assets of Commercial Banks	Number of Observations per Bank	Maximum Number of Coexceedances
France	7,089	3	36.0	2,363	3
Germany	16,541	7	46.5	2,363	7
Italy	28,356	12	52.1	2,363	11
The Netherlands	7,089	3	58.9	2,363	3
Spain	16,541	7	68.3	2,363	6
United Kingdom	18,904	8	56.1	2,363	7
Total	94,520	40	—	—	20

it is possible that there are volatility spillovers from other parts of the world as well. In order to control for this, we insert stock market volatility from the United States in the regressions. This has also been estimated with a GARCH (1,1) and is labeled "volatility US."[11] Because U.S. markets open later than European markets, "volatility US" is lagged by one day.

Further, we include one lag of the domestic coexceedances, as we suspect that first-differencing and using only the large negative tail events of the distance to default may not have removed all autocorrelation in the dependent variable.

Table 2 shows that the banks in the sample, on average, are just above four standard deviations away from the default point (mean distance to default of 4.13). One bank shows distances to default below 1, and there are a number of banks with a distance to default of above 10. The mean of the first percentage change in the distance to default is approximately 0; the largest negative change is 77 percent. The negative 95th percentile is at about −1 percent.

Tables 3 and 4 present some additional descriptive statistics on the number of banks simultaneously in the tail on a given day, i.e., the number of coexceedances. The number of banks per country differs somewhat: In Italy there are twelve banks in the sample, while in France and the Netherlands there are only three. The United Kingdom, Spain, and Germany are also well represented, with eight,

[11] "Volatility own" and "volatility US" were rescaled by multiplying the estimated values by 1,000.

Table 4. Coexceedances by Countries

	France* (FR)	Germany (DE)	Italy (IT)	Netherlands* (NL)	Spain (ES)	United Kingdom (UK)
Coexceedances = 0	2,085	1,822	1,591	2,066	1,795	1,628
Coexceedances = 1	203	385	495	219	407	486
Coexceedances = 2	75	89	152	78	111	161
Coexceedances ≥ 3	—	67	125	—	50	88
Total	2,363	2,363	2,363	2,363	2,363	2,363

*Due to the small number of banks in the sample, for France and the Netherlands the analysis is limited to coexceedances ≥ 2.

seven, and seven banks, respectively. Table 3 also shows that there is at least one day on which all, or almost all banks, experienced a large adverse shock simultaneously.

Table 4 shows that in Spain, for example, there were 50 days with three or more coexceedances, in the United Kingdom there were 88 such days, and in Italy 125 such days, while in the Netherlands and France there were 78 and 75 days with two or more coexceedances, respectively. The number of coexceedances is a function of the number of banks included in the sample and does not necessarily reflect the strength or weakness of the banking sector. Still, comparing countries with an equal number of banks in the sample suggests that Spanish banks tend to experience fewer shocks compared with German banks and that Dutch banks tend to be subject to large shocks about as frequently as French banks. Of the total of forty banks in the sample, a maximum of twenty are simultaneously in the tail (on October 2, 1998), and there are fourteen days with more than fifteen coexceedances (not reported).

3. Econometric Model

The dependent variable is the number of coexceedances of banks on a given day, which is a count variable. There are many methods to estimate a model with count data as the dependent variable, including tobit models, Poisson models, negative binomial models, and multinomial and ordered logit models. A tobit model relies on the assumption that the dependent variable is truncated normal, an assumption that Gropp and Moerman (2004) show to be rejected in

the data used in this paper. Poisson models rely on the assumption of equality between mean and variance of the dependent variable, an assumption also rejected in our sample. The negative binomial model avoids this restrictive assumption of mean/variance equality. Nevertheless, it does rely on the assumption that the dependent variable was drawn from a mixture of Poisson random variables. Given the evidence and arguments in Bae, Karolyi, and Stulz (2003) and Gropp and Moerman (2004), we do not think that the estimation of this model would be advisable. This leaves ordered logit and multinomial logit models as potential estimation methods. The main difference between the two is that the ordered logit model restricts the marginal effects at each outcome to be the same. On the other hand, in a multinomial logit model, there are many more parameters to estimate.

Given the relatively large sample size, we decided to use a multinomial logit model as our primary specification. We present results from an ordered logit model as a robustness check (see section 5). Hence, we estimate the number of coexceedances in one country (the number of banks simultaneously in the tail) as a function of the number of coexceedances in the other countries lagged by one day, controlling for common shocks:

$$\Pr_c[Y = j] = \frac{e^{\left[\alpha_j' F_c + \beta_j C_{ct-1} + \sum_{d \neq c} \gamma_{dj} C_{dt-1}\right]}}{\sum_k^J e^{\left[\alpha_k' F_c + \beta_k C_{ct-1} + \sum_{d \neq c} \gamma_{dk} C_{dt-1}\right]}}, \tag{2}$$

where $j = 1, 2, 3 \ldots J$ represents the number of banks in the tail simultaneously ("coexceedances") in country c, F_c represents the common shocks in country c, C_{ct-1} represents the lagged number of coexceedances in country c, and C_{dt-1} represents the coexceedances in period $t-1$ in country d. Insofar as common shocks are controlled for, the significant coefficients of C_{dt-1} would signal cross-border contagion. Given that we estimate a multinomial logit model, which implies that we will estimate one coefficient per outcome, we follow Bae, Karolyi, and Stulz (2003) and limit the number of outcomes to zero, one, two, and three or more coexceedances, except for France and the Netherlands, where we limit the number of outcomes to two or more.

In order to remove the indeterminacy associated with the model, we follow the convention and define $Y = 0$ (zero coexceedances) as

the base category. All coefficients are estimated relative to this base. Still, the coefficients from this model are difficult to interpret and, therefore, it is useful to also report the marginal effect of the regressors. The marginal effects are obtained from the probability for each outcome j:

$$\Pr[Y=j] = \frac{e^{\left[\alpha_j' F_c + \beta_j C_{ct-1} + \sum_{d \neq c} \gamma_{dj} C_{dt-1}\right]}}{1 + \sum_{k}^{J} e^{\left[\alpha_k' F_c + \beta_k C_{ct-1} + \sum_{d \neq c} \gamma_{dk} C_{dt-1}\right]}}. \tag{3}$$

Differentiating with respect to C_{dt-1} yields

$$\frac{\partial \Pr_c[Y=j]}{\partial C_{dt-1}} = \Pr[Y=j] * \left[\gamma_j - \sum_{k=1}^{J} P_k \gamma_k\right], \tag{4}$$

which can be computed from the parameter estimates, with the independent variables evaluated at suitable values, along with its standard errors. In all tables we will report the estimated coefficients alongside the marginal probabilities obtained from (4).

4. Estimation Results

4.1 Base Model

The baseline results are given in table 5. For each country, we first report the results for a specification in which the controls for systemic risk and common factors are the only explanatory variables (model 1 in table 5). We then add the lagged coexceedances from other countries (model 2 in table 5). Recall that the dependent variable is the number of banks whose daily percentage change in distance to default was in the negative 95th tail in a given country.

First consider the base model without contagion variables for the five countries (table 5, model 1). Overall, we are able to explain between 9 percent (IT) and 17 percent (NL) of the variation in the dependent variable using variables measuring common shocks only.[12]

[12] As a comparison, in the context of emerging markets, Bae, Karolyi, and Stulz (2003) find pseudo-R^2 of around 0.1 in a similar type of model, using three explanatory variables (conditional volatility, exchange rates, and interest rates).

Table 5. Multinomial Logit Model: Contagion in Daily Coexceedances of the Percentage Change in Distance to Default, Large EU Countries, January 1994–January 2003

	France				Germany				Italy			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=1												
Constant	−2.47***		−2.57***		−1.78***		−1.92***		−1.35***		−1.41***	
Coex. Lagged	0.40**	0.030**	0.28*	0.021*	0.61***	0.078***	0.51***	0.065***	0.36***	0.045***	0.31***	0.039***
Systemic Risk	0.24**	0.018**	0.21*	0.016*	0.15	0.020	0.11	0.014	0.24***	0.034**	0.22**	0.031**
Yield Curve	0.40	0.032	0.36	0.028	1.97	0.241	1.96	0.241	−0.01	−0.010	−0.19	−0.012
Volatility Own	0.29***	0.022***	0.29***	0.022***	0.15***	0.018***	0.16***	0.020***	0.10***	0.013***	0.10***	0.013***
Volatility US	−0.01	−0.001	−0.02	−0.002	0.02	0.002	0.01	0.000	0.02	0.002	0.01	0.001
Contagion DE			0.03	0.002							−0.01	−0.007
Contagion FR							0.07	0.009			0.05	0.010
Contagion IT			−0.09	−0.007			0.11	0.016*				
Contagion NL			−0.08	−0.006			0.40***	0.053***			0.12	0.017
Contagion ES			0.29***	0.022***			−0.10	−0.017			0.01	0.001
Contagion UK			0.15	0.011			0.16**	0.020*			0.14**	0.023*
Coexceedances=2												
Constant	−4.35***		−4.62***		−3.59***		−3.87***		−2.81***		−2.94***	
Coex. Lagged	0.90***	0.012***	0.68***	0.009**	0.95***	0.024***	0.77***	0.018***	0.70***	0.034***	0.62***	0.030***
Systemic Risk	0.39**	0.005**	0.35**	0.004**	0.09	0.002	0.01	−0.000	0.36***	0.017***	0.31***	0.015**
Yield Curve	−0.27	−0.004	−0.31	−0.0044	6.39***	0.178***	6.44***	0.168***	0.55	0.032	0.57	0.032
Volatility Own	0.64***	0.009***	0.65***	0.008***	0.30***	0.008***	0.31***	0.008***	0.15***	0.007***	0.15***	0.007***
Volatility US	0.08*	0.001*	0.07	0.001	0.05	0.001	0.02	0.001	−0.00	−0.000	−0.01	−0.001
Contagion DE			0.28	0.004							0.23*	0.012*
Contagion FR							0.09	0.002			−0.08	−0.005
Contagion IT			−0.07	−0.001			−0.14	−0.004				
Contagion NL			−0.25	−0.003			0.48**	0.011**			0.11	0.005
Contagion ES			0.54***	0.007**			0.29*	0.008*			0.09	0.005
Contagion UK			0.09	0.001			0.37***	0.009***			0.12	0.005

(continued)

Table 5. (Continued)

	France				Germany				Italy			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=3												
Constant					−4.61***		−5.01***		−3.91***		−3.99***	
Coex. Lagged					1.28***	0.015***	1.07***	0.011***	1.15***	0.026***	1.11***	0.025***
Systemic Risk					0.39***	0.005**	0.22	0.002	0.39***	0.008**	0.37***	0.007**
Yield Curve					0.12	−0.005	0.54	0.000	0.09	0.001	0.15	0.003
Volatility Own					0.39***	0.005***	0.41***	0.004***	0.29***	0.007***	0.30***	0.007***
Volatility US					0.12**	0.002**	0.09*	0.001*	0.09***	0.002**	0.08**	0.002**
Contagion DE											0.30**	0.007**
Contagion FR							0.32	0.004			0.09	0.002
Contagion IT							0.26	0.003				
Contagion NL							0.10	0.000			0.20	0.004
Contagion ES							0.42**	0.005**			−0.00	−0.000
Contagion UK							0.20	0.002			−0.12	−0.004
Pseudo-R^2	0.14		0.15		0.10		0.12		0.09		0.10	
Log-Likelihood	−878		−867		−1,523		−1,493		−1,982		−1,972	
N	2,361		2,361		2,361		2,361		2,361		2,361	
ΣContagion DE			1.36								4.21**	
ΣContagion FR							1.07				0.03	
ΣContagion IT			0.66				0.81					
ΣContagion NL			0.56				5.30**				1.34	
ΣContagion ES			11.08***				4.08**				0.14	
ΣContagion UK			0.92				9.01***				0.33	
ΣContagion			4.69**				25.91***				6.47**	

(continued)

Table 5. (Continued)

	The Netherlands				Spain				United Kingdom			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=1												
Constant	−2.54***		−2.72***		−1.72***		−1.82***		−1.48***		−1.60***	
Coex. Lagged	0.77***	0.060***	0.55***	0.043***	0.59***	0.079***	0.54***	0.073***	0.42***	0.057***	0.33***	0.044***
Systemic Risk	0.49***	0.039***	0.43***	0.034***	0.23**	0.029**	0.21**	0.027**	0.61***	0.092***	0.58***	0.089***
Yield Curve	0.78	0.064	0.65	0.053	0.11	0.007	0.03	−0.002	−0.35	−0.052	−0.42	−0.062
Volatility Own	0.25***	0.019***	0.26***	0.020***	0.27***	0.035***	0.27***	0.036***	0.29***	0.041***	0.33***	0.046***
Volatility US	0.02	0.001	0.00	0.0002	0.04	0.005	0.03	0.005	0.02	0.003	0.00	0.001
Contagion DE			0.14	0.011			0.07	0.010			0.12	0.017
Contagion FR			0.28*	0.022*			0.02	0.000			0.02	0.007
Contagion IT			0.24***	0.019***			0.21***	0.030***			0.07	0.012
Contagion NL							−0.07	−0.011			0.14	0.022
Contagion ES			−0.01	−0.001							0.24***	0.035**
Contagion UK			0.00	0.000			0.01	−0.001				
Coexceedances=2												
Constant	−4.39***		−4.76***		−3.51***		−3.71***		−3.00***		−3.16***	
Coex. Lagged	1.16***	0.016***	0.65***	0.008**	0.91***	0.030***	0.73***	0.021***	0.87***	0.043***	0.76***	0.037***
Systemic Risk	0.38*	0.005	0.25	0.003	0.55***	0.020***	0.48***	0.015***	0.70***	0.030***	0.68***	0.029***
Yield Curve	−0.76	−0.012	−1.44	−0.020	0.76	0.024	0.46	0.015	−0.71	−0.036	−0.89	−0.044
Volatility Own	0.47***	0.006***	0.48***	0.006***	0.46***	0.014***	0.47***	0.014***	0.54***	0.0326**	0.56***	0.026***
Volatility US	0.08**	0.001**	0.05	0.001	−0.03	−0.001	−0.06	−0.002	−0.01	−0.001	−0.03	−0.002
Contagion DE			0.08	0.001			0.08	0.002			0.15	0.006
Contagion FR			0.23	0.003			0.30	0.010			−0.22	−0.012
Contagion IT			0.30**	0.004**			0.10	0.002			0.00	−0.001
Contagion NL							0.04	0.002			0.25	0.012
Contagion ES			0.47***	0.006***							0.43***	0.020***
Contagion UK			0.07	0.001			0.28**	0.010**				

(continued)

Table 5. (Continued)

	The Netherlands				Spain				United Kingdom			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=3												
Constant					−5.04***		−5.37***		−4.50***		−4.92***	
Coex. Lagged					1.11***	0.008***	0.82***	0.006***	1.01***	0.015***	0.94***	0.011***
Systemic Risk					0.78***	0.006***	0.68***	0.005***	1.01***	0.013***	0.95***	0.011***
Yield Curve					2.55	0.021	2.12	0.017	0.43	0.009	0.24	0.005
Volatility Own					0.56***	0.004***	0.57***	0.004***	0.82***	0.011***	0.88***	0.010***
Volatility US					0.07*	0.001	0.04	0.000	0.07	0.001	0.05	0.001
Contagion DE							0.30*	0.002*			0.65***	0.008***
Contagion FR							0.27	0.002			−0.52*	−0.007*
Contagion IT							0.32*	0.002			0.24	0.003
Contagion NL							0.03	0.000			−0.26	−0.004
Contagion ES											0.47***	0.005**
Contagion UK							0.20	0.001				
Pseudo-R^2	0.17		0.18		0.12		0.13		0.12		0.13	
Log-Likelihood	−881		−866		−1,531		−1,516		−1,848		−1,821	
N	2,361		2,361		2,361		2,361		2,361		2,361	
ΣContagion DE			0.97				2.19				13.35***	
ΣContagion FR			2.84*				1.91				2.21	
ΣContagion IT			10.38***				5.77**				1.82	
ΣContagion NL							0.00				0.10	
ΣContagion ES			4.47**								17.31***	
ΣContagion UK			0.12				2.65					
ΣContagion			18.44***				13.40***				9.61***	

Notes: Dependent variable: Number of domestic banks simultaneously in the tail ("coexceedances"). Contagion effects are captured by the coefficient of lagged coexceedances in country i (labeled Contagion i). Base case: Zero coexceedances. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Robust standard errors are used. Tests reporting the joint significance of the coefficients capturing contagion from each country and from all countries are reported below and labeled with Σ. Example: The row ΣContagion DE reports the statistic for the test of the joint significance of the coefficients capturing contagion from Germany.

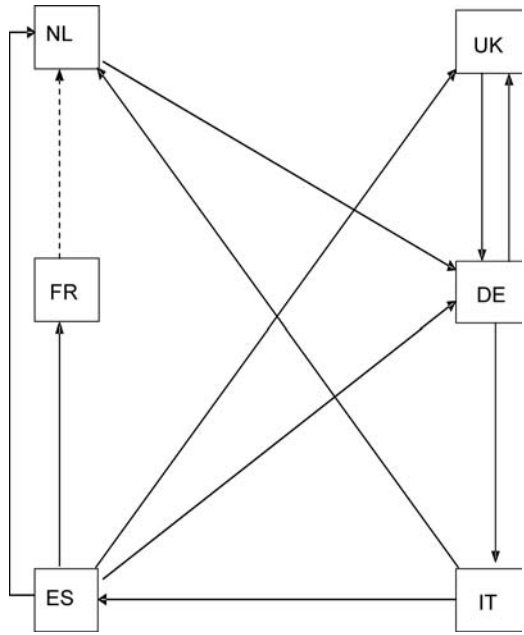
The notion that the number of coexceedances is autocorrelated is supported: The lagged (by one day) number of coexceedances is positive and significant for all countries. Further, the effect of global systemic risk (as measured by the number of stock markets in the tail) is positive and significant. A steepening of the yield curve tends to be only weakly associated with a higher number of coexceedances in most countries, maybe with the exception of Germany and France. As in Bae, Karolyi, and Stulz (2003), increases in conditional volatility are very important in our specification and are always significant at the 1 percent level. All these results conform to expectations. We also checked whether conditional volatility in the U.S. stock market matters for coexceedances among European banks, but the coefficients tend to be insignificant, except in the case of German and Italian banks.

In order to aid the interpretability of the results, we also report marginal probabilities for each coefficient (reported in the second column). We see, for example, that a 1 percent increase in the conditional volatility of the stock market in Germany increases the probability of one exceedance by 0.02 percent, the probability of two coexceedances by 0.01 percent, and the probability of three or more coexceedances by 0.005 percent. All of these marginal probabilities are significant at the 1 percent level. Similar magnitudes are found for all six countries.

Now consider the evidence on contagion (table 5, model 2). We measure contagion by including the one-day lagged coexceedances in the other five countries. If, after controlling for common shocks, any of these variables turn out to be positive and significant, we interpret this as contagion from that country. We also report significance tests for the sum of the contagion variables from each country, as well as the sum of all contagion variables.[13] We find that the contagion variables are jointly significant at least at the 5 percent level for explaining the number of coexceedances in all six countries. This is also reflected in an increase in pseudo-R^2 of generally about 1 to 2 percentage points. The one-day lagged coexceedances from other

[13]The tests are reported in the last rows of table 5 and are denoted with Σ. Example: The row ΣContagion DE reports the statistic for the test of the joint significance of the coefficients capturing contagion from Germany (i.e., the coefficients of the lagged coexceedances from Germany).

Figure 1. Contagion Directions

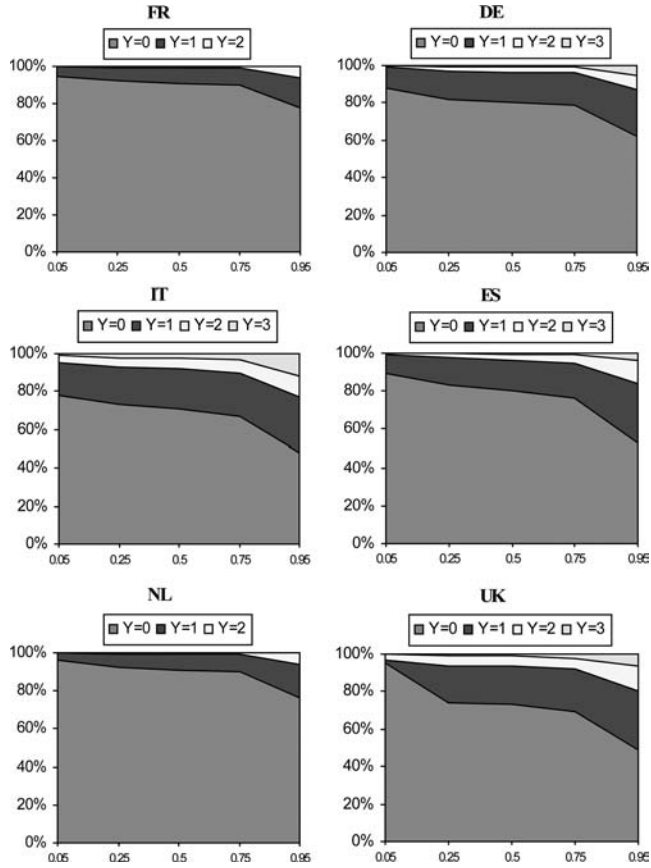


Note: Solid lines indicate significance of contagion parameters at least at the 5 percent level, and dotted line at the 10 percent level.

countries does not result in large changes in the level or significance of the controls, suggesting that adding foreign coexceedances adds information to the specification.

Figure 1 summarizes the patterns of contagion. In the figure, we represent the joint significance of the lagged coexceedance variable in country A in the specification for country B as an arrow from country A to country B. First, we see that the United Kingdom (UK) and Germany (DE) is the only country pair where we have evidence in favor of bilateral contagion. Adverse shocks affecting German banks have an impact upon UK banks and vice versa. Second, Spanish banks tend to be particularly important for the banking systems in other countries. In addition to German banks, French, UK, and Dutch banks have also been exposed to contagion from the Spanish banking system. Third, Spanish banks themselves are exposed to contagion from Italian banks only.

Figure 2. Response Curves to Volatility Shocks



In order to assess the economic magnitude of the effects, we use "coexceedance response curves" (Bae, Karolyi, and Stulz 2003). First let us examine the effect of conditional volatility of the stock market ("volatility own") on coexceedances of banks. In figure 2 we plotted coexceedances in each country as a function of conditional volatility increasing from the lowest 5th percentile (i.e., conditional volatility strongly decreasing) to the highest 5th percentile. We find that the curves are highly nonlinear, supporting our use of a multinomial logit model. If conditional volatility increases strongly (i.e., above the 75th percentile), the probability of more than one coexceedance increases to between 20 percent (FR) and 50 percent (IT) from 3

percent and 20 percent, respectively. Three or more coexceedances increase from about zero at negative changes in volatility to 2 percent (ES) to 10 percent (IT).

In comparison, consider the effect of contagion, shown in figures 3–8. The upper left-hand panel of figure 3 shows contagion from French banks to German banks. The probability of three or more German banks being in the tail is 1.1 percent if no French banks were in the tail the day before. If three French banks were in the tail, this probability increases to 2.8 percent. In the econometric analysis, we found this effect to be insignificant. Now consider the case of contagion from the Netherlands to Germany (depicted in the fourth panel from the left in figure 3). The probability that three or more German banks are in the tail remains unchanged at just above 1 percent no matter how many Dutch banks were in the tail, but the probability that at least one German bank is in the tail increases from 20 percent in the case of no Dutch banks in the tail to 42 percent in the case of three Dutch banks in the tail the day before. In the econometric analysis, we found this effect to be significant at the 5 percent level. Contagion from Dutch banks to the German banking system is significantly stronger than contagion from French banks, but it tends to affect only one or two banks, rather than a large number of banks. The opposite is true for contagion from Spain to Germany (panel 2 in figure 3). In this case, the probability of one or more coexceedances in Germany is not a function of lagged coexceedances in Spain, but the probability of three or more coexceedances increases from less than 1 percent to 3.5 percent. Contagion from Spain tends to affect many banks, rather than just one.

Finally, consider the case of contagion to the United Kingdom (figure 8). The case of the United Kingdom is particularly interesting, because it is the only country in the sample that did not introduce the euro in 1999. We find that there is significant contagion to the United Kingdom from German and Spanish banks. If there are no lagged coexceedances in Germany, the probability of three or more coexceedances in the United Kingdom is 1.1 percent, which increases to 6.7 percent if there are three or more German coexceedances the day before (the change is significant at the 1 percent significance level). The contagion effects from Spain to the United Kingdom, although also statistically significant, are much smaller:

Figure 3. Contagion to Germany

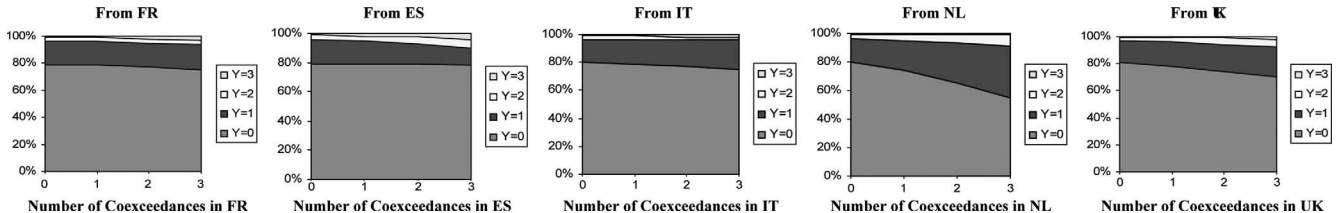


Figure 4. Contagion to France

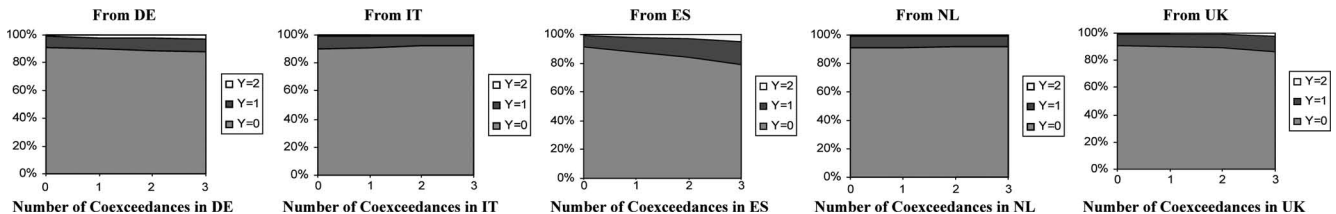


Figure 5. Contagion to Spain

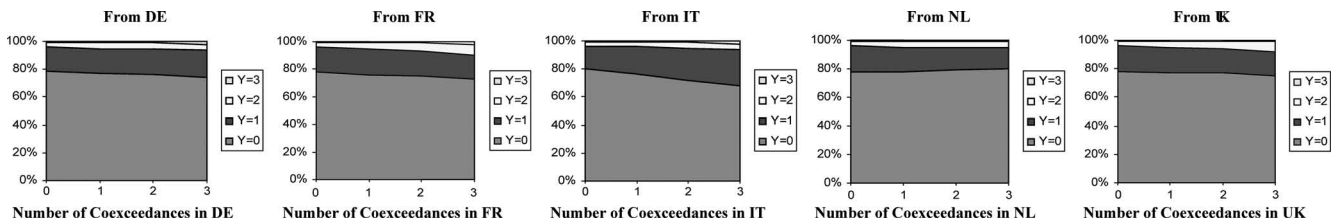


Figure 6. Contagion to Italy

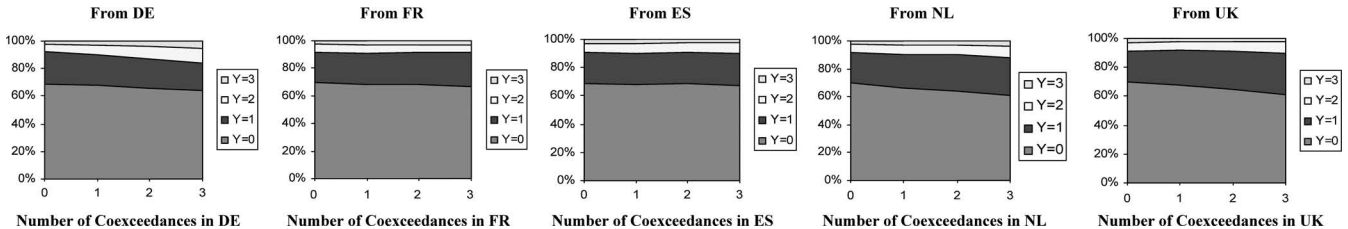


Figure 7. Contagion to the Netherlands

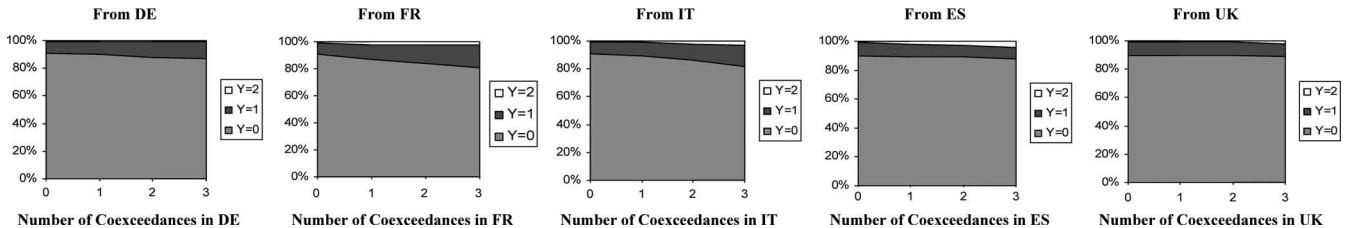
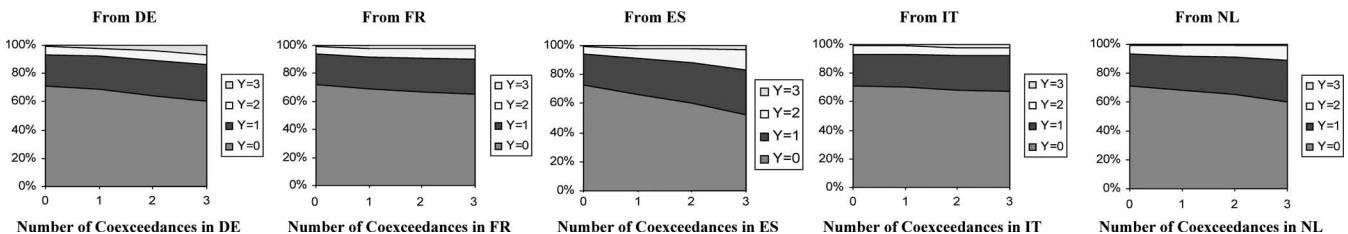


Figure 8. Contagion to the United Kingdom



the increase is from 1.2 percent to 3.5 percent.[14] We explore the relationship between UK banks and the euro area before and after 1999 in more detail in the next section.

4.2 Extension: Effect of the Introduction of the Euro

The effect of the introduction of the common currency on cross-border contagion risk among EU countries is ambiguous ex ante. One could argue that the common currency may result in an increase of cross-border contagion risk, since it led to a single money market for liquid reserves in euro, strengthening the cross-border interbank links among banks. On the other hand, Allen and Gale (2000) argue that when interbank liabilities and assets are well diversified across many banks, cross-border contagion risk should decrease. Hence, the integration of the money market in the wake of the introduction of the common currency may have resulted in a reduction in contagion risk.

In order to address this issue, we estimate the model separately for the pre- and post-euro periods. The results are reported in table 6. Before we discuss the results regarding contagion, note that the fit of the model is better in most countries for the post-euro period. This result is consistent with the idea that idiosyncratic factors explain less of the coexceedances after the euro was introduced and may reflect increasing financial integration (see, e.g., Baele et al. 2004). In addition, the coefficients on some of the control variables change substantially, both in terms of economic magnitude and in terms of econometric significance, although conditional volatility remains the most important variable explaining coexceedances.

Figures 9 and 10 represent graphically the estimated patterns of cross-border contagion for the two periods. Overall, the introduction of the euro appears to have increased cross-border contagion. We distinguish three cases: (i) contagion between two countries exists before and after the introduction of the euro, (ii) contagion exists only before the introduction of the euro, and (iii) contagion exists only after the introduction of the euro. While

[14]It is in line with our priors that we find that German and Spanish banks have contagious effects on the United Kingdom. German banks have large interbank exposures to the United Kingdom, and Spanish banks have quite close ties with UK banks, as evidenced by the recent merger between Banco Santander and Abbey National.

Table 6. Multinomial Logit Model: Contagion in Daily Coexceedances of the Percentage Change in Distance to Default, Large EU Countries, January 1994–January 2003, Pre- and Post-Euro

	France				Germany				Italy			
	Pre-Euro		Post-Euro		Pre-Euro		Post-Euro		Pre-Euro		Post-Euro	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=1												
Constant	−2.36***		−3.01***		−1.96***		−1.88***		−1.15***		−1.77***	
Coex. Lagged	0.40*	0.034*	0.28	0.015	0.38***	0.050***	0.74***	0.096***	0.31***	0.040***	0.22*	0.0232
Systemic Risk	0.07	0.005	0.45***	0.024***	0.41**	0.056**	−0.08	−0.012	0.35**	0.053*	0.22*	0.030*
Yield Curve	−0.08	−0.006	3.78	0.205	4.36**	0.575**	−2.07	−0.286	−0.10	−0.024	0.30	0.033
Volatility Own	0.54***	0.046***	0.18**	0.009**	0.26***	0.032***	0.13***	0.017***	0.11***	0.015***	0.10***	0.013***
Volatility US	−0.16	−0.014	0.01	0.001	0.01	0.001	−0.00	−0.000	−0.02	−0.005	0.01	0.001
Contagion DE	−0.00	−0.001	−0.01	−0.001					−0.23**	−0.046**	0.32**	0.045**
Contagion FR					0.10	0.013	0.08	0.010	0.20	0.028	−0.20	−0.021
Contagion IT	−0.07	−0.006	−0.25	−0.014	0.14*	0.023*	0.02	0.001				
Contagion NL	0.07	0.007	−0.92**	−0.050**	0.64***	0.086***	0.05	0.008	0.19	0.032	0.03	−0.001
Contagion ES	0.25*	0.021*	0.41**	0.022**	−0.15	−0.025	−0.04	−0.007	−0.11	−0.018	0.22	0.030
Contagion UK	0.04	0.003	0.37**	0.020**	0.17	0.021	0.18	0.023	0.09	0.021	0.20*	0.027
Coexceedances = 2												
Constant	−4.56***		−4.76***		−3.66***		−4.23***		−2.58***		−3.51***	
Coex. Lagged	0.82**	0.009**	0.46	0.005	0.43**	0.009**	1.24***	0.026***	0.53***	0.028***	0.71***	0.027***
Systemic Risk	0.46**	0.005*	0.31	0.003	0.34	0.007	−0.09	−0.002	0.48**	0.025**	0.26*	0.009
Yield Curve	−1.07	−0.012	2.50	0.028	8.68***	0.209***	−1.52	−0.028	0.2	0.017	1.45	0.058
Volatility Own	0.91***	0.010***	0.59***	0.007***	0.59***	0.014***	0.25***	0.005***	0.15***	0.008***	0.16***	0.006***
Volatility US	0.02	0.000	0.10*	0.001*	0.05	0.001	−0.04	−0.001	−0.03	−0.002	−0.01	−0.001
Contagion DE	0.31	0.004	0.22	0.003					0.17	0.016	0.37*	0.012
Contagion FR					−0.10	−0.003	0.11	0.002	0.33	0.018	−0.96**	−0.038**
Contagion IT	−0.15	−0.002	0.04	0.001	−0.55***	−0.015***	0.22	0.005				
Contagion NL	−1.02**	−0.012**	0.38	0.005	0.68***	0.015**	0.00	−0.000	0.08	0.001	0.38	0.016
Contagion ES	0.48*	0.005*	0.72**	0.008**	0.38*	0.010**	0.38	0.009	−0.16	−0.009	0.42**	0.016**
Contagion UK	0.12	0.001	−0.20	−0.003	0.39**	0.009**	0.28	0.006	−0.06	−0.005	0.33*	0.012*

(continued)

Table 6. (Continued)

	France				Germany				Italy			
	Pre-Euro		Post-Euro		Pre-Euro		Post-Euro		Pre-Euro		Post-Euro	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=3												
Constant					−4.78***		−5.69***		−3.68***		−4.58***	
Coex. Lagged					0.89***	0.010***	1.40***	0.008***	1.00***	0.028***	1.26***	0.019***
Systemic Risk					0.24	0.002	0.35*	0.002	0.56***	0.014**	0.32	0.004
Yield Curve					−1.45	−0.031	5.04	0.037	0.04	0.002	0.55	0.007
Volatility Own					0.73***	0.009***	0.34***	0.002***	0.32***	0.009***	0.29***	0.004***
Volatility US					−0.09	−0.001	0.15**	0.001**	0.12***	0.004***	0.03	0.000
Contagion DE									0.08	0.004	0.62**	0.001**
Contagion FR					0.50	0.006	0.08	0.000	0.32	0.008	−0.36	−0.005
Contagion IT					−0.06	−0.001	0.68**	0.005*				
Contagion NL					0.20	0.001	−0.21	−0.002	0.31	0.008	0.16	0.002
Contagion ES					0.67***	0.009***	−0.12	−0.001	0.03	0.002	−0.12	−0.003
Contagion UK					0.06	0.000	0.34	0.002	−0.21	−0.007	0.11	0.001
Pseudo-R^2	0.14		0.21		0.15		0.14		0.10		0.12	
Log-Likelihood	−506		−332		−808		−639		−1,168		−766	
N	1,302		1,058		1,302		1,058		1,302		1,058	
ΣContagion DE	0.76		0.17						0.01		9.40***	
ΣContagion FR					0.47		0.14		3.77*		4.47**[a]	
ΣContagion IT	0.66		0.44		2.10		3.97**					
ΣContagion NL	2.73*[a]		0.53		6.94***		0.04		1.67		0.62	
ΣContagion ES	4.98**		8.27***		5.80**		0.17		0.60		0.98	
ΣContagion UK	0.23		0.20		3.28*		3.75*		0.27		2.42	
ΣContagion	0.00		1.28		8.33***		5.98**		2.83*		3.29*	

[a]The sum of the coefficients is significantly negative. Not represented as an arrow in figures 9 and 10.

(continued)

Table 6. (Continued)

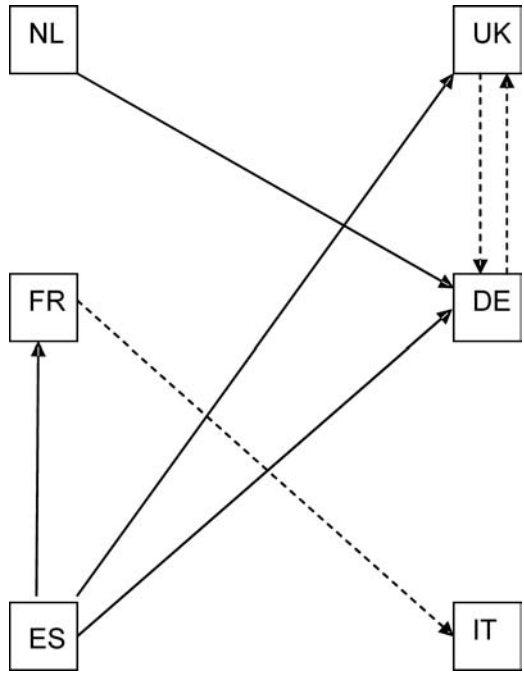
	The Netherlands				Spain				United Kingdom			
	Pre-Euro		Post-Euro		Pre-Euro		Post-Euro		Pre-Euro		Post-Euro	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=1												
Constant	−2.40***		−3.16***		−1.58***		−2.10***		−1.51***		−1.79***	
Coex. Lagged	0.56***	0.050***	0.52*	0.033*	0.46***	0.064***	0.66***	0.087***	0.39***	0.058***	0.32**	0.039*
Systemic Risk	0.51***	0.050***	0.46***	0.029***	−0.14	−0.025	0.34***	0.044***	0.63***	0.100***	0.64***	0.094***
Yield Curve	−0.67	−0.060	2.14	0.135	−0.47	−0.080	1.09	0.162	−1.21	−0.212	1.04	0.176
Volatility Own	0.28***	0.024***	0.25***	0.015***	0.42***	0.059***	0.21***	0.026***	0.84***	0.134***	0.20***	0.026***
Volatility US	−0.01	−0.001	0.00	0.000	0.02	0.007	0.02	0.002	−0.02	−0.004	−0.00	0.000
Contagion DE	0.05	0.004	0.24	0.016	0.02	0.002	0.17	0.022	0.16	0.027	0.10	0.009
Contagion FR	0.33*	0.030*	0.15	0.009	0.05	0.005	−0.17	−0.024	0.22	0.046*	−0.31	−0.044
Contagion IT	0.15	0.014	0.34**	0.021**	0.20**	0.030**	0.21*	0.028*	0.05	0.010	0.08	0.012
Contagion NL					−0.23	−0.035	0.11	0.015	0.07	0.011	0.30	0.044
Contagion ES	−0.14	−0.013	0.19	0.012					0.14	0.017	0.42***	0.062***
Contagion UK	−0.11	−0.010	0.10	0.006	−0.20	−0.030*	0.20*	0.026				
Coexceedances = 2												
Constant	−4.69***		−5.04***		−3.51***		−4.26***		−3.00***		−3.37***	
Coex. Lagged	0.62*	0.007	0.48	0.005	0.67***	0.019***	0.93***	0.020***	0.71***	0.034***	0.89***	0.044***
Systemic Risk	0.44*	0.005	0.16	0.001	0.32	0.011	0.65***	0.014***	0.84***	0.038***	0.66***	0.027***
Yield Curve	−0.14	−0.001	0.42	0.003	1.07	0.038	−2.24	−0.06	−0.05	0.016	−1.47	−0.095
Volatility Own	0.66***	0.008***	0.42***	0.004***	0.69***	0.020***	0.40***	0.009***	1.06***	0.047***	0.43***	0.020***
Volatility US	0.03	0.000	−0.06	0.001	−0.65***	−0.022***	−0.00	−0.000	−0.07	−0.003	−0.04	−0.002
Contagion DE	0.21	0.003	−0.24	−0.003	0.08	0.003	0.13	0.002	0.00	−0.002	0.36*	0.018*
Contagion FR	0.18	0.002	0.38	0.004	0.30	0.009	0.15	0.004	−0.24	−0.016	−0.41	−0.018
Contagion IT	0.08	0.001	0.63**	0.006**	0.07	0.001	0.02	−0.000	−0.05	−0.004	0.00	−0.001
Contagion NL					−0.06	−0.001	0.21	0.005	0.21	0.011	0.35	0.015
Contagion ES	0.56***	0.008***	0.12	0.001					0.44***	0.022**	0.43**	0.019*
Contagion UK	−0.04	−0.000	0.32	0.003	0.05	0.003	0.49***	0.011**				

(continued)

Table 6. (Continued)

	The Netherlands				Spain				United Kingdom			
	Pre-Euro		Post-Euro		Pre-Euro		Post-Euro		Pre-Euro		Post-Euro	
	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.	Coeff.	ΔProb.
Coexceedances=3												
Constant					−5.12***		−5.78***		−5.38***		−5.02***	
Coex. Lagged					0.66**	0.004*	1.02***	0.006**	1.18***	0.009***	1.01***	0.012***
Systemic Risk					0.86***	0.007***	0.50**	0.003*	1.06***	0.007***	1.03***	0.011***
Yield Curve					1.95	0.016	−1.12	−0.008	−2.87	−0.022	4.10**	0.053*
Volatility Own					0.88***	0.006***	0.43***	0.002***	1.87***	0.014***	0.63***	0.007***
Volatility US					0.09	0.001	0.01	0.000	0.05	0.001	0.05	0.001
Contagion DE					0.17	0.001	0.57**	0.003*	0.48**	0.004**	1.01***	0.013***
Contagion FR					0.24	0.002	0.01	0.000	−0.82*	−0.007*	−0.59	−0.007
Contagion IT					0.21	0.001	0.28	0.002	0.25	0.002	0.08	0.001
Contagion NL					0.13	0.001	−0.07	−0.001	−0.43	−0.004	−0.10	−0.002
Contagion ES									0.68***	0.005**	0.07	−0.001
Contagion UK					−0.08	−0.000	0.51	0.003				
Pseudo-R^2	0.18		0.23		0.15		0.15		0.14		0.16	
Log-Likelihood	−509		−334		−837		−632		−991		−780	
N	1,302		1,058		1,302		1,058		1,302		1,058	
ΣContagion DE	0.84		0.00		0.49		2.98*		3.24*		11.98***	
ΣContagion FR	1.84		1.20		1.12		0.00		1.50		3.02*	
ΣContagion IT	1.32		8.41***		1.94		1.52		0.69		0.14	
ΣContagion NL					0.08		0.13		0.06		0.65	
ΣContagion ES	2.41		0.55						13.49***		3.40*	
ΣContagion UK	0.28		1.51		0.30		7.04***					
ΣContagion	4.06**		12.47***		1.27		9.11***		1.54		4.12**	

Figure 9. Contagion Directions—Pre-Euro



Note: Solid lines indicate significance of contagion parameters at least at the 5 percent level, and dotted lines at the 10 percent level.

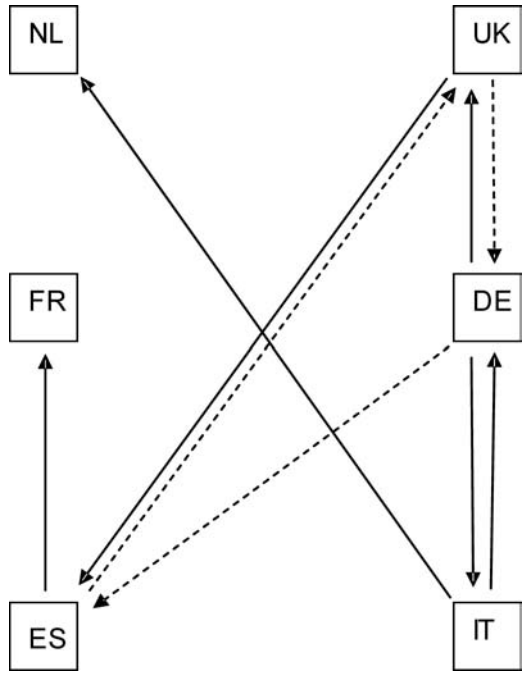
we do not want to discuss these patterns in detail, it clearly emerges that the number of links increases in the post-euro period.

We now turn to the question of whether the economic magnitude of contagion has also changed. To examine this, we prepared the conditional probability charts for the two periods separately (not shown; available from the authors upon request). Overall, the economic magnitude of contagion before and after the introduction of the euro has remained unchanged. Hence, the main effect of the introduction of the euro is the more widespread presence of contagion, rather than a stronger effect due to its presence.

5. Robustness

Because we are estimating a large number of coefficients, we were concerned that some of our results may be spurious. Hence, we

Figure 10. Contagion Directions—Post-Euro



Note: Solid lines indicate significance of contagion parameters at least at the 5 percent level, and dotted lines at the 10 percent level.

subjected the results to five robustness checks: (i) we excluded from the sample well-identified systemic crisis periods; (ii) we reestimated the model using ordered logit, rather than multinomial logit, models; (iii) we added foreign-country conditional volatilities to the specification; (iv) we reestimated the model for the largest and smallest banks in the sample separately; and (v) we relaxed the assumption of a common stochastic process driving the change in distance to default across banks.[15] Rather than report a full set of results for

[15]We also estimated the model with domestic stock market tail events as a separate explanatory variable (rather than incorporated in the variable "systemic risk"). The contagion patterns obtained are broadly unchanged, and the domestic stock market variable is generally insignificant, suggesting that domestic systemic risk is picked up by the conditional volatility variable. The results are available from the authors upon request.

each specification, we summarized the robustness checks in simple matrix tables reported in appendix 3.

As a first robustness check, we reestimated the base model with contagion effects (table 5), excluding the following periods clearly associated with common shocks affecting all banks, rather than contagion: the week of September 11, 2001 (U.S. terror attacks), the second half of October 1997 (Hong Kong crisis), and the first two weeks of October 1998 (Russia's default). The results are reported in table 9 in appendix 3. Comparing the results with table 8 in appendix 3, which summarizes the base specification in table 5, however, reveals that the results tend to strengthen rather than weaken when these crisis periods are excluded.

As we discussed in section 2, an ordered logit model represents a valid alternative to the multinomial logit model used in the baseline specification. The results for an estimation of the baseline model using ordered logit are reported in table 10 in appendix 3 and reveal almost identical patterns of contagion compared with the base line. Our results do not seem to be driven by the estimation method.

Next, it is possible that our results are at least in part driven by volatility spillovers from other countries rather than contagion. Hence, we reestimated the base model and included also the conditional volatility variables of the other countries in cases where we found significant contagion. For example, we detect contagion from the United Kingdom to Germany. It is possible that the coexceedances in the United Kingdom only proxy for large changes in conditional volatility in the United Kingdom, which in turn have an effect on coexceedances in Germany. The results of this exercise are reported in table 11 in appendix 3 and are identical to our baseline results.

As documented earlier, our sample of banks is very heterogeneous in size. This permits a check of whether our results are primarily driven by large banks. In general, large banks can be expected to be more important in cross-border contagion simply because they are large, but also because cross-border interbank money-market links tend to be primarily through these banks (Degryse and Nguyen 2007; Freixas and Holthausen 2005).

Hence, we split the sample into small and large banks and reestimated the basic model. Such a sample split is somewhat arbitrary. In

this paper, we use all banks larger than €170 billion (the median). The results (reported in table 12 in appendix 3) suggest that the patterns when estimating the model with large banks are again very similar to those reported earlier, while we find very little contagion from small banks to small banks across borders (appendix 3, table 13). These results are consistent with the tiered interbank structure obtained in a model of the cross-border interbank market in Freixas and Holthausen (2005), in which only large banks operate across borders in the interbank market and act as money centers for smaller domestic banks. However, the evidence is also consistent with large banks sharing common exposures to some sophisticated markets, such as credit derivatives, in which small banks do not participate.

Finally, we also redefined our threshold for coexceedances. In the base specifications, we used the 5 percent tail of the joint distribution of the percentage change in distance to default of all banks in the sample. This implies that each individual bank may be more or less frequently in the tail, depending upon the frequency with which it was hit by a large adverse shock. More fundamentally, the approach implicitly relies on the idea that the stochastic process governing the percentage change in distance to default of individual banks is the same. In order to check the robustness of the results with respect to this assumption, we reestimated the models taking bank-specific cutoff points at the 5 percent negative tail. The results are essentially identical to the base line, which supports the assumption that the stochastic process governing the distance to default of individual banks is similar and more generally enhances the confidence in the robustness of the results.

6. Conclusions

In this paper, we analyze cross-border contagion in the EU banking sector using a multinomial logit approach, focusing on the tail observations in banks' distance to default. We identify contagion by showing that the incidence of tail events in one country is significantly influenced by lagged coexceedances in other countries, controlling for common shocks.

The evidence is consistent with cross-border contagion among large European banks. There is no evidence of cross-border contagion for small banks. The patterns of contagion are robust across a wide variety of specifications. This suggests an important pan-European dimension in the monitoring of systemic risk. This conclusion is strengthened by the increase in cross-border contagion after the introduction of the euro.

While in this paper we do not take a position on the precise transmission channel of contagion, the results suggest that the integrated money market in the euro area may have resulted in an increase in contagion risk. We would take this as evidence that the interbank market is not fully integrated in the sense of Allen and Gale's (2000) complete set of linkages among banks. Instead, the results indicate a "tiered" interbank structure at the cross-border level such that small banks only deal with domestic counterparties, leaving foreign operations to major international banks. However, we cannot reject two alternative explanations for the contagion patterns. It is possible that large banks are more likely than smaller banks to be subject to contagion via depressed market valuations of structured instruments and credit derivatives (Cifuentes, Ferrucci, and Shin 2004). In addition, runs by equity holders, in which equity holders are unable to assess the exposures and quality of individual banks, would be consistent with the evidence. We can, however, reject domino effects of defaults as the source for the observed contagion in our results, as contagion occurs even in the absence of any bank in the sample defaulting on its obligations.

The results should be viewed as a lower bound to the true contagion risk in the euro area. First, we estimate the model for a relatively calm period without major financial disruptions in any of the banking systems or in any of the major banks. If contagion risk increases during crises, this is not reflected in our estimates. Second, we use lagged coexceedances (by one day) as our measure of contagion. If financial markets are semi-efficient and incorporate information efficiently, we will miss those cases of contagion taking place within one day. Third, in some countries in the sample (e.g., Spain) banks play a dominant role in the available stock market indices, suggesting that our common-shock variables, such as conditional volatility, may in fact pick up effects that are related to contagion.

Appendix 1. Calculation of Distances to Default

The distance to default is derived by starting with the Black-Scholes model, in which the time path of the market value of assets follows a stochastic process:

$$\ln V^T = \ln V + \left(r - \frac{\sigma^2}{2}\right) T + \sigma\sqrt{T}\varepsilon, \tag{5}$$

which gives the asset value at time T (i.e., maturity of debt), given its current value (V). ε is the random component of the firm's return on assets, which the Black-Scholes model assumes is normally distributed, with zero mean and unit variance, $N(0, 1)$.

Hence, the current distance d from the default point (where $\ln V = \ln D$) can be expressed as

$$\begin{aligned} &d = \ln V^d - \ln D = \ln V + \left(r - \frac{\sigma^2}{2}\right) T + \sigma\sqrt{T}\varepsilon - \ln D \Leftrightarrow \\ &\frac{d}{\sigma\sqrt{T}} = \frac{\ln\left(\frac{V}{D}\right) + \left(r - \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}} + \varepsilon. \end{aligned} \tag{6}$$

That is, the distance to default,

$$dd \equiv \frac{d}{\sigma\sqrt{T}} - \varepsilon = \frac{\ln\left(\frac{V}{D}\right) + \left(r - \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}}, \tag{7}$$

represents the number of asset-value standard deviations (σ) that the firm is from the default point. The inputs to dd, V, and σ can be calculated from observable market value of equity capital (V_E), volatility of equity σ_E, and D (total debt liabilities) using the system of equations below.

$$\begin{aligned} V_E &= VN(d1) - De^{-rT}N(d2) \\ \sigma_E &= \left(\frac{V}{V_E}\right) N(d1)\sigma, \\ d1 &\equiv \frac{\ln\left(\frac{V}{D}\right) + \left(r + \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}} \\ d2 &\equiv d1 - \sigma\sqrt{T} \end{aligned} \tag{8}$$

The system of equations was solved by using the generalized reduced gradient method to yield the values for V and σ, which in turn entered into the calculation of the distance to default.[16] The results were found robust with respect to the choice of starting values. The measure of bank risk used in this paper is then obtained by first-differencing (7), yielding the change in the number of standard deviations away from the default point, which is denoted as Δdd.

As underlying data, we used daily values for the equity market capitalization, V_E, from Datastream. The equity volatility, σ_E, was estimated as the standard deviation of the daily absolute equity returns, and, as proposed in Marcus and Shaked (1984), we took the six-month moving average (backwards) to reduce noise. The presumption is that the market participants do not use the very volatile short-term estimates but, instead, use more smoothed volatility measures. With this approach, equity volatility is accurately estimated for a specific time interval, as long as leverage does not change substantially over that period (see, e.g., Bongini, Laeven, and Majnoni 2002). The total debt liabilities, D, are obtained from published accounts and are interpolated (using a cubic spline) to yield daily observations. This suggests that our variation in the dependent variable arises from either changes in the value of the bank or in changes in volatility. The time to the maturing of the debt, T, was

[16]See Bharath and Shumway (2008), Delianedis and Geske (2003), Eom, Helwege, and Huang (2004), KMV Corporation (2002), and Vassalou and Xing (2004), for a similar derivation and more ample discussions. Duan (1994, 2000) proposes an alternative way to calculate the distance to default, which is based on maximum likelihood estimation of the parameters. We feel that our choice of the "traditional" approach is justified by the fact that the distance to default does not enter directly in our model. Instead, we use it to build a count variable that takes value 1 if the change in distance to default falls in the bottom 95th percentile and 0 elsewhere. In our opinion, this transformation smoothes differences between different computation methods of distance to default. In order to make this point clear, it must be kept in mind that one of the main differences between the traditional method and Duan's approach is that in the former, stock volatility is estimated using historical data. Duan (1994, 2000), hence, corrects the fact that in periods of increasing prices, the traditional approach tends to overestimate the default probability, while the opposite happens in periods of decreasing prices. As we do not consider the level of the distance to default but, rather, the change, the distortion is essentially spread out through the sample. It is also important to stress that in our study we use data at relatively high frequency and therefore any movements in the distance to default will largely be driven by changes in equity prices under either approach.

set to one year, which is the common benchmark assumption without particular information about the maturity structure. Finally, we used the government bond rates as the risk-free rates, r.

Appendix 2. Results from a GARCH (1,1) Model

Table 7. Estimated Coefficients of the Garch (1,1) Model for Daily Stock Market Returns in the Analyzed Countries

	Coefficient	Std. Error	Z-Stat	Probability
FR				
Constant	0.00	0.00	3.03	0.00
ε^2_{t-1}	0.06	0.01	9.60	0.00
σ^2_{t-1}	0.93	0.01	125.21	0.00
DE				
Constant	0.00	0.00	5.64	0.00
ε^2_{t-1}	0.10	0.01	10.47	0.00
σ^2_{t-1}	0.89	0.01	97.08	0.00
IT				
Constant	0.00	0.00	5.00	0.00
ε^2_{t-1}	0.11	0.01	9.84	0.00
σ^2_{t-1}	0.86	0.01	58.21	0.00
NL				
Constant	0.00	0.00	3.68	0.00
ε^2_{t-1}	0.09	0.01	10.11	0.00
σ^2_{t-1}	0.91	0.01	102.81	0.00
ES				
Constant	0.00	0.00	5.67	0.00
ε^2_{t-1}	0.08	0.01	10.08	0.00
σ^2_{t-1}	0.91	0.01	108.16	0.00
UK				
Constant	0.00	0.00	3.61	0.00
ε^2_{t-1}	0.08	0.01	9.17	0.00
σ^2_{t-1}	0.91	0.01	99.71	0.00
US				
Constant	0.00	0.00	4.61	0.00
ε^2_{t-1}	0.07	0.01	11.80	0.00
σ^2_{t-1}	0.92	0.01	144.88	0.00

Note: Equation and variable definitions are given in the text.

Appendix 3. Robustness Checks

The following tables indicate where contagion is present and its direction. Countries receiving contagion are reported in rows; countries transmitting contagion are in columns. The symbols *, **, and *** indicate contagion significance at the 10 percent, 5 percent, and 1 percent levels, respectively. Example: Row 1 of table 8 indicates that contagion goes from the Netherlands (5 percent significance), Spain (5 percent significance), and the United Kingdom (1 percent significance) to Germany.

Table 8. Results of the Basic Contagion Model (See Table 5)

To↓ From→	DE	FR	IT	NL	ES	UK
DE	X			**	**	***
FR		X			***	
IT	**		X			
NL		*	***	X	**	
ES			**		X	
UK	***				***	X

Table 9. Results after Excluding Major Crises from the Sample (Asia, Second Half of October 1997; Russia, First Half of October 1998; and September 11, 2001)

To↓ From→	DE	FR	IT	NL	ES	UK
DE	X				***	**
FR		X			***	
IT	*		X		***	
NL		*	***	X	**	
ES			**		X	*
UK	***				***	X

Table 10. Results Using an Ordered Logit Model

To↓ From→	DE	FR	IT	NL	ES	UK
DE	X			***		***
FR		X			***	
IT	*		X			
NL		**	***	X		
ES			***		X	
UK	***				***	X

Table 11. Adding the Volatilities of the Countries with Significant Contagion Coefficients

To↓ From→	DE	FR	IT	NL	ES	UK
DE	X			**	**	***
FR		X			***	
IT	**		X			
NL		*	***	X	*	
ES			**		X	
UK	***				***	X

Table 12. Results Using Large Banks Only

To↓ From→	DE	FR	IT	NL	ES	UK
DE	X			***		***
FR		X			***	
IT	**		X			
NL		**		X	***	
ES			**		X	*
UK	***		***			X

Table 13. Results Using Small Banks Only

To↓ From→	DE	FR	IT	NL	ES	UK
DE	X					
FR		X				
IT			X	**		
NL				X		
ES			**		X	
UK				*	***	X

Note: We find a negative impact from French and Dutch banks on German banks and from French banks on UK banks.

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Fiscal Burden Sharing in Cross-Border Banking Crises*

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This paper focuses on the recapitalization of failing banks. A recapitalization is efficient if the social benefits (preserving systemic stability) exceed the cost of recapitalization. In a national setting, the implementation of an optimal policy is relatively straightforward. But in a cross-border setting, one is confronted with possible coordination failure. Using a multi-country model, it is shown that ex post negotiations on burden sharing lead to an underprovision of recapitalizations. Next, we explore different ex ante burden-sharing mechanisms to overcome the coordination failure. The first is a general scheme financed collectively by the participating countries (generic burden sharing). The second relates the burden to the location of the assets of the bank to be recapitalized (specific burden sharing). The working of the two mechanisms is calibrated with data on large cross-border banks in Europe. Because the costs and benefits are better aligned in the specific scheme, it is better able to overcome the coordination failure.

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1. Introduction

An integrated European banking system is emerging with a small group of large pan-European banks spanning national banking markets. This raises the issue of the appropriate level (federal or national) for managing financial stability (Vives 2001). Financial stability is currently managed at the national level. In particular, the fiscal competence to deal with banking crises is a responsibility of national governments.

The fiscal costs of resolving a banking crisis can be large. In a worldwide sample of forty banking crisis episodes, Honohan and Klingebiel (2003) find that governments spent on average 13 percent of national GDP to clean up the financial system. To clarify our position, the preferred route to solving a banking failure is a private-sector solution. The use of public money should only be considered when the social benefits (in the form of preventing a wider banking crisis) exceed the costs of recapitalization via taxpayers' money. The issue at stake in the European context is that not only national, but also cross-border, externalities should be taken into account in the process of decision making (Schoenmaker and Oosterloo 2005).

In a multicountry setting, the costs of such recapitalization can be shared between countries. Freixas (2003) shows in a model that ex post negotiations on burden sharing lead to an underprovision of recapitalizations. Countries have an incentive to understate their share of the problem in order to have a smaller share in the costs. This leaves the largest country, almost always the home country, with the decision whether to shoulder the costs on its own or to let the bank close and possibly be liquidated. Freixas (2003) labels this mechanism, which reflects the current arrangements in Europe, as improvised cooperation.

The aim of the paper is to explore possible ex ante mechanisms for fiscal burden sharing in a banking crisis in Europe. We will expand the Freixas model. The first mechanism could be a general fund to shoulder the burden of recapitalization. This general fund could be financed directly by the participating countries, which would pay their relative share (e.g., based on GDP) in the fund. The main advantage of this system is that the cost of recapitalization is smoothed over countries. There are, however, serious problems with this approach, not least that there is little (political) enthusiasm for

cross-border fiscal transfers. The second mechanism involves specific burden sharing. In this scheme, only countries in which the problem bank is conducting business contribute to the burden sharing. A country's contribution can be related to the share of the problem bank's business in that country. In this way, cross-border transfers are largely avoided. Both schemes are subject to the free-rider problem. Countries that do not sign up for burden sharing nevertheless profit from burden sharing, as the stability of the European financial system is a public good.

The paper is organized as follows. In section 2, we model the possibility of coordination failure in crisis management in a multi-country setting. Next, in section 3, we explore different mechanisms for ex ante burden sharing to overcome the coordination failure. The mechanisms are illustrated with numerical examples. In section 4, we discuss the policy implications of the different burden-sharing mechanisms. The final section concludes.

2. A Model of Cross-Border Recapitalizations

The fiscal costs of resolving a banking crisis can be large. Scandinavia and Japan, for example, experienced a severe banking crisis in the 1990s. While the Scandinavian crisis amounted to a fiscal cost of 8 percent of GDP, the long, drawn-out Japanese crisis added up to a total fiscal cost of 20 percent of GDP. There are also broader, real, costs to the welfare of the economy. Hoggarth, Reis, and Saporta (2002) find that the cumulative output losses incurred during crisis periods are roughly 15–20 percent of GDP.

National authorities (central banks and finance ministries) have a mandate for financial stability in their national financial system. They may be reluctant to provide liquidity or solvency support for solving problems in other European Union (EU) countries, and thus not take into account cross-border externalities caused by financial institutions under their jurisdiction (Schoenmaker and Oosterloo 2005). Financial problems occurring in one country can affect the health of the financial system in other countries through different channels. The first type of contagion risk occurs when the financial shock causes the institution itself to fail. We refer to this state of affairs as the first-round effect of financial contagion. In this round,

financial problems spread throughout the institution and across borders to its foreign branches and subsidiaries. In particular, in countries where the financial system is dominated by foreign banking groups, the consequences of these first-round effects can be significant. The second type of contagion risk is the risk that the failure of an institution will be transmitted to other institutions because of explicit financial linkages between these institutions. This is referred to as the second-round effect of financial contagion; see also De Bandt and Hartmann (2002). What is the impact of these cross-border externalities on the economy? When parts of the financial system break down, the credit capacity may be constrained. In this paper, we are interested in the economic effects of credit contraction in a country as a result of financial contagion.[1]

Current nationally based arrangements do not incorporate these cross-border externalities and may therefore lead to a coordination failure in crisis management. To formalize this issue, we look at two different models of recapitalization developed by Freixas (2003): a single-country model and a multicountry model. The models only deal with the funding of a recapitalization. In an earlier paper (Goodhart and Schoenmaker 2006), we also deal with some practical aspects of a recapitalization. For example, before public money is considered, private-sector solutions should be explored and the shareholders and managers of an ailing bank should be removed to preserve incentives to prevent problems developing.

2.1 Single-Country Model of Recapitalization

Freixas (2003) presents a model of the cost and benefits of recapitalization.[2] The model considers the ex post decision whether to recapitalize or to liquidate a bank in financial distress. The choice to continue or to close the bank is a variable x with values in the space $\{0, 1\}$. Moreover, θ denotes the social benefits of a recapitalization and C its costs. Among other things, the benefits of a recapitalization may include those derived from avoiding contagion

[1]See Allen and Gale (2000) and De Bandt and Hartmann (2002) for a full discussion of contagion risk.

[2]The recapitalization would involve firing the pre-existing management and writing down shareholder value to zero.

and maintaining financial stability. If the direct cost of continuing the bank activity is denoted by C_c and the cost of stopping its activities by C_s, we only deal with the difference, $C = C_c - C_s$. The case $C < 0$ is obviously possible, but is a case where continuing the bank's operations is cheaper than closing it down, so that continuation is preferred and the recapitalization decision is simplified. In this situation private-sector solutions are possible and the central bank can play the role of "honest broker."

The optimal decision for the authorities will be to maximize

$$x^*(\theta - C)$$

so that

$$\begin{cases} x^* = 1 & \text{if } \theta - C > 0 \\ x^* = 0 & \text{if } \theta - C < 0. \end{cases} \tag{1}$$

This simple model shows that a bank will be recapitalized whenever the total benefits of an intervention are larger than the net costs. In the case of recapitalization, the authorities will contribute C.

2.2 Multicountry Model of Recapitalization

In the multicountry model, Freixas (2003) considers the case where the mechanism is set in such a way that the bank is recapitalized only if a sufficient contribution from the different countries can be collected. This is an interpretation of improvised cooperation:[3] the different countries meet to find out how much they are ready to contribute to the recapitalization, denoted by t. If the total amount they are willing to contribute is larger than the cost, the bank is recapitalized. The decision is

$$\begin{cases} x^* = 1 & \text{if } \sum_j (t_j - C_j) > 0 \\ x^* = 0 & \text{if } \sum_j (t_j - C_j) < 0 \end{cases} \tag{2}$$

[3]The term "improvised cooperation" has been coined to convey the view of an efficient, although adaptive, exchange of information and decision making. It relies on the idea that financial stability is a goal that every individual country is interested in achieving, so there are good grounds for cooperation (Freixas 2003). In our opinion, improvised cooperation corresponds to the current situation in the EU.

and the j-country objective will be to maximize

$$x^*(\theta_j - t_j).$$

This game may have a multiplicity of equilibria, and, in particular, the closure equilibrium $t_j = 0$, $x^* = 0$ will occur, provided that for no j we have

$$\theta_j - \sum_j C_j > 0.$$

That is, no individual country is ready to finance the recapitalization by itself. Obviously, if this equilibrium is selected, the recapitalization policy is inefficient, as banks will almost never be recapitalized.

The fact that in most cases the closure equilibrium will occur can be explained by the fact that part of the externalities fall outside the home country, although we assume that the country with the highest social benefits of a recapitalization is the home country. The home country may not be prepared to meet the costs of recapitalizing a failing bank in its entirety. The problem becomes more acute for large banks in small countries. The cost relative to the fiscal budget may be large in small countries, so the home country simply cannot bear the full burden alone (Dermine 2000). We group the countries as follows: the home country, denoted by H; all European countries, denoted by E; and all countries in the world, denoted by W. The social benefits can then be decomposed into the social benefits in the home country ($h \cdot \theta = \theta_h$), the rest of Europe ($e \cdot \theta = \theta_e$), and the rest of the world ($w \cdot \theta = \theta_w$):

$$\sum_{j=1}^{W} \theta_j = \theta_h + \sum_{j \notin H}^{E} \theta_{e,j} + \sum_{j \notin E}^{W} \theta_{w,j}.$$

In this equation h, e, and w are indexes for the social benefits (i.e., externalities caused by the possible failure of a financial institution) in the home country, the rest of Europe, and the rest of the world. The sum of h, e, and w is 1.

Proposition 1. *In a setting of improvised cooperation, the efficiency of the recapitalization scheme depends on the size of h. When the total social benefits are close (or equal) to the social benefits*

of the home country ($h \to 1$)*, the home country recapitalizes the entire financial institution, provided that recapitalization is the optimal strategy. This is situation (1). Otherwise* ($h \prec 1$)*, the home country only deals with the social benefits within its territory and the closure equilibrium occurs for sufficiently low levels of* h*, even when recapitalization is the optimal strategy.*

Current nationally based arrangements undervalue externalities related to the cross-border business of financial institutions. As a result, insufficient capital will be contributed and the financial institution will not be recapitalized. The model pinpoints the public-good dimension of collective recapitalization and shows why improvised cooperation (ex post negotiations) will lead to underprovision of public goods—that is, to an insufficient level of recapitalizations. The outcome of our model is consistent with Schinasi (2007). Applying the theory on "economics of alliances," he examines decision making in a group of countries. Schinasi (2007) also concludes that the provision of shared financial stability public goods results in an equilibrium that is suboptimal from a European perspective, even though each country views its own decision as optimal and has no incentive to change its resource allocation decision if other countries maintain theirs. More specifically, countries choose a level of the public good that is inferior relative to the socially optimal level for European financial stability.

To avoid an insufficient level of recapitalizations, other—more centralized—coordination mechanisms may be explored. While a global jurisdiction does not exist, the member states of the European Union have a possibility of extending the jurisdiction to the European level in order to incorporate the social benefits in other European countries in the decision making. Schoenmaker and van Laecke (2007) document a statistically significant upward trend of emerging European banking groups. This trend illustrates that the need for coordination mechanisms at the European level is becoming more acute.

3. Mechanisms for Fiscal Burden Sharing

We extend the model of Freixas (2003) to explore ex ante mechanisms for burden sharing to overcome the coordination failure in

ex post negotiations. At the outset, we note that burden sharing in the case of an international banking crisis is a general problem. The Freixas model applies to any multicountry setting. We confine our search for solutions to the European setting, as a jurisdiction is available in the EU to implement binding agreements amongst national states. Treaties with a wider coverage of states can, of course, be signed, but there is no international enforcement mechanism.

3.1 Modeling Burden Sharing

In our model of burden sharing, the European countries (E) share the burden according to a prespecified key denoted by k with $\sum_{j=1}^{E} k_j = 1$, while countries outside Europe ($W - E$) do not participate in the scheme. The contribution will become for the European countries and non-European countries, respectively,

$$\begin{cases} t_j = k_j \cdot C & \forall j \in E \\ t_j = 0 & \forall j \notin E. \end{cases}$$

The European countries will maximize

$$x^*(\theta_j - (k_j \cdot C)) \quad \forall j \in E.$$

We assume that there is a collective vote of all involved countries: they jointly decide to rescue or to close the bank. In the particular case that the share of a country's contribution to the costs is fully aligned with that country's benefits ($k_j/\theta_j \ \forall j \in E$ is a constant), every country will vote in the same way. The decision in (2) will become

$$\begin{cases} x^* = 1 & \text{if } \sum_{j=1}^{E} \theta_j - C > 0 \\ x^* = 0 & \text{if } \sum_{j=1}^{E} \theta_j - C < 0. \end{cases} \tag{3}$$

If the social benefits in the home country and other European countries are larger than the total costs, the involved countries vote in favor of recapitalization. So the underprovision of recapitalizations would be reduced and come closer to the optimal solution of (1).

Proposition 2. *European coordination improves the efficiency of the recapitalization policy for positive values of e. If a bank's activities outside Europe are negligible* ($(h + e) \to 1$)*, we get an optimal*

decision for recapitalization (situation (1)), even for low values of h. Only when a bank's activities outside Europe are large $((h+e) \prec 1)$ *does the closure equilibrium occur, even when recapitalization is the optimal strategy.*

Proposition 2 demonstrates that European coordination is useful when cross-border business of banks (e) is non-negligible. In that case, coordination will improve the efficiency of the recapitalization policy, as both the externalities in the home country (h) and other European countries (e) are incorporated in the decision making. Only truly international banks with sizable business outside Europe (w) will pose a problem leading to socially insufficient recapitalizations.

Earlier we assumed that the share of a country's contribution to the costs is aligned with that country's benefits. However, the social benefits (financial stability) and the contributions to the costs may not be evenly spread over the different European countries. The design of the key for sharing the burden, k, is crucial for solving the model. The key needs to reflect the financial stability benefits. In a first general mechanism, we assume that financial stability is a truly public good which affects all participating countries. All countries then contribute according to their relative share. In a second specific mechanism, we assume that financial stability is only affected in those countries where a failing bank is doing business. The burden is financed directly by the involved countries according to some key reflecting the geographic spread of the business of the failing bank.

The working of the mechanisms will be illustrated with examples of sharing the burden for the recapitalization of some European banks. As small and medium-sized banks tend to be predominantly domestically oriented, we focus on the cross-border activities of large banking groups. To calibrate the numerical examples, table 1 provides some details on the twenty-five largest banks in Europe. The assets of this top twenty-five range from €300 to €1,500 bn. The average minimum capital requirement (calculated as the regulatory minimum of 4 percent of risk-weighted assets) of this group of large banks is €12.6 bn. These banks conduct on average 55 percent of their business at home ($h = 0.55$) and 26 percent in the rest of Europe ($e = 0.26$).

Table 1. Top 25 European Banks (2006 Figures)

Bank (Country)	Minimum Capital in €bn	Assets in €bn	h (%)	e (%)
1. HSBC (UK)	28.5	1,412.9	30	14
2. Royal Bank of Scotland (UK)	23.8	1,298.9	68	7
3. Crédit Agricole (France)	20.9	1,380.6	77	13
4. Santander Central Hispano (Spain)	19.1	833.9	36	47
5. BNP Paribas (France)	18.5	1,440.3	66	23
6. Barclays Bank (UK)	17.7	1,485.8	41	20
7. UniCredit (Italy)	16.9	823.3	26	70
8. HBOS (UK)	16.4	880.9	85	8
9. ING Bank (Netherlands)	13.5	895.0	38	32
10. Sociéte Générale (France)	11.4	956.9	63	18
11. ABN AMRO Bank (Netherlands)	11.2	987.1	29	43
12. Deutsche Bank (Germany)	11.0	1,126.2	18	47
13. Banco Bilbao Vizcaya Argentaria (Spain)	10.1	411.9	80	2
14. Rabobank Group (Netherlands)	9.9	556.3	61	19
15. Fortis Group (Belgium)	9.6	674.7	55	37
16. Lloyds TSB Group (UK)	9.3	512.1	97	2
17. Commerzbank (Germany)	9.1	608.4	73	21
18. Crédit Mutuel (France)	8.9	482.7	93	5
19. UBS (Switzerland)	8.5	1,491.2	9	31
20. Groupe Caisse d'Epargne (France)	8.4	539.7	94	1
21. Nordea Group (Sweden)	7.4	346.9	30	70
22. Groupe Banques Populaires (France)	6.5	305.3	75	10
23. Credit Suisse Group (Switzerland)	6.3	781.5	13	32
24. Danske Bank (Denmark)	6.0	367.4	67	33
25. Dexia (Belgium)	5.3	566.7	56	35
Average Top 25 Banks	12.6	846.7	55	26

Notes: Banks are ranked according to minimum capital, which is calculated as the regulatory minimum of 4 percent of risk-weighted assets (as of year-end 2006). Home is defined as a bank's assets in its home country (denoted by h); rest of Europe is defined as a bank's assets in other European countries (denoted by e); rest of world is defined as a bank's assets outside Europe (figures not shown). The three categories add up to 100 percent.
Source: "Top 1000 World Banks," *The Banker*, July 2007 for minimum capital and assets; Schoenmaker and Van Laecke (2007) for division of assets over home country and rest of Europe.

3.2 General Fund

In the first general mechanism, a European fund could be set up to shoulder the burden of a recapitalization. In an earlier paper (Goodhart and Schoenmaker 2006), we proposed to let the European Central Bank (ECB) issue bonds to set up a general fund and to use the seigniorage of the ECB to finance the annual costs (interest payment and write-down) of the fund. This solution has two drawbacks. First, it may violate the prohibition on monetary financing enshrined in the Maastricht Treaty. Second, it only provides an intermediary solution. While a central bank can create unlimited amounts of liquidity, its capacity to absorb losses is limited to its capital. To give the ECB a credible role in rescues (lender of last resort or recapitalization), its capital needs to be explicitly underwritten by national governments.[4]

Rather than using the ECB, the EU countries could use their own bank, the European Investment Bank (EIB),[5] to set up a general fund. There is no need to have a pre-funded (ex ante) fund, if receipts are nationally invested (Ricardian equivalence), since this would just raise the measured fiscal deficit while changing nothing real. During a crisis, bonds are issued by the EIB to finance the recapitalization. These borrowed moneys are used to recapitalize the failing bank. This would cover the full nominal value needed for the rescue. The annual servicing costs of the bonds would be paid by the governments. First, interest on the outstanding bonds (flow) is paid out of the fund. Second, any loss on the bonds (stock) is also paid out of the fund. This is a sinking fund for the amortization of losses. Each participating country would pay into the fund, as and when needed, according to a relative key: $k_j = g_j$. We propose to apply a GDP-based key, which measures a country's relative share

[4] A possible European Deposit Insurance Fund (EDIF), funded by premia levied on the large cross-border European banks, would run into the same problem. Deposit insurance schemes have at times run out of funds (as did the FSLIC in the United States) and, more generally, lack credibility without the ultimate backup of pledged government support. It only takes the issue of burden sharing back one step. In order to establish a credible EDIF, it would be necessary to decide how the burden of meeting shortfalls from the calls upon its funds could be met.

[5] The EU member states are the shareholders, and thus the owners, of the European Investment Bank.

in total GDP. GDP reflects the size of a country's economy and is an indirect indicator of a country's financial system (see the appendix).

3.2.1 Numerical Example

The working of a general fund for burden sharing can be illustrated with a numerical example for a possible recapitalization of a representative European bank i. We make the following assumptions:

(i) $L_i = 1.5 \cdot E_i$. There is a large loss (L_i). Equity is wiped out and there is negative equity of half of the regulatory minimum capital (E_i). Adequate recapitalization requires the restoration of the minimum capital requirement.
(ii) $W_i = 0.75 \cdot E_i$. In a worst-case scenario, the write-down (W_i) is the full negative equity with a margin of one-fourth of minimum capital. The write-down is over a period of four years (given a loss of this extent, it will take at least three to four years to restore the bank to health and to sell it back to the private sector).
(iii) $i = 5$ percent. Annual interest is 5 percent.
(iv) $E_i = 12.6$ bn. The regulatory minimum capital requirement of a "representative" European bank is €12.6 bn (average of the top twenty-five banks in table 1).
(v) All EU countries join the general fund.

The EIB needs to issue €18.9 bn of bonds to recover the negative equity of €6.3 bn and to restore minimum capital of €12.6 bn. The annual interest payment on the bonds is €0.9 bn. The sinking fund for write-down is €9.5 bn. The annual write-down is €2.4 bn. These amounts add to a total annual cost for countries of €3.3 bn. Countries that join the burden-sharing scheme pay this amount according to the GDP key (g_j) as specified in table 2 (see the appendix). The annual contribution is, for example, €0.7 bn ($k_j = 20.2$ percent) for Germany and €0.3 bn ($k_j = 8.6$ percent) for Spain.

This numerical example illustrates that the recapitalization of a "typical" large European bank appears to need a general fund of €18.9 bn. The servicing of this general fund results in an annual cost of €3.3 bn. The contribution of individual countries to the annual

cost ranges from €0.7 bn for Germany to €0.003 bn for countries such as Cyprus and Malta.

3.3 Specific Sharing

In the second mechanism, only countries in which the failing bank is present share in the burden. Each involved country pays its "relevant" part of the burden. A key can be designed to reflect the relative presence of the problem bank in the different countries. Sullivan (1994) has examined different indicators to measure the geographic segmentation of international firms. These indicators are assets, income, and employees. Using just a single indicator increases the margin for error, as the indicator could, for example, be more susceptible to external shocks. Sullivan (1994) has developed the Transnationality Index, which is calculated as an unweighted average of (i) foreign assets to total assets, (ii) foreign income to total income, and (iii) foreign employment to total employment.

The selection of an adequate key should be related to the aim of a possible rescue (i.e., the social benefits). We see two main aims. The first aim is mitigating the effects on the real economy. The second is mitigating the impact on the wider financial system (contagion). We do not include a third objective of helping depositors. There is already mandatory deposit insurance in the EU (with a minimum coverage of €20,000 per depositor) to take care of depositors. A good proxy for the real and contagious effects of the failure of bank i is assets: $k_{ij} = a_{ij}/(h_i + e_i)$. Note that since only European countries join the burden sharing, the key needs to be rebased to the European part $(h_i + e_i)$ of the assets of bank i (a_{ij}). On the real side, assets (including loans) reflect the credit capacity of a bank. The availability of credit will be disrupted in case of a failure (Gale 1993). The contraction of credit in the various countries further depends on the leverage of the respective entities in these countries. The higher the leverage, the larger the contraction would be. The asset key could be adjusted for that. However, banks are increasingly run on a consolidated basis.[6] On the contagion side,

[6] While subsidiaries have their own capital structure and thus their own leverage, branches are part of the overall group and do not have their own balance sheet. Deutsche Bank has organized its large cross-border operation in London

assets reflect the size of a bank. The contagious impact is (partly) related to the size of a failing bank. We have calculated how the assets of the top twenty-five European banks are allocated between the home market (h_i), the rest of Europe (e_i), and the rest of the world (w_i) for each bank i. While these three categories add up to 100 percent, we only show the home market and the rest of Europe shares in table 1.

3.3.1 Numerical Example

The working of a specific burden-sharing program can be illustrated with a numerical example for the possible recapitalization of a few large European banks. Three different banks i are taken to demonstrate the specifics of each case: a pan-European bank (Deutsche Bank), a regional bank (Nordea), and a global bank (HSBC). Again, we make the following assumptions:

(i) $L_i = 1.5 \cdot E_i$. There is a large loss (L_i). Equity is wiped out and there is negative equity of half of the regulatory minimum capital (E_i). Adequate recapitalization requires the restoration of the minimum capital requirement.
(ii) $W_i = 0.75 \cdot E_i$. In a worst-case scenario, the write-down (W_i) is the full negative equity with a margin of one-fourth of minimum capital. The write-down is over a period of four years (given a loss of this extent, it will take at least three to four years to restore the bank to health and to sell it back to the private sector).
(iii) $i = 5$ percent. Annual interest is 5 percent.
(iv) All EU countries join the specific burden-sharing program.

The involved countries need to issue €16.5 bn of bonds to rescue Deutsche Bank ($E_i = 11.0$ bn). The burden is shared according to the asset key: $a_{ij}/(h_i + e_i)$. The specific geographic distribution of Deutsche Bank's assets (in table 1) is used to calculate the respective shares of the countries. Deutsche Bank has 18 percent of its assets in Germany and 47 percent of its assets in the rest of Europe.

in a branch. Nordea is currently considering restructuring its organization from a subsidiary structure to a branch structure. In these cases, the parent bank and the foreign branches have a common leverage ratio.

The United Kingdom accounts for over half of assets in the rest of Europe; let's say 25 percent. So Germany needs to issue €4.6 bn of bonds ($k_{ij} = 0.28$), the United Kingdom €6.4 bn ($k_{ij} = 0.38$), and certain other EU countries €5.6 bn ($k_{ij} = 0.34$). The respective annual costs to service (interest and write-down) their bond issue are €0.8 bn for Germany, €1.1 bn for the United Kingdom, and €1.0 bn for the other EU countries.

The involved countries need to issue €11.1 bn of bonds to rescue Nordea ($E_i = 7.4$ bn). Nordea has 30 percent of its assets in Sweden and 70 percent of its assets in the rest of Europe. The rest of Europe is divided into 31 percent in Finland, 28 percent in Denmark, 11 percent in Norway,[7] and less than 1 percent in Poland and the Baltic States. So Sweden needs to issue €3.3 bn of bonds ($k_{ij} = 0.30$), Finland €3.4 bn ($k_{ij} = 0.31$), Denmark €3.1 bn ($k_{ij} = 0.28$), and Norway €1.2 bn ($k_{ij} = 0.11$). The respective annual costs to service its bond issue are €0.6 bn for Sweden, €0.6 bn for Finland, €0.5 bn for Denmark, and €0.2 bn for Norway.

The involved countries need to issue €42.8 bn of bonds to rescue HSBC ($E_i = 28.5$ bn). HSBC has 30 percent of its assets in the United Kingdom and only 14 percent of its assets in the rest of Europe. France accounts for 6 percent of assets in the rest of Europe. So the United Kingdom needs to issue €29.2 bn of bonds ($k_{ij} = 0.68$), France €5.8 bn ($k_{ij} = 0.14$), and certain other EU countries €7.8 bn ($k_{ij} = 0.18$). The respective annual costs to service its bond issue are €5.1 bn for the United Kingdom, €1.0 bn for France, and €1.4 bn for the other EU countries.

Summing up, it appears that in the case of the Scandinavian bank, Nordea, the costs are shared almost equally by the four Scandinavian countries—Denmark, Finland, Norway, and Sweden. This is a clear example of a regional distribution of the burden. The costs of rescuing a pan-European bank, such as Deutsche Bank, are spread over Europe, with large contributions by the home country, Germany (28 percent), and Europe's financial center, London, in the United Kingdom (38 percent). Finally, the burden sharing for the international bank HSBC, headquartered in London, would be difficult.

[7]Norway is not a member state of the European Union. For this example, we assume that Norway, as a member of the European Economic Area, joins the specific burden-sharing scheme.

Less than half of HSBC's business is in Europe (44 percent, of which 30 percent is in the United Kingdom, 6 percent is in France, and 8 percent is in other European countries), while these European countries have to shoulder the full burden in a European-based specific burden-sharing program.

4. Policy Implications

Which mechanism is better? We will assess both mechanisms in detail below. The main issue is the specification of the key for burden sharing. The goal of selecting an appropriate key is to align the benefits and the contribution to the costs as much as possible. If the alignment is perfect, we get into the situation of equation (3): a bank will be recapitalized if the social benefits in Europe exceed the total costs of recapitalization.

4.1 General Fund

The general fund mechanism is an example of generic burden sharing by countries (proportionate to the size of the participating countries). The costs of recapitalization are smoothed over the participating countries, irrespective of the location of the failing bank. In addition, the costs are smoothed over time. From a macroeconomic perspective, these smoothing mechanisms are positive.

However, we see three major problems with such a general fund mechanism. First, this construction will lead to international transfers between countries (a country may have to contribute its share to a recapitalization while the problem bank is not operating in its jurisdiction). Countries are not keen to sign up for schemes with built-in transfers, unless there is strong political commitment for solidarity (e.g., development aid and, less so, European regional funds). This is a reflection of the earlier-mentioned problem that benefits and costs are not aligned. Second, general burden sharing generates adverse selection and moral hazard problems. Countries with weak banking systems profit over countries with strong banking systems. Therefore, countries with strong banks are less inclined to sign up (adverse selection). As the link between payment for a recapitalization and responsibility for ex ante supervision is lessened, supervisory authorities may feel less of an incentive to provide an

adequate level of supervisory effort (moral hazard). Third, burden-sharing arrangements are subject to the free-rider problem. Countries that do not sign up for burden sharing profit from burden sharing, as the stability of the European financial system is a public good.

There are also some technical issues. What happens if the fund is exhausted? The numerical example in section 3.2.1 illustrates that a large bank can be saved at a moderate annual cost for countries. The general fund can thus shoulder the recapitalization of a few large banks. In the case of multiple, contagious bank failures, we are in a different setting, as explained above. The authorities will then need to take more drastic action to restore confidence in the financial system. Moreover, the authorities may also need to take measures, such as reductions in interest rates, to counter the macroeconomic causes of the banking crisis.

4.2 Specific Sharing

An important advantage of specific sharing arrangements is that there are almost no international transfers. Countries that experience the benefits of the recapitalization also pay for the recapitalization. Provided that assets are a good proxy for measuring the benefits (i.e., averting the real and contagious effects of a bank failure), the costs and the benefits are fully aligned. The specific sharing scheme is also incentive compatible: the fiscal authorities as principal will require from the supervisor as agent an optimal level of supervisory effort.

As in the general fund scheme, however, the specific sharing arrangement is subject to a free-rider problem. This would be, in particular, a problem for the United Kingdom. All major banks have a large presence in London. Twenty-six percent of banking assets in the EU are located in the United Kingdom, while the United Kingdom's share in the EU economy is far lower, at 17 percent of GDP (see the appendix). So it might be more difficult for the United Kingdom to join such a specific sharing arrangement. The United Kingdom would have to pay a sizable proportion of such burden sharing, as can be seen in the numerical example of Deutsche Bank in section 3.3.1 But, at the same time, the United Kingdom

might also experience sizable stability benefits from pre-arranged recapitalizations.[8]

An important technical issue is gaming on the key. A country may have an incentive to put pressure on a faltering bank to move assets cross-border or off-balance (securitization) to reduce its share in any such burden sharing. To prevent last-minute asset movements at the onset of banking problems, we would propose to use the last audited (and published) figures on assets. Moreover, securitization does not pose a problem if it is properly done (i.e., the risk has really gone from the balance sheet in line with the Basel II rules on securitization). Finally, there are various ways of measuring assets—for example, measuring whether they are risk-weighted assets or not, and measuring their historic cost or market value. At this early stage in the discussion we would not want to try to be too specific, except to note that, in order to deter gaming, the key should relate to the last pre-crisis set of audited figures, not to post-crisis estimates.

4.3 Overall Assessment

Insofar as assets are a good proxy for the real and contagious effects of a bank failure, the specific sharing mechanism will come close to an efficient solution of the coordination problem. Countries facing systemic disruption are asked to contribute. They will do so if the stability effects in their country exceed their contribution. The general mechanism will work differently: there need to be a majority of countries that have sufficient benefits. For example, regional banks (Scandinavia, Benelux) will never be rescued, because the share of their countries in the vote is too small. Remember that we assume that there is a collective vote of all involved countries: they jointly decide to rescue or to close the bank. Given that most European banks do not have a relatively equal spread over all European countries, the voting in the general scheme will be suboptimal to the voting in the specific scheme.

[8]An issue for discussion is whether assets are a good proxy for the presence of banks in the United Kingdom. The London operations of the major banks are primarily wholesale. This should make no difference for measuring the contagious effects. But the real effects can be overstated, as these effects are more related to retail than to wholesale operations of banks.

It is possible to implement a mix of general and specific sharing. To the extent that EU-wide financial stability is affected, general sharing will be preferable. When only stability in the countries where the bank is located is affected, specific sharing will be the preferred solution. While each banking crisis is different, we detect an overall pattern. It appears that most bank failures affect the countries concerned in particular (e.g., the Scandinavian and Japanese banking crises in the 1990s). In addition, there is often a (minor) impact on worldwide interbank markets affecting worldwide/EU-wide financial stability. We could imagine a division, though admittedly arbitrary, of 10 percent general sharing and 90 percent specific sharing.[9]

Our results with one bank can be easily generalized to multiple banks. However, when one moves to the mode of a full-blown banking crisis, the differences between the mechanisms become less relevant, and macroeconomic factors, such as a deep recession or large terms of trade decline, come into play (see, e.g., Caprio and Klingebiel 1997; Kaminsky and Reinhart 1999; Honohan and Klingebiel 2003). During such crisis periods, the authorities (government and central bank) will need to stand behind the banks and implicitly or explicitly guarantee their deposits to restore confidence in the financial system. This was the experience of the Scandinavian authorities during the 1990s.

There are some concerns surrounding both mechanisms. First, there is a concern with foreign banks in small countries. What if the bank is systemic in the host country, but not in the home country? The bank might then not be rescued. This could be a problem for the new member states in particular. To alleviate this problem, the key could be made a function of the assets of the problem bank in a country and the assets of the problem bank in that country divided by the total assets of that country's banking system. The small countries would then shoulder a larger share of the burden and have, accordingly, a larger share in the vote. However, the mostly West European parent banks of the subsidiary banks in Eastern Europe are often large retail banks that are also systemic in the home country.

[9] We would like to thank Xavier Freixas for suggesting this mix of 10–90 percent.

Second, some would argue that crisis-management arrangements for lender-of-last-resort and solvency support should not be specified in advance to counter moral hazard. We agree that constructive ambiguity regarding the decision to recapitalize or not can be useful to contain moral hazard (Freixas 1999). But the model of Freixas (2003), replicated in this paper, demonstrates that additional ambiguity over burden sharing would lead to fewer recapitalizations than socially optimal. Our goal is to attain the same clarity at the European level that we currently have at the national level. At the national level, the ministry of finance bears the financial risk of support operations, if any, and therefore decides on these operations. Clarity at the European level on how to share the costs among treasuries in the case of the failure of a European bank does not increase moral hazard compared with the national level in the case of the failure of a domestic bank. So we propose full transparency on crisis-management arrangements (the "how" question) but constructive ambiguity on the application of these arrangements (the "whether" question).

Third, it could be difficult to organize burden sharing for truly international banks that have a large part of their business outside Europe (see also proposition 2). While only a part of the benefit will fall within Europe, the European countries have to pay the full cost. Examples are the Swiss banks (UBS and SBC) and HSBC (see the numerical example in section 3.3.1). Moreover, such mechanisms fail to address crisis problems caused by the failures of banks headquartered outside Europe—e.g., in the Americas, Asia, or Australia. That said, the specific approach to burden sharing could be undertaken for any international group, not just within the EU. Indeed, the wider the set of countries involved, the better. There would be nothing, in principle, to stop such cross-border burden-sharing arrangements from being extended beyond the EU to encompass the United States, Australia, Japan, and other willing countries.

Fourth, it should be recognized, however, that a legal basis is needed to create binding ex ante burden-sharing arrangements. We believe that memoranda of understanding (MoUs), which are often used between national supervisors (and central banks), will not be sufficient because MoUs (soft law) are not enforceable. A legal basis (hard law) can be readily provided within the EU. The legal instruments and the institutional framework to negotiate and enforce such

instruments are available. Legally binding arrangements beyond the EU (i.e., a full international treaty) may be much more difficult to get agreed upon, signed, and enforced. Clear and hard-edged ex ante rules are also helpful during a crisis, when speed of decision making is crucial. By contrast, ex post principles on burden sharing leave themselves open to interpretation, delaying the decision-making process.

Finally, the guiding principle for decision making on crisis management is "he who pays the piper calls the tune" (Goodhart and Schoenmaker 1995). So long as recapitalizations are organized on a national basis, the national governments will normally want to oversee and undertake the function of supervision. That is the current setup for financial supervision and crisis management, which are nationally organized. As there is no fiscal backup to the ECB, the ECB is happy to let the national central banks take the lead on lender-of-last-resort operations. The decision-making arrangements to support an ex ante burden-sharing scheme would be complex, but manageable, and modeled on the kind of tripartite (supervisor, central bank, finance minister) system already in place in the United Kingdom. The Committee of European Banking Supervisors (CEBS) would provide information on the scale of the problem. The General Council of the ECB (i.e., including the EU countries outside the euro zone) would decide whether the crisis was systemic. The Ministers of Finance in Ecofin would decide on the use of taxpayers' funds.[10] In the specific sharing mechanism, only the countries in which the failing cross-border bank had a significant presence would attend and vote.

5. Conclusions

The management of a banking crisis is always difficult. Decisions to close or to recapitalize an ailing bank have to be made under time pressure. Theory suggests that recapitalization of a failing bank is only efficient if the expected benefits (prevention of a systemic crisis) exceed the costs of a recapitalization. Crisis management is even more difficult in a cross-border setting, in which various countries have to coordinate. Applying the model of Freixas (2003), we show

[10]The European Commission needs to be consulted to ensure that the rules on state aid are not violated.

that ex post negotiations on burden sharing lead to an underprovision of recapitalizations. Countries have an incentive to understate their share of the problem in order to have a smaller share in the costs. The model suggests that the home country would be left with the decision, including the funding, on the recapitalization of a failing bank.

We doubt whether the home-country supervisors, politicians, and taxpayers would, in the event of a failure of a large cross-European bank, be prepared to meet the costs of recapitalizing such a bank in its entirety. While depositors would be partly protected by national deposit insurance, the bank itself, perhaps outside its own country, would then probably be forced to close. Such abrupt closure could cause widespread concern and systemic effects.

If pan-European burden sharing to allow for cross-border recapitalization is to be made possible, it would have to be on the basis of agreed ex ante rules. This paper explores two sets of ex ante burden-sharing mechanisms. The first is a general mechanism, based on full solidarity between EU member states. The underlying assumption is that financial stability is a truly public good. While general burden sharing has some attractive smoothing properties, it runs into problems of causing cross-border fiscal transfers and adverse selection (countries with weak banking systems are keen to join the burden-sharing scheme). The second is a specific burden-sharing mechanism. The assumption is that financial stability is only affected in the countries in which the bank is located. These countries contribute according to the geographical spread of that bank's business. Specific burden sharing has somewhat fewer problems. Because a country's benefits (in the form of preserving systemic stability) and that country's contribution to the costs are better aligned in the specific burden-sharing scheme, this scheme is better able to overcome the coordination failure in the Freixas model.

With the ongoing integration of European financial markets, symbolized by the emergence of pan-European banks, there may be a need for European arrangements for financial stability.

Appendix. Country Keys

Table 2 contains several keys that can be used to share the costs in case of a general burden-sharing mechanism for a banking crisis. The

GDP key is a country's share in total GDP. GDP reflects the wealth of a country and is an indirect indicator of the size of a country's financial system. The assets key is total assets of credit institutions (banks) in a country divided by total assets of EU-25 credit institutions. The banking assets key is a direct indicator of the size of a country's banking system.

Table 2. Country Keys (in %; 2006 Figures)

Country	GDP	Assets
Austria	2.3	2.1
Belgium	2.8	3.0
Cyprus	0.1	0.2
Czech Republic	1.0	0.3
Denmark	1.9	2.2
Estonia	0.1	0.0
Finland	1.5	0.7
France	15.7	15.6
Germany	20.2	19.3
Greece	1.7	0.9
Hungary	0.8	0.3
Ireland	1.5	3.2
Italy	12.9	7.6
Latvia	0.1	0.1
Lithuania	0.2	0.0
Luxembourg	0.3	2.3
Malta	0.0	0.1
Netherlands	4.6	5.1
Poland	2.4	0.5
Portugal	1.4	1.1
Slovakia	0.3	0.1
Slovenia	0.2	0.1
Spain	8.6	6.8
Sweden	2.7	2.1
United Kingdom	16.7	26.2
Total EU-25	100	100

Source: Authors' calculations based on "EU Banking Structures," ECB (2007).

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