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The vulnerability of banks to government default risk in the EMU

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Abstract

This paper examines the vulnerability of banks in EMU countries to shocks to default risk premiums on public debt. This vulnerability depends on (1) the total amount of public debt in bank portfolios, (2) the extent to which the default risk of public debt of EMU member states is diversifiable, and (3) the degree of actual geographical diversification of public debt holdings by banks. We simulate the effect of country-specific default shocks on the market value of public debt held by banks. The simulations are based on data of public debt positions at the aggregate banking sector level and take into account the historical covariance structure of default risk premiums in the EMU. We compare two scenarios. First, we calculate the effect on the standard deviation of the equity-to-assets ratio if banks continue to hold mainly domestic public debt. Next, we calculate this effect if banks diversify their investments in public debt across EMU governments. We find that the standard deviation of the equity-to-assets ratio declines considerably if banks diversify their public debt holdings and conclude that the risks of bank failures caused by default on public debt can be reduced through proper geographical diversification. We close with some implications for prudential regulation.

JEL Classification: H6, G18, G28.

Keywords: government bond markets, banking regulation, EMU.

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1. Introduction

In many EMU member states, public debt is still one of the favourite investment opportunities of banks, witness the large proportions of bank assets held in the form of domestic public debt. Our concern in this paper is with the change in the riskiness of these investments following the move towards EMU. As argued by Goodhart (1997) and McKinnon (1997), EMU will alter the risk profile of public debt. Governments joining EMU lose their monetary sovereignty, that is, the right to print money to pay off domestic currency debt. Goodhart (1997) describes this fundamental shift in the nature of public debt as follows: "once national authorities give up their command over money creation, they lose the unchallenged absolute ability to pay off their domestic currency debt, interest and principal, in legal tender, whatever may happen to demand in the bond market."

In the face of this changing risk profile, the current credit exposures of banks to their own government could potentially endanger the stability of the financial system, increasing the bailout pressure on the European Central Bank (ECB) in the event of a fiscal crisis. Indeed, in the literature, the potential consequences of a fiscal crisis for financial sector stability have been regarded as the main justification for the Stability Pact (1996), see Grilli, Masciandaro and Tabellini (1991), Buiter, Corsetti and Roubini (1993) and Eichengreen and Wyplosz (1998).

The Stability Pact is aimed at lowering the likelihood of a fiscal crisis.1 It tries to discipline governments by a combination of deficit rules and penalties for breach of those rules. The no-bailout clause in the Maastricht Treaty serves a similar purpose, by reducing the bailout expectations of profligate governments. In addition to these legalistic measures, we may expect financial markets to price the risk of government default, so that spendthrift governments will be confronted with higher borrowing costs. Together, the Stability Pact, the no-bailout clause and the role of financial markets should provide the necessary incentives for budgetary reforms at an early stage, thus preventing a fiscal crisis.

Still, it remains to be seen how successful these disciplinary devices will be in reducing the likelihood of a fiscal crisis. Some sceptics regard the Stability Pact as a paper tiger and have little faith in the

ability of financial market participants to correctly price default risk (Lemmen, 1998). Though we take an agnostic view on this debate, we are unwilling to wholly exclude the possibility that someday a government in an EMU member state will fall back to the spendthrift habits of the past. It then makes sense to try to limit the consequences of a fiscal crisis if such a crisis were to occur. Applied to the financial sector, where the consequences of a fiscal crisis are likely to be gravest, such an approach would be aimed not at reducing the likelihood of a fiscal crisis, but at reducing the likelihood of bank failures following a fiscal crisis. This paper addresses two questions regarding such damage limitation. First, what is the potential for damage limitation? Second, how can this potential be fully realized?

The first question is analyzed by measuring the benefits from a better diversification of banks' public debt holdings across European governments. These benefits depend on three factors. The first factor is the appetite for public debt by banks. Recent data show this appetite still to be strong in many EMU countries. Second, it matters whether government default risk is diversifiable across EMU countries. Will default risk be mainly country-specific or will there be a strong common EMU component to it? The third factor relates to the degree of actual geographical diversification of public debt holdings by banks. Since such geographical diversification is currently still lacking, we resort to a simulation approach.[2]

We simulate the effect of country-specific default shocks on the market value of public debt held by banks. The simulations are based on data of public debt positions at the aggregate banking sector level and take into account the historical covariance structure of default risk premiums in the EMU. We compare the following two scenarios. First, we calculate the effect on the standard deviation of the equity-to-assets ratio if banks continue to hold domestic public debt only. Next, we calculate this effect if banks are properly diversified across EMU governments. We find that the risks of bank failures following a fiscal crisis in the EMU can be reduced through proper geographical diversification of public debt holdings.

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[1] For a discussion about the Stability Pact, see Amtenbrink, de Haan and Sleijpen (1997).

[2] Unfortunately, data to substantiate the claim for the home bias in banks' public debt portfolio are unavailable. Nevertheless, this seems a realistic assumption, see Gros and Thygesen (1998, p. 332).

The second question relates to prudential regulation. At present, most public debt is exempted from rules forcing banks to diversify their private loan portfolios. The large exposure directive states that banks cannot lend more than 25 per cent of their capital to a single borrower, but excludes most governments. Banks also do not need to hold any capital against their portfolio of government securities despite the fact that public debt issued by EMU member states carries credit risk as from January 1, 1999. Is there need for a change in these prudential regulations?

This paper is organized as follows. In section 2 we present data on the amount of public debt held by banks in the EMU area. Section 3 discusses the degree of correlation between default risk in EMU countries. Both sections contain the building blocks for the simulation of the impact of shocks to default risk premiums on the standard deviation of banks' equity-to-assets ratio. The simulation methodology and the results of the simulation are presented in section 4. Section 5 discusses the implications of our results for prudential regulation and supervision. Section 6 concludes.

2. Public debt holdings by European banks

Revealed preference shows that banks prefer to hold a large percentage of their assets in the form of domestic public debt. Adherents to the narrow banking school of thought have even advocated that bank deposits should be 100% backed by government securities, as a way to reduce the fragility of the banking system. Apart from other objections to narrow banking, see Freixas and Rochet (1997, pp. 262-263), the main advantage of narrow banking is lost in the EMU. Now that the functions of issuing government debt and printing money have been separated, government debt in domestic currency is no longer automatically free of default risk.

The cross-country variation in banks' appetite for public debt is high in Europe. Table 1 illustrates the current exposure of the banking sector to central government debt in relation to their total domestic assets. Especially the Belgian, Greek, Spanish and Italian banking sectors have large exposures to public debt. The UK banking sector is far less exposed to public debt than the banking sector in continental Europe, probably due to historical differences in banking tradition. Universal banks in

continental Europe engage in a full range of securities activities, usually through the bank entity itself rather than through separately incorporated subsidiaries. Table 1 also shows that in recent years the proportion of assets invested in public debt has decreased in many EMU countries, though at a slow pace.

Table 1: Banks domestic claims on the government as percentage of total domestic assets

	1992	*1995*	*1996*	*1997*
Belgium	26.12	26.18	24.50	22.85
Greece	24.34	25.54	22.10	n.a.
Spain	14.61	17.75	18.28	15.91
Italy	12.98	16.91	17.38	15.83
Germany	12.42	14.61	13.85	13.27
The Netherlands	11.40	10.96	10.17	8.88
Portugal	19.73	15.10	12.72	8.39
France	2.74	5.50	6.76	6.78
Denmark	12.25	11.40	8.62	6.45
Sweden	6.59	14.52	6.64	4.86
Finland	3.21	10.48	n.a.	n.a.
Ireland	n.a.	7.89	6.39	2.77
United Kingdom	1.47	2.12	1.81	1.28
Luxemburg	n.a.	0.21	0.20	n.a.

n.a.= non available.

Source: ECB (1999, Table 2.13a).

Aggregate banking sector data may disguise differences between public debt exposures of individual banks within a single country. We will discuss the most important features of the distribution of public debt holdings across individual banks in nine EMU countries on the basis of table 2, which contains summary statistics for a sample of 160 banks taken from the BankScope database.[3] The first column shows for each country the number of banks included in the sample. The selection criterion is size, measured by balance sheet total. All bank types have been included in the sample, apart from bank holdings. Table 2 also contains unweighted means and standard deviations of both the public debt-to-assets ratio and the public debt-to-equity ratio. These ratios have been calculated from the "raw" balance sheet data in BankScope. Unfortunately, the raw balance sheet data lack a uniform classification of bank assets and liabilities for every country. For Finland, the raw data do not allow for a separation between loans to the public sector and loans to the private sector. For Italy and France, we are only able to identify the proportion of banks assets invested in Treasury bills. In table

[3] We owe many thanks to Jane Carrett and Bosco Dias from Fitch-IBCA (London) for providing access to this database.

2, we also list important deviations from the "normal" pattern for each country, where applicable. We will proceed discussing the results country-by-country. Please note that the data in tables 1 and 2 are not directly comparable, as the ratios in table 2 are based on *unweighted* averages and a sample of the biggest banks. Note also the extremely high average public debt-to-equity ratios in table 2. Part of the explanation of these high values is the absence of a capital charge for bank loans to OECD governments. However, the current BIS capital regulations cannot explain the large cross-sectional variations in public debt to equity ratios as these regulations are the same for every EMU country.[4]

Table 2: Bank exposure to the public sector: micro-data

1997	*# banks*	*Public debt/assets*		*Public debt/equity*	
Unweighted		*Mean*	*Standard deviation*	*Mean*	*Standard deviation*
Germany	28	26.0%	12.2%	1306.0%	1170.2%
Landesbanken	10	22.6%	3.8%	1076.2%	498.1%
Real estate banks	4	49.4%	9.6%	2846.8%	1238.7%
All other banks	14	21.8%	8.9%	367.8%	1210.5%
The Netherlands	13	17.3%	27.9%	476.7%	793.1%
BNG and NWB	2	79.1%	12.0%	2218.0%	100.3%
All other banks	11	6.1%	3.7%	160.2%	192.7%
Ireland	15	7.2%	7.8%	210.4%	430.8%
DePfa-Bank Europe plc	1	28.8%		1738.9%	
All other banks	14	5.6%	5.2%	101.2%	85.6%
Spain	18	24.5%	17.4%	485.3%	583.9%
Banco de Credito Local	1	86.4%		2742.3%	
All other banks	17	20.9%	8.3%	352.6%	158.4%
Austria	14	8.2%	4.5%	195.7%	113.7%
Italy*	17	11.2%	4.9%	252.4%	207.7%
France*	16	8.0%	3.7%	377.3%	361.2%
Portugal	18	9.9%	4.5%	340.6%	578.4%
Belgium	21	24.0%	14.4%	1091.1%	1183.1%

*Treasury bills only.

Source: BankScope.

The micro-data in table 2 show that on average, German banks hold 26% of their assets in the form of public securities and loans to the public sector. Beneath the surface, though, there are important

[4] These cross-country differences can be better explained by differences in state involvement in the banking system and by differences in financial structure, see Arnold (1999).

differences between banks. The real estate banks in our sample hold more than double the proportion of public debt than the other banks. Also noteworthy are the so-called "Landesbanken". Though these publicly owned credit institutions have a public debt-to-assets ratio similar to that of other banks, their undercapitalisation yields a public debt-to-equity ratio almost triple that of the other banks. In the Netherlands, the public debt-to-assets and public debt-to-equity ratios are in general quite low, with the exception of two specialised public banks, the BNG and the NWB, catering to respectively municipalities and water-boards. The overall picture in Ireland very much resembles that in the Netherlands, with the exception of the high public debt ratios for DePfa-Bank Europe plc. In Spain, the overall level of public debt ratios is again much higher, close to German levels. The main outlier in Spain is Banco de Credito Local de Espana.

In the remaining five European countries listed, we didn’t observe any outliers nor any consistent differences in public debt ratios between bank types. The Austrian public debt ratios are on average much lower than those in Spain and Germany. In Austria, the publicly owned Oesterreichische Postsparkasse and Oberbank AG top the list with public debt-to-assets ratios of respectively 17% and 15%. Next, we turn to Italy and France. Though the data problem discussed above limits the comparability, the data on Treasury bill holdings do not seem to point to a wide dispersion of public debt ratios within these countries. For Portuguese banks, the ratios and their dispersion across banks are relatively low. In contrast, the Belgian data show high public debt-to-assets ratios and very high public debt-to-equity ratios. This is not caused by the presence of one or two outliers, but it is a general characteristic of the Belgian banking sector. Noteworthy is the Argenta Savings bank, which has a public debt-to-assets ratio equal to 60%.

3. The diversifiability of government default risk in the EMU

In the late 1970s, many Western banks thought their sovereign lending to Latin-American countries to be well diversified, see e.g. Cline (1984). To their surprise, these countries proved to be similarly affected by the reversal in the international economic conditions in the 1980s and equally vulnerable to the combination of high interest rates, low commodity prices and a switch in investor sentiment.

We may learn several lessons from this historical episode. The first two, rather trivial, lessons are that sovereign risk may change unexpectedly and that banks at times have difficulty coping with sovereign risk. The more interesting lesson though, is that the degree of diversification of a bank is determined not only by the number of debtors to which the bank lends, but also by the correlation pattern of these debtors' default risk. Applied to EMU, we may conclude that any estimate of default risk of public debt in the EMU area should take into account the covariance structure between default risk of EMU governments.

Because of data limitations to be discussed below and the fact that historical default risk patterns may not accurately reflect future default risk, it makes sense to discuss in a more qualitative way the economic factors which might lead to default risk in EMU countries and whether they will give rise to idiosyncratic or systemic components in default risk. Consider table 3 as a framework for the discussion. The first distinction made in table 3 is between idiosyncratic and systemic factors leading to a fiscal crisis. Idiosyncratic factors lead to fiscal shocks in just one EMU country, independent from what happens in other EMU countries. As an example of this type of shock, one can think of a domestic political crisis, resulting in a weak government, unable to raise taxes or cut government expenditures. In contrast, systemic factors affect public finances at the same time and in the same way in all EMU countries. An example of this could be the effect of aging on pension and health care expenditures. In reality, the distinction between idiosyncratic and systemic shocks may not be as black-and-white as stated here. For example, EMU governments may differ in the sensitivity of their finances for the effect of aging, depending on the amount of pension reserves. For the purpose of clarity, we will hang on to our black-and-white distinction for the moment. The third and fourth column in table 3 list the possible reactions of the EU and the ECB to a fiscal crisis.[5] A bailout by the EU has the effect of transforming idiosyncratic risk into EU-wide systemic default risk, whereas a bailout by the ECB has the effect of transforming default risk into inflation risk. The final column lists

[5] The no-bailout clause of the Maastricht Treaty formally forbids the ECB or EU from bailing out troubled governments. Article 104b of the Maastricht Treaty (1992) states: "The Community shall not be liable for or assume the commitments of central governments, regional, local or other public authorities, other bodies governed by public law, or public undertaking of any Member State, without prejudice to mutual financial guarantees for the joint execution of a specific project. A member state shall not be liable for or assume the commitments of central governments, regional, local or other public authorities, other bodies governed by public law or public undertakings of another Member State, without prejudice to mutual financial guarantees for the joint execution of a specific project." It remains to be seen whether these principles will be upheld in practice.

the implications for the presence of default risk and the extent to which it is diversifiable. Clearly, idiosyncratic fiscal shocks lead to diversifiable default risk only when both the EU and the ECB refrain from bailing out the government in question (case 1). In all other cases involving idiosyncratic risk factors (cases 2-4), either EU intervention or ECB intervention transforms diversifiable default risk into respectively systemic default risk or inflation risk. Systematic risk factors (cases 5-6) by definition do not give rise to diversifiable default risk.

Table 3: The diversifiability of default risk

Case	*Factors causing fiscal crisis*	*EU bailout*	*ECB bailout*	*Default risk*
1	Idiosyncratic	No	No	Diversifiable
2			Yes	None
3		Yes	No	Systemic
4			Yes	None
5	Systemic	n.a.	No	Systemic
6			Yes	None

Table 3 does not include any assessment about the feasibility of either an ECB or EU bailout, and how a bailout would be implemented. The market's expectation of a bailout following a fiscal shock is undoubtedly reflected in the size of the government default risk premium and the correlation pattern between government default risk premiums. But the likelihood of bailout can also be influenced by policy measures in the area of prudential supervision, as these will determine the potential spread of a local fiscal crisis, first to the local financial system and then to the financial system of the EU as a whole. This has the following important implication. The less banks diversify their holdings of public debt, the higher the probability that a fiscal crisis threatens the stability of the financial system, which in turn increases the likelihood of a bailout by either the EU or the ECB. We thus arrive at a positive relationship between diversification and diversifiability: the more banks actually diversify public debt holdings, the better the diversifiability of government default risk. As increased diversification reduces the need for EU or ECB intervention, it may prevent the transformation of diversifiable risk into systemic risk or inflation risk.

The credibility of bailout refusals by the EU also influences the likelihood of contagion and safe-haven effects. With a credible no-bailout clause, contagion effects between regions in a currency union give

rise to positive correlations between regional default risk premiums, as a fiscal crisis in one region may raise doubts about the fiscal situation in other regions. On the other hand, the safe-haven effect may lead to negative correlations, when investors substitute debt from fiscally prudent regions for debt from less prudent regions. Both effects may weaken when the credibility of the no-bailout clause is in doubt, and markets expect countries to be bailed out because of their importance for or interconnectedness with the EU economy.[6]

Considering both risk and return, an increased bailout-likelihood will reduce the size of the government default risk premium and at the same time increase the correlation coefficients between government default risk shocks. Notably, the resulting increased volatility of the overall government bond portfolio due to a fall in the gains from diversification will go together with a *reduction* in the portfolio's expected return.

We now turn to empirical measures of government default risk in the EMU. Much current work uses the spread between the 10-year benchmark government bond yield and the swap yield of the same maturity and denominated in the same currency (i-i^{swap}) to assess government default risk, see Giovannini and Piga (1994), Favero, Giavazzi and Spaventa (1996), IMF (1996), McCauley (1996) and Lemmen and Goodhart (1999). For want of better data, we will employ the same measure in the remainder of this paper. First, however, we will discuss some limitations of these data
The use of i-i^{swap} as our default risk measure suffers from the following handicap. It can be questioned whether i-i^{swap} really measures only default risk or a combination of several effects, including liquidity and withholding tax effects. Two other handicaps - though not necessarily typical of our measure of government default risk – plague our data. First, the correlation patterns between national default risk measures may change dramatically during a financial crisis or a recession. Second, at the moment, the default risk premiums on government debt are extremely low, reflecting the progress in recent years in reforming public finances in the run-up to EMU.

Tables 4 and 5 contain the variance-covariance and correlation matrices for $D(i$-$i^{swap})$, that is changes

[6] A country belonging to the "core" group of EMU countries may be more likely to receive a bailout than a "peripheral" country. Similarly, a country that coordinates its policies with the core group may be more likely to receive a bailout. Typically, core EMU countries are the “larger" EMU member states such as Germany and France with a large share in EMU

in government default risk, for both a 10-year and a 5-year maturity. The 10-year data include all EMU countries except Luxemburg; the 5-year data also exclude Ireland and Portugal due to data limitations. Both the 10- and 5-year data are at a monthly frequency. The data window for the 10- and 5-year data is based on the longest historical period for which swap data are available. On average, the correlation coefficients of $D(i\text{-}i^{swap})$ are low for both data sets: 0.33 for 10-year bonds and 0.23 for 5-year bonds, indicating that there might be some scope for diversification benefits. Our two default risk measures yield similar correlation patterns across EMU countries: the correlation coefficient between the bilateral correlation coefficients for both data sets is 0.75. However, in the 10-year bonds data set, the group of countries which in the pre-EMU era would have been regarded core-ERM countries, have much higher correlation coefficients than the other countries. This effect is much smaller for the 5-year bonds data set.

GDP.

Table 4: *D(i-i^swap)*, 10-year bonds, August 1996-November 1998

	AU	BE	FI	FR	GE	IR	IT	NL	PO	SP
	Variance-covariance matrix									
Austria	0.0066									
Belgium	0.0055	0.0059								
Finland	0.0007	0.0008	0.0071							
France	0.0035	0.0038	-0.0001	0.0044						
Germany	0.0062	0.0053	0.0005	0.0044	0.0074					
Ireland	0.0016	0.0009	0.0009	0.0005	0.0021	0.0056				
Italy	0.0013	-0.0002	-0.0005	0.0030	0.0031	-0.0014	0.0223			
Netherlands	0.0047	0.0049	0.0009	0.0033	0.0053	0.0014	-0.0006	0.0056		
Portugal	0.0013	0.0026	0.0014	0.0021	0.0017	0.0001	0.0001	0.0023	0.0048	
Spain	0.0027	0.0020	-0.0005	0.0033	0.0038	-0.0002	0.0087	0.0015	0.0001	0.0062
	Correlation coefficients									
Austria	1.0000									
Belgium	0.8821	1.0000								
Finland	0.0967	0.1212	1.0000							
France	0.6549	0.7425	-0.0260	1.0000						
Germany	0.8835	0.7965	0.0699	0.7766	1.0000					
Ireland	0.2673	0.1492	0.1358	0.1060	0.3192	1.0000				
Italy	0.1034	-0.0216	-0.0426	0.3073	0.2373	-0.1236	1.0000			
Netherlands	0.7714	0.8557	0.1353	0.6640	0.8170	0.2513	-0.0579	1.0000		
Portugal	0.2323	0.4811	0.2346	0.4502	0.2846	0.0126	0.0101	0.4364	1.0000	
Spain	0.4206	0.3309	-0.0739	0.6366	0.5632	-0.0275	0.7419	0.2584	0.0203	1.0000

Table 5: *D(i-i^swap)*, 5-year bonds, January 1995-February 1999

	AU	BE	FI	FR	GE	IT	NL	SP
	Variance-covariance matrix							
Austria	0.0099							
Belgium	0.0056	0.0098						
Finland	-0.0011	0.0000	0.0210					
France	0.0019	0.0025	-0.0005	0.0045				
Germany	0.0031	0.0039	0.0009	0.0026	0.0122			
Italy	0.0032	0.0026	0.0005	0.0029	0.0082	0.0257		
Netherlands	0.0011	0.0027	0.0000	0.0017	0.0044	0.0032	0.0062	
Spain	0.0019	0.0031	-0.0012	0.0034	0.0040	0.0076	0.0013	0.0155
	Correlation coefficients							
Austria	1.0000							
Belgium	0.5717	1.0000						
Finland	-0.0752	0.0017	1.0000					
France	0.2911	0.3793	-0.0490	1.0000				
Germany	0.2825	0.3586	0.0575	0.3544	1.0000			
Italy	0.2016	0.1612	0.0213	0.2671	0.4644	1.0000		
Netherlands	0.1338	0.3442	-0.0038	0.3292	0.5096	0.2543	1.0000	
Spain	0.1522	0.2512	-0.0646	0.4036	0.2896	0.3830	0.1303	1.0000

For the purpose of comparison, table 6 below summarizes cross-regional correlation coefficients in five currency unions: Australia, Canada, Germany, the United States and the EMU. In all five cases, the correlation coefficients of changes in government default risk premiums are on average much lower than one, leaving room for diversification benefits. The low average level of cross-regional correlation in the EMU corresponds most closely to that of the United States. In the absence of a "supraregional" European government issuing higher-quality debt than the national European governments, any flight to quality will probably involve an intra-EMU redistribution of debt holdings.[7] Also, an EMU-wide recession will affect some countries more than other countries. This safe-haven effect will give banks in the EMU more room to diversify their government default risk exposure than banks in other federal states such as Australia, Canada and Germany. A large public debt exposure to the group of EMU countries as a whole therefore does not necessarily have to pose a problem for systemic risk reasons.

Table 6: Summary statistics of cross-regional correlations in default risk

Area	*Bonds*	*Period*	*Average correlation*	*Standard deviation between correlations*
Australian States	10-year bonds	10/89-6/97	0.679	0.088
Canadian Provinces	10-year bonds	6/92-11/98	0.670	0.165
Canadian Provinces	5-year bonds	6/92-11/98	0.629	0.192
German Länder	10-year bonds	1/94-1/98	0.485	0.239
US States	20-year bonds	1/73-1/98	0.302	0.405
10 EMU countries	10-year bonds	8/96-11/98	0.331	0.311
8 EMU countries	5-year bonds	1/95-2/99	0.229	0.179

Note: see tables 4-5 and A1-A5 for details.

4. Model and implementation

The expanding role of financial markets has led to fundamental changes in the supervisory approach to calculating capital adequacy requirements. The most significant step in this direction has been allowing the use of banks' value-at-risk models for calculating regulatory capital to cover market risk. This paper will apply a research method akin to credit-at-risk models to examine the banks' exposure to government default risk, see BIS (1999) for an overview of current practices and

[7] Naturally, a flight to quality could also involve the purchase of non-EMU debt, such as US government bonds. This would,

applications of credit risk modeling.

We use the concept of duration to measure the sensitivity of the market value of banks' public debt portfolio to changes in government default risk premiums (government default risk shocks). The sensitivity of the market value of banks' public debt to changes in government default risk premiums can be measured by rewriting the formula for the MacAuley duration.[8] Let P be the current price of a coupon bond, y the yield to maturity, C the coupon payment, M the maturity value payment (that is, the principal repayable at maturity) and T the number of years to maturity. The approximate change in P with respect to a change in y is:

$$\frac{dP}{dy} = -\frac{1}{1+y} \times D \times P$$

where

$$D = \frac{1}{P}\left(\sum_{t=1}^{T} \frac{tC}{(1+y)^t} + \frac{TM}{(1+y)^T}\right).$$

D is called the MacAuley duration. The higher a bond's MacAuley duration, the higher the sensitivity of the price of a bond to changes in its yield. We rework the above formula to estimate the sensitivity of the bank's position in public debt to a change in default risk premiums:

$$P_1 = P_0 - D^* \, dy \, P_0$$

where

$$D^* = D / (1+y).$$

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however, force investors to take on currency risk.

[8] Note that as the price-yield relationship is not linear, the accuracy of the estimated change in the market value of public debt due to a government default shock (a change in yield) will vary with the size of the shock. It is possible to improve upon the accuracy of the estimated change by adjusting the estimated change for the convexity of the price - yield relationship (d^2P / dy^2).

D^* is called the modified duration.[9] Given estimates of P_0 and D^*, we simulate the effect of a government default shock, resulting in a yield change *dy*, on the new market value of public debt held by a country's banking sector (P_1). In other words, the expected loss due to a government default shock is equal to the difference between the current and the new market value of public debt at the end of some time horizon over which the banks monitor default risk.[10]

We use aggregate banking sector data gathered by the ECB instead of individual banking data from BankScope to reduce the sensitivity of our results to the recent bank merger activity within EMU countries, that produces large shifts in bank size and portfolio composition. EMU banks' exposure to government default risk crucially depends on the duration of the public debt holding by banks. Unfortunately, data on the exact duration of public debt holdings by banks are not available. We therefore use two proxies: the effective maturity obtained from Missale (1998) and a uniform modified duration of 3.5. The use of the former measure assumes that the duration of bank holdings of public debt is similar to the duration of other non-bank public debt. The latter duration is pinned down to a value 0.5 percent point lower than the average maturity, since maturity overstates duration in the presence of coupon payments.

Table 7 summarizes all inputs for the simulation exercise, with the exception of the variance-covariance matrices of the changes in default risk premiums, which are in tables 4 and 5. We next calculate the effect of a fall in the value of government bonds on banks' equity-to-assets ratio using two scenarios. First, we calculate the effect on the equity-to-assets ratio if the banking sector is not geographically diversified and all their public debt holdings are domestic. Second, we calculate the same effect if the banking sector is diversified, that is, if banks' portfolio holdings of EMU public debt are spread out in proportion to a country's GDP weight. All calculations are done for both the 10-year and 5-year bond variance-covariance matrices. We also assume that changes in default risk

[9] The modified duration is the weighted average term-to-maturity of the bonds' cash flows (i.e. interest and principal) and is a measure of price volatility. The higher the modified duration of a bond, the higher the percentage price volatility of a given change in government default risk.

[10] We assume that prices vary in a continuous manner, ignoring the possibility that price movements may be discontinuous in an environment where liquidation risks are present.

premiums follow a multivariate normal distribution.[11] For each simulation, we apply 500 trials. The length of our simulation horizon is 12 months. Thus, we show the impact for a full 12-month period and subtract the loss caused by a fall in the market value of public debt from the banks' equity capital, assuming that all other categories of assets and liabilities remain unchanged.

Table 7: Inputs for the simulation

	D^**(years)*	*Public debt/equity (%)*	*Equity/assets (%)*	*GDP-shares (%)*
Austria	4.8	23.80	4.69	3.4
Belgium	3.8	26.18	2.56	3.9
Finland	1.9	10.48	4.81	1.8
France	5.6	5.50	4.44	23.2
Germany	5.0	14.16	4.21	34.0
Ireland	3.7	7.89	6.93	0.9
Italy	1.8	16.91	9.19	17.5
The Netherlands	6.7	10.96	4.18	5.7
Portugal	3.5	15.10	4.69	1.5
Spain	3.0	17.75	8.59	8.0

Note: Equity-to-assets is defined according to OECD definitions and not according to the Basle Tier I and II definitions of capital. GDP shares are the shares in total GDP of the EMU aggregate used.

Sources: D^*: Missale (1998); *Public debt/equity*: ECB (1999), except Austria (IFS); *Equity/Assets*: OECD; *GDP-shares*: IFS.

Table 8 summarises the results of the impact of government default shocks derived from Monte Carlo simulations.[12] It gives the standard deviations of the equity-to-assets ratio in the two scenarios: 1) without diversification of public debt across EMU governments and 2) with diversification of public debt across EMU governments. That is, default risks are measured on a portfolio basis allowing idiosyncratic shocks to be diversified away. Also included in table 8 is the percentage change in the standard deviation when we move towards diversification. We will focus on this percentage in the remainder of the discussion, as it is a handy summary statistic of the effects of diversification.

The percentage change in the standard deviation of the equity-to-assets ratio following diversification is the resultant of three effects: 1) the diversification benefits resulting from the non-unitary correlation coefficients between government default shocks in tables 4 and 5; 2) the change in the average

[11] It is a generally accepted that high-frequency movements in prices of many financial instruments are not normally distributed, in particular, that the probability of extreme movements is considerably higher than would be predicted by an application of the normal distribution (Danielsson and De Vries, 1997). However, since we use monthly data, our application is not very sensitive to the assumption of non-normality.

variance of government default shocks if banks switch from domestic public debt to a basket of EMU public debt and 3) the change in the average duration following such a switch.

The third effect may have a strong influence, as the 109.1% increase for Finland in part A of table 8 shows. Using the Missale (1998) measure, the duration of Finnish public debt is currently very low. In such a situation, diversification into foreign public debt with a higher duration may actually increase the riskiness of public debt holdings. This perverse effect is also present in Ireland (5.4%), Italy (1.8%), Portugal (20.4%) and Spain (25.4%). It therefore makes sense to consider the results for the uniform duration measure of 3.5 in parts C and D of table 8, which leave out the distortionary effect of differences in duration. The percentages in parts C and D show that for all countries except France, the standard deviation of the equity-to-assets ratio is reduced through diversification. The positive percentage for France results from France having the lowest variance of government default shocks (see tables 4 and 5). In the case of France the diversification benefits do not compensate for the switch to riskier public debt. Yet, for all other countries the diversification benefits range from a 6.6% reduction in the standard deviation of the equity-to-assets ratio in Portugal to a 56.1% reduction in Italy.

[12] All simulations in this paper are realised with SIM.xla, a Monte Carlo simulation add-in for Excel.

Table 8: Historical simulation results for government default shocks

Duration:	Effective maturity, Missale (1998)			3.5 years		
	Standard deviation of equity-to-assets ratio			*Standard deviation of equity-to-assets ratio*		
	Without diversification	*With diversification*	*% change*	*Without diversification*	*With diversification*	*% change*
Variance-covariance matrix: 10-year bonds, August 96 - November 1998						
	Part A			Part C		
Austria	0.00315	0.00239	-24.3	0.00219	0.00187	-14.9
Belgium	0.00251	0.00247	-1.5	0.00228	0.00206	-9.5
Finland	0.00052	0.00109	109.1	0.00103	0.00078	-24.3
France	0.00071	0.00055	-21.5	0.00044	0.00046	4.3
Germany	0.00210	0.00142	-32.1	0.00140	0.00106	-24.2
Ireland	0.00069	0.00073	5.4	0.00063	0.00058	-8.5
Italy	0.00147	0.00150	1.8	0.00276	0.00121	-56.1
Netherlands	0.00181	0.00104	-42.6	0.00095	0.00088	-7.5
Portugal	0.00128	0.00155	20.4	0.00122	0.00114	-6.6
Spain	0.00132	0.00165	25.4	0.00151	0.00129	-14.9
Variance-covariance matrix: 5-year bonds, January 95 – February 1999						
	Part B			Part D		
Austria	0.00390	0.00247	-36.8	0.00269	0.00217	-19.2
Belgium	0.00328	0.00264	-19.7	0.00291	0.00237	-18.5
Finland	0.00097	0.00106	9.6	0.00166	0.00093	-44.2
France	0.00069	0.00058	-15.5	0.00043	0.00047	9.7
Germany	0.00245	0.00142	-41.9	0.00187	0.00124	-33.8
Italy	0.00152	0.00161	5.7	0.00310	0.00148	-52.3
Netherlands	0.00184	0.00113	-38.8	0.00103	0.00094	-9.1
Spain	0.00209	0.00172	-17.7	0.00247	0.00146	-40.8

Note: Due to data availability we cannot calculate the impact of 5-year government default shocks for Ireland and Portugal.

5. Implications for prudential regulation and supervision

Section 4 has shown that encouraging banks to geographically diversify their government bond holdings can reduce the variability of the banks' equity-to-assets ratio and thus the risk of bank failures. Finance theory would predict that this diversification results in a lower return on investments, discouraging banks from diversifying out of their own free will. Moreover, a political reason why banks might be reluctant to diversify their public debt is that they might want to preserve good relations with their Minister of Finance. It therefore may be necessary that regulators impose exposure limits to banks' public debt holdings, for example along the lines of the large exposure rules which are currently in force for private sector debt.[13] Increased diversification of the credit exposures

[13] Alternatively, the maximum allowable credit exposure to a government could be determined with reference to that government's credit rating.

of banks to their own government would increase the stability of the EMU financial system and thereby strengthen the credibility of the no-bailout clause.

The current capital adequacy requirements apply different weights to claims on sovereigns depending on whether the claim is on a member of the OECD. The Basle Committee on Banking Supervision (1999) recently issued a consultative paper entitled "A New Capital Adequacy Framework" to overcome some of the shortcomings of this approach. Particularly, some countries that might not merit inclusion on grounds strictly related to default risk are included in the preferential group, while potentially high credit quality countries outside the OECD would be excluded.

The Basle Committee now proposes to replace the current approach with a system that would permit the risk weights applied to such claims to be benchmarked to the assessment results of eligible external credit assessment institutions (see Table 9). The assessments for sovereigns used should generally be in respect of the sovereign's long-term foreign currency obligations.[14] Table 9 shows that claims on governments rated AAA to BBB- would still receive a lower risk weighting than comparable claims on banks or corporates. We have no good explanation for this. Are governments still positively discriminated or are we not allowed to compare sovereign ratings with bank or corporate ratings for example because an AAA sovereign is less risky than an AAA corporate?

Table 9: The new capital adequacy framework

Claim		*Standard & Poors' assessment*					
		AAA to AA-	A+ to A-	BBB+ to BBB-	BB+ to B-	Below B-	Unrated
Sovereigns		0%	20%	50%	100%	150%	100%
Banks	Option 1[1]	20%	50%	100%	100%	150%	100%
	Option 2[2]	20%	50%	50%	50%	100%	50%
Corporates		20%	100%	100%	100%	150%	100%

Source: Basle Committee on Banking Supervision (1999).

Table 10 summarises the current ratings and spreads versus the 10-year Bund of the EMU-11 countries. Interestingly, the proposed change to the capital adequacy requirements would at present

not require banks to hold more capital against EMU-11 sovereigns.

Table 10: Long-term domestic and foreign currency debt ratings of governments in the Euro area

	Standard & Poors' assessment	*Spread versus 10-year Bund as at 26 May 1999*
Germany	AAA	-
Austria	AAA	+ 9
Belgium	AA+	+29
Finland	AA	+23
France	AAA	+14
Ireland	AA+	+ 2
Italy	AA	+30
Netherlands	AAA	+17
Portugal	AA	+33
Spain	AA+	+28

Source: Bank of England (1999).

Having established the need for a change in the prudential regulation of public debt exposures, the question remains as to what should be the role of the ECB in all this. There has been a lively debate about whether monetary policy and prudential supervision should reside in one institution. At present, the ECB has only an advisory and co-ordinating role in prudential supervision (Articles 105(5) and Article 106(6) of the Maastricht Treaty and Article 25 of the ECB statute). Its task is to conduct monetary policy with the primary objective of achieving price stability. Responsibility for prudential supervision and regulation in order to preserve financial stability is in the hands of national authorities (national central banks and/or other regulatory agencies). In contrast, the US Federal Reserve regards its supervisory and regulatory functions as a prerequisite and complement to its monetary policy responsibilities. We would favour a bigger role for the ECB in financial stability.[15] The ECB should be given responsibility for banking supervision and vital financial markets such as the market for government securities.[16] There are close linkages between financial markets and banking, both within and across jurisdictions, witness the Asian and Russian crises. The ECB would gain valuable insights into the financial markets conditions through its daily participation in the financial markets, and into the health of the banking sector through its banking supervision responsibilities. Lannoo (1999,

[14] Remember that the domestic currency (i.e. the Euro) ratings and foreign currency ratings are the same.

[15] Prudential supervision - which is by definition about the solvency of financial institutions - is undertaken for both systemic stability and investor protection objectives. The case for a role of the ECB in investor protection is less strong.

[16] The arguments for prudential supervision to reside with the central bank are adapted from the Reserve Bank of Australia's (1996) submission to the Financial System Inquiry in Australia, the Wallis Committee (1996), Arnold (1999) and Lannoo (1999).

p. 13) observes that within EMU, nobody is in charge of aggregating and examining exposures in the European banking system to detect signs of potential financial trouble.

For the ECB to be in the position to assess whether a fall in bond market values will endanger the liquidity and solvency of banks, it will need information about the vulnerability of the banking sector to default risk. Information about the health of the financial sector is also needed in determining monetary policy, as the implementation and ultimate effect of monetary policy is still largely dependent on the banking system, given its role as lender to small and medium sized business. In addition, familiarity with government bond markets is becoming more important as potential fiscal crises may be initiated in the government bond market. Fluctuations in government bond market liquidity may have direct impact on the ECB's activities. Depending on the level of market liquidity shocks may be amplified rather than dampened. This amplification coupled, in some cases, with the presence of "feedback trading", can lead to liquidity or solvency problems at key financial intermediaries, which, if held unchecked, could lead to payment system disruptions and/or a collapse in credit allocation (Gravelle, 1999).

The ECB’s current lack of hands-on experience with the banking sector and government bond markets may have unwelcome consequences. It will seriously impede her capacity to assess liquidity crises in European markets. It will also complicate the ECB’s role as the supplier of emergency liquidity, and invoke co-ordination problems during a systemic crisis. Where there is a threat to liquidity, the ECB should work with the national central banks to restore liquidity to maintain confidence, either to the whole system or on a lender of last resort basis. However, the present capacity of national central banks to provide liquidity assistance to local problem banks at their own discretion is potentially in conflict with the ECB's responsibility for determining liquidity at EMU level. Procedures for Lender of Last Resort operations should be harmonised and responsibility for emergence liquidity provision should be clearly allocated between the ECB and national central banks (Lannoo, 1999, p. 12). Finally, in crisis situations, prior knowledge about a troubled bank might prove vital for the bank’s survival. If adequately informed, the ECB’s crisis managers would be ideally placed to initiate the troubled banks' recapitalisation by shareholders or its merger with a stronger bank.

6. Conclusion

Part of the rationale for prudential supervision of banks is that, left to themselves, banks will take on a degree of risk that is not socially optimal, and that government intervention is needed to correct for this. Following from this is that one of the objectives of banking regulators and supervisors should be the assessment of the vulnerability of banks to government default risk.

The EMU regime-shift entails a yet untested separation of fiscal and monetary powers. Banks and bank regulators should be prepared for the change in the risk profile of public debt which results from this. Specifically, bank regulators and supervisory authorities should address the need for a better geographical diversification of public debt holdings and for an increase in capital that banks are required to hold against public debt. Banks that buy public debt of EMU governments currently have to put aside 0 % of their value as capital against them. This gives governments the opportunity to borrow at cheaper rates than the private sector, something that is no longer appropriate since public debt issued by EMU governments is not risk-free. Capital adequacy regulations for debt issued by EMU governments should therefore be changed to reflect more closely its true riskiness.

This paper has shown that banks’ total exposure to government default risk in the EMU depends not only on the total amount of public debt that is held and on the number of different public sector debtors, but also on the covariance structure of default risks. Diversification of public debt will increase banks' ability to withstand market disruptions. The added advantage is that non-resident banks tend to have different risk exposures than resident banks and tend to react differently to a government default shock. This different behaviour of non-resident banks may dampen the price fall following a government default shock. Our results show that a better diversification of banks’ investments in public debt across European governments may reduce the standard deviation of banks' capital-to-assets ratio and the risk of bank failures, thus providing empirical support for measures requiring European banks to better spread out their public debt holdings across the EMU area.

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Appendix: The correlation matrices of government default shocks

Table A1: $D(i-i^{Federal})$, 10-year bonds, October 1989-June 1997 Australian states

	NSW	*QL*	*SA*	*TAS*	*VIC*	*WA*
	Correlation coefficients					
New South Wales	1.0000					
Queensland	0.8234	1.0000				
South Australia	0.5428	0.5591	1.0000			
Tasmania	0.5974	0.6013	0.6530	1.0000		
Victoria	0.6251	0.6646	0.6826	0.8191	1.0000	
Western Australia	0.7304	0.7818	0.6491	0.7306	0.7218	1.0000

Source: Queensland Treasury Corporation

Table A2: $D(i-i^{Federal})$, 5-year bonds, 18 June 1992 - 5 November 1998 Canadian provinces

	ALB	*BC*	*MAN*	*NB*	*NFL*	*NS*	*ONT*	*PEI*	*QUE*	*SAS*
	Correlation coefficients									
Alberta	1.0000									
British Columbia	0.8139	1.0000								
Manitoba	0.7105	0.8243	1.0000							
New Brunswick	0.7033	0.7985	0.9332	1.0000						
Newfoundland	0.4707	0.6104	0.7128	0.6853	1.0000					
Nova Scotia	0.6491	0.7469	0.8808	0.8531	0.7747	1.0000				
Ontario	0.4536	0.5806	0.7175	0.6902	0.6597	0.7382	1.0000			
Prince Edward Island	0.4991	0.5707	0.7101	0.7018	0.7312	0.7648	0.5975	1.0000		
Quebec	0.2358	0.3178	0.3236	0.3090	0.3041	0.3709	0.3942	0.2367	1.0000	
Saskatchewan	0.5513	0.6645	0.8287	0.8104	0.7149	0.8331	0.6633	0.8479	0.2998	1.0000

Source: CIBC Wood Gundy Securities, weekly frequency, bid rates.

Table A3: $D(i-i^{Federal})$, 10-year bonds, 18 June 1992 - 5 November 1998 Canadian provinces

	ALB	*BC*	*MAN*	*NB*	*NFL*	*NS*	*ONT*	*PEI*	*QUE*	*SAS*
	Correlation coefficients									
Alberta	1.0000									
British Columbia	0.8658	1.0000								
Manitoba	0.7627	0.7324	1.0000							
New Brunswick	0.7772	0.7507	0.8925	1.0000						
Newfoundland	0.6550	0.5915	0.7021	0.7267	1.0000					
Nova Scotia	0.7406	0.7138	0.8451	0.8332	0.7851	1.0000				
Ontario	0.6939	0.8053	0.7759	0.8034	0.6325	0.7488	1.0000			
Prince Edward Island	0.7379	0.6838	0.7418	0.7542	0.7776	0.8303	0.6436	1.0000		
Quebec	0.3112	0.3104	0.4126	0.4364	0.4282	0.3950	0.3176	0.3592	1.0000	
Saskatchewan	0.6857	0.6466	0.7717	0.7732	0.7421	0.7564	0.6640	0.7910	0.3484	1.0000

Source: CIBC Wood Gundy Securities, weekly frequency, bid rates.

Table A4: $\Delta(i-i^{Federal})$, 10-year bonds, 1 January 1994 - 1 May 1998, German Länder

	BW	*BY*	*BE*	*BA*	*BR*	*HA*	*HE*	*MV*	*NS*	*NW*	*RP*	*SR*	*SA*	*SC*	*SH*	*TU*
	Correlation coefficients															
Baden-Wuerttemberg	1.0000															
Bayern	0.6658	1.0000														
Berlin	0.7314	0.6331	1.0000													
Brandenburg	0.7514	0.6001	0.9452	1.0000												
Bremen	0.7549	0.6854	0.9326	0.9341	1.0000											
Hamburg	0.7714	0.7020	0.8504	0.8768	0.9060	1.0000										
Hessen	0.3678	0.2631	0.3928	0.4215	0.4612	0.4106	1.0000									
Mecklenburg	0.6468	0.8015	0.6795	0.6348	0.6793	0.7326	0.2157	1.0000								
Niedersachsen	0.1053	0.1767	0.1058	0.1171	0.1677	0.2071	-0.1674	0.2458	1.0000							
Nordrhein-Westfalen	0.5299	0.4131	0.5048	0.5584	0.5074	0.5642	0.3846	0.4713	0.1594	1.0000						
Rheinland-Pfalz	0.6166	0.4990	0.5955	0.5275	0.5621	0.5660	0.1735	0.4923	0.1354	0.2804	1.0000					
Saarland	0.7060	0.7053	0.8903	0.9052	0.9690	0.9206	0.4766	0.6915	0.1716	0.5168	0.4955	1.0000				
Sachsen-Anhalt	0.7076	0.7416	0.7381	0.7100	0.7139	0.7574	0.4280	0.7489	0.1676	0.5220	0.4923	0.7091	1.0000			
Sachsen	0.4035	0.3417	0.3463	0.3857	0.3966	0.4799	0.1851	0.3279	0.2328	0.3633	0.6157	0.4056	0.3115	1.0000		
Schleswig-Holstein	0.2627	0.2221	0.3947	0.3928	0.3909	0.3566	0.4353	0.2506	0.0649	0.0623	0.1581	0.4118	0.1976	0.0143	1.0000	
Thueringen	0.6041	0.6478	0.4551	0.4797	0.5498	0.5744	0.2799	0.5416	0.1302	0.4403	0.5475	0.5376	0.5790	0.4538	0.1549	1.0000

Source: Datastream, monthly frequency, last business day of the month.

Table A5: $D(V\text{-}V^{New\ Jersy})$, 20-year general obligation bonds trading values relative to New Jersey, 1/ 73 – 1/98, US

	AL	AK	CA	CT	DE	FL	GA	HI	IL	KY	LA	ME	MD	MA	MI	MN	MS	MO	MT	NV
	Correlation coefficients																			
AL	1																			
AK	0.66	1																		
CA	0.3	0.19	1																	
CT	-0.28	-0.22	-0.31	1																
DE	-0.37	-0.27	-0.07	0.43	1															
FL	0.36	0.54	0.36	-0.15	-0.16	1														
GA	0.31	0.2	0.58	-0.41	-0.19	0.58	1													
HI	0.54	0.57	0.46	0.1	0.07	0.67	0.35	1												
IL	0.31	0.19	0.61	-0.28	-0.11	0.64	0.69	0.52	1											
KY	0.48	0.3	0.53	-0.44	-0.35	0.52	0.86	0.33	0.7	1										
LA	0.36	0.24	0.19	-0.52	-0.24	0.42	0.51	0.2	0.54	0.57	1									
ME	0.35	0.21	0.58	-0.22	-0.09	0.6	0.6	0.53	0.77	0.64	0.48	1								
MD	-0.16	-0.16	0.35	-0.17	0.03	0.37	0.54	0.13	0.47	0.43	0.2	0.55	1							
MA	-0.04	0.06	-0.5	0.59	0.26	-0.3	-0.65	-0.01	-0.49	-0.55	-0.48	-0.52	-0.64	1						
MI	0.39	0.08	0.24	0.2	-0.12	0.41	0.22	0.5	0.42	0.19	0.03	0.35	0.09	-0.03	1					
MN	0.53	0.21	0.46	-0.42	-0.3	0.56	0.8	0.31	0.65	0.78	0.47	0.65	0.43	-0.56	0.5	1				
MS	0.81	0.55	0.52	-0.42	-0.36	0.41	0.51	0.5	0.53	0.7	0.48	0.58	0.11	-0.29	0.31	0.67	1			
MO	0.59	0.35	0.56	-0.48	-0.35	0.55	0.83	0.35	0.63	0.89	0.53	0.64	0.43	-0.56	0.21	0.82	0.76	1		
MT	0.45	0.33	0.58	-0.46	-0.35	0.61	0.86	0.35	0.72	0.91	0.56	0.61	0.36	-0.55	0.26	0.81	0.68	0.87	1	
NV	0.75	0.64	0.46	-0.39	-0.56	0.54	0.44	0.58	0.54	0.64	0.49	0.46	0	-0.19	0.38	0.58	0.81	0.65	0.66	1
NH	0.55	0.24	0.5	-0.34	-0.41	0.41	0.63	0.26	0.58	0.75	0.38	0.5	0.23	-0.39	0.6	0.78	0.67	0.69	0.74	0.63
NM	0.32	0.19	0.61	-0.46	-0.27	0.61	0.84	0.36	0.78	0.83	0.58	0.75	0.51	-0.64	0.32	0.82	0.62	0.81	0.89	0.53
NY	0.01	0.12	-0.39	0.38	0.16	-0.34	-0.66	-0.1	-0.6	-0.59	-0.43	-0.64	-0.72	0.82	-0.11	-0.6	-0.3	-0.56	-0.56	-0.14
NC	0.41	0.22	0.57	-0.44	-0.29	0.49	0.89	0.25	0.65	0.88	0.5	0.66	0.52	-0.61	0.24	0.83	0.65	0.93	0.85	0.55
ND	0.44	0.35	0.51	-0.55	-0.36	0.47	0.79	0.23	0.65	0.92	0.61	0.54	0.33	-0.5	0.1	0.72	0.68	0.87	0.89	0.67
OH	0.84	0.51	0.14	-0.03	-0.32	0.21	0.04	0.46	0.1	0.2	0.11	0.1	-0.33	0.21	0.53	0.29	0.6	0.35	0.22	0.6
OK	0.38	0.29	0.41	-0.47	-0.32	0.47	0.78	0.25	0.6	0.8	0.65	0.51	0.38	-0.53	0.06	0.64	0.59	0.8	0.8	0.55
OR	0.65	0.49	0.24	-0.02	-0.32	0.28	0.08	0.46	0.22	0.23	0.19	0.19	-0.26	0.17	0.51	0.18	0.53	0.34	0.26	0.56
PA	-0.02	-0.01	0.15	0.24	0.05	0.08	-0.11	0.34	0.22	-0.05	-0.18	0.14	-0.08	0.28	0.34	-0.11	0.07	-0.1	0	0.19
PR	-0.15	0.15	-0.23	0.29	0.2	-0.02	-0.41	0.07	-0.22	-0.3	-0.24	-0.16	-0.36	0.52	0.06	-0.3	-0.09	-0.37	-0.22	0.04
RI	0.28	0.19	0.57	-0.27	0.12	0.3	0.42	0.54	0.45	0.39	0.2	0.42	0.19	-0.25	0.07	0.36	0.41	0.31	0.37	0.41
SC	0.34	0.18	0.43	-0.23	-0.22	0.45	0.43	0.35	0.51	0.45	0.43	0.68	0.46	-0.51	0.12	0.41	0.46	0.49	0.43	0.34
TN	0.37	0.12	0.56	-0.41	-0.27	0.48	0.9	0.25	0.68	0.9	0.55	0.65	0.53	-0.63	0.2	0.8	0.62	0.93	0.87	0.51
TX	0.35	0.26	0.43	-0.51	-0.28	0.42	0.81	0.24	0.66	0.82	0.66	0.55	0.43	-0.57	0.1	0.68	0.59	0.77	0.8	0.53
UT	0.46	0.27	0.54	-0.48	-0.4	0.49	0.85	0.27	0.67	0.9	0.58	0.63	0.44	-0.57	0.2	0.79	0.68	0.91	0.88	0.61
VT	0.45	0.32	0.67	-0.24	-0.06	0.65	0.68	0.69	0.83	0.69	0.47	0.84	0.43	-0.44	0.49	0.68	0.65	0.66	0.69	0.6
VA	0.46	0.22	0.56	-0.46	-0.4	0.49	0.85	0.28	0.67	0.89	0.52	0.69	0.5	-0.61	0.2	0.82	0.7	0.94	0.84	0.6
WA	0.33	0.1	0.35	-0.12	-0.03	0.24	0.26	0.41	0.48	0.32	0.23	0.49	0.23	-0.28	0.52	0.56	0.55	0.31	0.35	0.41
WV	0.81	0.66	0.28	-0.17	-0.39	0.45	0.28	0.61	0.43	0.48	0.35	0.44	-0.08	-0.02	0.51	0.48	0.75	0.52	0.5	0.74
WI	0.55	0.24	0.5	-0.39	-0.27	0.55	0.8	0.36	0.75	0.79	0.51	0.67	0.42	-0.55	0.55	0.95	0.68	0.8	0.81	0.58

Table A5: Continued

	NH	NM	NY	NC	ND	OH	OK	OR	PA	PR	RI	SC	TN	TX	UT	VT	VA	WA	WV	WI
NH	1																			
NM	0.65	1																		
NY	-0.34	-0.72	1																	
NC	0.7	0.85	-0.63	1																
ND	0.71	0.79	-0.51	0.84	1															
OH	0.42	0.1	0.27	0.2	0.17	1														
OK	0.52	0.74	-0.55	0.8	0.8	0.13	1													
OR	0.46	0.19	0.19	0.23	0.27	0.84	0.17	1												
PA	0.08	0.03	0.2	-0.04	-0.11	0.22	-0.07	0.33	1											
PR	-0.12	-0.28	0.49	-0.33	-0.25	0.04	-0.32	0.03	0.52	1										
RI	0.22	0.32	-0.2	0.29	0.3	0.01	0.26	-0.13	0.12	0.02	1									
SC	0.34	0.47	-0.55	0.44	0.34	0.06	0.42	0.17	-0.07	-0.46	0.24	1								
TN	0.68	0.84	-0.68	0.95	0.85	0.14	0.83	0.19	-0.04	-0.41	0.32	0.52	1							
TX	0.54	0.79	-0.62	0.81	0.83	0.1	0.89	0.17	-0.09	-0.38	0.27	0.42	0.82	1						
UT	0.69	0.85	-0.62	0.92	0.89	0.22	0.88	0.25	-0.07	-0.38	0.27	0.5	0.92	0.87	1					
VT	0.67	0.75	-0.51	0.65	0.62	0.2	0.55	0.31	0.25	-0.12	0.57	0.57	0.67	0.59	0.64	1				
VA	0.67	0.86	-0.67	0.95	0.85	0.21	0.81	0.22	-0.05	-0.4	0.31	0.52	0.94	0.8	0.94	0.66	1			
WA	0.44	0.41	-0.41	0.31	0.27	0.21	0.24	0.12	0.04	-0.01	0.45	0.29	0.3	0.28	0.32	0.52	0.35	1		
WV	0.54	0.45	-0.08	0.39	0.46	0.74	0.39	0.67	0.14	-0.04	0.1	0.3	0.33	0.42	0.49	0.51	0.43	0.41	1	
WI	0.8	0.85	-0.59	0.82	0.73	0.32	0.68	0.27	-0.07	-0.37	0.29	0.43	0.79	0.75	0.81	0.74	0.8	0.54	0.57	1

Source: Chubb Corporation. US states except AZ, AR, CO, ID, IN, IA KS, NE, SD and WY. State abbreviations follow BEA notation.