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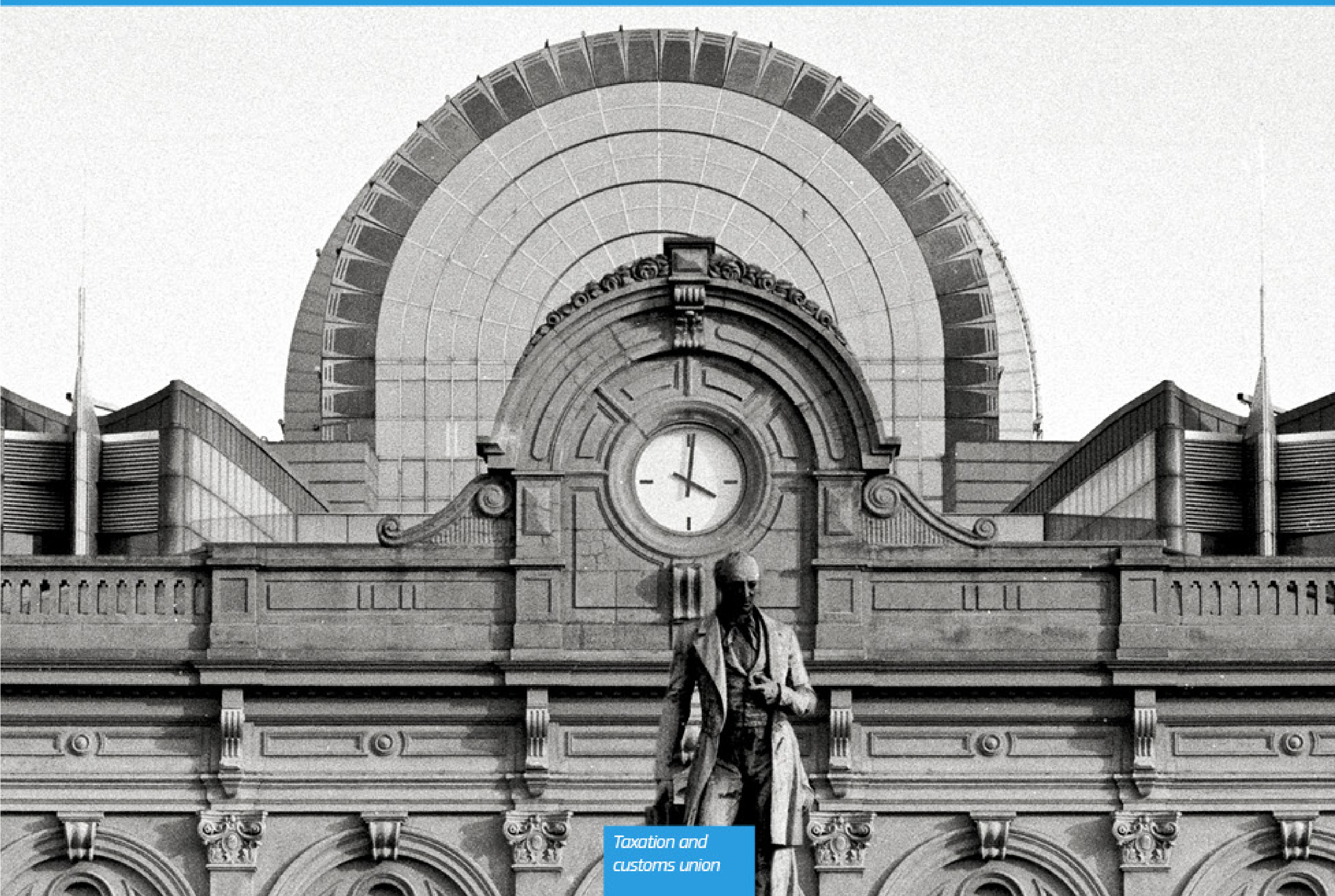

Taxation and customs union

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Financial Activities Taxes, Bank Levies and Systemic Risk

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Abstract: The question of additional taxes on banking institutions has recently been debated. At the same time, financial regulation in the banking sector is undergoing many changes aimed at strengthening financial stability. This paper uses SYMBOL, a micro-simulation model of the banking system, to estimate contributions to systemic risk of individual banks under various future regulatory scenarios and compares them to their potential tax liabilities under alternative designs of Financial Activity Taxes and Bank Levies. The results show that when contagion is not avoided, all taxes perform about the same way. However, when contagion is avoided, bank levies outperform FATs.

Keywords: Taxation, Banks, Financial Activity Tax, Bank levy, Systemic Risk, regulation.
JEL classifications: F23, G32, H25, R38

[1] Corresponding author: marco.petracco@jrc.ec.europa.eu. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors and should not be attributed to the European Commission. Possible errors and omissions are those of the authors. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this publication. An earlier version of this paper appeared in the Impact Assessment of the European Commission on Financial Sector Taxation (European Commission, 2011a). This paper will be published in de Mooij and Nicodeme (eds), Taxation and Regulation of the Financial Sector, published by MIT Press.The authors thank Jin Cao, Philip Kermode, one anonymous referee and the participants to the 2012 Venice Summer Institute hosted by CESifo for valuable comments.

1. Introduction

In the run-up and in the wake of 2007 financial crisis, the question of additional taxes on the financial sector taxation has been debated in academic and policy circles "*as to how the financial sector could make a fair and substantial contribution toward paying for any burden associated with government interventions to repair the banking system*" (IMF, 2010). One of the drivers of this debate was the fact that the financial sector might be under-taxed, at least in the European Union, thanks to its compulsory exemption to Value-Added Taxation (VAT).[2]

Among the various proposals, the introduction of a tax on profits and remunerations, called "financial activities tax" or FAT (see e.g. Keen et al., 2010) would take up a role similar to VAT. The Financial Activities Tax has - in particular - been considered as a possible option by the European Commission (2010a, 2010b) in its Communication on Taxation of the Financial Sector. Buettner and Erbe (2014) find that a 4% FAT in Germany would generate similar revenues and welfare effects as the repeal of VAT exemption (at a rate of 19%) for the financial sector but with much smaller changes in consumer and producer prices. Another proposal introduced by several authors, and notably by the IMF (2010) that saw this as the first-best solution for the financial sector, is the Financial Stability Contribution or Bank Levy. Several countries have implemented such a tax with various designs. Such a tax could also be designed to reduce risk when applied to uninsured liabilities[3].

At the same time, the banking sector is subject to various other regulatory proposals, aimed at strengthening its stability at the individual and systemic level such as Basel III and several policy initiatives in the European Union (see section 3.3) and the United States (e.g. the Frank-Dodd Act). Those initiatives are particularly designed to strengthen the capital base of financial institutions and to decrease the risks of contagion. Financial and banking crises are indeed found to be extremely adverse in terms of output losses (Laeven and Valencia, 2012) and policies to curtail the risks associated with financial crises are therefore high in the political agenda.

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[2] See e.g. European Commission (2011a) and Huizinga (2002) who found an advantage that amounts to 0.15% GDP. Using a general equilibrium model for Germany in 2007, Erbe and Buettner (2014) find that repealing the VAT exemption for financial services would raise total tax revenues by EUR 1.2 billion, which at a 2007 GDP of 2,428.5 billion (AMECO database) represents about 0.05% GDP.

[3] See however Devereux (2014) and Coulter, Mayer and Vickers (2014) for counter-arguments why such levy could actually increase risk, and Devereux, Johannesen and Vella (2013) for empirical evidence that levies induce banks to hold more risky assets when the regulatory capital requirement is binding.

Therefore, a natural question to ask is whether a FAT or a bank levy would be a good proxy for a fee mirroring the individual contributions of banks to systemic risk (and possibly a contribution to a rescue or resolution fund), and how it would interact with other regulatory measures under the expected future regulatory scenario.

In order to investigate this question, we employ SYMBOL[4], a micro-simulation model of the banking system, to estimate contributions of individual banks within a large sample to total systemic losses under future capital requirements and resolution regimes and calculate the correlations of these contributions with alternative designs of FATs and bank levies. Under the regulatory scenarios, a capital requirement of 8% under a possibility of contagion is used as a proxy for the current situation while a capital requirement increased to 10.5% with curtailed risks of contagion is used as a proxy for the future regulatory design. A high correlation between the tax liability of financial institutions under a FAT or a bank levy and their individual contribution to systemic risk would indicate that the tax could be a serious candidate for a fee designed to reflect risk.

The literature on risk contributions of banks to systemic risk includes two approaches. The first one uses market data to investigate the correlation structure of returns and/or prices of assets of different institutions. It estimates the contribution of individual financial institutions to systemic risk using quantile regression. Systemic risk is generally measured as the change in system value at risk (e.g. Adrian and Brunnermeier, 2011; Segoviano and Goodhart, 2009; Acharya et al., 2012). The alternative approach uses structural 'network' models to simulate losses affecting financial institutions, via the value process of the banks' assets or a "stress test" on assets' values and represents the channels of contagion between banks, eventually in conjunction with interbank clearing algorithms (Upper and Worms, 2004; Müller, 2006; Cifuentes at al., 2005; Gauthier et al., 2012; Bluhm et al., 2013).

The approach used in this paper to calculate contributions to systemic risk broadly falls into the latter approach: SYMBOL is a structural model of the value of banks' assets which generates simulated losses for a sample of real banks, based on balance sheet and regulatory capital data. Additionally, as the model is based on individual banks, a direct contagion mechanism is modelled via the use of an interbank loans and deposits matrix. We define systemic risk as the total amount of funds which would be necessary to cover all non-equity creditors of defaulting banks, i.e. to cover all losses in excess of banks' capital. We then

[4] The SYMBOL model (SYstemic Model of Banking Originated Losses) has been jointly developed by the European Commission's Joint Research Centre, DG MARKT, and the University of Cagliari (see De Lisa et al., 2011).

calculate the contribution to systemic risk based on the amount of funds necessary to cover expected losses generated by individual banks.

The simulation nature of SYMBOL also allows constructing "counter-factual" or "what if" scenarios based on future regulatory set-ups: losses in each scenario are distributed as implicitly defined by the Basel Regulation, correlated between banks, and based on proxies of assets Probability of Default (PD) and actual values of the total capital. Based on the results of simulations we are able to construct the distribution of losses at the individual and aggregate levels and to define the contribution to risk as the average losses in excess of capital generated by each bank across all simulations.[5] Since we are not exclusively interested in tail events, we consider the whole distribution of losses.

Coming to the FAT, the tax is in essence a tax on the sum of profit and remunerations of the financial sector.[6] This tax has the features of being a good substitute for the VAT on the sector (because the sum of profit and remuneration is a good proxy for value-added) and to present little distortions to the extent that it can be designed to mostly tax the rents of the sector. We compute the amounts of FAT that would be charged under three alternative designs to each bank in the sample. Finally, we calculate the correlations between the FAT charged to individual banks under each design and the individual risk from the SYMBOL simulations. We find that FAT1, the broader version of the base, is the best correlated with systemic risk and that regulatory improvements increase this correlation. This is mainly because FAT1 is the best correlated with the size of the institution, which appears to be a major determinant of the impact on aggregate risk. Several designs of bank levies are also tested. Broader versions of those levies appear to be best correlated to individual risks. Under a scenario of contagion, FATs and Levies have similar performances. When contagion is contained, however, bank levies outperform FATs, mainly because of their stronger correlation with the size of financial institutions, a prime determinant of risk in this case.

The remainder of this paper is organized as follows: Section 2 introduces the FAT and bank levy designs considered, section 3 illustrates the procedure to calculate risk contributions

5 This could seem more in line with CoVar-like indicators (e.g. Adrian and Brunnermeier, 2011) used in the correlation/reduced form works, while normally structural models tend to employ a Shapley value methodology (Tarashev et al. (2010). However, this choice of the measure of systemic risk contributions is dictated by the fact that it is the most apt at measuring the optimal contribution to a possible rescue/resolution fund. This contribution would be based on the amount of resources the fund would need to dedicate to that institution in crisis events, reflecting its chance of participating to the event, independently of the banks' chance of contributing to starting the event itself. For a discussion on the different roles, see Tarashev et al. (2010)

6 For a description of the FAT, see Hemmelgarn and Nicodeme (2010, 2012).

under future regulatory scenarios with the SYMBOL model, section 4 presents the main results and section 5 concludes.

2. FAT and Bank Levies designs

In October 2010, the European Commission (2010a, 2010b) evaluated options regarding the introduction of a harmonized Financial Sector Taxation framework. Among these options, the European Commission considered a Financial Activities Tax.

In its Impact Assessment of Financial Sector Taxation Proposals, the European Commission (2011a) considered three versions of the FAT. The first version, FAT1, defines the profit of financial institutions in cash-flow terms and adds the remunerations paid by the sector. FAT2 takes the same base for profit but only adds 'excessive' remunerations, i.e. those above a defined threshold. Finally, FAT3 takes as tax base the sum of cash-flow profit above a defined return on capital and 'excessive' remunerations.

To calculate the profit part of the Financial Activity Tax, we would ideally have a Cash-Flow financial statement. This is not available to us. Nevertheless, we can use the information contained in the unconsolidated financial statements of banks as available in ORBIS.[7] The profit part of the FAT base is computed as a R+F (i.e. Real + Financial transactions) base by adapting accounting profit to cash-flow profit. This is done by starting with the profit and loss before tax and distribution, subtracting the dividends received from subsidiaries (i.e. applying an exemption to avoid double-taxation), adding the change in (non-equity) liabilities, subtracting the change in assets, except for change in cash hold and investment in subsidiaries. The labour costs part is the costs of personnel. As for the IMF's computation, the FAT1 is the sum of these two parts, the FAT2 takes the same cash-flow profit definition and 12% of labour costs[8] and the FAT3 limits the cash-flow profit to what

[7] Orbis is a database on financial statements of companies published by Bureau Van Dijk. Note that the sample can be biased towards large banks as financial information could be harder to obtain for smaller banks. Our version of Orbis contains 7,343 banks and 3,609 insurance companies for the EU27 (not of all with exploitable financial information). For many banks, several variables necessary to compute FAT revenues are missing. In this case, they are estimated in the following way: for companies for which consolidated statements are available in Orbis, the missing variable of interest is replaced by the one from the consolidated statements, adjusted by the ratio of total assets between unconsolidated and consolidated statements. If the information is still missing, the same procedure is applied using country- level information on banking structures from the ECB publication "EU Banking Sector Stability" of September 2010. Our matching between the FAT computations and the individual contributions to risk leaves us with 2,843 financial institutions for which we have the necessary information.

[8] This is estimated to be 40% of the wage differential in the UK between the top 25 percent of earners in the financial sector and the top 25 percent earners in the rest of the economy. The 40% is based on the study by Philippon and Reshef (2009) for the US who find that between 30% and 40% of the wage differential is rent. See Keen et al (2010), page 138. Note that Egger et al. (2012) found evidence of a wage premium in the financial sector which amounts to about 43% in the OECD.

excesses 15% of total equity and adds it to 12% of the labour costs. It is important to note that the first two methods allow a loss-relief between the profit and the labour parts of the base, while the last method essentially put a ceiling of zero on the profit part. Hence, the base of a risk-taxing FAT could in theory be larger than the base for the other two methods. In all cases, an illustrative rate of 5% is applied to the base for 2009.

A bank levy is a tax on specific elements of the balance sheets of financial institutions and can hence take many forms. A first design could be a tax on total assets (i.e. the total of the balance sheet), which is a measure of the size of the bank. Another design may a tax on Total Regulatory Capital, the sum of Tier1 and Tier2 capital. A third option would be a contribution on covered deposits. This is the system currently in place in all EU Member States (and in many other financial systems in the world) under the Deposit Guarantee Schemes that protect depositors up to EUR 100,000 per insured banks. Such schemes are commonly funded by fees paid by banks on deposits. An alternative design is to tax non-insured liabilities. Such option which taxes total assets minus the covered deposits and Tier1 regulatory capital is expected to induce banks to switch their structure of assets towards more capital or covered deposits. Finally, a fifth option is to tax both covered deposits and uninsured liabilities – that is all liabilities except for Tier1 regulatory capital.

3. Estimation of risk contributions

3.1. The SYMBOL model

The main idea behind SYMBOL is to use the Basel formula for the Foundation Internal Rating Based (FIRB) Loss Distribution (BCBS, 2004) to estimate the average probability of default of the portfolio of assets of a bank and to numerically simulate future losses. The model estimates the distribution of losses at systemic level by simulating correlated losses in a banking system and aggregating losses in excess of available capital of defaulting banks. In this way SYMBOL estimates the distribution of losses passed over from the banking sector to the economy. Contagion effects between banks, i.e. the fact that bank failure can be driven by the default of the other(s) due to their interconnectedness, can also be taken into account using data on interbank exposures between banks.

More in detail, SYMBOL is based on the following steps:

(1) Estimate the obligors' implied probabilities of default for each individual by inverting the Basel FIRB formula.

(2) Using the same formula, generate a sample of loan losses via a Monte Carlo simulation.

(3) Check which banks fail in the sample (when losses are in excess of capital).

(4) Use the contagion model (and go back to step 3 to see which additional bank(s) fail because of contagion losses).

(5) Once no additional bank fails, derive the final matrix of total losses for the economy (systemic losses).

(1) In the first step, the implied probability of default of the banks' portfolio is estimated by inverting the Basel FIRB formula. This formula is used by many banks to estimate the risk of their portfolios and to calculate accordingly their minimum capital requirements K_n for each loan on the base of its probability to default, loss given default, size and maturity. In unitary terms (1 euro loan) we have:

$$K_n = \left\{ LGD_n \times N\left[\frac{\sqrt{R(PD_n, S_n)}N^{-1}(0.999) + N^{-1}(PD_n)}{\sqrt{1-R(PD_n, S_n)}} \right] - LGD_n \times PD_n \right\} +$$
$$\left[1+(M_n-2.5)\times \mathrm{B}(\mathrm{PD_n})\right]\times\left[1-1.5\times \mathrm{B}(\mathrm{PD_n})\right]^{-1}\times 1.06$$

where

PD_n is the probability of default of the *h* asset in the bank portfolio; LGD_n is the Loss Given Default, i.e. the average loss expected on a defaulted loan; N and N^{-1} are the standard normal density function and its inverse, respectively; $R(PD_n)$ is the correlation between the assets in the banks' portfolio (as estimated by a specific formula on the base of the asset PD and size of the firm, S_n); M_n is the asset maturity; $B(PD_n)$ is another correction term based on the asset PD. The confidence level for Value At Risk (VaR) is imposed by Basel regulation at 99.9%;
The total capital requirement for the bank *i* is then obtained summing up the product of the unitary capital requirement times the amount of each loan:

$$K_i = \sum_n K_n \times A_n$$

In the above formula all variables (the totals for the bank, the values for each loan being evidently confidential) and parameters except $\hat{PD_i}$ are either available on public balance sheets (K_i , ΣA_n) or can be set at their default levels in the FIRB approach (*LGD*, *R*,

M).[9] Thus the FIRB formula can be numerically inverted to obtain an estimate of the average implied probability of default of the obligors of each bank, $\hat{PD}_i$.[10]

$$\frac{K_i}{\sum_n A_n} = \left\{ LGD \times N\left[\frac{\sqrt{R(\hat{PD}_i)}N^{-1}(0.999) + N^{-1}(\hat{PD}_i)}{\sqrt{1-R(\hat{PD}_i)}} \right] - LGD \times \hat{PD}_i \right\} + \left[1 - 1.5 \times \mathrm{B}(\hat{PD}_i)\right]^{-1} \times 1.06$$

where

ΣA_n is the total value of assets detained by the bank (i.e. $K_i / \Sigma A_n$ is the MCR in relative terms);

(2) In the second step SYMBOL generates a sample of loan losses via a Monte Carlo simulation. To this goal, the estimated probability of default $\hat{PD}_i$ is plugged back into the FIRB loss distribution, with all parameters set at their default values, to simulate individual bank's losses:

$$L_{ij}\left(z_{ij}, \hat{PD}_i\right) = \left[0.45\, N\left[\sqrt{\frac{1}{1-R\left(\hat{PD}_i, 50\right)}} N^{-1}\left(\hat{PD}_i\right) + \sqrt{\frac{R\left(\hat{PD}_i, 50\right)}{1-R\left(\hat{PD}_i, 50\right)}} N^{-1}\left(z_{ij}\right) \right] - 0.45\, \hat{PD}_i \right] \times \left(1 - 1.5\, B\left(\hat{PD}_i\right)\right)^{-1} \times 1.06$$

where $i = 1, ..., H$ banks; $j = 1, ..., J$ simulations; $z_{ij} \sim N(0,1)\, \forall i, j$; and $\mathrm{cov}\left(z_{ij}, z_{lj}\right) = 0.5\ \forall i \neq l$ (where i, l are bank indexes).

(3) In the third step SYMBOL verifies which banks default due to the simulated losses. To this goal, losses are compared with the total capital of each bank including any excess capital held above minimum requirements: whenever the losses exceed capital, the bank is considered to default (see Figure (1) for a graphical explanation):

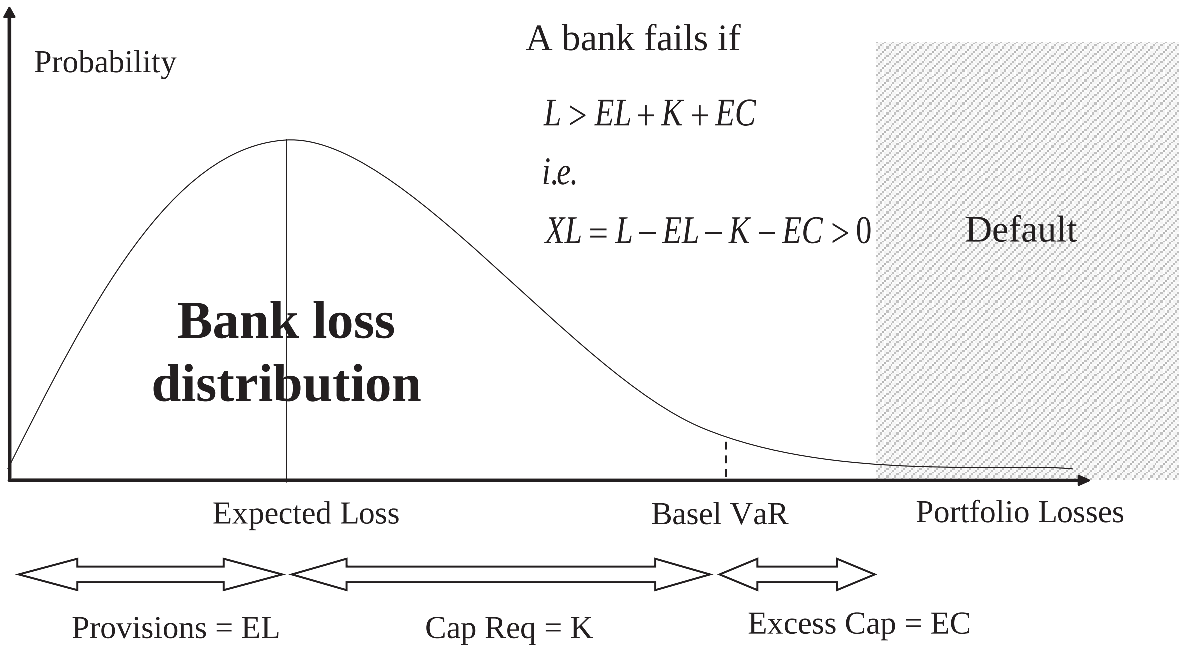
$$L_{ij}\left(z_{ij}, PD_i\right) \geq CAP_i \Rightarrow \text{bank } i \text{ defaults (no contagion case)}$$

When at least one bank defaults, these 'excess losses' are recorded as 'no contagion losses'.

9 See De Lisa et al. (2011) for technical details.

10 Under the assumption that the loss distribution for all assets held by the bank can be approximated by considering as if all of them were loans. This assumption does not seem extreme given that the largest part of minimum capital requirements held by most banks is represented by credit risk capital.

Figure (1): Loss distribution and default of banks.



Note:The first losses are absorbed by the bank provisions (EL), the next by the required capital (K) and further losses could be absorbed by excess capital (EC), when available. The tail risk, represented at the extreme right of the graph, is the portfolio losses that occur with a low probability but which are very high in value and cannot be completely absorbed by provisions and capital of the financial institution, hence a default.

(4) To include the contagion effects[11] in the absence of an effective intervention by resolution facilities,[12] exposures via the interbank market are used. Following the empirical literature, whenever a bank defaults, it is assumed that 40% of the amounts of its InterBank (IB) debits are passed as losses to creditor banks and distributed among them.[13] Missing a full interbank matrix, we estimate one using a maximum entropy criterion: the portion of losses absorbed by each 'infected' bank is proportional to its creditor exposure in the IB market. Whenever, with this additional loss, the simulation shows that another bank's losses

[11] Only domestic contagion is included in the current version of SYMBOL.

[12] In the "best case" scenario, a resolution fund operating in coordination with a liquidity facility would be able to neutralize contagion by absorbing a share of excess losses proportional to the size of a banks' interbank liabilities, while resolution and liquidity facilities are able to completely eliminate additional losses due to liquidation costs, fire sale effects and market congestion.

[13] A loss of 40% on the interbank exposure is coherent with economic research on this issue. See James (1991), Mistrulli (2007), Upper and Worms (2004). The use of a matrix of exposures proportional to interbank credits is dependent on the fact that a bank-to-bank interbank lending matrix is not yet available to the Commission; however sensitivity analysis conducted by the authors on this aspect points to the fact that the exact shape of the matrix is less important than total size of interbank market. See Zedda et al. (2012) for details. Gauthier at al. (2010, section 2.3) reach a similar conclusions on the impact of using maximum entropy matrices in this context. It is worth noting that contagion effects are sensitive to the two assumptions made: the 40% of interbank debits that are passed as losses to creditor banks in case of failure, and the criterion of proportionality used to distribute these losses across banks.

exceed its capital, that banks is also considered to default, and so on until no additional bank defaults.

Therefore losses for each bank i in each j run in case of contagion become:

$$L_{ij}^{c}\left(z_{ij}, PD_{i}, IB\right) = L_{ij}\left(z_{ij}, PD_{i}\right) + 0.4\sum_{h \neq i} D_{h} x_{ih}(IB)$$

where

D_h =1 if bank h defaulted, and 0 otherwise; x_{ih} are the elements of the maximum entropy interbank matrix.

Considering this, bank i defaults when $L_{ij}^{c}\left(z_{ij}, P\hat{D}_{i}, IB\right) \geq CAP_{i}$.

The fact that the "contagion" results are based on the same starting seed in a random number generator and on the same simulation runs assures that differences in contagion results are only due to the effects of contagion.

(5) Once at least 100,000 runs with at least one simulated default in the no contagion case are obtained the simulation is stopped. Systemic losses are then obtained by aggregating losses in excess to banks' capital over the entire population of banks in the considered banking system (e.g. one country):

$$L_{j}^{Syst} = \sum_{i=1}^{N} L_{ij} - CAP_{i}$$ in the *no contagion* case and

$$L_{j}^{Syst,c} = \sum_{i=1}^{N} L_{ij}^{c} - CAP_{i}$$, in the *contagion* case.

As in the current analysis we rely on a sample of banks (see annex), the distributions for the population of all banks in each member state are finally obtained by rescaling the distributions proportionally according to the ratio of total assets in the sample to the total banking sector in the Member State.

3.2. Systemic risk contributions

Our methodology for calculating the contributions of individual banks *c(i)* to systemic risk is a variation of the one proposed by Praschnik et al. (2001) and is such that *c(i)* are directly proportional to total losses simulated for each bank in all simulation runs.

The contribution of bank i to systemic losses is defined as the expected yearly loss for this bank and is estimated as its average loss over the whole set of simulations, as it follows:

$$c_i = \frac{\sum_{j=1}^{K} L_{ij}^{Syst}}{K}$$

where c_i is the risk contribution of bank i, expressed in money terms (i.e. EUR or USD); $\sum_{j=1}^{K} L_{ij}^{Syst}$ is the total of losses in excess of capital for bank i across all K simulations and for simplicity we drop the contagion/no contagion label.[14]

The contribution of each individual bank to the systemic risk as a share of the total can be expressed as:

$$pc_i = \frac{c_i}{\sum_{h=1}^{H} c_h}.$$

3.3. Regulatory Scenarios

As a micro-simulation tool, SYMBOL can be used to simulate losses based on alternative settings attempting to capture the effects due to regulatory proposals. In this paper three distinct elements of the European regulatory framework related to banking stability and systemic risk are considered.

First, the Capital Requirements Directive (CRD IV)[15], which entered into force in July 2013 and translates into European regulation the rules proposed in the Basel III Accord, including new definitions of capital for regulatory purposes, a new set of capital requirements and the introduction of a capital conservation buffer of 2.5% of Risk Weighted Assets (RWA).

Second, on 12 July 2010, the Commission adopted a legislative proposal for a thorough revision of the Directive on Deposit Guarantee Schemes[16]. It mainly deals with a harmonisation and simplification of protected deposits, a faster payout, and an improved

[14] Contributions are calculated by excluding the more extreme events above the 99.999th quantile, in order to exclude the influence of events in the leftmost tail which could be suffering excess variance due to undersampling.

[15] Directive 2013/36/EU

[16] European Commission (2010d)

financing of schemes, as well as a substantial enlargement of the coverage (up to EUR 100,000).

Third, the European Commission has put forward a proposal for the introduction of a EU framework for bank recovery and resolution, including the creation of Resolution Funds in all Member States that would help stopping contagion.[17]

These regulatory aspects are modelled by running SYMBOL under different "regulatory settings" and "contagion situations". In the current analysis, SYMBOL is run based on two alternative regulatory settings and two alternative contagion situations[18]:

The first setting regards the *level of regulatory capital* expressed as the minimum ratio of Capital to RWA. Two different capital requirement settings are considered to evaluate the effects of the introduction or not of a mandatory "capital conservation buffer" for banks in Basel III. In other words, we distinguish between the situation where banks must hold a minimum capital equal to 8% of their RWA – considered as a proxy for the current situation – and the situation where a minimum capital conservation buffer of 2.5% is also put on top, so to reach at least a capital equal to 10.5% of RWA.

Next, the second setting regards the *contagion situations*. They represent polar extremes of the effectiveness of interventions during the crisis. In the "best case" situation, funds and facilities are assumed to be able to work in such a way that no additional losses due to liquidity or "fire sale" effects are generated, so that only economic losses due to defaults in bank's portfolios need to be covered, i.e. contagion effects are contained. In contrast, the "worst case" situation funds and facilities intervene, but they are not able to avoid liquidity and "fire sale" additional losses and to stop contagion. In sum, two situations are considered: one where intervention is perfectly effective in blocking contagion, and one where interventions are only able to reimburse losses but are not able to prevent contagion. As mentioned above, the second scenario assumes that 40% of the losses due to interbank exposures are passed to creditors.

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[17] See European Commission (2010c and 2012). As far as Deposit Guarantee Schemes and Resolution Funds are concerned, a possible amount of funds available to DGS+RF purposes is the maximum between 1.5% of a country covered deposits and 0.3% of the amount of liabilities, in line with discussion at the time when the simulations were run . Amounts of funds to be collected by the considered Member State are reported in last column of Table A.1. in the annex. Figures refer to the sample of banks considered. As rules on the determination of the total amounts of funds available to DGS and RF in each MS are still under negotiation in the Council and the European Parliament, any rule adopted in the present study for simulation purposes can not reflect the final form of the rule as it will eventually be implemented. It was therefore chosen to calibrate funds available to DGS/RF on the basis of SYMBOL results.

[18] On top of this, SYMBOL is also able to include the possibility of a "no bail-in" or a "bail-in" framework. This distinction is not considered in this paper.

The combination of these hypotheses yields four possible "scenarios", represented in Table (1). Scenario 1 represents a proxy for the current situation: banks do not hold a capital conservation buffer (i.e. they hold at least a capital of 8% of RWA) and DGS/RF are not effective/available in blocking contagion. In Scenario 2, while the minimum capital stays at 8% of RWA, DGS/RF are effective in blocking contagion (no contagion). Scenario 3 and Scenario 4 include the capital conservation buffer (i.e. banks hold at least a capital of 10.5% of RWA). Scenario 4 proxies the desired long-term regulatory setting where there would be a conservation buffer and where there would be no contagion.

Table (1): Scenario definition

Scenario Number	Scenario label	Capital Setting		Situations	
		No Conservation Buffer, i.e. capital ≥ 8% RWA	Conservation Buffer, i.e. capital ≥ 10.5% RWA	Contagion	No Contagion
1	080_c	X		X	
2	080_n	X			X
3	105_c		X	X	
4	105_n		X		X

3.4. Data Sample

SYMBOL, as a micro-simulation model, uses data from the balance sheet data of individual banks. The main data source is Bankscope, a proprietary database of banks' financial statements produced by Bureau van Dijk. The dataset covers a representative large sample of banks in 19 EU countries. Since at the time of preparing the analysis, the latest available complete year of data was 2009, all data used refers to that year.

The data needed to run the model include minimum capital requirements, total capital, interbank deposits and loans and total assets. When needed and possible, Bankscope data have been completed with public information on bank financial statements released by Supervisory Authorities and/or Central Banks. European Central Bank (ECB) data has also been used to complete or correct the dataset.[19]

For the purposes of simulation, we consider the stricter Basel III definition of capital to be relevant, while all regulatory capital is currently reported by banks according to the

[19] Data from the ECB has been used for various purposes. For instance, in the Bankscope sample some values of key variables were missing for some banks. In some cases missing values have been filled in using estimations obtained from ECB aggregated data on banks' ratios such as the minimum capital ratio, the solvency ratio or the Tier 1 ratio. Moreover ECB data has been used to estimate the size of the Bankscope sample and to rescale SYMBOL results across the entire population of banks in each country. Finally, ECB data has been employed to validate the reliability of interbank data in Bankscope.

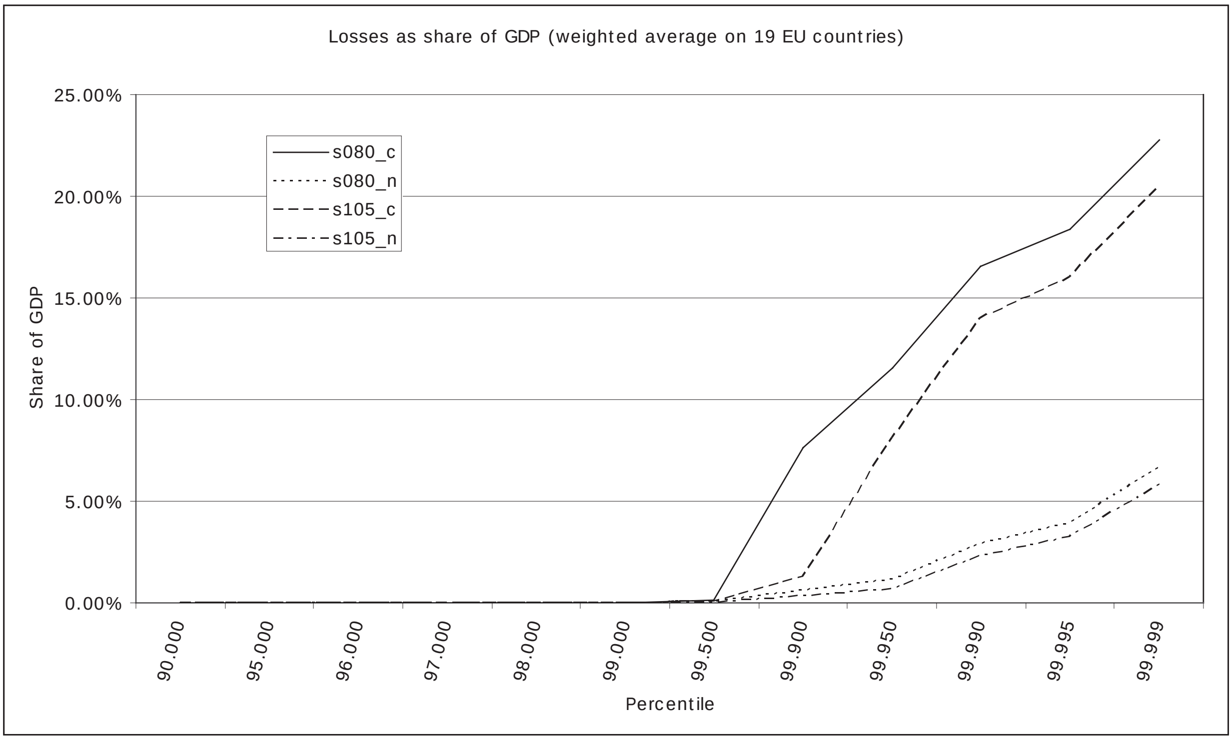
Basel II definition. In order to estimate capital ratios under the stricter Basel III definitions of eligible capital and RWA we apply a corrective factor, namely the average changes in RWA and capital for each country and banks' size groups as estimated in the Basel III Quantitative Impact Study exercises conducted by EBA and CEBS.[20] After applying the correction, all banks which do not meet minimum capital requirements (8% or 8% plus a capital conservation buffer of 2.5%, see section 3.3 for details) are brought back to them (i.e. minimum capital requirement).

4. Results

4.1. Distribution of excess losses

Figure (2) shows some selected percentiles of the distribution of systemic losses under the various scenarios for a weighted average of the considered MS. The graph reports the cumulative distribution function of systemic excess losses.

Figure (2): Simulated losses as share of GDP



Note: the vertical axe is the losses in % of GDP, the horizontal axis is the inverted cumulated percentile of probability. Moving to the right indicates a lower level of probability, while moving upwards indicates a higher

20 The Basel Committee and CEBS have published anticipated average variations in bank capital ratios due to implementation of Basel III. In this report, we have used the country-level confidential data on the estimated variations in banks' capital ratios that underlie published figures. See BCBS(2010) and CEBS (2010).

loss. For example, losses representing 5% of GDP have a probability of about 0.25% under the scenario (8%, contagion) and a probability of 0.001% under the scenario (10.5%, no contagion).

It is clear that losses decrease moving from Scenario 1 to Scenario 2, and from Scenario 3 to Scenario 4, depending on the fact that contagion between banks is considered (Scenario 1 and 3) or not (Scenario 2 and 4). Moreover losses decrease when moving from a minimum capital ratio of 8% (Scenario 1 and 2) to a minimum capital ratio of 10.5% (Scenario 3 and 4).

4.2. Results for individual contributions to systemic losses

Unreported concentration curves of the distribution of individual percentage contributions to systemic losses for all banks in the sample - illustrating individual contributions for the whole set of cases (i.e. without considering cases where losses exceed or are below the amount of funds available to DGS/RF) – have average yearly individual contributions that are usually much higher than the median, suggesting that there are few banks contributing most to the systemic risk.

This is a not surprising results as bigger banks (less numerous) tend to relatively contribute more to higher systemic losses, while smaller banks (more numerous) tend to relatively contribute lower systemic losses.

Table (2) tests the correlation between the individual contributions to systemic risk under each of the scenario and several balance sheet variables that can contribute to systemic risk. Adrian and Brunnermeier (2011) find that the contribution of an individual institution to systemic risk is correlated with leverage, the relative size and maturity mismatch.

Each of the variables is indeed significantly correlated with systemic risk, although at various degree. Total assets appear the most correlated, in particular when contagion is contained. This confirms the above conjecture. Next, maturity mismatch is proxied by the short-term funding ratio, defined as the ratio of short-term funding on regulatory capital. More stringent regulatory capital ratio increase its correlation with systemic risk but the absence of contagion goes in the opposite direction. It is worth mentioning that the Basel II FIRB formula and consequently the SYMBOL estimations are affected by the maturity of loans (not the maturity mismatch), as longer maturities are equivalent to higher PDs (See par. 3.1 above.). Finally, leverage, defined as one minus the ratio of equity to total assets acts in the same way as maturity mismatch, although correlations are lower.

Table (2) Correlation between individual contributions to Systemic Risk and balance sheet variables.

Scenario	Total Assets	RWA	STFR	Leverage
Contagion 8%	0.582***	0.482***	0.183***	0.078***
No Contagion 8%	0.878***	0.891***	0.055***	0.044**
Contagion 10.5%	0.550***	0.422***	0.192***	0.085***
No Contagion 10.5%	0.927***	0.874***	0.095***	0.078***

*Note: *** significant at the 1% level, ** 5% level, * 10% level.*

4.3. The FAT

Table (3) provides the coefficient of correlations between the three types of FAT and the four scenarios of systemic risk[21]. Several messages stand out. First, when contagion is not avoided, all versions of FAT perform in about the same way. Second, when contagion can be avoided, FAT1 is the best aligned to risk.[22]

As indicated in Table (3), FAT1 is also the option that is best correlated with size, as measured by total assets, which may explain the results. Finally, increasing capital requirement from 8% to 10.5% decreases the correlation between the contributions to FAT as measured by FAT1 and the contribution to systemic risk under contagion but increases this correlation when there is no contagion. This reveals the fact that, under no contagion, higher capital requirements are able to contain the part of the risks that are not necessarily linked to the size of the institution (e.g. leverage), increasingly leaving the remaining risk to be linked to size only.

Finally, more restricted definitions of the FAT base increase the correlation with maturity mismatch while none of the versions of the FAT is significantly correlated with leverage.

Table (3) Correlation between individual contributions to Systemic Risk and FATs.

Scenario	FAT1	FAT2	FAT3
Contagion 8%	0.566***	0.529***	0.518***
No Contagion 8%	0.600***	0.408***	0.342***
Contagion 10.5%	0.526***	0.500***	0.483***
No Contagion 10.5%	0.630***	0.441***	0.373***
Total Assets	0.714***	0.535***	0.448***
Risk-weighted assets	0.574***	0.383***	0.308***
ST Financing ratio	0.059***	0.073***	0.081***
Leverage	0.014	0.027	0.029

[21] We ran additional (unreported) scenarios with capital requirements of 7, 9 and 10%. The results confirm that correlations increase with capital requirement under no contagion and decrease with capital requirement under contagion.

[22] In theory, FAT3 would be designed to tax risk, but this rests on the hypothesis that high returns are due to higher risks. While this could be true, other factors may trigger higher returns such as a lack of competition or more efficient production methods (e.g. superior knowledge of markets, a more productive workforce, better management structures). In this latter case, the tax could be a tax on talent rather than a tax on high risk.

*Note: *** significant at the 1% level, ** 5% level, * 10% level.*

4.4. Bank Levies

As shown in Table (4), of all five options of bank levies, taxing regulatory capital would provide the solution that performs the worst when the aim is to obtain a fee that reflects individual contributions to systemic risk. All other variants perform in a relatively similar way. When contagion is not contained, bank levies and FAT perform in ways that are very close in terms of their correlation to systemic risk. When contagion is contained, however, bank levies outperform FATs in their correlation to risk. Here again, the reason seems to be that when contagion cannot be avoided, both FAT and bank levies perform equally but when an efficient resolution mechanism is put in place and allows avoiding contagion, bank levies – which are based on balance sheets (i.e. 'stock') elements of financial statements – perform better than FAT – which are based on income statements (i.e. 'flows') elements of financial statements – as counterpart to the systemic risk created by individual financial institutions. The more so, the broader their base. In such case, their correlation with the size of the financial institutions, which is a prime determinant of risk in the absence of contagion, matters. Bank levies are also better correlated with maturity mismatch and leverage than FATs. An assets-based or a broad-base version (i.e. that simply excludes Tier1 capital) are found to display the higher levels of correlation. Increasing capital requirement improves the correlations when contagion is absent.

Note that those measures are static and do not include behavioural reactions of banks which could affect the structure of their balance sheet and hence both their contribution to risk and their levy. As seen before (see footnote 3), the direction of such change is ambiguous.

Table (4) Correlation between individual contributions to Systemic Risk and Bank Levies

Scenario	Assets-based	Total Regulatory capital	Covered Deposits	Non-Covered Liabilities	Non-covered liabilities + covered deposits
Contagion 8%	0.582***	0.432***	0.503***	0.588***	0.586***
No Contagion 8%	0.878***	0.800***	0.886***	0.850***	0.877***
Contagion 10.5%	0.550***	0.389***	0.461***	0.560***	0.554***
No Contagion 10.5%	0.927***	0.804***	0.901***	0.907***	0.928***
Total Assets	1.000***	0.899***	0.896***	0.994***	0.999***
Risk-weighted assets	0.906***	0.953***	0.872***	0.878***	0.898***
ST Financing ratio	0.102***	0.030	0.046**	0.122***	0.107***
Leverage	0.053	-0.005	0.066***	0.052***	0.058***

*Note: *** significant at the 1% level, ** 5% level, * 10% level.*

6. Conclusions and policy implications

The financial crisis has highlighted the potential contributions of banks, in particular large ones, on systemic risk. Several regulatory measures – among which a strengthening of capital requirements and a funding of Deposit Guarantee Schemes - are currently being implemented to minimise this risk and its consequences for both public finances and economic growth, in particular given the possibility of contagion of failing banks to other financial institutions.

At the same time, several options on how to increase the contribution of the financial sector to the cost of the crisis have been at the political agenda. One of the possible desired features of such a tax could be its ability to curb risk and/or to be in relation with the risk posed by individual institutions to the whole financial system. The possibility to introduce a bank levy or a Financial Activities Tax (FAT), in their various versions, has been recently discussed by the IMF and the European Commission.

This paper uses the SYMBOL model to estimate the contribution of each bank to systemic losses under alternative scenarios of capital requirements and (absence of) contagion. In parallel, we compute bank levies and FATs liabilities for individual banks under several alternative designs of the taxes and look at correlations between those liabilities and individual contributions to systemic risk. Of the three alternative designs of the FAT, the broader version (FAT1) is found to be the one that would be best correlated with individual risk under all scenarios of regulatory capital and contagion. This correlation is highest when contagion is contained and capital requirement increased. This is mainly due to the fact that FAT1 is the design that is best correlated with the size of the institution which appears to be a major determinant of its impact on aggregate risk, the more so the higher the level of capital requirements. In the presence of contagion, bank levies display comparable correlations to individual banks' risk as do FATs. When contagion is contained, however, bank levies outperform FATs and display very high correlation to individual contributions to systemic risk. In particular, broad-based bank levies – thanks to their own correlation with banks' size – work particularly well.

As reported in this paper, the absence of contagion is a prime determinant for decreasing the probability of losses, while increasing regulatory capital also provides an additional security, the more so if contagion cannot be contained. Measures to avoid contagion are therefore of a prime importance, such as for example the presence of resolution funds. While any tax or government transfer could in principle finance those funds, the possibility of a tax that decreases individual contributions to systemic risk and/or is correlated with it could be of interest.

The effects of taxes on individual contributions to systemic risks are however beyond the scope of this paper as the current version of the SYMBOL model does not account for dynamic effects, which are left for future developments. Generally, well-designed bank levies could possibly play an interesting role in creating disincentives to leverage and, possibly, the size of financial institutions. A FAT could also in theory reduce the size of financial institutions to the extent that the tax is passed through into higher prices for financial services and that the demand for these services is sufficiently elastic. The pass-through into higher prices is more likely under the broader design of the FAT because for the same rate the tax would be higher but also because smaller designs of the FAT would increasingly target the economic rent and not the normal profit. A FAT would however normally have little effect on leverage.

In the absence of contagion, systemic risk is very much linked to the relative size of financial institutions. Hence, bank levies whose design would be linked to the size of the institutions could be a logical choice as taxes that charge financial institutions in relation to their contribution to systemic risk.

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ANNEX: Description of the sample of banks for the SYMBOL simulations

Table A.1*: Description of the samples used for the simulations, data as of end 2009*[23].

	Number G1 Banks	Number G2 Banks	Sample % Population[24]	Total Assets (m€)	Total Liabilities (m€)	Total Interbank Debt[25] (m€)	Total Interbank Credit[26] (m€)	Total Covered Deposits(+) (m€)	Total Capital Requirements (8% RWA) (m€)	Total Capital (m€)	DGS/RF funds[27] (+) (m€)
BE	3	20	82.26%	878,336	829,934	184,888	160,678	260,890	23,413	48,401	2,516
BG(*)	0	24	94.77%	34,383	29,614	6,521	6,521	14,074	2,239	4,769	223
DK	3	96	71.05%	756,678	708,878	143,362	92,279	118,179	23,749	47,800	2,168
DE	6	1,476	64.19%	4,648,331	4,415,620	1,086,016	790,975	1,093,841	125,452	232,711	20,096
GR	3	13	71.42%	322,714	295,667	43,441	20,313	135,758	16,781	27,047	1,511
ES	8	135	73.95%	2,370,807	2,188,636	348,780	226,113	542,332	115,565	182,171	7,874
FR	17	178	102.59%	7,191,608	6,817,107	842,666	779,727	1,550,504	245,024	374,500	22,850
IE(*)	5	19	101.91%	1,221,181	1,155,789	276,738	148,729	147,145	44,121	65,392	3,488
IT	8	465	81.81%	2,827,051	2,556,174	188,375	195,958	476,963	97,416	270,876	7,816
CY (*)	0	15	80.80%	107,446	100,436	53,067	53,067	22,661	4,883	7,011	537
LV(*)	0	21	72.65%	19,088	17,037	5,943	2,609	3,995	1,127	2,050	58
LU	1	55	68.35%	465,539	441,916	169,984	161,827	103,441	11,485	23,622	1,321
MT	0	10	43.83%	18,076	16,225	5,222	2,689	6,893	760	1,851	58
NL	4	17	78.02%	1,680,455	1,600,687	319,699	398,659	314,059	46,903	79,768	5,091
AT	1	172	29.88%	306,457	282,380	50,382	39,692	71,381	14,656	24,077	860
PT	3	11	66.49%	323,762	297,421	43,561	34,505	82,952	17,704	26,342	1,121
FI	1	8	78.36%	290,500	275,621	54,361	79,820	48,998	7,968	14,879	1,024
SE	3	63	52.37%	455,355	422,301	97,604	122,872	75,383	16,356	33,054	1,314
UK	7	78	73.97%	4,278,074	4,074,946	743,978	691,049	464,241	110,757	203,129	12,313

Notes: (*) Source is Central Bank or Supervisory Authority; (+) Estimated.

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[23] Year 2009 is the latest year available in *Bankscope* and, even more importantly, 2009 is the year on which the Basel and the CEBS committee have based their Quantitative Impact Study exercises for the foreseen change on banks' capital and RWA when moving from Basel II to Basel III.

[24] The sample of banks covered in each Member States represents the indicated percentage of total assets for any Member State as shown for 2009 in the 2010 ECB EU banking structures publication, computed as the amount of total assets for all banks minus total assets of branches from abroad. European Central Bank (2010a)

[25] A correction factor for the volume of the interbank debt/credit has been applied to the following MS, to correct for the inclusion of some classes of debts certificates: GR (56.5%), FR (39.1%), IT (26.9%), LU (79.8%), and AT (48.4%). The correction factors employed have been estimated using the 2010 ECB *Banking Sector Stability*, Table 11a.

[26] Data on interbank credits was not available for BG and CY so equality of interbank debits and credits has been assumed.

[27] The amount of funds for DGS/RF purposes is rescaled on the size of the sample (column 3).

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