The Burden of Bank Supervision

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Abstract

We use the announcement of the centralization of banking supervision in Europe, which applied to institutions above a size threshold, to document the shadow cost of banking supervision. We first show that expectations of stricter supervision drove banks' actions. This has a cost for borrowers as these banks significantly rationed their lending relative to banks in the control group. We then calculate a back-of-the-envelope shadow cost of supervision in the eyes of banks.

Keywords: Banks, bank supervision, credit rationing

JEL Classification: G21, G28

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Non Technical Summary

Banking supervisors are responsible for mitigating the likelihood and severity of banking crises. These are crucial tasks as banking crises tend to be followed by protracted economic recoveries, have large fiscal costs, and, at times, lead to political unrest. In this paper we analyze the impact of expectations on the effectiveness of banking supervision. There are good reasons to assume that banks' expectations about how strictly their supervisor would conduct their tasks would impact on the effectiveness of supervisors. In fact, expectations play a central role influencing the actions of economic agents and are, therefore, instrumental in determining the outcomes of many policy interventions. For instance, it is well established that monetary policy—another major policy intervention—works largely by shaping expectations. How important are expectations for the workings of supervision? Would banks modify their action if their supervisory burden was expected to increase? If this was the case, one can, in principle, calculate how much banks are willing to forsake, say in profits or growth opportunities, to avoid this perceived heavier burden of supervision. One can also have an estimation of how these changes in banks' behavior impact on other policy objectives, such as the transmission of credit to the economy, so that trade-offs can be considered. Answering these questions is, in a nutshell, the objective of this paper. The announcement of the centralization of banking supervision in Europe provides a good setting to analyze how banks react to the prospect of having a new supervisor. Crucially this new supervisor, the European Central Bank (ECB), was expected to impose a heavier supervisory burden for certain banks. The assignment of banks to supervisors depended on the size of the banks' assets; those with assets above a size threshold were to be supervised by the ECB, and those below would continue to be supervised by their National competent authorities as before. We exploit this unexpected event to measure the burden of supervision as perceived by the banks. We document that in expectation of a heavier burden of supervision banks close to the threshold reduced their size and this decline led to credit rationing. We also provide an stylized calculation of the burden of supervision as perceived by the banks. Overall, our analysis sheds light on how expectations about banking supervision can affect bank decision making.

1 Introduction

The inherent fragility of the financial system—subject to runs, contagion, and fire sales—and the practical inability of most bank creditors to comprehend the risk undertaken by financial institutions give rise to supervision. Banking supervisors are the main agents responsible for mitigating the likelihood and severity of banking crises. This is a crucial task as banking crises tend to be followed by protracted economic recoveries, large fiscal costs, and even political unrest (Pennacchi, 2005; Doerr, Gissler, and Peydro, 2019; Thakor, 2021).

While banking supervision primary aims at promoting the safety and soundness of banks (Pennacchi, 2006; Bank for International Settlements, 2012), individual banks do not necessarily internalize the benefits of supervision (Dewatripont and Tirole, 1995; Karolyi and Taboada, 2015). In practice, the strictness of supervision varies across banks because of resource scarcity, bank complexity, or political pressures (Kroszner and Strahan, 1996; Brown and Dinç, 2005; Cetorelli, 2014; Hirtle, Kovner, and Plosser, 2020). As a result, some supervisors are stricter than others (Rosen, 2003; Agarwal, Lucca, Seru, and Trebbi, 2014); therefore, banks probably adjust their behavior as a response to heterogeneity in supervision scrutiny.

In this paper, we consider the burden, or shadow cost, that stricter supervision has for banks and borrowers. We first see whether supervision really "bites" in the sense of significantly altering banks' actions. We then show whether these actions impose a burden (or cost) for banks' borrowers, especially in terms of credit supply restrictions. Finally, we provide a back-of-the-envelope estimation of the price banks willing to pay to evade a more demanding supervisor.

The announcement of the centralization of banking supervision in Europe [Single Supervisory Mechanism (SSM) under the leadership of the European Central Bank (ECB)][1]

[1] As the ECB hosts the SSM, we interchangeably use SSM and ECB in this paper.

provides a good setting to our aims.[2] In December 2012, the ECB announced that banks with assets above €30bn would be classified as "*significant*" and fall under the direct supervision of a supranational institution (the ECB), whereas smaller banks would be considered *"less significant"* and remain under the direct supervision of their national authorities [National Competent Authorities (NCAs)].[3] From the outset, the ECB publicly recognized that *significant banks* would be subjected to higher supervisory standards,[4] *de facto* creating two separated supervisory strands in European banking. On one side, there are banks with size above €30bn subject to greater supervisory scrutiny. On the other, there are those with size below €30bn. They benefit from a lighter supervisory burden but, in this setting, might have growth constraints over time linked to the threshold. The timing of the announcement allowed some banks to choose among these two segments. Specifically, the criteria for classifying banks as *significant* were already announced by the end of 2012, but the SSM implementation was based on banks' size as of the end of 2013. Thus, banks close to the €30bn asset had sufficient time (one year) to take actions to alter their size. We call this period of time, which broadly coincides with 2013, the *interim* period.

Our analysis consists of three parts. In the first part, we address whether a higher burden of supervision alters banks' behavior. Here, we consider whether some banks would shrink their size. In particular, we explore whether some banks around the €30bn threshold shrank their balance sheets to avoid ECB's heavier burden of supervision. First in a difference-in-differences (DID) framework, we compare banks around the size threshold (treated) with similar banks away from the threshold (control). We show that, in years leading up to the announcement, banks in the treatment and control groups had statistically indistinguishable characteristics. However, during the interim period, i.e., in 2013, banks above but close to

[2]The shock was largely unexpected. Many countries fiercely resisted surrendering bank supervision to a multinational institution; hence, the outcome of the negotiation was ex ante uncertain, and its outcome was reflected on significant movements in financial asset prices (Fiordelisi, Ricci, and Stentella-Lopes, 2017).

[3]In the context of the United States, Gopalan, Kalda, and Manela (2017) discuss the trade-offs between local and centralized supervision.

[4]In her first regular public hearing at the Committee on Economic and Monetary Affairs of the European Parliament (Brussels, March 18, 2014), Danièle Nouy, first chair of the ECB's supervisory arm, immediately clarified that the ECB will be a rigorous supervisor and would accurately measure banks' risks.

the threshold (in the €30–50bn size range) significantly reduced their size relative to the control group.

Do banks' actions to evade a stricter supervisor also impose a burden or cost for borrowers? In the second part of the paper, we show that banks around the supervisory threshold registered a substantial decline in loan growth relative to the control group. We use a confidential dataset comprising *all* corporate loans outstanding to assess whether this decline was due to constraints on banks' supply of credit. As in Khwaja and Mian (2008), we concentrate on borrowers with multiple lending relationships in which the same borrower obtained loans from two or more banks, where (at least) one bank is in the treatment (close to the threshold) *and* and at least one bank is in the control. We find that banks closer to the threshold were more likely to restrict the credit to *the same* borrower by around 10%, and up to 18% for micro-firms. This reinforces the idea that banks' asset reductions stem from the supply side (initiated by banks), as opposed to an unobserved demand shock.

In the third part of the paper, we provide a stylized estimation of the cost that banks are willing to pay to avoid a stricter supervision. We test whether banks close to the supervisory threshold obtained lower profits than similar banks above the threshold after the start of the SSM (2014–2018). We show that banks below the threshold (in the €15–30bn band) that obtained lower profits than the control because of missing new business opportunities is not offset by the lower cost of supervision. We provide a back-of-the-envelope estimation of the burden of supervision, calculated as the gap between potential profits that banks just below the threshold could have made after the SSM started its functioning, and their actual profits. In other words, we estimate the costs incurred by the banks subject to growth constraints due to the cutoff and quantify the cost of supervision in terms of "missing profits" between 2014 and 2018. During this period, these banks could have generated more net income had they had grown as similar banks with no growth constraints. We buttress the robustness of these results adopting a different estimation method (elastic net approach) and an alternative control group (only banks from euro area countries).

Our paper relates to the literature that analyzes the impact of regulation on bank behavior (Plosser and Santos, 2018; Manela and Kisin, 2016), lending (Hao, Nandy, and Roberts, 2012; Carlson, Shan, and Warusawitharana, 2013; Ongena, Popov, and Udell, 2013; Agarwal et al., 2014; Demyanyk and Loutskina, 2016; Bindal, Bouwman, Hu, and Johnson, 2020), risk-taking (Harris and Raviv, 2014), equity issuance (Dinger and Vallascas, 2016), economic growth (Kroszner and Strahan, 1996; Berger and Hannan, 1998), mergers and acquisitions (Karolyi and Taboada, 2015), banking competition (Calderon and Schaeck, 2016), and financial sector development (Barth, Caprio, and Levine, 2004). The literature analyzing the effectiveness of supervision is less developed. Since the 2007–2009 financial crisis, a growing body of research studies the incentives of banking supervisors. In addition to evidence from Agarwal et al. (2014), described above, showing that different supervisors exercise different levels of supervisory intensity, other research suggests that supervisory strength impacts on bank performance and economic activity (Granja and Leuz, 2017; Fiordelisi et al., 2017) and on borrowing conditions in the syndicated loan market (Ivanov, Ranish, and Wang, 2000) and that supervisors can compete with one another by giving new clients (i.e., banks) better supervisory ratings (Rezende, 2014).

Our paper provides policy makers with new important insights. First, we show how an increase in the expected burden of supervision impacts on banks' actions. Second, we document that the identity and credibility of the supervisor is important to banks and that they are willing to take actions to influence the outcome. We also illustrate how these actions have a material impact on borrowers' access to credit. We also develop a stylized metric to measure the costs of those actions for banks and show that they can be considerable.

The remainder of the paper is structured as follows: First, we summarize the centralization of banking supervision in the euro area that provides us with a quasi-natural experiment setting (Section 2) and describe our data (Section 3). Second, we analyze whether expectations of a tougher supervisor led banks to alter their actions (Section 4). Then, we investigate the actions banks near the threshold took and their impact on credit to borrowers (Section 5).

We also provide a simplified estimation of the cost supervision (Section 6). Finally, we draw our conclusions in Section 7.

2 The Single Supervisory Mechanism (SSM)

On December 14, 2012, the European Council agreed to the creation of a new supranational supervisor for euro area banks [i.e., the Single Supervisor Mechanism (SSM) hosted by the ECB] and spelled out the criteria that would be used to identify those banks subject to the supervision of the ECB's supervisory arm (ECOFIN, 2012).[5] By the end of 2013, banks operating in the euro area would be classified as *significant* if the value of their total assets exceeded €30bn or 20% of the national GDP[6], The centralization of banking supervision involved the euro area countries, but banks from EU countries not belonging to the euro were not included.[7]

Banks had strong reasons to expect that the launch of the SSM would lead to a heavier supervisory burden. First, the main motivation for establishing a supranational authority was to implement stricter supervisory standards, and from the beginning, the ECB's supervisory arm strategic directions pointed to more stringent supervision including a sounder capital base and reducing credit risks. In fact, the first stated priority of the new supervisor was to rebuild confidence in the banking sector and address its weaknesses (Draghi, 2014). ECB bank supervision thus involved an unprecedented level of scrutiny.

Second, banks could anticipate that local supervisors would be easier to negotiate with— because of cultural familiarity and/or political influence— than a supranational supervisor. The latter would be more remote geographically, institutionally, and culturally than national

[5]The European Council includes the heads of state of the EU member states, the European Council president, and the president of the European Commission. The creation of the SSM was meant to overcome the limits of fragmented nationally based banking supervision (see Beck, 2016, for a review).

[6]There were two other additional criteria: a) if the bank was one of the three largest institutions established in a member state or (b) the ratio of its cross-border liabilities in more than one other participating member state to its total assets was above 20%. In practice, these latter criteria were applicable to only a few institutions at the time.

[7]Bulgaria, Croatia, the Czech Republic, Denmark, Hungary, Poland, Romania, Sweden, and the United Kingdom.

supervisors. In this direction, there is evidence from the United States showing that switching from a local (state) to a central (federal) supervisor leads to tougher supervision, suggesting that geographic proximity between banks and its supervisor is associated with more lenient supervision (Agarwal et al., 2014).

Third, large banks are complex organizations; thus, efficiencies of scale and scope arise when supervision is conducted by a single larger organization that is technically better prepared. The ECB indeed quickly ramped up its supervisory expertise ahead of the transition, and by 2014, 1,070 new staff had already been hired through a competitive process. In practice, the supervision of each significant bank is entrusted to a supervisory team, led by the ECB, which is ultimately responsible for its supervision. It performs its supervisory reviews and evaluations, conducts any additional supervisory examinations, and undertakes supervisory decisions. Supervisory teams have a pan-European perspective and a multinational staff. They are generally directed by a person of a different nationality than that of the supervised bank.

Not surprisingly, banks realized that the interim period or time lag between the announcement of the criteria and their implementation could potentially be used to avoid stricter supervision. Specifically, the €30bn asset size threshold was publicly disclosed by the end of 2012. Yet, the positioning of banks in relation to the threshold would be measured using banks' financial statements only as of the end of 2013—i.e., one year after the announcement but prior to the transition in supervisory responsibilities, which eventually took place on November 4, 2014.

3 Data

We use two main types of data with two distinct levels of aggregation: bank-level data (balance sheet) and loan-level data. We first collect publicly available annual information

from banks' financial statements from the BankScope and BankFocus databases.[8] Our original sample comprises all banks that have a consolidated balance sheet available and are headquartered in the European Union as follows: (a) banks in the euro area countries from its earliest stages[9] (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain) and (b) in Europe, but outside the SSM (Czech Republic, Denmark, Poland, Sweden, and the United Kingdom). To ensure comparability, we exclude banks nationalized after the recent financial crisis, non-depository financial institutions,[10] banks classified as *significant* by the ECB according to criteria other than the €30bn threshold[11], and very small (Total Assets <€7bn) and very large (total assets > €100bn) banks.

We supplement the annual financial statements from BankScope and BankFocus with additional information for some balance sheet items available at *monthly* frequency from a regulatory confidential dataset named iBSI. This dataset reports several asset and liability items for more than 300 banks located in the euro area from July 2007 onward. Banks are legally obliged to report these data items to the ECB.

We also use loan-level information from a confidential dataset collected by the ECB and labeled as Pre-AnaCredit hereafter. This new database aims to aggregate and harmonize information from existing national credit registers and provides information on the exposure of *each* bank to *each* nonfinancial corporate borrower.

Table 1 presents summary statistics of our main datasets. Panel A reports the descriptive statistics for the bank-level data of the main variables used in the empirical analysis run in

[8]Both databases are managed by Bureau van Dijk. BankScope collected data up to 2014; BankFocus started collecting data in 2011. As such, we use BankScope data up to 2014 and matched data from BankFocus after 2014.

[9]We exclude banks from Luxembourg since their business model substantially differs from euro area banks.

[10]We exclude securities firms, group finance companies, investment and trust corporations, clearing institutions, custodians, subsidiaries of non-European banks, bank controlled by non-European banks, and investment banks. We also exclude financial institutions that, although classified as commercial banks, have customer deposits lower than 1% of their total assets. None of our results are qualitatively affected by including these banks in our analysis.

[11]We exclude two banks from Austria, one from Belgium, and one from Finland.

sections 4 and 5 by distinguishing the groups used in our empirical analyzes as treatment and control. Not surprisingly, the number of observations in each group declines as the asset size band increases. In Panel B, we present the summary statistics of the loan data. The average loan amount per borrower with a given bank at the end of 2013 is €0.84m, with a mean increase of 9.9% between 2012 and 2013. The distribution is highly asymmetrical. The median value for the borrower loan amount is €0.93 million, with a median growth rate of −5.8%. In Panel C, we report the summary statistics for the bank-level data of the main variables used in section 6 to estimate the burden of supervision after the SSM starts.

Appendix A describes the variables used in our empirical analysis.

Table 1. Summary Statistics

Table 1 reports summary statistics for three datasets used in the paper. Panel A reports statistics for the bank-level data (collected from BankScope) of the main variables used to investigate banks' reaction to the announcement of the SSM. Panel B reports statistics for the loan-level data (Pre-AnaCredit database) used to investigate the burden of supervision on borrowers. Panel C reports statistics for the bank-level data (collected from BankFocus) of the main variables used to estimate the burden of supervision on banks. All variables are described in Appendix A. Growth rates and ratios are winsorized at the 1% and 99%. All variables are in percentages unless specified otherwise. bn and K stand for billions and thousands or euro, respectively.

Panel A: Bank Level (2010–2013)

	Banks "below" the threshold (€15–30bn asset range)						Control group for banks "below"the threshold (€7–15bn asset range)					
	N	Mean	SD	p1	p50	p99	N	Mean	SD	p1	p50	p99
Asset Growth	142	0.014	0.093	-0.276	0.020	0.283	221	0.027	0.086	-0.224	0.024	0.274
Bank Deposit Growth	142	0.021	0.257	-0.363	0.005	0.754	221	0.073	0.280	-0.363	0.012	0.754
Customer Deposit Growth	142	0.053	0.077	-0.061	0.038	0.206	221	0.053	0.072	-0.061	0.047	0.206
Deposit Ratio	142	0.401	0.186	0.027	0.318	0.711	221	0.399	0.186	0.016	0.341	0.748
Derivative Ratio	142	0.023	0.040	0.000	0.007	0.149	221	0.015	0.025	0.000	0.006	0.145
Equity Growth	142	0.049	0.157	-0.470	0.052	1.008	221	0.050	0.122	-0.410	0.055	0.505
Equity Ratio	142	0.088	0.034	0.023	0.080	0.161	221	0.100	0.041	0.032	0.099	0.245
Intangible Asset Ratio	142	0.003	0.006	0.000	0.001	0.029	221	0.004	0.008	0.000	0.000	0.041
Loan Growth	142	0.010	0.097	-0.356	0.018	0.306	221	0.027	0.082	-0.120	0.019	0.347
Loan Ratio	142	0.733	0.188	0.189	0.771	1.042	221	0.767	0.167	0.190	0.800	1.074
NPL Ratio	142	0.032	0.026	0.006	0.024	0.109	221	0.040	0.034	0.003	0.030	0.167
Nonearning Asset Growth	142	0.075	0.247	-0.311	0.043	0.559	221	0.052	0.233	-0.311	0.025	0.559
Other Earning Asset Growth	142	0.062	0.197	-0.213	0.037	0.470	221	0.064	0.191	-0.213	0.040	0.470
ROA	142	0.004	0.009	-0.032	0.005	0.019	221	0.005	0.009	-0.028	0.006	0.026
Total Assets (€bn)	142	19.457	5.357	11.697	17.648	40.135	221	10.065	2.482	5.140	9.707	15.104

	Banks "above" the threshold (€30–50bn asset range)						Control group for banks "above" the threshold (€50–100bn asset range)					
	N	Mean	SD	p1	p50	p99	N	Mean	SD	p1	p50	p99
Asset Growth	134	0.035	0.133	-0.353	0.019	0.546	121	0.017	0.101	-0.231	0.004	0.307
Bank Deposit Growth	134	0.061	0.351	-0.363	-0.004	0.754	121	0.039	0.325	-0.363	-0.040	0.754
Customer Deposit Growth	134	0.053	0.083	-0.061	0.034	0.206	121	0.058	0.086	-0.061	0.044	0.206
Deposit Ratio	134	0.418	0.195	0.052	0.401	0.841	121	0.413	0.171	0.013	0.449	0.701
Derivative Ratio	134	0.030	0.033	0.000	0.017	0.155	121	0.023	0.023	0.001	0.015	0.112
Equity Growth	134	0.060	0.213	-0.472	0.049	1.028	121	0.022	0.218	-0.472	0.030	0.931
Equity Ratio	134	0.075	0.063	0.016	0.064	0.195	121	0.060	0.026	0.004	0.058	0.114
Intangible Asset Ratio	134	0.007	0.012	0.000	0.001	0.042	121	0.007	0.008	0.000	0.003	0.034
Loan Growth	134	0.026	0.121	-0.356	0.026	0.462	121	0.005	0.107	-0.267	0.000	0.312
Loan Ratio	134	0.655	0.205	0.242	0.682	1.074	121	0.714	0.203	0.257	0.781	0.969
NPL Ratio	134	0.048	0.075	0.002	0.029	0.339	121	0.041	0.044	0.004	0.028	0.205
Nonearning Asset Growth	134	0.072	0.276	-0.311	0.029	0.559	121	0.080	0.246	-0.311	0.095	0.559
Other Earning Asset Growth	134	0.069	0.219	-0.213	0.041	0.470	121	0.076	0.203	-0.213	0.046	0.470
ROA	134	0.000	0.014	-0.049	0.003	0.014	121	0.000	0.011	-0.049	0.002	0.028
Total Assets (€bn)	134	37.066	7.989	12.747	37.139	52.762	121	73.857	18.544	47.272	74.043	109.427

Panel B: Loan Level (end 2013)

Banks with total Loans to Nonfinancial Corporations (L-NFC) in the €2.0–8.0bn range	Obs	Mean	SD.	p25	p50	p75
Loan-Level Exposure (LLE) in (€k)	946,545	840.633	24,804.26	33.810	93.230	286.230

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Table 1. Summary Statistics (Cont.)

Panel C: Bank-level data (2011-2018)

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	Banks "below" the threshold (€15-30bn asset range)						Control group for banks "below" the threshold (€7–15bn asset range)					
	N	Mean	SD	p25	p50	p75	N	Mean	SD	p25	p50	p75
After-Tax Return on Assets	113	0.517	0.588	0.306	0.677	0.856	424	0.535	1.288	0.161	0.472	0.932
Derivative Ratio	113	0.037	0.067	0.005	0.012	0.037	424	0.019	0.041	0.002	0.007	0.019
Equity Ratio	113	0.098	0.030	0.067	0.099	0.123	424	0.092	0.042	0.061	0.083	0.122
Intangible Asset Ratio	113	0.002	0.004	0.000	0.000	0.003	424	0.004	0.008	0.000	0.001	0.005
Loan Ratio	113	0.682	0.195	0.660	0.744	0.788	424	0.635	0.218	0.538	0.699	0.782
Nonoperating income ratio	113	0.003	0.134	0.000	0.001	0.010	424	0.011	0.136	-0.002	0.000	0.012
NPL Ratio	113	0.003	0.004	0.001	0.001	0.003	424	0.005	0.010	0.000	0.002	0.006
Operating Income Ratio	113	0.733	0.693	0.408	0.914	1.182	424	0.777	1.393	0.261	0.621	1.258
Pre-Tax Return on Assets	113	0.736	0.723	0.397	0.935	1.211	424	0.791	1.422	0.268	0.639	1.321
Total Assets (in bn)	113	21.955	5.288	18.209	20.512	25.571	424	11.061	4.676	8.582	10.226	13.152

	Banks "above" the threshold Banks in the asset range €30–50bn						Control group for banks "above" the threshold Banks in the asset range €50–100bn					
	N	Mean	SD	p25	p50	p75	N	Mean	SD	p25	p50	p75
After-Tax Return on Assets	283	0.444	0.753	0.184	0.392	0.782	126	0.007	1.327	0.035	0.301	0.513
Derivative Ratio	283	0.030	0.037	0.006	0.015	0.046	126	0.036	0.064	0.009	0.014	0.034
Equity Ratio	283	0.075	0.029	0.056	0.068	0.095	126	0.063	0.027	0.045	0.062	0.080
Intangible Asset Ratio	283	0.003	0.005	0.000	0.001	0.004	126	0.005	0.006	0.001	0.003	0.008
Loan Ratio	283	0.592	0.205	0.495	0.635	0.738	126	0.658	0.186	0.520	0.707	0.819
Nonoperating Income Ratio	283	0.023	0.264	-0.002	0.002	0.044	126	-0.010	0.161	-0.006	0.002	0.025
NPL ratio	283	0.003	0.005	0.000	0.002	0.003	126	0.007	0.010	0.000	0.003	0.011
Operating Income Ratio	283	0.538	0.815	0.256	0.500	0.876	126	-0.010	1.451	0.024	0.345	0.681
Pre-Tax Return on Assets	283	0.562	0.961	0.278	0.553	0.996	126	-0.009	1.478	0.016	0.353	0.694
Total Assets (in bn)	283	41.735	11.777	34.385	39.569	46.266	126	73.649	22.880	59.982	71.979	82.007

4 Does supervision intensity alter banks' behavior?

Here, we first test whether the announcement of a new stricter supervisor led to a substantial change in banks' actions. The stricter supervision by the ECB has not only its costs but also advantages for banks. On the one side, *significant banks* (i.e., supervised by the ECB) have to bear higher supervisory costs but are more free to grow and benefit from better supervisory reputation. Conversely, *less-significant banks* (under NCAs' direct supervision) have lower supervisory costs but might be constrained to grow above €30bn in total assets and may not exploit profitable business opportunities. In this section, we explore whether, in expectation of a tougher supervisor, some banks (those around the €30bn threshold) changed their size away from the threshold.

4.1 Identification strategy

We assess the anticipated effect of the SSM on banks in a treatment-control framework. We argue that the announcement at the end of 2012 caused a dilemma for banks around the €30bn threshold. The burden of ECB supervision was perceived to be heavier and to impose higher costs on banks above the cutoff. Also, the cost of avoiding ECB supervision is likely to increase with total assets: Shrinking a bank's balance sheet by €5bn is arguably easier than shrinking it by €20bn or €40bn.

We argue that the announcement at the end of 2012 caused a dilemma for banks around the €30bn threshold. As the burden of ECB's supervision was perceived to be heavier, it imposed higher costs on banks above the cutoff. At the same time, the cost of avoiding ECB's supervision is likely to increase with total assets: Shrinking a bank's balance sheet by €5bn is arguably easier than shrinking it by €20bn or €40bn particularly in a highly scrutinized setting such the creation of a new supervisor. Accordingly, for a bank, the chance of being caught artificially manipulating its size is likely to be higher for those banks farther away from the threshold: a bank close to the threshold whose assets shrink might simply

be seen as having a bad year. Conversely, a large bank dramatically shrinking its assets to a level just below the threshold would invite a thorough investigation and closer scrutiny. Thus, we can think about the 2012 announcement as imposing tighter supervision on banks with assets greater than €30bn and at the same time providing different incentives across banks to avoid this supervision. Our identifying assumption is that the incentive to avoid supervision depends on a bank's distance from the threshold.

As we do not observe the cost-benefit calculation that banks perform with respect to actively shrinking their size, we use an intent-to-treat approach (ITT; Angrist, Imbens, and Rubin, 1996) and lump together the banks most likely to actively reduce their size. Specifically, we define as our treatment group two bank groups close to the €30bn threshold. The first includes those just above (i.e., in the €30–50bn asset range) since these banks have the possibility of reducing their size to keep their national supervisor authority rather than the ECB. The second, those below, includes those in the €15–30bn asset range since these can either increase their total assets to select ECB as supervisor or drop their size to keep their NCAs also in the future.[12]

The control group for banks in the €30–50bn asset range includes banks in SSM countries with assets sufficiently away from the threshold (€50–100bn) by the end of 2012. Being sufficiently far away from the threshold, it would have been almost impossible for this banks to change their size to avoid the new supervisor with attracting notoriety and scrutiny.[13]) The comparison of these two groups (i.e., treatment and control above the threshold) after the SSM announcement enables us to verify whether some banks actively aimed to avoid a certain supervisor. Similarly, the control group for the treated banks below the threshold (i.e., in the €15–30bn asset range) includes those with assets below and sufficiently away from the threshold (€7–15bn).

As our identification hinges on distance from the threshold (i.e., intention to treat),

[12]We omitted from the sample those banks classified as *significant* by the ECB based on a criterion different from the total assets, including those that failed or received funding.

[13]Legally, the ECB could unilaterally decide to undertake this scrutiny if warranted.

three considerations on the composition of our treatment and control groups are warranted. First, we progressively proceed. That is, to assess the validity of our assumptions and consistency of our results, the exact composition of the treatment and control groups changes to progressively incorporate more banks further away from the threshold. If the SSM was indeed affecting banks' actions, the results would be stronger (weaker) as the band size of the group of treated banks narrows and gets closer (farther away) to (from) the threshold. Second, we account for the possible impact of bank characteristics as it could be that the distribution of bank characteristics changed around the threshold and had an effect on the intention to treat. For this reason, we incorporate bank-level characteristics with equal weight in the main analysis and in allowing for different weights in the robustness tests. Third, we double-check our statistical assumptions on the composition of the control and treatment groups with opinions from supervisory experts to make them realistic.

We use the following DID specification using data for the years 2010–2013:

$$\begin{aligned} y_{i,t} =& \alpha + \beta_1 \text{I(Close to €30bn)}_{i,2012} + \beta_2 \text{I(Close to €30bn)}_{i,2012} \times \text{I(Year=2013)} + \\ &+ \beta_3 \text{X}_{i,2009} + \gamma_c + \gamma_t + \epsilon_{i,t} \end{aligned} \tag{1}$$

where $y_{i,t}$ is the annual growth rate of total assets and I(Year=2013) is a dummy variable taking a value of 1 if the year is 2013 and 0 otherwise. We run the model (1) twice by dividing the group of treated banks [I(Close to €30bn)=1] into those above (€30–50bn) and those below (€15–30bn) the threshold. The interaction term [I(Close to €30bn) x I(Year=2013)], the main variable of interest, captures the drop in total assets in 2013 for banks in the SSM close to the cutoff at the end of 2012. $\text{X}_{i,2009}$ includes the following series of bank-level control variables as of the end of 2009: total assets, NPL ratio, equity ratio, loan ratio, derivative ratio, intangible asset ratio, and return on assets (ROA). Adding these variables helps toward restoring the randomization conditions by controlling for eventual differences in size, business models, risk-taking, capitalization, profitability, and opacity between banks

in the treatment and control groups,[14]. γ_c and γ_t, on the other hand, are country and time fixed effects, respectively.

4.2 Parallel trends analysis

We begin by testing the parallel trends assumption between the treatment and control groups. Our test compares the growth of various balance sheet items for banks with an incentive to strategically change their size (also labeled "treated") and for those in the control group. We first assess whether, in years prior to the announcement, banks around the threshold are comparable to those in the control. As mentioned, we have two treatment groups: above and below the supervisory cutoff (€30–50bn and €15–30bn, respectively) corresponding to two control groups, including banks with total assets in the €50–100bn and €7–15bn size range, respectively. Table 2 presents the results using difference-in-means estimations prior to the SSM announcement for several key variables. Banks in the control and treatment groups are largely statistically indistinguishable in the run up to the announcement (years 2010–2012).

4.3 Results

We find that, following the announcement, banks close to the €30bn threshold declined their asset growth relative to banks in the control group (Table 3). Specifically, in 2013, banks in the €30–50bn size band declined their asset growth by 7.6%, relative to the control group. This is the average treatment effect of the treated banks, and this provides evidence of the average "shrinking" effect of the SSM announcement on banks just above the €30bn cutoff. In this direction, banks with an asset size in the €15–30bn size band also declined their asset growth by 3.6%, relative to banks in the control group. This suggests that banks just below the threshold were worried about the heavier burden of supervision as the thresholds probably was already working as an "invisible" hurdle dampening bank growth.

[14]We proxy for opacity using intangible assets whose return and valuation is more uncertain.

Table 2. Testing the Parallel Trends Assumptions

Table 2 reports the difference in means between euro area banks in the control and treatment groups prior to the SSM announcement (end of 2012) focusing on various bank characteristics that are likely to be influenced by banks' reaction to the SSM announcement. Column (1) reports the difference in means between banks in the treatment (total assets in the €15–30bn band) and control (total assets in the €7–15bn range) groups. Column (2) reports the difference in means between banks in the treatment (total assets in the €30–50bn band) and control (total assets in the €50–100bn range) groups. All control and treatment groups include only banks in the euro area. The number of treated and control banks is 28 and 44, respectively, in column (1) and 27 and 26, respectively, in column (2). The variable construction is reported in Appendix A. Source of data: BankScope. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

Asset size as of 12/2012:		Difference in means relative to control	
		Below (€15-€30bn)	Above (€30-€50bn)
		(1)	(2)
2010	Asset Growth Rate	-0.023	-0.041
	Loans Growth Rate	0.012	-0.057
	NPL Growth Rate	-0.075	-0.31
	Other Earning Assets	-0.081*	0.054
	Nonearning Asset Growth	-0.042	-0.031
	Customer Deposit Growth	-0.011	0.015
	Bank Deposit Growth	-0.024	-0.216**
	Equity Growth	-0.018	-0.026
	ROA	0.001	0.001
2011	Asset Growth Rate	-0.013	-0.068*
	Loans Growth Rate	0.008	-0.01
	NPL Growth Rate	0.063	0.073
	Other Earning Assets	-0.008	-0.054
	Nonearning Asset Growth	-0.083	0.046
	Customer Deposit Growth	-0.005	-0.024
	Bank Deposit Growth	0.022	-0.009
	Equity Growth	-0.008	-0.035
	ROA	0.000	-0.006
2012	Asset Growth Rate	0.044	-0.025
	Loans Growth Rate	0.026	-0.047
	NPL Growth Rate	-0.169	0.028
	Other Earning Assets	0.025	0.035
	Earning Asset Growth	0.024	-0.014
	Customer Deposit Growth	0.003	-0.035
	Bank Deposit Growth	0.201***	-0.038
	Equity Growth	-0.017	-0.177
	ROA	0.001	-0.003

Our identification implicitly assumes that the incentives to shrink to avoid the new supervisor for banks above the €30bn cutoff depend on their distance to the threshold. As mentioned, at the time of the announcement, the opportunity cost to avoid the SSM increases

Table 3. DID Analysis of Asset Growth Around the Threshold

Table 3 reports the results of our main DID model (1), where the dependent variable is asset growth. The treatment and control groups comprise banks in the euro area around both sides of the €30bn cutoff at the end of 2012. In columns (1) and (2), treated banks [I(Total Assets €15–30bn)=1] are those with total assets in the €15–30bn band as the end of 2012. The control group is composed of banks in the €7–15bn size range. In columns (3) and (4), treated banks fall in the €30–50bn total asset band, and banks in the control group fall in the €50–100bn total asset band. The treatment period [I(Year=2013)=1] is 2013. The coefficients of main interest are the interaction terms [I(Assets €15–30bn) × I(Year = 2013), and I(Assets €30–50bn) × I(Year = 2013)] capturing the effect during 2013 for banks in the SSM close to the cut-off point at the end of 2012. The number of treated banks [I(Total Assets €15–30bn) × I(Year = 2013) = 1] is 28 in columns (1) and (2) and 25 in columns (3) and (4). The variable construction is reported in Appendix A. Standard errors (in parentheses) are robust. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. Source of data: BankScope.

	(1)	(2)	(3)	(4)
I(Total Assets €15–30bn) × I(Year = 2013)	-0.034*	-0.036**		
	(0.020)	(0.017)		
I(Total Assets €15–30bn)	-0.001	0.055***		
	(0.011)	(0.015)		
I(Total Assets €30–50bn) × I(Year = 2013)			-0.075**	-0.076**
			(0.032)	(0.031)
I(Total Assets €30–50bn)			0.053***	-0.059*
			(0.018)	(0.032)
Total Assets (2009)		-0.096***		-0.138***
		(0.023)		(0.040)
NPL Ratio (2009)		-0.078***		-0.241
		(0.217)		(0.705)
Equity Ratio (2009)		-0.256		0.265
		(0.186)		(0.295)
Loan Ratio (2009)		0.006		-0.068*
		(0.045)		(0.037)
Derivative Ratio (2009)		-0.289		0.064
		(0.261)		(0.482)
Intangible Asset Ratio (2009)		1.923***		-0.299
		(0.736)		(0.826)
ROA (2009)		1.050		1.524
		(0.798)		(1.331)
Observations	363	363	255	255
R-squared	0.173	0.358	0.212	0.324
Time effects	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes

with distance. For a very large bank, say of €60bn, reducing its size to below the threshold without drawing unwanted scrutiny from supervisors would be almost impossible. Hence, as a first robustness test, we check the consistency of our results running our model (1) several times, augmenting our treatment group by increasing the band of bank size, thereby

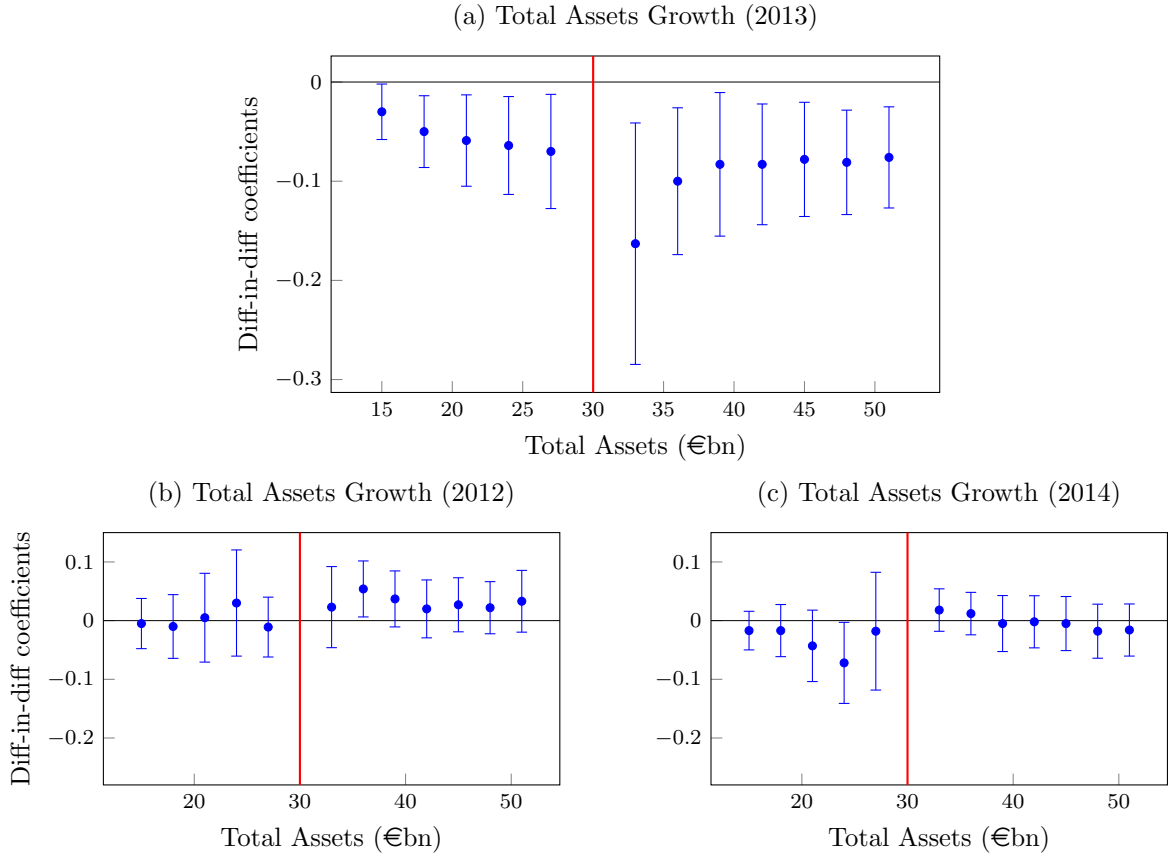
progressively incorporating also banks further away from the threshold. The objective is to check if banks close to the threshold (with the greater incentive to avoid ECB's supervision) have stronger incentives to shrink their size (i.e., strategically behave). That is, we progressively increase the number of banks treated with increments in bank size of €3bn: Specifically, I(Close to €30bn) is a dummy variable taking a value of 1 for banks with total assets at the end of 2012 within the €30bn–€$(30 + h)$bn (with h being the interval width) size band and 0 for banks in the control group. In the first analysis, treated banks are those with total assets at the end of 2012 of €30–33bn. The second group includes those banks with total assets within the €30–36bn size band and so on. We perform a similar procedure below the threshold (graphically to the left of the threshold). That is, the first treated group comprises banks with total assets of €27–30bn in 2012; the second group includes banks in the €24–30bn range and so on.

We plot the coefficients from these regressions (Figure 1, Panel a). In 2013, banks with total assets ranging from €30 to 51bn, as of 2012, exhibit lower asset growth relative to the control group: The asset drop is greater for banks closer to the €30bn threshold: -16.3% for banks in the €30–33bn size band and -10.0% for banks in the €30–36bn range. It stabilizes around 7.6% for banks in the €30–50bn range. This confirms that banks closer to the ECB threshold have a stronger incentive to avoid the ECB, and this effect declines as bank size increases. For banks below the ECB threshold, we observe a symmetrically similar path: Banks closer to the threshold (€27–30bn size band) drop their assets relative to those in the control group (by -7.0%) while the effect stabilizes to -3.0% in the €15–30bn range, as the number of banks in the treated group increases and includes more banks further away from the threshold.

It can be argued that the decline in size found above is in part due to a "cleanup" operation by all banks above the threshold trying to reduce their credit risk exposure in expectation of a stricter supervisor. This cleanup effect latter would also lead to a drop in assets in 2013 and would also be part of banks' response to the heavier burden of supervision.

Figure 1. DID Analysis of Asset Growth Around the Threshold

Figure 3 reports the graphical representation of the coefficient estimates for the interaction term [I(Close to €30bn) × I(Year = 2013)] in our main DID Model (1). The dependent variable is asset growth. The treatment groups comprise banks in SSM countries around both sides of the €30bn cutoff at the end of 2012. On the right side of the cutoff point, we run a series of DID models by increasing assets (in the first regression, the treated banks are those in the €30–33bn size band in 2012; the second group includes treated banks that fall within the €30–36bn size band and so forth). Similarly, on the left side of the €30bn cutoff, we run a series of DID models by progressively decreasing assets (in the first regression, treated banks are those that fall within the €27–30bn size band in 2012; in the second group, treated banks are those in the €24–30bn size band and so forth). In Panel (a) to the left of the cutoff, the number of treated banks in 2013 ranges from 7 in the €27–30bn size band to 28 in the €15–30bn size band. To the right of the cutoff, the number of treated banks in 2013 increases from 3 in the €30–33bn size band to 25 in the €30–51bn size band. The treatment period is 2013 in Panel (a), 2012 in Panel (b), and 2014 in Panel (c). In all panels, the control group is composed of the following: For treated banks below the €30bn threshold, the control group is composed of banks in SSM countries with total assets in the €7–15bn range; for treated banks above the €30bn threshold, the control group is composed of banks in SSM countries with total assets in the €50–100bn range. We control for total assets, NPL ratio, equity capital ratio, loan ratio, derivative ratio, intangible asset ratio, and ROA as of the end of 2009. Standard errors are robust. The confidence intervals represent 90% level. Source of data: BankScope.



However, it would affect not only banks close to the threshold but also all banks above €30bn in total assets, leading to an underestimation of the effect of the burden of supervision on

bank size in our previous estimations. One could also aim to capture only the part of the decline in size due to the threshold and call this "avoidance." To do this, we select banks in the treatment and control groups so that they are necessarily under the supervision of the same authority. Specifically, the control for banks in the €30–50bn asset range includes SSM banks with assets above and sufficiently away from the threshold (€50–100bn) by the end of 2012. Being too large, these banks did not reasonably attempt to change their size to avoid the ECB. At the same time, they expect to be under a stricter supervisor (i.e., the ECB) and are therefore subject to the "cleanup" incentive. Thus, a difference in asset growth between the two groups after the SSM announcement can be attributed to the "avoidance" effect. Similarly, the control group for the second treatment group, including banks in the €15–30bn asset range, includes those with assets sufficiently away from the threshold (€7–15bn), so that banks in both treated and control groups fall under the NCA supervision.

As a further robustness, we do two placebo tests, so we rerun the same analysis twice but using the year before or 2 years after the announcement (i.e., 2012 or 2014, respectively) as the treatment period. That is, we see whether the results hold in periods in which there was no announcement. The results, reported on Figure 1, (Panels (b) and (c)), do not show any special pattern around the supervisory threshold buttressing the idea that the announcement of the SSM was driving bank's incentives to shrink in 2013 rather than other factors. As further robustness, we repeat our main DID analysis using a bias-corrected (Abadie and Imbens, 2011) matching estimator (see previous applications by Almeida, Campello, and Weisbach, 2011; Campello and Giambona, 2013; Kahle and Stulz, 2013; Gropp, Mosk, Ongena, and Wix, 2018). The idea here is to further balance bank characteristics in our treatment and control groups. The results, presented in Appendix B.1, are qualitatively similar.

In sum, we document the existence of a "shrinking" effect connected to the announcement of the SSM. As the burden of supervision was expected to be higher, banks just above the ECB's supervisory threshold in 2012 shrank their size relative to banks with no possibility to avoid ECB's supervision, and this avoidance effect is stronger as banks get closer to the

threshold.

5 How a heavier burden of supervision played out on banks

In this section, we investigate the actions undertaken by banks near the threshold to shrink their size. First, we explore which balance sheet items changed the most following the announcement of the €30bn threshold so we rerun our main DID Model (1) using the growth of various balance sheet items as response variable. We first graphically present our results (Figure 2). In line with the drop in size by banks right above the threshold (Figure 1), these banks also reduced their lending activities, nonearning assets, and other-earning assets (Panels (a), (c), and (d)). Significantly and in line with our previous results for size, this effect was more pronounced for banks closer to the €30bn threshold. We also observe an increase in NPLs, suggesting that these banks increased their recognized losses. On the liability side, we observe a reduction in bank (Panel (f)) and, to a lesser extent, in customer deposits (Panel (c)). We do not appreciate material changes in equity or profitability.

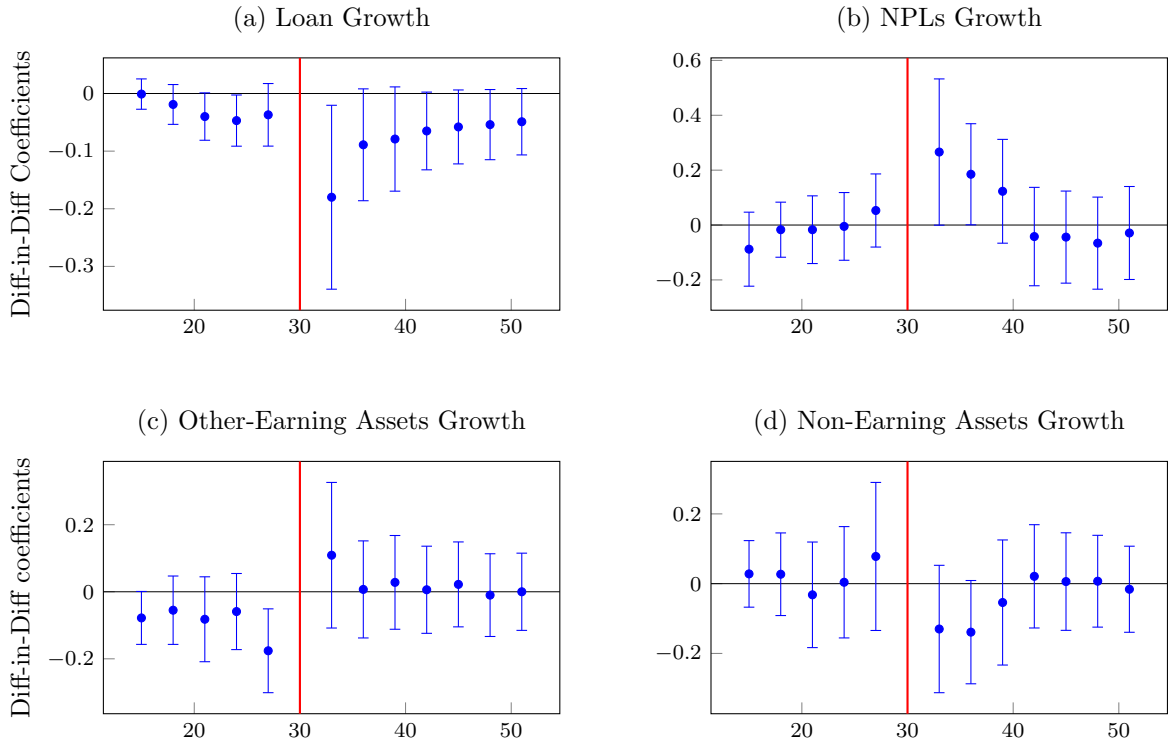
The announcement of the SSM led to an economically and statistically significant drop in lending suggesting an impact of the heavier burden of supervision not only on banks but also on borrowers. That is, it suggests that banks' actions to evade a stricter supervisor also imposed a burden, or cost, for borrowers. This suggests a channel connecting the heavier supervision to the real economy. In fact, lending is indeed a key variable closely scrutinized by many central banks to assess whether the transmission mechanism of monetary policy to the real economy smoothly works (Gertler and Kiyotaki, 2010).

To address this question, we formally test whether the lending drop was a supply effect driven by banks close to the €30bn threshold or due to demand factors[15]. To model banks'

[15]Using bank-level data, we could not rule out that some demand shock affected loan growth by SSM banks around the threshold following the announcement of the SSM leading to a decline in lending.

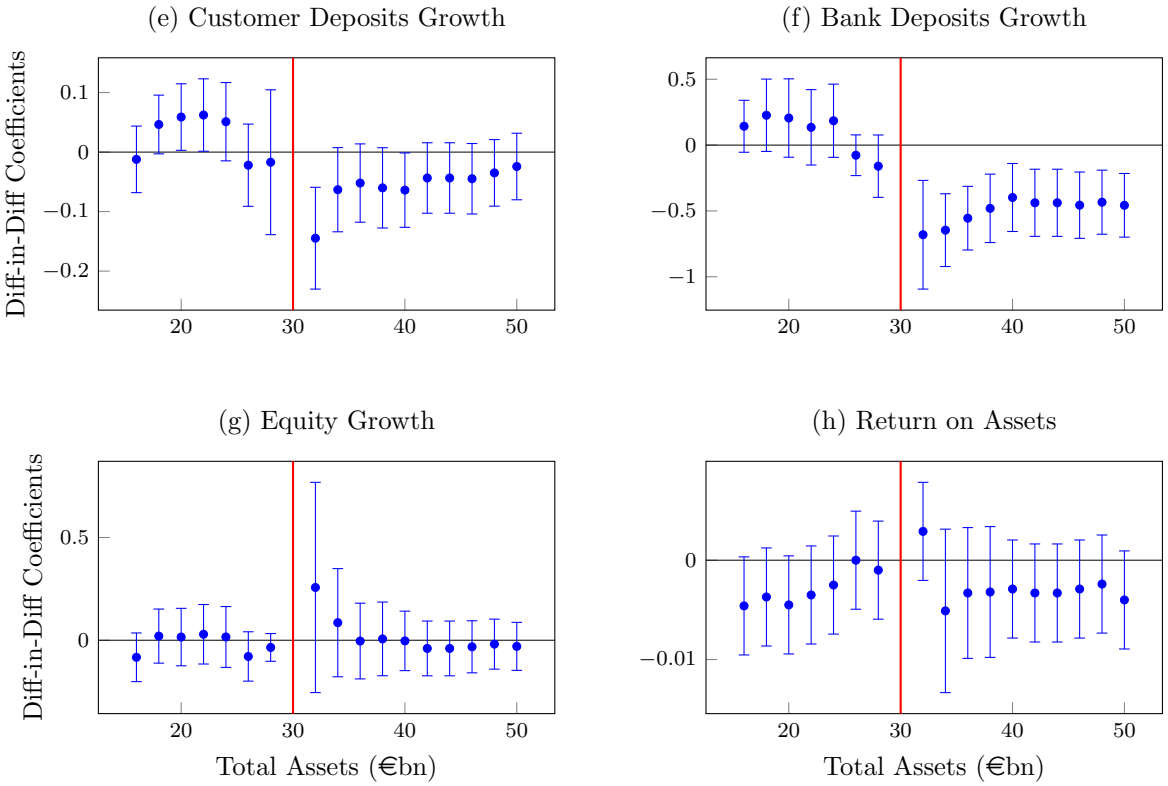
Figure 2. DID Analysis of Banks' Performance

Figure 4 reports the graphical representation of the coefficient estimates for the interaction term [I(Close to €30bn) × I(Year = 2013)] in our main DID Model (1). The dependent variables are various asset and liability items: (a) loan growth, (b) NPL growth, (c) other-earning asset growth, (d) nonearning asset growth, (e) customer deposit growth, (f) bank deposit growth, (g) equity growth, and (h) ROA. The treatment period is 2013. The treatment groups comprise banks in SSM countries around both sides of the €30bn cutoff at the end of 2012. On the right side of the cutoff point, we run a series of DID models by increasing assets (in the first regression, the treated banks are those in the €30–33bn size band in 2012; in the second group, treated banks fall within the €30–36bn size band, and so forth). Similarly, on the left side of the €30bn cutoff, we run a series of DID models by progressively decreasing assets (in the first regression, treated banks fall within the €27–30bn size band in 2012; in the second group, treated banks are those in the €24–30bn size band and so forth). In Panel (a) to the left of the cutoff, the number of treated banks in 2013 ranges from 7 in the €27–30bn size band to 28 in the €15–30bn size band. To the right of the cutoff, the number of treated banks in 2013 increases from 3 in the €30–33bn size band to 25 in the €30–51bn size band. The control group is composed of the following: For treated banks below the €30bn threshold, the control group is composed of banks in SSM countries with total assets in the €7–15bn range; for treated banks above the €30bn threshold, the control group is composed of banks in SSM countries with total assets in the €50–100bn range. We control for total assets, NPL ratio, equity capital ratio, loan ratio, derivative ratio, intangible asset ratio, and ROA as of the end of 2009. Standard errors are robust. The confidence intervals represent 90% level. Source of data: BankScope.



loan supply, one would need detailed information on bank-borrower relationships. Hence, we turn to the Pre-AnaCredit database, which includes data on, almost, all the loans granted in the euro area. As explained in Section 3, this is an extensive pilot database constructed harmonizing existing national credit registers from euro area countries.

Figure 2. Balance Sheet Items Around the Threshold (Cont.)



5.1 Identification strategy

Our identification is based on the same selection used earlier (Section 4.1) to identify treated and control banks. The main difference is the use of loan-level data to capture the net effect of banks' actions on loan supply. Specifically, to hold borrowers' characteristics constant, we limit our sample to borrowers who had relationships with at least two banks (multiple-relationship lending) in 2012 (prior to the SSM announcement). These borrower relationships should include at least a bank in the treatment group (i.e., close to the threshold) and, at least, another bank in the control group. This identification builds on recent papers that have used multiple bank-firm relationships to identify credit supply shocks (see Khwaja and Mian, 2008; Gropp et al., 2018). In this vein, we explicitly control for borrowers' demand effects by including borrower and time fixed effects into the regressions. Thus, any change in the amount that banks lend can be attributed to a supply effect.

We run various analyses to isolate the loan supply effects linked to the SSM announcement. We first collect data on all loans from a confidential credit registry data entitled Pre-AnaCredit.[16] Also, in this section, we select banks close to the threshold using the actual size data definition used by the ECB to select *significant banks*. The identification of banks in the treatment and control groups follows the criteria of previous analyses that define treated [I(Close to €30bn)$_{i,2012}$=1] as those banks around the €30bn cutoff at the end of 2012.[17] Specifically, we estimate the following regression model:

$$\begin{aligned} y_{i,j,t} =& \alpha + \beta_1 \text{I(Close to €30bn)}_{i,2012} + \beta_2 \text{I(year=2013)} + \\ &+ \beta_3 \text{I(Close to €30bn)}_{i,2012} \times \text{I(year=2013)} + \beta_4 \text{X}_{i,t-1} + \beta_5 \text{Z}_{j,t-1} + \\ &+ \gamma_c + \gamma_i + \epsilon_{i,t}, \end{aligned} \tag{2}$$

where $y_{i,j,t}$ is the natural log of loan-level exposure from bank j to borrower i at the end of the year and I(Close to €30bn)$_{i,2012}$ is a dummy taking a value of 1 if the loan was made by a bank in the treatment group (banks with total assets in 2012 close to the cutoff) and 0 if in the control group. We run the model (2) twice by dividing the group of treated banks [I(Close to €30bn)=1] into those above (€30–50bn) and below (€15–30bn) the threshold. The control groups are composed of banks in SSM countries with total assets in the €7–15bn and €50–100bn size bands, respectively. The interaction term [I(Close to €30bn) x I(Year=2013)], the main variable of interest, captures the drop in lending in 2013 for banks in the SSM close to the cutoff point at the end of 2012. $\text{X}_{i,t-1}$ and $\text{Z}_{j,t-1}$ are bank and borrower control variables taken with one-year lag. γ_i represents borrower, and γ_c represents collateral-type fixed effects.

[16] Collected by the ECB under Decision ECB/2014/6, labeled as Pre-AnaCredit. For a few countries, the bank name is not internally disclosed in this database. For these countries, we create a statistical procedure to ascertain whether banks were treated or not. See Appendix B.2, where we replicate the analysis carried out in this section using the entire Pre-AnaCredit database with the mentioned procedure.

[17] Described in Section 4.1.

5.2 Results

Table 4 documents an overall decline in loan exposures of about 8% by treated banks in the €30–50bn asset band to the same borrower, compared with banks in the control. For treated banks just below the ECB's threshold, there is no evidence of different lending patterns to the same borrower. As in previous models, we also rerun this analysis for an increasingly larger group of treated banks, allowing for progressive increments in bank size of €5bn.[18] Also, here, the idea is to check the consistency of our results by testing if the impact of the SSM decreases as the distance to the thresholds increases. Consistent with earlier results, the credit drop was greater for banks with the greatest opportunity to avoid the €30bn threshold. Indeed, banks in the €30–40bn size range experience a 15.5% drop relative to banks in the control group, and the decline progressively drops when we stretch the size of treated banks (Figure 3). Since banks in the treatment and control groups are under the supervision of the same authority, we can also rule out the possibility that the lending drop is driven by higher prices on bank products (*significant banks*, under the ECB direct supervision, may have increased loan rates to shift to borrowers the higher costs due to a more intense supervision). As robustness check, we formally test the existence of a price effect in Appendix C.

Is this credit supply shock similarly distributed across borrowers? To answer this question, we next divide our sample into three subsamples of firms: micro (< 10 employees and either turnover <€2m or total assets <€2m), small (10–49 employees and either turnover <€10m or total assets <€10m), medium (50–249 employees and either turnover <€50m or total assets <€43m), and large (all remaining) firms. As shown in Table 5, the supply shock affected the smaller firms the most (micro, −5.7%; small, −10.7%; medium, −8.6%). This probably magnified the shock, as smaller firms tend to find more difficulties raising

[18] As the focus is on borrowers with multiple-lending relationships for those countries where the name of the bank is known, the sample size does not enable us to run: (a) the incremental analysis by €3bn ticks, as done in Figures 1 and 2, rather we use €5bn ticks, and (b) the model 2 for treatment banks in the asset bands €25–30bn and €30–35bn.

Table 4. Credit to Nonfinancial Companies Around the Threshold

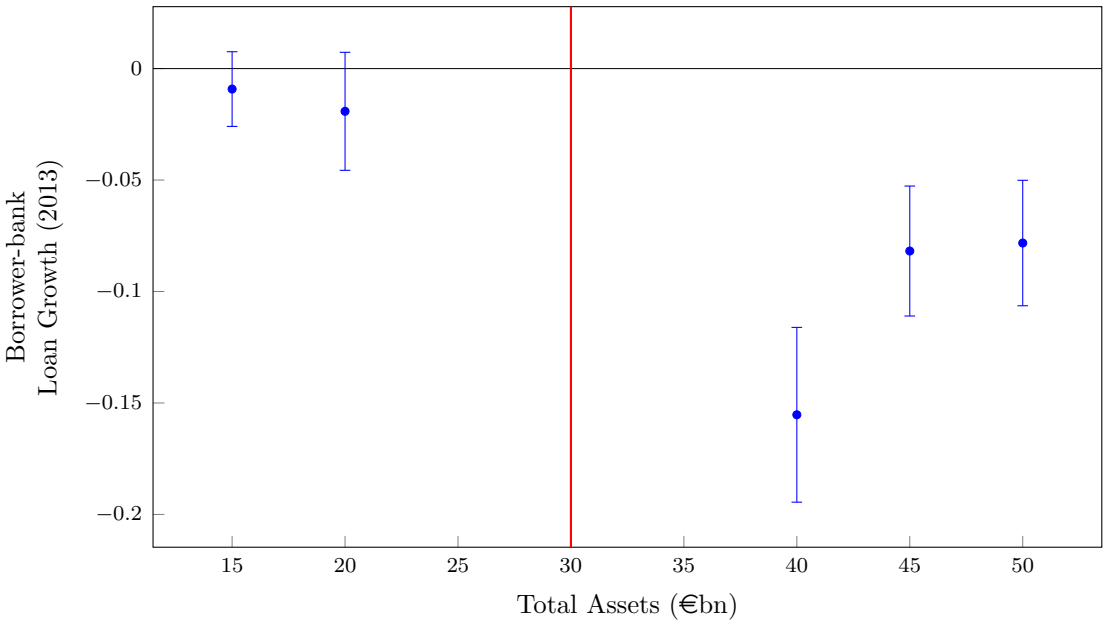
Table 4 presents the results for regression model (2) estimated on a sample of multiple-lending relationships (borrowers included in the sample must have at least one loan with a bank in the treated group and one loan with a bank in the control group). The dependent variable is the borrower-bank log value of the credit exposure. The treatment and control groups are consistently defined with earlier analyses (section 4.1). Specifically, the two treatment groups include banks in SSM countries in the total asset band €15–30bn [I(Assets €15–30bn) × I(Year = 2013) = 1] and €30–50bn [I(Assets €30–50bn) × I(Year = 2013) = 1], both taken as of the end of 2012. As usual, the control groups are composed of banks either in the €7–15bn (for treated banks in the band €15–30bn) or €50–100bn (for treated banks in the band €30–50bn) asset ranges as of 2012. The treatment period [I(Year = 2013) = 1] is 2013. The coefficients of main interest are the interaction terms [I(Assets €15–30bn) × I(Year = 2013) and I(Assets €30–50bn) × I(Year = 2013)] capturing the effect for banks in the SSM countries close to the €30bn asset threshold at the end of 2013. All models are run controlling for both bank and borrower sizes and using borrower and collateral-type fixed effects. The variable construction is reported in Appendix A. Standard errors are clustered at the bank level and reported in parentheses. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. Source of data: ECB's Pre-AnaCredit database.

	(1)	(2)	(3)	(4)
I(Assets €15–30bn) × I(Year = 2013)	-0.009	-0.009		
	(0.010)	(0.010)		
I(Assets €15–30bn)	0.044***	0.054***		
	(0.007)	(0.007)		
I(Assets €30–50bn) × I(Year = 2013)			-0.078***	-0.078***
			(0.017)	(0.017)
I(Assets €30–50bn)			-0.127***	-0.114***
			(0.012)	(0.012)
I(Year = 2013)	-0.067***	-0.067***	-0.107***	-0.105***
	(0.007)	(0.007)	(0.012)	(0.012)
Borrower Total Assets		0.605		-0.128**
		(2.184)		(0.052)
Bank Total Assets		-0.0418***		0.186***
		(0.008)		(0.008)
Constant	5.245***	6.224***	4.892***	0.571***
	(0.005)	(0.187)	(0.008)	(0.216)
Observations	95,702	95,702	81,856	81,856
R-squared	0.756	0.756	0.734	0.735
Borrower Effects	Yes	Yes	Yes	Yes
Collateral-Type Effects	Yes	Yes	Yes	Yes

alternatives sources of funding, such as the corporate bond market. In fact, we do not find any evidence that there was a statistically significant difference in 2013 for loans provided to large firms between banks in the treatment and control groups. Our results therefore show

Figure 3. Credit to Nonfinancial Companies Around the Threshold

Figure 5 graphically presents coefficient estimates for the interaction term [I(Close to €30bn)$_{i,2012}$ × I(year=2013)] in model (2), capturing the effect during 2013 for banks in the SSM countries close to the €30bn asset threshold at the end of 2012. We use a sample of multiple-lending relationships (borrowers included in the sample must have at least one loan with a bank in the treated group and one with a bank in the control group). The dependent variable is the natural log of borrower-bank loan-level exposure. The treatment and control groups are consistently defined with earlier analyses (section 4.1). The treatment groups comprise SSM banks around both sides of the €30bn cutoff at the end of 2012. On the right side of the cutoff, we run a series of DID models by progressively increasing assets. In the first regression, treated banks are those in the €30–40bn size band; in the second regression, treated banks fall within the €30–45bn size band; and, in the third regression, banks are in the €30–50bn band. Similarly, on the left side of the €30bn cutoff, we run a series of DID models by progressively decreasing assets; therefore, in the first regression, treated banks fall within the €20–30bn size band in 2012; in the second regression, treated banks are those in the €15–30bn size. The number of banks in the asset band €20–40bn in the countries with no-anonymous data is too small to run the analysis with treated banks selected in smaller asset buckets. As usual, the control groups are composed of banks either in the €7–15bn (for treated groups below the €30bn threshold) or €50–100bn (for treated groups above the €30bn threshold) asset ranges as of 2012. The treatment period is 2013. All models are run controlling for both bank and borrower sizes and using borrower and collateral-type fixed effects. Standard errors are clustered at the bank level. The confidence intervals represent 90% level. Source of data: ECB's Pre-AnaCredit database.



that, following the announcement and after controlling for borrowers' demand, banks above (but close to) the threshold reduced the credit offered to the same borrower by more. This strongly suggests that this reduction in credit is due to supply constraints and more strongly affected the smallest firms.

Our results have two implications: First, it bolsters our earlier findings that banks that tried to avoid ECB's supervision indeed reduced lending. Second, it shows that the effects

Table 5. Credit to Nonfinancial Companies by Borrower Size

Table 5 presents the results for model (2) estimated on a sample of multiple-lending relationships (borrowers included in the sample must have at least one loan with a bank in the treated group and one with a bank in the control group as of 2012) in 2013. The dependent variable is the borrower-bank log value of the credit exposure. The treatment and control groups are consistently defined with earlier analyses (section 4.1). Specifically, the two treatment groups include banks in SSM countries in the asset band €15–30bn [I(Assets €15–30bn)=1] and €30–50bn [I(Assets €30–50bn)=1], both taken as of the end of 2012. The control groups are composed of banks either in the €7–15bn or €50–100bn asset ranges as of 2012. The treatment period is 2013 [I(Year = 2013) = 1]. The coefficient of main interest is the interaction term [I(Assets €30–50bn) × I(Year = 2013)], capturing the effect for banks in the SSM countries close to the €30bn threshold. We control for the bank total assets. Rather than controlling for borrower size, we divide our sample into four subsamples: micro (< 10 employees and either turnover <€2m or total assets <€2m), small (10–49 employees and either turnover <€10m or total assets <€10m), medium (50–249 employees and either turnover <€50m or total assets <€43m), and large firms (all remaining firms). All models are run using borrower and collateral-type fixed effects. The variable construction is reported in Appendix A. Standard errors are clustered at the bank level and reported in parentheses. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. Source of data: ECB's Pre-AnaCredit database.

Panel A: Micro and Small Companies

	(1) Micro	(2) Small	(3) Micro	(4) Small
I(Assets €15–30bn) × I(Year = 2013)	-0.008	-0.026		
	(0.011)	(0.026)		
I(Assets €15–30bn)	0.069***	0.067***		
	(0.008)	(0.018)		
I(Assets €30–50bn) × I(Year = 2013)			-0.057**	-0.107***
			(0.024)	(0.030)
I(Assets €30–50bn)			-0.177***	-0.090***
			(0.017)	(0.020)
I(Year = 2013)	-0.060***	-0.076***	-0.123***	-0.099***
	(0.008)	(0.018)	(0.017)	(0.020)
Bank Total Assets	-0.047***	-0.139***	0.171***	0.203***
	(0.009)	(0.019)	(0.011)	(0.014)
Constant	6.049***	8.425***	0.044	-0.204
	(0.212)	(0.440)	(0.268)	(0.340)
Observations	63,644	16,446	35,117	28,175
R-squared	0.730	0.657	0.766	0.609
Borrower Effects	Yes	Yes	Yes	Yes
Collateral-Type Effects	Yes	Yes	Yes	Yes

Table 5. Credit to Nonfinancial Companies by Borrower Size (Cont.)

Panel B: Medium and Large Companies

	(1) Medium	(2) Large	(3) Medium	(4) Large
I(Assets €15–30bn) × I(Year = 2013)	0.001	0.006		
	(0.036)	(0.058)		
I(Assets €15–30bn)	-0.001	0.026		
	(0.025)	(0.042)		
I(Assets €30–50bn) × I(Year = 2013)			-0.085*	-0.025
			(0.045)	(0.085)
I(Assets €30–50bn)			-0.064**	0.100
			(0.031)	(0.064)
I(Year = 2013)	-0.070***	-0.120***	-0.086***	-0.076
	(0.025)	(0.043)	(0.029)	(0.057)
Bank Total Assets	0.022	0.117***	0.160***	0.232***
	(0.026)	(0.040)	(0.021)	(0.043)
Constant	5.563***	4.689***	2.108***	1.509
	(0.604)	(0.945)	(0.509)	(1.031)
Observations	10,144	5,468	14,108	4,456
R-squared	0.625	0.603	0.556	0.654
Borrower Effects	Yes	Yes	Yes	Yes
Collateral-Type Effects	Yes	Yes	Yes	Yes

we documented earlier are not driven by some unobserved demand shock unrelated to the SSM announcement. The loan-level results indicate that the reduction in lending is material and driven by a supply effect, i.e., driven by banks' decisions.

6 Estimating banks' burden of supervision

In this section, we provide a simplified estimation of the cost of stricter supervision for banks. The start of the SSM provides a useful setting as banks below the €30bn threshold avoided ECB's direct supervision. They were not subjected to the costs of dealing with a heavier supervisor while they have constraints on their growth connected to their size, thereby missing profitable business opportunities. Conversely, banks just above the threshold fall under the ECB direct supervision and are under higher costs of supervision but can more easily take advantage of profitable business opportunities linked to growth.

We quantify this cost by focusing on banks below the threshold and compare their profits with those of similar banks above overtime. That is, we aim to quantify the following counterfactual: What would have been the profits of banks below if they were above the threshold? In other words, how much money are banks willing to leave on the table to avoid a stricter supervisor? Of course, running the perfect experiment that randomly selects some banks to be supervised by their national supervisors and others by the ECB is impossible. Yet the existence of a threshold helps us create a simple but still reasonable counterfactual.

First, we measure whether there is a burden of supervision at all. Hence, we test whether banks below the supervisory threshold obtained lower profits than similar banks after the SSM started. Specifically, we run a DID test of banks' performance around the threshold after the SSM launch defining treatment groups as usual (section 4.1). Second, we quantify the burden of supervision as the gap between "potential" profits that banks just below the threshold could have made between 2014 and 2018 and their actual profits.

6.1 Is there a burden of supervision?

We first test whether it is costly for banks close to the threshold to avoid the SSM by analyzing whether banks below the threshold obtained lower profits after the SSM implementation. We run a formal triple DID test of banks' performance around the threshold after the SSM launch (2014–2018). As before, the treatment groups consists of banks in SSM countries with total assets sufficiently close to the €30bn cutoff: On one side, those above the threshold (€30–50bn band) as the SSM started do not have growth constraints linked to the threshold but are subject to a more intense supervision and thus have more expenses (staff, data and models, additional prudential supervision requirements, etc.). On the other side, banks in the €15–30bn size band are subject to growth constraints but have lower supervision expenses. We identify our control groups in this section in a richer way than in previous analyses (Sections 4 and 5) as we are now also able to include European banks in non-SSM countries (i.e., countries nonsubject to a change of supervisor) in the same asset band. This is important as we are able to calculate our counterfactual using banks of similar size that are the natural counterfactual for treated banks. Specifically, the control group includes three subgroups of banks: (a) banks in SSM countries in the €7–15bn size band by the end of 2013 (for treated banks in the €15–30bn band) and in the €50–100bn size band (for treated banks in the €30–50bn band), (b) all EU banks from non-SSM countries in the €7–30bn asset band (for treated banks in the €15–30bn band) and €30–100bn (for treated banks in the €30–50bn band) asset bands, and (c) all banks in groups (a) and (b) prior to the treatment. Unlike in previous analyzes, the treatment period begins with the SSM starting date running from 2014 to 2018.

We use the following DID specification (estimated using data for the years 2011–2018):

$$\begin{aligned} y_{i,t} =& \alpha + \beta_1[\text{I(Close to €30bn)}_{i,2013} \times \text{I(SSM country)} \times \text{I(year}\geq 2014)] + \\ & \text{double interactions } [\text{I(Close to 30bn)}, \text{I(SSM country)}, \text{I(year} \geq 2014)] + \\ & + \beta_2 \text{I(Close to €30bn)}_{i,2013} + \beta_3 \text{X}_{i,2011} + \gamma_{i\times c} + \epsilon_{i,t}, \end{aligned} \tag{3}$$

where $y_{i,t}$ is the ratio of various performance measures to total assets, including operating income, nonoperating income, and net profits (both pre- and after-taxes). I(year $\geq$ 2014) is a dummy variable taking a value of 1 if the year falls after the start of the SSM 92014 to 2018) and 0 otherwise. I(SSM country) is a dummy variable taking a value of 1 if the European bank is in a SSM country and 0 otherwise. I(Close to €30bn)$_{i,2013}$ is a dummy variable taking a value of 1 if the bank is in the treatment group (total assets in 2013 close to the cutoff) and 0 if in the control group. We run the model (1) twice by dividing the group of treated banks [I(Close to €30bn)=1] into those above (€30–50bn) and below (€15–30bn) the threshold, labeled in tables reporting results as I(Assets €30–50bn) and I(Assets €15-30bn), respectively. The triple interaction term (I(Close to €30bn)$_{i,2013}$ $\times$ I(SSM country)) is the main variable of interest. It captures the effect for treated banks (SSM banks close to the cutoff point after the SSM starts. $X_{i,2011}$ includes previously used bank-level control variables as of the end of 2012. These variables control for differences in banks business models (loan and derivative ratios), risk-taking (NPL ratio), capitalization (equity ratio), and opacity (intangible asset ratio). $\gamma_{i\times c}$ represents the "time x country fixed effects" [19]

First, we test the parallel trends assumption between the treatment and control groups. Our test compares various profit ratio indicators and the main balance sheet items for banks in the treatment and control groups. We aim to assess whether banks around the threshold are comparable to those in the control in years prior to the SSM start. Table 6 presents the results. Columns (1) and (2) report the difference-in-means for banks in the control and treatment groups prior to the start of the SSM in 2014. Banks' profits and other rations in the treatment are largely statistically indistinguishable from those in the control groups before the start of the SSM.

As shown in Table 7, we find that the SSM produced two distinct effects on profits for the two subgroups (i.e., those below and above the threshold). Those banks below (€15–30bn) attained lower profits (pre- and after-tax) relative to banks in the control. Differences in

[19]The terms I(year $\geq$ 2014), I(SSM Country), and I(year $\geq$ 2014) $\times$ I(SSM Country) are captured by the (time x country) fixed effects.

Table 6. Testing Parallel Trends in the Burden of Supervision Estimation

Table 6 reports the difference in means between banks in the control and treatment groups prior to SSM start in 2014. It shows various assets and profit indicators that are likely to be influenced by banks' reaction at the SSM start. Specifically, column (1) reports the difference in means between banks in the treatment (banks in the SSM countries with total assets in the €15–30bn band) and control (banks in SSM countries in the €7–15bn size band at the end of 2013 and EU banks from non-SSM countries in the €7–30bn band) groups. In Column (2), we report the difference in means between banks in the treatment (banks in the SSM countries with total assets in the €30–50bn band) and control (banks in SSM countries in the €50–100bn size band as of the end of 2013 and EU banks from non-SSM countries in the €30–100bn band) groups. Details on the construction of each variable is reported in Appendix Table A.I. Source of data: BankFocus. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

		Difference in means relative to control	
Asset size as of 12/2013:		Below (€15–30bn)	Above (€30–50bn)
Year		(1)	(2)
2011	Operating Income Ratio	-0.106	-0.332
	Nonoperating Income Ratio	0.039	-0.134
	Pre-Tax ROA	-0.058	-0.465
	After-Tax ROA	-0.117	-0.408
	NPL Ratio	0.003	0.002
	Equity Ratio	-0.017	-0.010
	Loan Ratio	-0.130	0.020
	Derivative Ratio	0.015	0.014
	Intangible Asset Ratio	0.002	0.000
2012	Operating Income Ratio	0.034	0.121
	Nonoperating Income Ratio	0.088*	-0.050
	Pre-Tax ROA	0.122	0.135
	After-Tax ROA	0.082	0.063
	NPL Ratio	0.004	0.003
	Equity Ratio	-0.014	-0.011
	Loan Ratio	-0.108	0.002
	Derivative Ratio	0.011	0.018
	Intangible Asset Ratio	0.003	0.000
2013	Operating Income Ratio	-0.231	0.314
	Nonoperating Income Ratio	0.003	-0.030
	Pre-Tax ROA	-0.228	0.373
	After-Tax ROA	-0.201	0.346
	NPL Ratio	0.004	0.001
	Equity Ratio	-0.021	-0.003
	Loan Ratio	-0.146	0.001
	Derivative Ratio	0.013	0.011
	Intangible Asset Ratio	0.003	0.001

profits are driven by banks' operating activities as nonoperating profits did not differ around both sides of the threshold. Also, we do not find evidence that banks above the threshold (€30–50bn) achieved different profits relative to banks in the control group, indicating that the impact for banks' below the threshold is due to the SSM and having remained below the threshold as the SSM started. Our results suggest that banks just below the threshold registered a drop in revenues (due to missed business opportunities) that is greater than the lower cost related to a lighter supervision.

6.2 How much is the burden of supervision?

We now calculate a stylized estimate of the cost of supervision. We do this projecting the performance ($\widehat{y}_{i,t}$) that banks just below the threshold (€15–30bn size range) would have had if they were free to grow up unconstrained by the threshold, in other words, what profits would they had obtained had they had been just above the threshold and thereby under ECB's direct supervision. The difference between fitted and actual performance provides us an estimate of the cost of supervision.

We proceed in two steps. First, we focus on banks with no growth constraints to identify the drivers of their performance. As in Section 6.1, we collect banks in SSM countries with total assets just above the threshold (€30–50bn) as the SSM started (at the end of 2013). We then run a straightforward linear OLS model to estimate the relationship between profits and bank characteristics for the period starting after the SSM launch (2014–2018) as follows:

$$y_{i,t} = \alpha + \beta_1 \mathrm{X}_{i,t} + \gamma_t + \gamma_c + \epsilon_{i,t} \tag{4}$$

where $y_{i,t}$ is a measure of income (as usual, we include operating and nonoperating income ratios, pre-tax ROA, and net income ratio); $\mathrm{X}_{i,t}$ is the usual vector of bank-level variables

Table 7. Profits Around the Supervisory Threshold, Pre- and Post-SSM

Table 7 reports the results of our DID model (3). As a dependent variable, we use the operating income ratio, nonoperating income ratio, pre-tax ROA, and after-tax ROA. The treatment group comprises banks in SSM countries around both sides of the €30bn cutoff at the end of 2012. Specifically, treated banks are those with total assets at the end of 2013 in the band €15–30bn [I(Assets €15–30bn] (columns (1), (3), (5), and (7)) and €30–50bn [I(Assets €30–50bn] (columns (2), (4), (6), and (8)). The control groups now include three subgroups of banks: (a) banks in SSM countries in the €7–15bn asset band (for treated banks in the band €15–30bn) and in the €50–100bn asset band (for treated banks in the band €30–50bn) by the end of 2013, (b) all EU banks from non-SSM countries with total assets in the range €7–30bn (for treated banks in the band €15–30bn) and €50–100bn (for treated banks in the band €30–50bn), and (c) all banks in groups (a) and (b) prior to the treatment. The treatment period is after the start of the SSM (2014–2018). The coefficients of interest are the triple interaction terms [I(Assets €15–30bn) × I(year≥ 2014) ×I(SSM), and I(Assets €30–50bn) × I(year≥ 2014) ×I(SSM)] capturing the effect after the SSM starts (2014–2018) for banks close to the cutoff point at the end of 2013. The variable construction is reported in Appendix A. Standard errors are clustered at the bank level and reported in parentheses. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. Source of data: BankFocus.

Dependent variable:	*(Op Inc)/TA*	*(Op Inc)/TA*	*(NonOp Inc)/TA*	*(NonOp Inc)/TA*
	(1)	(2)	(3)	(4)
I(Assets €15–30bn)×I(SSM country) ×I(year≥ 2014)	-0.626**		-0.027	
	(0.288)		(0.087)	
I(Assets €15–30bn) × I(SSM country)	0.489		0.024	
	(0.314)		(0.070)	
I(Assets €15–30bn) × I(year≥ 2014)	0.353		0.055*	
	(0.224)		(0.032)	
I(Assets €15–30bn)	-0.04		-0.106**	
	(0.424)		(0.050)	
I(Assets €30–50bn)×I(SSM country) ×I(year≥ 2014)		-0.309		-0.041
		(0.408)		(0.084)
I(Assets €30–50bn) × I(SSM country)		-0.381		-0.048
		(0.839)		(0.091)
I(Assets €30–50bn) × I(year≥ 2014)		0.135		-0.049**
		(0.321)		(0.019)
I(Assets €15–30bn)		0.022		0.016
		(0.785)		(0.054)
Total Assets (2012)	-1.595	-1.273*	0.209**	-0.062
	(1.475)	(0.690)	(0.080)	(0.132)
NPL Ratio (2012)	-11.435	19.835	0.721	-6.013
	(22.174)	(27.547)	(1.565)	(5.853)
Equity Ratio (2012)	10.285**	3.317	0.607**	1.910*
	(4.858)	(3.685)	(0.257)	(0.973)
Loan Ratio (2012)	-1.692**	0.347	-0.127**	-0.07
	(0.812)	(0.494)	(0.054)	(0.088)
Derivative Ratio (2012)	-3.022	4.831**	-0.404***	0.474
	(2.807)	(2.133)	(0.131)	(0.608)
Intangibles Asset Ratio (2012)	-13.394	-12.81	-4.031***	-1.223
	(10.848)	(19.365)	(1.353)	(2.306)
Observations	537	409	537	409
R-squared	0.535	0.747	0.176	0.459
Cluster SE	Bank	Bank	Bank	Bank
Country x Year Effects	Yes	Yes	Yes	Yes

Table 7. Profits Around the Supervisory Threshold, Pre- and Post-SSM (Cont.)

Dependent variable:	*(Pre-Tax Prof)/TA*	*(Pre-Tax Prof)/TA*	*(Aft-Tax Prof)/TA*	*(Aft-Tax Prof)/TA*
	(5)	(6)	(7)	(8)
I(Assets €15–30bn) × I(SSM country) ×I(year≥ 2014)	-0.681**		-0.526**	
	(0.295)		(0.237)	
I(Assets €15–30bn) × I(SSM country)	0.535		0.499*	
	(0.329)		(0.264)	
I(Assets €15–30bn) × I(year≥ 2014)	0.430*		0.307	
	(0.251)		(0.195)	
I(Assets €15–30bn)	-0.184		-0.273	
	(0.428)		(0.343)	
I(Assets €30–50bn) × I(SSM country) ×I(year≥ 2014)		-0.276		-0.255
		(0.409)		(0.339)
I(Assets €30–50bn) × I(SSM country)		-0.522		-0.472
		(0.846)		(0.728)
I(Assets €30–50bn) × I(year≥ 2014)		0.086		0.011
		(0.310)		(0.227)
I(Assets €15–30bn)		-0.019		0.087
		(0.790)		(0.686)
Total Assets (2012)	-1.319	-1.476*	-0.608	-1.075**
	(1.483)	(0.745)	(1.174)	(0.498)
NPL Ratio (2012)	-10.214	16.344	-13.907	4.692
	(21.164)	(31.422)	(17.322)	(23.523)
Equity Ratio (2012)	11.065**	5.571	8.183**	5.027*
	(4.779)	(3.697)	(3.789)	(2.911)
Loan Ratio (2012)	-1.855**	0.214	-1.679**	0.143
	(0.828)	(0.479)	(0.672)	(0.386)
Derivative Ratio (2012)	-3.494	5.400**	-3.424	3.999**
	(2.890)	(2.368)	(2.365)	(1.860)
Intangibles Asset Ratio (2012)	-18.003	-18.537	-12.865	-10.818
	(11.719)	(22.722)	(9.504)	(16.142)
Observations	537	409	537	409
R-squared	0.531	0.721	0.553	0.711
Cluster SE	Bank	Bank	Bank	Bank
Country x Year Effects	Yes	Yes	Yes	Yes

as of the end of 2012,[20]; and γ_t and γ_c represent year and country fixed effects, respectively.

Second, we use the parameters estimated in the first step[21] from the model (4) to predict the performance ($\widehat{y}_{i,t}$) of banks with total assets in the €15–30bn range after the SSM started (2014–2018). The difference between actual performance ($y_{i,t}$) and the fitted values ($\widehat{y}_{i,t}$) provide us with an estimate of the costs (lower income) incurred by these banks to avoid ECB's supervision.

Figure 4, Panel (a), shows that banks below the supervisory threshold generated lower net income than banks above (by €8.6bn between 2014 and 2018) mostly in the form of fewer operating profits. Looking at the net income shortfall (the difference between the real and fitted profits), the average bank missed €4.5bn of potential profits: these banks achieved only 66% of potential net income (€13.1bn). Thus, we can roughly argue that the cost of supervision for these banks was around 34% of their potential profits. Looking at the overall pre-tax profit shortfall in the same period, the burden of supervision is also greater: the€15–30bn size range in 2012 missed €7.2bn of potential profits (mainly operating profits, €6.7bn) and thus achieved only about 62% of potential pre-tax profits (€19.1bn). As shown in Panel (b), both pre-tax actual and profit shortfall are relatively constant overtime, and the cost of supervision (the ratio between the profit shortfall and potential profits) ranged between around 25% in 2015 and 48% in 2016. In Panel (c), we report real (i.e., realized) profits (pre-tax) shortfalls across asset size deciles. Not surprisingly, banks closer to the asset threshold (10^{th} decile) give up a larger chunk of potential profits (93%).

As robustness checks, we run two additional analyses. First, we change the model to estimate the relationship between profits and bank characteristics using a machine learning technique for optimal prediction as the elastic net regularized regression. Compared with the standard regression model (4), the elastic net approach improves prediction by penalizing

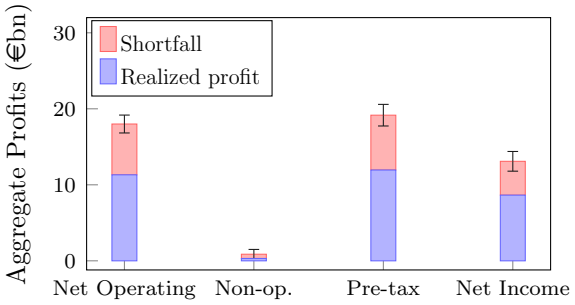
[20]Control variables are taken as of the end of 2011, when the SSM criteria become publicly available. Thus, our predictions of bank performance are not biased by the threshold effects in 2013 (the asset and liability decline documented in the first part of the paper for banks with total assets close to the €30bn cutoff).

[21]The coefficient estimates of the model (4) are reported in Appendix D.1.

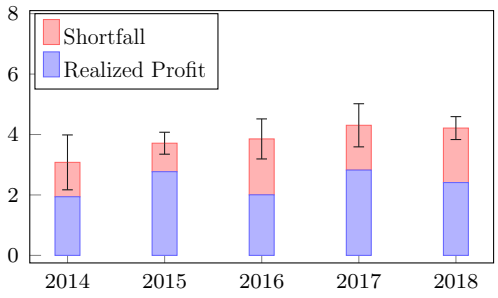
Figure 4. Estimation of the Cost of Supervision

Figure 6 describes the gap between the real ($y_{i,t}$) and potential ($\widehat{y}_{i,t}$) performance of banks with a total assets of €15–30bn at the end of 2012 over the period 2014–2018 predicted using model (4). This provides us with a measure of the cost (lower income) or revenues (higher income) that these banks have due to more intense supervision. We report the following: *i*) the overall generated profits (in €bn) and the overall profit shortfall (summation of all the banks' gap between the real and fitted profits) for various income measures ($y_{i,t} - \widehat{y}_{i,t}$) in Panel (a), *ii*) overall real profits ($y_{i,t}$) and profit shortfall ($y_{i,t} - \widehat{y}_{i,t}$) in €bn in each year of the time period analyzed in Panel (b), and *iii*) overall real profits ($y_{i,t}$) and profit shortfall ($y_{i,t} - \widehat{y}_{i,t}$) in €bn by total asset deciles in Panel (c). The confidence intervals represent 90% level. The coefficient estimates used to fit bank performance ($\widehat{y}_{i,t}$) are reported in Appendix D.1. Source of data: BankFocus.

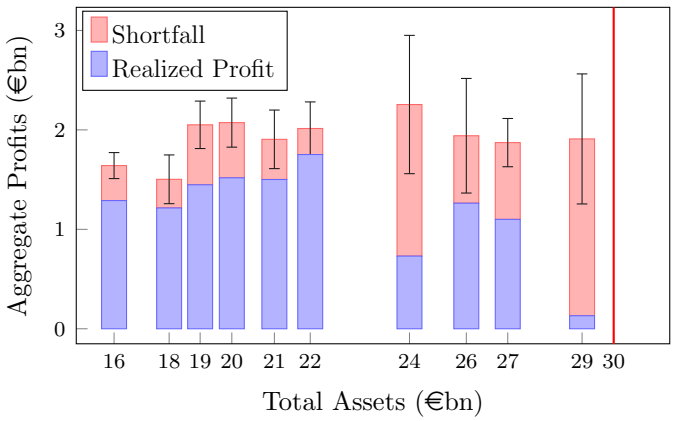
(a) Predicted and Realized Profits



(b) Predicted and Realized Profits, by Year



(c) Predicted and Realized Profits, by Assets



bank features that do not contribute to predictive power, thus exploiting the prediction bias-variance trade-off. That is, we do not "force" bank characteristics to have all the weight. Appendix D.2 reports both the model explanation and results. Second, we rerun the model (4), changing the sample composition by including European banks outside the euro area in the sample (the results are reported in Appendix D.3). In both cases, the estimates of the burden of supervision are highly consistent with our main estimates in Figure 4.

7 Conclusion

The centralization of banking supervision in Europe is a historic event. For the first time, 19 sovereign national states surrendered their responsibility for supervising their largest banks to a multinational institution, the ECB. The assignment of banks to supervisors depended on the size of the banks' assets; those larger than €30bn were to be supervised by the ECB, and those below this threshold would continue to be supervised by their NCAs.

We resort to this event to calculate the cost of supervision for banks and borrowers. We first document that expectations of a heavier burden of supervision spurted major changes in banks to the extent that many banks close to the threshold reduced their size to remain with their local supervisors. We also show how this decline in size had an economic impact for borrowers. It led to credit rationing to borrowers from banks near the threshold.

Finally, we estimate the cost incurred by banks to avoid more intense supervision. We show that banks close, but below, the supervisory threshold at the end of 2012 gave up around 38% of their potential profits from the start of the SSM (in 2014) to 2018. In line with the hypothesis of a heavier burden of supervision, banks closer to the supervisory threshold gave up more "potential" profits than those further away.

Overall, our analysis sheds light on how expectations affect the workings of banking supervision on the lengths institutions are willing to go to avoid a heavier supervisory scrutiny and on how this heavier burden of supervision has a real economic impact on borrowers.

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Appendix A Variable Definitions

Table A.I. Variable Definitions

Variables	Definition and calculation method
Asset Growth	Annual growth rate in banks' total assets.
Bank Deposit Growth	Annual growth rate in total deposits from banks.
Borrower Size	Natural log of borrowers' total assets.
Customer Deposit Growth	Annual growth rate of total customer deposits.
Deposit Ratio	Total deposits to total assets.
Derivative Ratio	Total derivatives to total assets.
Equity Growth	Annual growth in bank total equity.
Equity Capital Ratio	Total equity to total assets.
Intangible Asset Ratio	Total intangible assets to total assets.
Loan-Level Exposure	Natural log of the total amount lent by a bank to a given borrower.
Loan Growth	Annual growth rate of total loans.
Loan Ratio	Total loans to total assets.
Loans to Nonfinancial Corporations	Total loans to nonfinancial corporations.
Net NPL to Equity Ratio	Net nonperforming loans (total NPL minus the reserve for impaired losses) to common equity Tier 1 (CET1) capital.
Nonearning Asset Growth	Annual growth of nonearning assets, i.e., the difference between total assets and total earning assets.
Nonoperating Income Ratio	The amount of profit realized from bank activities not related to its core business operations to total assets.
NPL Growth	Annual growth rate in gross nonperforming loans, i.e., total impaired loans.
NPL Ratio	Nonperforming loans (NPLs) to total assets.
Operating Income Ratio	The amount of revenue realized from usual bank business operations to total assets.
Other-Earning Asset Growth	Annual growth of other-earning assets (i.e., total earning assets minus total loans).
Reserve for Impaired Loans Ratio	Reserve for impaired losses to common equity Tier 1 (CET1) capital.
Pre-Tax Return on Assets (ROA)	Pre-tax profits to total assets.
Total Assets	Natural log of banks' total assets.

Appendix B Additional Results

B.1 Robustness: Abadie and Imbens (2011) Matching Estimators

For robustness purposes, we replicate our main DID analysis (model (1) using the bias-corrected matching estimator proposed by Abadie and Imbens (2011). This estimator has been recently used in several financial intermediation studies (Almeida et al., 2011; Campello and Giambona, 2013; Kahle and Stulz, 2013; Gropp et al., 2018).

We replicate Table 3 and Figure 1 by matching with a one-to-one nearest neighbor on the pretreatment levels of the bank nationality and total assets, as at the end of 2009. We then run a DID estimation using matching weights, where weights are used to balance banks close to the threshold with banks far from it. In our case, the DID exploits the group (close to vs. far from the threshold) instead of the time (before versus after SSM) dummy variable. The use of matching (instead of the standard control function approach for DID used in the main analysis) resides in the nonparametric identification of the counterfactual operated by the former approach. Although matching relaxes the confounders' linearity assumption (thus entailing a model-free approach), it increases bias when the sample size is not large enough (as in any other nonparametric model).

We reports the results in Table B.I (replicating Table 3) and Figure B.I, Panel (a) (replicating Figure 1). By comparing the right-hand graph of Figure 1 (Panel a) with Figure B.I, we observe that the results are very similar: The pattern of the DID using matching weights is visibly similar than the pattern generated when using the DID with linear controls.

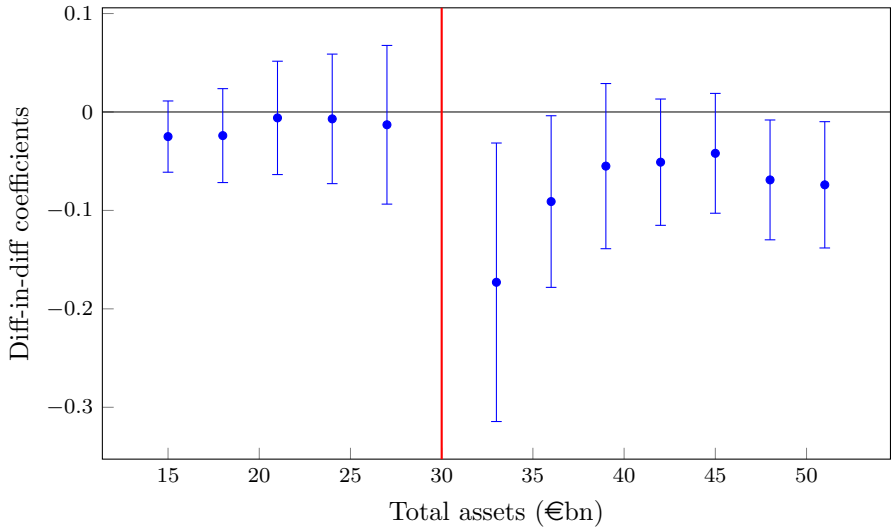
Table B.I. DID Analysis of Asset Growth Around the SSM Threshold: Matching Estimator

Table B.I reports the results of DID model (1) estimated using a matched-sample estimator. We match on bank nationality and the pretreatment levels of total assets (at 2009). The dependent variable is asset growth. The treatment and control groups are defined as reported in Section 4.1. The treatment period [I($Year$ = 2013) = 1] is 2013. The coefficients of main interest are the interaction terms [I(Assets €15–30bn) × I(Year = 2013) and I(Assets €30–50bn) × I(Year = 2013)], capturing the effect for banks close to the cutoff point during 2013. The variable construction is reported in Appendix A. Standard errors (in parentheses) are robust. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. Source of data: BankScope.

	(1)	(2)	(3)	(4)
I(Assets €15–30bn) × I(Year = 2013)	0.067***	0.027**		
	(0.016)	(0.013)		
I(Assets €15–30bn)	-0.024	-0.026		
	(0.022)	(0.022)		
I(Assets €30–50bn) × I(Year = 2013)			-0.056*	-0.047
			(0.032)	(0.034)
I(Assets €30–50bn)			-0.075**	-0.075**
			(0.038)	(0.037)
Total Assets (2009)	-0.128***	-0.086***	-0.140***	-0.123***
	(0.025)	(0.025)	(0.039)	(0.043)
NPL Ratio (2009)		-1.623***		-0.076
		(0.417)		(0.844)
Equity Ratio (2009)		-0.482**		0.038
		(0.230)		(0.420)
Loan Ratio (2009)		0.033		-0.054
		(0.069)		(0.057)
Derivative ratio (2009)		0.363		-0.244
		(0.258)		(0.574)
Intangible Asset Ratio (2009)		3.621***		-0.663
		(1.273)		(1.449)
ROA (2009)		2.205*		2.341
		(1.199)		(1.513)
Observations	254	254	208	208
R-squared	0.358	0.428	0.290	0.311
Time Effects	Yes	Yes	Yes	Yes
Country Effects	Yes	Yes	Yes	Yes

Figure B.I. DID Analysis of Asset Growth Around the SSM Threshold: Matching Estimator

Figure B.I reports the graphical representation of the coefficient estimates for the interaction term [I(Close to €30bn) × I(Year = 2013)], capturing the effect for banks in the SSM close to the cutoff point during 2013 in our main DID model (1), where the dependent variable is asset growth. Consistent with the main analysis (Figure 1), the treatment groups comprise SSM banks around both sides of the €30bn cutoff at the end of 2012. On the right side of the cutoff point, we run a series of DID models by increasing assets (in the first regression, treated banks are those in the €30–33bn size band in 2012; in the second regression, treated banks fall within the €30–36bn size band and so forth). Similarly, on the left side of the €30bn cutoff, we run a series of DID models by progressively decreasing assets (in the first regression, treated banks fall within the €27–30bn size band in 2012; in the second regression, treated banks are those in the €24–30bn size band and so forth). To the left of the cutoff, the number of treated banks ranges from 7 in the €27–30bn size band to 28 in the €15–30bn size band. To the right of the cutoff, the number of treated banks increases from 3 in the €30–33bn size band to 25 in the €30–51bn size band. The control group includes banks in SSM countries with assets (as of 2012) either between €50 and 100bn, when treated banks are those with total assets of €30–50bn (on the right of the €30bn vertical bar), or between €7 and 15bn, when treated banks are between €15 and 30bn (on the left of the €30bn vertical bar). We also use the same control variables (NPL ratio, equity capital ratio, loan ratio, derivative ratio, intangible asset ratio, and ROA, as at the end of 2009). The confidence intervals represent 90% level. Source of data: BankScope.



B.2 Credit Rationing: Result Using the Entire Pre-AnaCredit

As robustness for the loan-level analysis (Section 5.2), we replicate our empirical analysis using the entire confidential short-term credit registry data (collected by the ECB under Decision ECB/2014/6, labeled as Pre-AnaCredit). We aim to use a larger sample by including also loan-level deals in which we do not know the identity of lenders and borrowers. To this purpose, we must take a preliminary step: since we do not know the bank identity and its total assets, we cannot measure the distance from the €30bn threshold and thus cannot select banks in the treatment and control groups. Thus, we estimate a "pseudo-threshold"; that is, we map the size of a loans to nonfinancial companies (L-NFC), which we can estimate using the ECB loan-level dataset, to the bank's total assets so we can infer whether the bank is close to the €30bn threshold. The regression model is run on total L-NFC on total assets using monthly data between December 2011 and December 2013. Table B.II presents the results of this regression.

Table B.II. Supervision Threshold and Banks' Loan Portfolio

Table B.II shows the relation between bank-level L-NFC and total assets. The dependent variable is banks' total assets between 2012 and 2013. L-NFC and total assets are monthly data between December 2011 and December 2013 obtained from the ECB's iBSI database (including the largest 315 banks in the euro area). The variable construction is reported in Appendix A. Standard errors (in parentheses) are clustered at the bank level. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable:	Loans to Nonfinancial Companies (L-NFC)	
	(1)	(2)
Total Assets	0.104***	0.099***
	(0.012)	(0.013)
Country × Month FE	No	Yes
Observations	7,149	7,149
R-squared	0.733	0.698

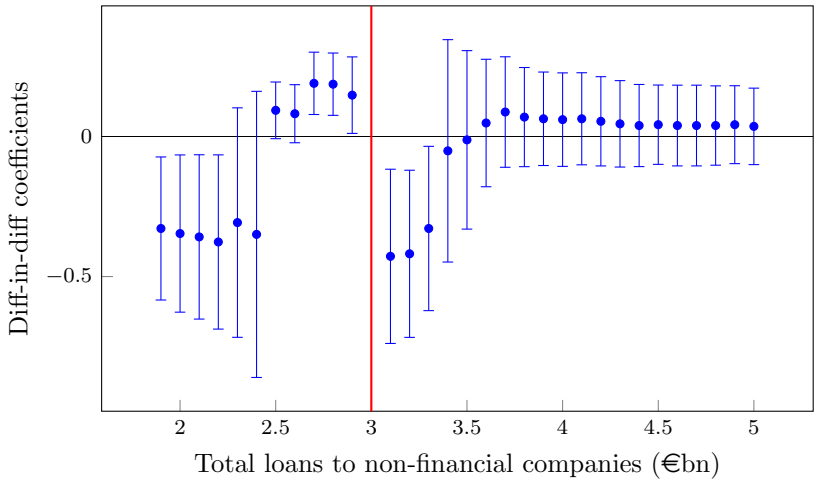
The coefficient on this regression is 0.1 (with country × month fixed effects). The explanatory power is high with an R^2 of 73%. Thus, the €30bn asset corresponds (on average) to a total L-NFC of around €3.0bn. Next, we estimate the threshold's effect on loan supply. We rely again on a DID framework and present the information in graphical form running regression models in which we keep the control group constant but progressively increase

the number of banks in the treatment group. Specifically, in each regression, we extend the total L-NFC size band by a small tick of €0.1bn. We start with a band that includes banks with total L-NFC in the range of €3.0–3.1bn and increase the band up to and including all banks in the total L-NFC band of €3.0–5.0bn. We also run a series of models exploring the region below the threshold. We start with the band €2.9–3.0bn and increase the bandwidth all the way to €1.5–3.0bn. As before, we hold the control sample constant and vary the bandwidth around the threshold so that the treatment group is increasing in size as the bandwidth expands. The control group is composed of banks in SSM countries under the same supervisory authority of treated banks (ECB or NCA) that have no incentive to strategically change total assets either because they are too big or too small, as those having a total L-NFC in the range of €0.7–1.5bn (for treated banks below the €3.0bn threshold) and those in in the range of €5–10bn (for treated banks above the €3.0bn threshold).

Our results (Figure B.II, Panel a) show that banks with total L-NFC ranging from €3.0bn to €3.3bn (corresponding to an estimated total assets range of €30–33bn) display a decline in the amount of credit provided to borrowers, compared with banks in the control group. The magnitude of the shortfall for these banks is in the range of 4%–5%, reaching a maximum of 5% among banks with loan portfolios of €3bn–€3.1bn. Overall, these results are strongly consistent with our main findings reported in Table 4 and Figure 3.

Figure B.II. Credit to Nonfinancial Companies Around the Threshold

Figure B.II presents the graphical representation of the coefficient estimates for the interaction term ($z \times T$), capturing the effect for banks in the SSM countries close to the €30bn asset threshold at the end of 2013 in model (2). We use a specific sample of multiple-lending relationships so borrowers included in the sample must have at least one loan with a bank in the treated group and one loan with a bank in the control group as of the end of 2012. Different from Figure 3, we use the entire Pre-AnaCredit database (thus also including anonymous data). The dependent variable is the natural log of the borrower-bank loan-level exposure. Treated banks are those with total L-NFC of around €3.0bn in 2012. Each bar presents the effect of the treatment group, where the treatment group spans all the banks with L-NFC portfolios that are between €3.0bn and the bar. All models are run using borrower and collateral-type fixed effects. As usual, the control groups comprise all bank-borrower relationships of banks with total L-NFC in the €0.7–1.5bn band, corresponding to expected total assets of €7–15bn, for treated banks below the €3.0bn threshold, and all bank-borrower relationships of banks with total L-NFC in the €5.0–10.0bn band, corresponding to expected total assets of €50–100bn, for treated banks above the €3.0bn threshold. The treatment period is 2013. All models are run controlling for both bank and borrower sizes and using borrower and collateral-type fixed effects. Standard errors are clustered at the bank level. The confidence intervals represent 90% level. Source of data: ECB Pre-AnaCredit database.



Appendix C The effect of SSM on bank prices

In section 5, we show that banks closer to the threshold reduced in 2013, after controlling for borrower demand, the credit offered to the same borrowers by more. This strongly suggests that this reduction in credit for banks around the threshold is due to supply constraints. We also rule out the possibility that this lending drop is driven by higher prices on bank products. Although banks under the ECB's direct supervision may have increased prices of their products (essentially, loans) to shift to customers the costs of a more intense (and thus costly) supervision by the ECB), our results are obtained comparing banks under the same supervisory intensity since banks in both the treated (those with a total assets between €30bn and €50bn) and control (those with a total assets between €50bn and €100bn) groups are under the ECB supervision.

We formally test the existence of a price effect by testing whether *significant banks* (under the ECB's direct supervision) have increased prices of their products (essentially, loans) to shift to customers the costs of a more intense (and thus costly) supervision by the ECB, compared with *less-significant banks* (under the supervision of NCAs). We collect ending rates for each bank from the ECB's iBSI dataset and test whether *significant banks* transferred the cost of a more intense supervision to their customers using the following model:

$$y_{i,t} = \alpha + \beta_1 \mathrm{S}_i + \beta_2 \mathrm{T} + \beta_3 \mathrm{S}_i \times \mathrm{T} + \beta_4 \mathrm{X}_{i,2009} + \epsilon_{i,m} \tag{5}$$

where $y_{i,t}$ is the monthly interest rate of bank product for the bank i and in month m. We consider four types of interest rates: bank deposit, total loans, real estate loans (RELs), and L-NFC. $\mathrm{S_i}$ is a dummy variable taking a value of 1 if the bank is *significant* (under the direct supervision of the ECB) and 0 otherwise; T is a dummy variable taking a value of 1 for any month between December 2014 and December 2018 and 0 otherwise (any month from December 2010 to December 2013). The interaction term $\mathrm{S}_i \times \mathrm{T}$ is the main variable of interest as it captures the effect for *significant banks* from the beginning of the ECB su-

pervision. $X_{i,2009}$ includes the usual bank-level control variables. We do not find statistically significant evidence (Table C.I) that *significant banks* increased interest rates on any of the main products offered to customers after the launch of the SSM, and this further support that our loan-level results (indicating a reduction in lending) are driven by supply effects, i.e., motivated by banks' actions constraining credit.

Table C.I. Bank Rate Changes

Table C.I shows whether *significant banks* (under the ECB direct supervision) increased rates on their products after the beginning of the SSM (shifting to customers the cost of a more intense supervision). Table C.I reports the results obtained when estimating model (5). In Panel (a), the dependent variable is the interest rate on bank' products (deposits and loans). In Panel (b), we focus on the rates on REL and L-NFC. In all models, the treatment group consists of *significant banks* in SSM countries (S), thus all banks under the ECB's direct supervision. The control group comprises the *less-significant banks* (banks located in SSM countries under the direct supervision of NCAs). The treatment period (T) is from December 2014 to the end of 2018. The variable of main interest is the interaction between *significant banks* and treatment period (S×T). We control for a series of bank-level control variables: total assets, equity capital ratio, deposit ratio, and loan ratio, as of December 2009. The variable construction is reported in Appendix A. Standard errors are clustered at the bank level and reported in parentheses. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. Source of data: ECB's IBSI database.

Panel A: Deposit and Loan Rates

Dependent variable:	Deposit Rate			Loan Rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Significant Bank (S)	0.045	0.071**	0.030	−0.019	−0.008	−0.0113
	(0.043)	(0.036)	(0.045)	(0.011)	(0.009)	(0.011)
Post-Nov 2014 (T)	−0.283***	−0.301***	−0.301***	−0.070***	−0.332***	−0.332***
	(0.027)	(0.034)	(0.034)	(0.011)	(0.001)	(0.001)
S × T	0.071	0.062	0.075	0.016	0.008	0.007
	(0.056)	(0.050)	(0.047)	(0.016)	(0.013)	(0.013)
Total Assets (2009)			0.000			0.000
			(0.001)			(0.001)
Equity Ratio (2009)			−0.011			0.003*
			(0.012)			(0.002)
Deposit Ratio (2009)			−0.141***			0.011
			(0.050)			(0.010)
Loan Ratio (2009)			0.165***			−0.010
			(0.047)			(0.011)
Observations	8,338	8,338	8,338	8,453	8,453	8,453
R-squared	0.044	0.216	0.224	0.041	0.192	0.194
Bank Effects	No	Yes	Yes	No	Yes	Yes
Country × Year Effects	No	No	Yes	No	No	Yes
Year FE	No	Yes	No	No	Yes	No

Table C.I. Bank Rate Changes (Cont.)

Panel B: Rate on Real Estate Loans (REL) and Loans to Nonfinancial Corporations (L-NFC)

Dependent variable:	REL Rate			L-NFC Rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Significant Bank (S)	−0.004	0.005	0.008	−0.015	0.004	0.002
	(0.013)	(0.012)	(0.015)	(0.015)	(0.011)	(0.015)
Post-Nov 2014 (T)	−0.061***	−0.190***	−0.190***	−0.091***	−0.143***	−0.143***
	(0.010)	(0.001)	(0.001)	(0.014)	(0.044)	(0.044)
S × T	0.006	0.000	−0.001	0.008	−0.009	−0.010
	(0.018)	(0.017)	(0.017)	(0.020)	(0.016)	(0.016)
Total Assets (2009)			0.000			0.000
			(0.001)			(0.001)
Equity Ratio (2009)			0.003			0.003
			(0.002)			(0.002)
Deposit Ratio (2009)			0.013			0.013
			(0.011)			(0.016)
Loan Ratio (2009)			−0.016			−0.011
			(0.011)			(0.017)
Observations	8,193	8,193	8,193	8,207	8,207	8,207
R-squared	0.036	0.146	0.148	0.040	0.237	0.238
Bank Effects	No	Yes	Yes	No	Yes	Yes
Country × Year Effects	No	No	Yes	No	No	Yes
Year FE	No	Yes	No	No	Yes	No

Appendix D Burden of Supervision

D.1 Estimating Drivers of Bank Performance

Table D.I. Full Estimates

Table D.I reports the results for model (4) estimated on banks with total assets (as at the end of 2013) above the threshold (€30–50bn) over the period 2014–2018. The coefficient estimates reported are then used to predict the performance ($\widehat{y}_{i,t}$) of banks in SSM countries with total assets of €15–30bn over the same time period (2014–2018). The variable construction is reported in Appendix A. Standard errors (in parentheses) are clustered at the bank level. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively. Source of data: BankFocus

Dependent variable:	Operating Income	Nonoperating Income	Pre-Tax Profits	After Tax Profits
	(1)	(2)	(3)	(4)
Total Assets (2011)	−0.003	0.000	−0.004	−0.002
	(0.007)	(0.001)	(0.007)	(0.005)
NPL Ratio (2011)	−0.134	−0.022	−0.147	−0.094
	(0.150)	(0.036)	(0.129)	(0.102)
Equity Capital Ratio (2012)	0.106**	0.006	0.120***	0.094***
	(0.049)	(0.007)	(0.041)	(0.032)
Loan Ratio (2011)	0.003	−0.002*	−0.002	−0.003
	(0.008)	(0.001)	(0.006)	(0.005)
Derivative Ratio (2011)	0.055*	−0.002	0.046	0.031
	(0.031)	(0.010)	(0.032)	(0.026)
Intangible Asset Ratio (2011)	−0.500***	0.004	−0.501***	−0.360***
	(0.159)	(0.017)	(0.147)	−0.116
Observations	191	191	191	191
R-squared	0.550	0.344	0.557	0.574
Country Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes

D.2 Robustness Check: Elastic Net Regularized Regression

In this appendix, we change the model to estimate the relationship between profits and bank characteristics using an alternative approach to the OLS regression in model (4). Our approach draws on statistical learning methods, specifically, on the elastic net regularized regression. The elastic net approach proposed by Zou and Hastie (2005) is a machine learning penalized regression approach, entailing a compromise between the Ridge and Lasso regressions, which has increasingly been used in finance, as a robustness check for estimates based on traditional approaches [22]. Developed to improve prediction and overcome some limits of both Lasso and Ridge, the elastic net penalization uses a weighted average (with weight α) of the Lasso and Ridge penalization, that is:

$$\widehat{\boldsymbol{\beta}}_{\text{eln}} = \arg\min_{\boldsymbol{\beta}} \left\{ \sum_{i=1}^{n} \left(y_i - \mathbf{x}_i\boldsymbol{\beta}\right)^2 + \lambda \left[\alpha \sum_{j=1}^{p} (\beta_j)^2 + (1-\alpha) \sum_{j=1}^{p} |\beta_j| \right] \right\} \tag{6}$$

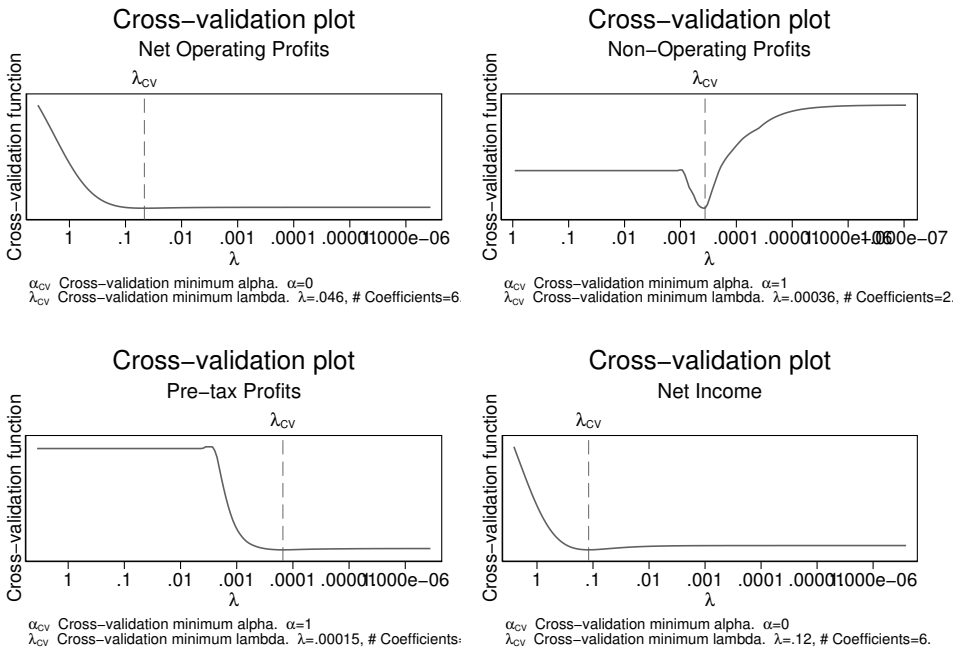
The elastic net approach is characterized by two parameters: the penalization parameter $\lambda \geq 0$ and the weight parameter $\alpha \in (0, 1)$. The elastic net approach improves prediction compared with least squares, as it maximizes the out-of-sample performance accuracy (or minimizes the test error) over both λ and α. The optimal λ and α are obtained via K-fold cross-validation (CV_k), upon providing a grid of values for both parameters.

Consistent with our main model (4), we estimate our elastic net model four times, one for each measure of income (as usual, we include operating income ratio, nonoperating income ratio, pre-tax ROA, and net income ratio). $x_{i,2012}$ is the vector of the usual bank-level variables, as the total assets, NPL ratio, equity ratio, loan ratio, derivative ratio, and intangible asset ratio, as of the end of 2012 [23]. For each outcome variable, the elastic net

[22] For example, Feng, Giglo, and Xiu (2020) use the elastic net approach to systematically evaluate the contribution to asset pricing of any new factor, above and beyond what a high-dimensional set of existing factors explains. Pelger (2020) adopt the elastic net approach to estimate the time-varying latent continuous and jump factors that explain individual stock returns.

[23] Control variables are taken as of the end of 2012, when the SSM criteria became publicly available. Thus, our predictions of bank performance are not biased by the threshold effects in 2013 documented in the first part of the paper.

Figure D.I. Parameters' cross-validation of the elastic net regularized regression.



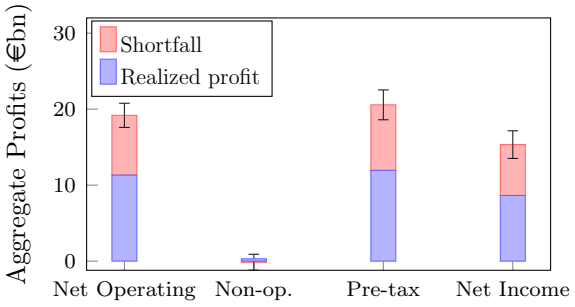
CV_k optimal tuning is reported in Figure D.I, where we can see that the tuning parameters minimize the empirical test error function. The elastic net results are in line with the one provided by the standard regression model reported in the text, thus lending robustness in this case to the traditional approach.

The estimates for the predicted profits obtained using the elastic net approach are strongly consistent with those obtained from our linear OLS estimation reported in Figure 4. Looking at the overall pre-tax profit shortfall (the difference between the real and fitted profits) in the same period, the same bank missed €8.6bn of potential profits (Panel a). We estimate that banks in the€15–30bn size range in 2012 could have generated pre-tax profits of €20.6bn between 2014 and 2018 if they were free to grow as banks in the control group. Thus, these banks achieved only 58.1% of these profits; thus, we can roughly argue that the cost of supervision for these banks was around 41.9% of their potential profits. As shown in Panel (b), both pre-tax actual and profit shortfall are relatively constant overtime, and the cost of supervision (the ratio between the profit shortfall and potential profits) ranged

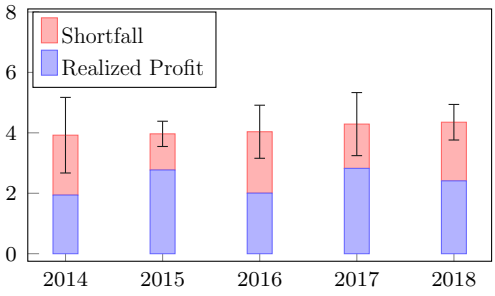
Figure D.II. Estimation of the Cost of Supervision: The Elastic Net Approach

Figure D.II describes the gap between real ($y_{i,t}$) and potential ($\widehat{y}_{i,t}$) performance of banks in the Euro zone with a total assets of €15–30bn at the end of 2012 over the period 2014–2018. Gap estimates are obtained using the elastic net approach (model (6)) on the usual sample including only banks from SSM countries. The estimated gaps provide us with a measure of the cost (lower income) or revenues (higher income) that these banks have due to more intense supervision. We report the following: *i*) the overall profits (in €bn) generated and the overall profit shortfall (summation of the all banks' gap between the real and fitted profits) for various income measures ($y_{i,t}-\widehat{y}_{i,t}$) in Panel (a), *ii*) overall real profits ($y_{i,t}$) and profit shortfall ($y_{i,t}-\widehat{y}_{i,t}$) in €bn in each year of the time period analyzed in Panel (b), and *iii*) overall real profits ($y_{i,t}$) and profit shortfall ($y_{i,t}-\widehat{y}_{i,t}$) in by total asset deciles in Panel (c). Source of data: BankFocus.

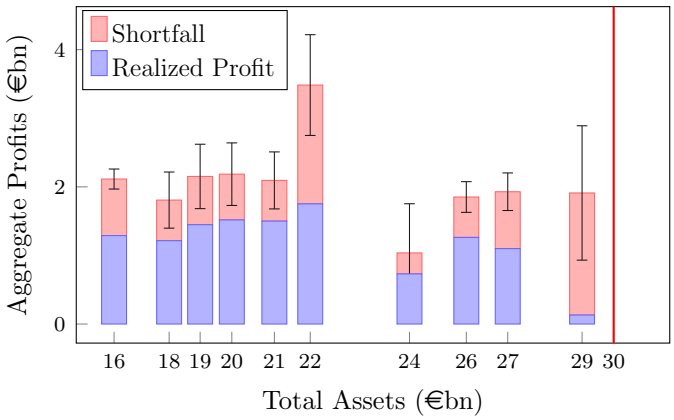
(a) Predicted and Realized Profits



(b) Predicted and Realized Profits, by Year



(c) Predicted and Realized Profits, by Assets



between 30.1% in 2015 and 50.5% in 2014. In Panel (c), our estimates confirm that banks closer to the asset threshold (10$^{\text{th}}$ decile) give up a larger (around 93%) chunk of potential profit.

D.3 Robustness Check: Restricting the Control Group to Only Banks in SSM Countries

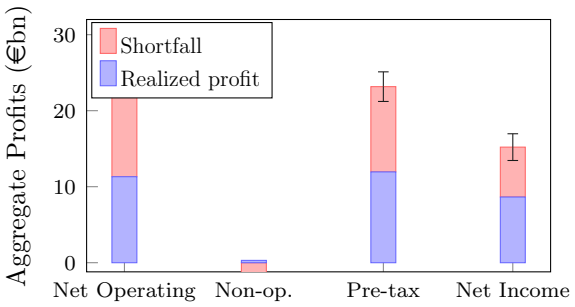
For robustness purposes, we replicate the analyses run in section 6.2 by selecting the control group using the selection criteria used in the first part of the paper (as described in Section 4.1) by excluding European banks outside the euro area. The selection criteria described in section 4.1) aimed to estimate the "escape" effect of banks above the ECB threshold in 2012. To this aim, banks in the treatment and control groups have necessarily to be under the supervision of the same authority (and thus in the euro area) to compare banks with a "cleanup" incentive so that differences capture to the "escape" incentive. This constrain is not necessary to estimate the burden of supervision; thus, we removed in the main analysis (section 6). As robustness check, we now replicate the estimation using a stricter definition of the control sample to check the sensitivity of our results to the inclusion of banks in European countries not interested by the SSM process.

Thus, we report the predicted performance ($\widehat{y}_{i,t}$) of banks with total assets in the €15–30bn range after the SSM start (2014–2018) obtained using only banks in the Euro zone. The difference between the real performance ($y_{i,t}$) and the fitted values ($\widehat{y}_{i,t}$) provides us with an estimate of the costs (lower income) incurred by these banks to avoid ECB's supervision. As shown in Figure D.II, our results are strongly consistent with those discussed in Section 6.2: banks missed €11.2bn of pre-tax profits, achieving only 51.8% of their potential profits, and the burden of supervision increases as banks get closer to the €30bn asset threshold (e.g., banks in the 10^{th} decile give up a larger 95%) chunk of potential profits).

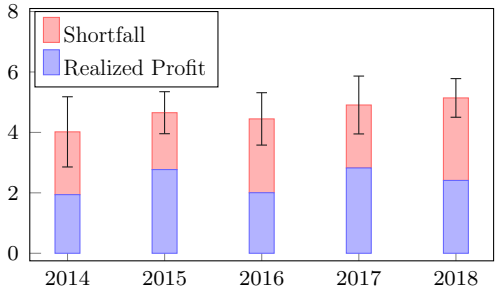
Figure D.III. Estimation of the Cost of Supervision: The restricted control group analysis

The figure describes the gap between real ($y_{i,t}$) and potential performance ($\widehat{y}_{i,t}$) of banks in the Euro zone with a Total Assets of €15–30bn at the end of 2012 over the period 2014–2018. Gap estimates are obtained using Model (4) on an extended sample including also European banks outside the euro area. Estimated gaps provides us with a measure of the cost (lower income) or revenues (higher income) that these banks have due to more intense supervision. We report: *i*) The overall profits (in €bn) generated and the overall profit shortfall (summation of the all banks' gap between real and fitted profits) for various income measures ($y_{i,t} - \widehat{y}_{i,t}$) in the Panel (a); *ii*) overall real profits ($y_{i,t}$) and profit shortfall ($y_{i,t} - \widehat{y}_{i,t}$) in €bn in each year of the time period analyzed in Panel (b); *iii*) overall real profits ($y_{i,t}$) and and profit shortfall ($y_{i,t} - \widehat{y}_{i,t}$) in by Total Assets deciles in the Panel (c). Coefficient estimates used to fit bank performance ($\widehat{y}_{i,t}$) are reported in the Appendix D. Source of data: BankFocus.

(a) Predicted and Realized Profits



(b) Predicted and Realized Profits, by Year



(c) Predicted and Realized Profits, by Assets