EUROPEAN CENTRAL BANK
EUROSYSTEM

Working Paper Series

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Stress tests and capital requirement disclosures: do they impact banks' lending and risk-taking decisions?

No 2679 / July 2022

Abstract

How do banks respond to changes in capital requirements as a result of the stress tests? Does the disclosure of stress test results matter? To answer these questions, we study the impact of European stress tests on banks' lending, their corresponding risk-taking, the ensuing effect on their profitability and the respective publication effect. Exploiting the centralised European stress tests in conjunction with two unique confidential databases containing (i) stress test information for the 2016 and 2018 exercises covering a total of 93 and 87 banks, respectively; and (ii) quarterly supervisory information on approximately 1000 banks (stress-tested and non-tested), allow us to implement a dynamic difference-in-differences strategy for a comparable sample of banks. We find that banks participating in the stress tests reallocate credit away from riskier borrowers and towards safer ones in the household sector, making them in general safer but also less profitable. This is especially the case for the set of banks part of the Supervisory Review and Evaluation Process with undisclosed stress tests, which were also not disclosing their Pillar 2 Requirements voluntarily. Our results confirm that the publication of capital requirements can have a disciplinary effect since banks publishing their requirements tend to have more robust capital ratios, which improves market discipline and financial stability.

Keywords: Stress-testing, Credit supply, Profitability, Financial stability, Market discipline
JEL Codes: E51, E58, G21, G28

Non-Technical Summary

The Global Financial Crisis demonstrated the limitations of the supervisory framework in safeguarding the resilience of the banking system to adverse macro-financial shocks. Especially in the European Union (EU), it triggered far-reaching structural changes by moving to a centralised Banking Union in its various dimensions – the establishment of the Single Supervisory Mechanism (SSM) and the corresponding joint approach to micro- and macroprudential policies. Stress tests quickly became an important assessment tool to identify capital shortfalls in the banking sector, informing supervisory evaluations and contributing to higher capital requirements enforced on banks, with the objective of ensuring a resilient banking system.

The aim of our paper is threefold. First, we contribute to the growing literature on the impact of stress tests (on euro area banks) and the mechanisms underlying the pass-through of those tests on lending and risk-taking. Second, we broaden the scope of the analysis beyond lending and banks' risk-taking behaviour, by also investigating the impact on banks' profitability, which allows for a more comprehensive assessment of the stress tests from a financial stability perspective. Third, we exploit a particular uniqueness of the stress tests to study the heterogeneity in the responses of banks required to disclose their results and banks not required to disclose their results. Before the 2021 stress tests, only the test results of banks that form part of the European Banking Authority (EBA) sample were published, while results of banks that are part of the Supervisory Review and Evaluation Process (SREP) sample were not published. We further study the disclosure effect by analysing the voluntary publication of Pillar 2 Requirements (P2R) of banks part of the SREP sample.

Identification relies on the centralised European stress tests setting by combining two confidential datasets. First, a unique stress-testing dataset for the 2016 and 2018 exercises with a total of 93 and 87 banks, respectively, of which a fraction was under direct EBA coordination (public results) while the larger sample was led by the European Central Bank (ECB) banking supervision as part of the SREP exercise (non-disclosed results). In 2016, the EBA to SREP ratio was 37 to 56 banks and in 2018 it was 33 to 54 banks. Second, a quarterly confidential supervisory dataset with around 1000 relevant reporting banks,[1] which includes both "stress-tested" and "non-tested" banks (banks subject to the stress tests exercises are called the "stress-tested" banks). The two datasets containing granular confidential data enable us to implement a dynamic difference-in-differences strategy, where the selection of banks participating in the stress tests is exploited in a quasi-natural experimental manner. The empirical strategy allows us to assess the impact of the stress tests on European banks´ lending, risk-taking, and profitability.

In our study three main findings are established. First, banks subject to stress tests reallocate credit

[1]In total, there are around 3000 reporting entities but not all of them have sufficient data available.

away from riskier borrowers and towards safer ones in the household sector. This derisking has negative consequences for banks' profitability, not unexpectedly since a re-direction in lending towards safer assets usually results in lower profitability.[2] Second, the EBA sample of banks, which have their results disclosed, do not change their balance-sheet behaviour as much as the SREP banks, which do not have their results disclosed. Both groups reduce their risk-weights towards households, but the SREP banks decrease them by more (i.e., larger magnitude). While the stress tests do not affect lending overall, for the SREP banks there is evidence of a reduction in lending to both non-financial corporations and households, but mainly among risky borrowers. Third, our results for the SREP banks are driven by the portion of banks that do not voluntarily disclose their P2R. The SREP sample of banks that voluntarily disclosed their P2R are less prone to balance-sheet adjustments. Hence, solidifying the evidence of a clear association between effects of stress tests and the disclosure of bank requirements.

In brief, our study presents evidence on whether banks respond to changes in capital requirements, as a result of the stress tests, by deleveraging or by derisking their risk-weighted assets. Our study shows that banks subject to stress test exercises reduce lending to risky borrowers, resulting in generally safer banks in terms of capital and risk-weighted asset ratios. This supports the hypothesis that the stress tests and the respective publication have a positive disciplinary effect mainly by reducing banks' risk-taking. Therefore, the publication of bank requirements improves market discipline and promotes financial stability.

Our findings fit in a growing literature showing that stress tests are effective in reducing banks incentives to take risks (Calem et al. (2020), Pierret and Steri (2020), Cortés et al. (2020), Acharya et al. (2018), Connolly (2018) and Covas (2018). The causal identification of the effect of stress tests on lending and banks' risk-taking behaviour contributes to the debate on how banks adjust their balance-sheets in response to higher capital requirements (Gropp et al. (2019), Cappelletti et al. (2019), Kok et al. (2021), and Gersbach and Rochet (2017)). We contribute to this debate by showing that higher capital requirements, as a result of the stress tests, and the respective publication have a positive disciplining effect by reducing banks' risk-taking, while also having an adverse impact on the real economy through a temporary decrease in credit supply (by the SREP banks) and consequent profitability. The combination of regulatory and market discipline by increasing transparency and disclosure requirements is crucial to ensure financial stability. Market discipline improves the ability of customers, investors, and intermediaries to monitor and influence the management of banks and adds a new dimension to the regulatory process since it disciplines bank risk-taking therefore improving financial stability. Our findings support the discussion on the benefits and short-run costs of the stress tests and provide policymakers with relevant information to calibrate their policy action.

[2]These findings are subject to a series of robustness checks, including placebo tests in the treatment timing, variations of size-overlapping samples, and a different window length for the dynamic estimation approach.

1 Introduction

The Global Financial Crisis vividly demonstrated the limitations of banking supervision in ensuring the resilience of the financial system to adverse shocks. Especially in the European Union (EU), it triggered far-reaching structural changes by moving to a Banking Union in its various dimensions – the establishment of the Single Supervisory Mechanism (SSM) and the corresponding joint approach to micro- and macroprudential policies. In the euro area, the supervisory setting moved to a centralised banking supervision, while, at the same time, the EU built up the macroprudential toolkit to address risks of a systemic nature. This new institutional framework led to a higher scrutiny from supervisors and regulators to the banking system. At the same time, from a financial stability perspective, it was also important to mitigate a potential increase in banks' risk-taking due to monetary policy easing. Stress tests quickly became an important assessment tool for supervisors and regulators ensuring a banking system resilient to adverse macro-financial shocks. Stress tests identify capital shortfalls in the banking sector to inform supervisory evaluations and contribute to higher capital requirements enforced on banks, with the objective of ensuring a resilient banking system. Banks comply with those higher capital requirements by raising new equity (or through the usability of the voluntary buffers – numerator of the capital ratio) or by reducing the denominator (deleveraging and derisking).

This paper aims to present evidence whether banks respond to changes in capital requirements as a result of the stress tests by deleveraging or derisking their risk-weighted assets, by using two confidential datasets with uniquely granular supervisory data in a dynamic difference-in-differences approach. In detail, the motivation of our paper is threefold. First, we investigate whether the stress tests of banks affect credit supply and banks' risk-taking of euro area banks, which contributes to the growing literature on the impact of the stress tests and the mechanisms underlying the pass-through of those stress tests on lending, risk-taking and the real economy. Second, we broaden the scope of the analysis beyond lending and banks' risk-taking behaviour, by also investigating the impact on banks' profitability, which allows for a more comprehensive assessment of the stress tests from a financial stability perspective. Third, we exploit a particular uniqueness of the stress tests of 2016 and 2018 to explore heterogeneity in the responses of banks that are required to disclose their results and banks that are not required to disclose their results. Before the 2021 stress tests, only the test results of banks that form part of the European Banking Authority (EBA) sample were published on individual level, while results of banks that are part of the Supervisory Review and Evaluation Process (SREP) sample were not published. We further study the disclosure effect by analysing the voluntary publication of Pillar 2 Requirements (P2R) of banks part of the SREP sample[3].

[3] The ECB published bank-specific P2Rs on 28 January 2020 for the first time.

Our findings for the baseline specification indicate no significant change for banks participating in the stress tests in credit extended to either non-financial corporations or households. Regarding changes in risk-weights, our estimates show a significant (in statistical and economic terms) coefficient for banks participating in the stress tests, mainly by the derisking towards households, which is close to 1 percentage point (pp) for every sample. At the same time, a reduction in banks' profitability – possibly explained by the banks' re-balancing behaviour for risk-taking, in approximately 2 pp. The impact on risk-weights to households show (almost) no anticipatory response but turns highly significant around two quarters after the publication of the stress tests. Along with the significant effects of stress-testing on banks' risk-taking towards households, it is also possible to observe a significant decrease of lending towards households and a late lagged significant decrease of lending extended towards non-financial corporations in some cases. At the same time, results suggest no anticipatory effects or any other effects for all variables being studied. Our estimates show that the qualitative implications do not change even with a considerable variation across specifications. Results are especially relevant for the set of banks that are part of the SREP sample for which stress test results are not publicly disclosed. These results are validated by studying the effect of the publication of P2R. These findings confirm that the set of banks that are part of the SREP sample and do not publish their P2R tend to adjust more their balance-sheet.

In our study three main findings are established. First, banks subject to stress tests reallocate credit away from riskier borrowers and towards safer ones in the household sector. This derisking has negative consequences for banks' profitability, not unexpectedly since a re-direction in lending towards safer assets usually results in lower profitability.[4] Second, the EBA sample of banks, which have their results disclosed, do not change their balance-sheet behaviour as much as the SREP banks which do not have their results disclosed. While both groups reduce their risk-weights towards households, the SREP banks decrease them by more. We also find evidence, for the SREP banks, of a reduction in banks' credit supply to both non-financial corporations and households, but mainly among risky borrowers. Third, we find evidence that the subset of the SREP banks which were publicly disclosing their P2R voluntarily are less prone to balance-sheet adjustments.

In sum, we present evidence on whether banks respond to changes in capital requirements, as a result of the stress tests, by deleveraging or by derisking their risk-weighted assets. Having better capitalised banks enhances financial stability by reducing banks' risk-taking incentives and increasing banks' capital against losses. Our results show that banks subject to stress tests reduce lending to risky borrowers, resulting in generally safer banks in terms of capital and risk-weighted asset ratios. We also find evidence that the SREP

[4] These findings are subject to a series of robustness checks, including placebo tests in the treatment timing, variations of size-overlapping samples, and a different window length for the dynamic estimation approach.

banks, which were publicly disclosing their P2R voluntarily, are already well capitalised being therefore less prone to balance-sheet adjustments. This confirms that the publication of the stress test results (and P2R) can have a disciplinary effect by reducing banks' risk-taking since banks would publish their P2R if their capital ratios were robust enough. Therefore, the publication of stress test results (and P2R) improves market discipline and promotes financial stability.

Our findings fit in a growing literature showing that stress tests are effective in reducing bank incentives to take risks (Acharya et al. (2018), Connolly (2018), Covas (2018), Calem et al. (2020), Cortés et al. (2020), Pierret and Steri (2020), and Kok et al. (2021)). The causal identification of the effect of stress tests on lending and banks' risk-taking behaviour contributes to the debate on how banks adjust their balance-sheets in response to higher capital requirements (Gropp et al. (2019), Gersbach and Rochet (2017), Cappelletti et al. (2019), and Kok et al. (2021)). We contribute to this debate by showing that higher capital requirements, as a result of the stress tests, and the respective publication have a positive disciplining effect by reducing banks' risk-taking, while also having an adverse impact on the real economy through a temporary decrease in credit supply (by the SREP banks) and consequent profitability. The combination of regulatory discipline and market discipline by increasing transparency and disclosure requirements is crucial to ensure financial stability. Relying also on market discipline improves the ability of customers, investors, and intermediaries to monitor and influence the management of banks and adds a new dimension to the regulatory process since it disciplines bank risk-taking therefore improving financial stability.

In terms of policy implications, and in line with what is suggested by Hanson et al. (2011), Cappelletti et al. (2020) and Gropp et al. (2019), our study suggests that targeting the absolute amount of new capital to be raised instead of the capital ratio could mitigate the temporary adverse impact on the real economy, along with the potential optimisation of the risk-weighted assets. Our findings support the discussion on the benefits and short-run costs of the stress tests and provide policymakers with relevant information to calibrate their policies.

The remainder of the paper is organised as follows: Section 1.1 describes the institutional setting of the stress tests and Section 1.2 reviews the relevant literature. Section 2 presents the data and descriptive statistics. Section 3 explains the identification strategy and lays out the results. Section 4 reviews the validity of our empirical strategy and conducts several robustness checks. Section 5 extends the analysis by studying the heterogeneous effects of the disclosure of the stress test results by the EBA and SREP banks. Section 6 concludes.

1.1 Stress test exercises: institutional framework

The EU-wide stress tests assess the banks' capital position, assuming a static balance-sheet, over a period of three years, under both a baseline and an adverse scenario. It is led by the EBA, which develops the methodology for the exercise, in cooperation with the European Systemic Risk Board (ESRB), the European Central Bank (ECB) and national authorities. The ECB and the ESRB provide the macroeconomic scenarios and the top-down credit risk benchmarks and the ECB Banking Supervision is responsible for coordinating instructions to banks under its direct supervision, receiving the resulting information and performing the quality assurance, i.e., validating banks' data and stress test results. The stress tests identify capital shortfalls and enhance market discipline through the publication of the stress test results and transparency reports by the EBA, which are disclosed, at bank level, for the most systemic banks in the EU. In addition to the EBA EU-wide exercise, the ECB conducts the SREP stress tests for an additional set of banks under direct ECB supervision. The stress test results of banks that form part of the EBA sample (henceforth, "EBA banks") are published, while results of banks that are part of the SREP sample ("SREP banks") were not published at individual level until the 2021 stress tests.[5] Except for the requirement to disclose the stress tests, all other institutional settings, such as the scenario, supervisory quality assurance and respective response, are identical for both the EBA and the SREP sample of banks. Supervisors use stress tests to identify and address banks' vulnerabilities in the SREP activity.[6] There is no "failing" or "passing" for either the EBA or SREP banks but the results influence the Pillar 2 capital required to banks, which is determined in the SREP exercise. The stress tests may therefore translate into higher capital requirements, where additional Common Equity Tier 1 (CET1) can be required to banks in order to maintain the financial stability by ensuring the resilience of the banking system.[7]

The 2016 EU-wide stress test included 51 banks covering 70 percent of total banking assets in the EU, of which 37 banks are within the euro area (EBA banks), and thus under the ECB Banking Supervision.[8] The additional 56 SREP banks were also examined by the ECB Banking Supervision. This totals to 93 banks under consideration for 2016. The 2018 EU-wide stress test included 48 banks, of which 33 banks are within the euro area (EBA banks), and thus under the ECB Banking Supervision. The additional 54 SREP banks were also under the ECB Banking Supervision. As such, 87 banks comprise the stress test sample of the EBA and SREP banks in 2018. Both, the EBA and SREP exercises, were conducted concurrently and followed

[5] This was the first time the ECB published more individual data on ECB-supervised supervised banks not part of the EBA sample.

[6] Supervisors assess the bank risks and check that they are equipped to manage those risks properly. This process is called the Supervisory Review and Evaluation Process, or SREP, and its purpose is to allow banks' risk profiles to be assessed consistently and decisions about necessary supervisory measures to be taken.

[7] The results of the stress tests are incorporated into the definition of supervisory measures and can even have an impact on Pillar 2 capital needs (requirements or guidance).

[8] This paper only focuses on this euro area sub-sample of the EBA banks in both years of the exercise.

the EBA methodology. As in regular stress tests, the aim of the exercises was to analyse the development of the banks' capital position over a period of three years under both – a baseline and an adverse scenario. The stress tests assumes a static balance-sheet over the period and as a result, any feedback effects and countermeasures that a bank would take against the stressed assumptions are not taken into account. In 2016, the exercise was launched on 24 February 2016 and results were published on 29 July 2016. In 2018, it started on 31 January 2018 and results were published on 2 November 2018[9].

The criteria chosen by the EBA to select the participating banks in the stress tests was designed to keep the focus on a broad coverage of EU banking assets and to capture the largest banks. In general, the EBA sample of banks accounts for a share of over 70 percent of bank assets in Europe.[10] The ECB performs the stress tests for the remaining significant institutions not included in the EBA sample,[11] i.e., additional SREP banks which are also SSM significant institutions but are below the EBA threshold for asset size. The stress tests are run at the highest level of consolidation (i.e., at the banking group level), as defined by the Capital Requirements Directive (CRD). The ECB and the ESRB, in close cooperation with national authorities, provide a common macroeconomic baseline and adverse scenarios, which includes risk-type specific shocks. The impact of the stress tests is reported in terms of CET1 capital depletion over a three year horizon. Results are published on a fully-loaded and transitional basis.[12] The stress test results are subject to a quality assurance process, covering the stress-testing design, development and execution. Since 2016, stress test results are no longer a "pass or fail" exercise. The main objective of the exercises is to assess the resilience of financial institutions to adverse market developments, as well as to contribute to the overall assessment of systemic risk in the EU financial system.

1.2 Related literature

The empirical literature related to the effects of the stress test exercises on banks´ lending and risk-taking is scarce, in particular in the European context. So far, there are mostly empirical studies estimating the effects of stress tests in the United States (U.S.). The consensus of these studies, by for example Acharya et al. (2018), Connolly (2018), Covas (2018), Berrospide and Edge (2019), Calem et al. (2020), Cortés et al.

[9] Also see Table 1 in Section 2 for an overview of the relevant sample.

[10] In particular, banks must have a minimum of EUR 30 bn in assets. This minimum is consistent with the criteria used for inclusion in the sample of banks reporting supervisory data to the EBA, as well as with the SSM definition of a significant institution. Also, competent authorities could, at their discretion, request to include additional institutions in their jurisdiction provided that they have a minimum of EUR 100 bn in assets.

[11] Defined as banks with i) assets exceeding EUR 30 bn, ii) economic importance for a country or the EU economy, iii) assets exceeding EUR 5 bn and cross-border exposures above 20 percent of their total assets, iv) requested funding from the European Stability Mechanism or the European Financial Stability Facility.

[12] The implementation of the Basel III capital rules was designed to be phased-in. The process of implementation for the rules was calibrated such that the capital rules began to take effect in 2013, but the full suite of changes only came into effect later. Because of this phased-in implementation, bank capital ratios (i.e., CET1 ratio) are often reported on both transitional and fully loaded basis to allow regulators and other stakeholders to better understand the current capital position of a bank, as well as what the capital position of a bank will be when the full suite of new capital rules apply.

(2020), and Pierret and Steri (2020), is that banks participating in stress tests tend to decrease their credit supply and/or risk-taking. A more detailed description is available in the Appendix, Table 10.

The literature has also attempted to shed light on the relation between higher capital requirements and economic growth. The focus of most papers has been on the effects of higher capital buffer requirements on the cost of banks' equity, lending and risk-taking, which implies an impact on the real economy. For Europe, Gropp et al. (2019) study the impact of higher capital requirements on banks' balance-sheets and its transmission to the real economy through the EBA 2011 capital exercise. Their main conclusions are that stress-tested banks reduce lending to corporate and retail customers and increase their capital ratios by reducing their risk-weighted assets. Similarly, Aiyar et al. (2014a) and Cappelletti et al. (2020) find that banks constrained with higher capital requirements tend to increase their capital ratios not by raising their levels of equity, but by reducing their credit supply. Cappelletti et al. (2019) discuss phase-in arrangements, for instance, which may allow banks to smoothly adjust their balance-sheets, thereby limiting possible repercussions of tighter restrictions for the real economy. Noss and Toffano (2016) show that an increase in aggregate capital ratios of banks operating in the United Kingdom is associated with a reduction in lending. Bridges et al. (2014) show that in the year following an increase in capital requirements, banks deleveraged loans to commercial real estate, other corporates and households. Yet, lending mostly recovers within three years. In the same vein, Martynova (2015) suggests that banks facing higher capital requirements can reduce credit supply as well as decrease credit demand by raising lending rates which may slow down economic growth. Buch and Prieto (2014) find no evidence for a negative impact of bank capital on business loans in Germany. Niepmann and Stebunovs (2018) show that banks under the EBA 2016 stress tests used systematic model adjustment. The authors find that if banks had used their 2014 impairment models in the 2016 stress test, their projected loan losses would have been materially higher. Niepmann and Stebunovs (2018) includes both the EBA and SREP banks. Kok et al. (2021) confirm this evidence showing that such behaviour may indeed be practised by banks. This, in turn, requires a robust quality assurance of banks' stress test projections by the competent authorities (including the ECB), to enforce more realistic results.

A related strand of literature focuses on the stress test disclosures and respective information effects in the market behaviour. Georgescu et al. (2017) evaluate the impact of the 2014 and 2016 stress tests looking at the effects of reduction of information asymmetries in the markets through the publication of the stress test results. Similar work has been done by Breckenfelder and Schwaab (2018) for example, who find that equity prices fall in countries where stress test results were disclosed. Other similar work is available from Alves et al. (2015), Flannery et al. (2017), Barucci et al. (2018), Dogra and Rhee (2020), Fernandes et al. (2020), and Sahin et al. (2020).

In contrast to the hypothesis that moral hazard costs amplify risk-taking,[13] some literature suggests that regulatory surcharges had a positive disciplining effect. This is in line with some of the theoretical literature on the impact of capital based regulation on risk-taking. Having better capitalised banks, as a result of higher capital requirements, enhances financial stability by reducing bank risk-taking incentives and increasing banks' capital buffers against losses. Repullo (2004) for example finds that capital requirements can reduce banks' gambling incentives, leading to a "prudent equilibrium". Cappelletti et al. (2019) find that banks subject to higher capital buffers reduced, in the short-term, their credit supply to households and financial sectors and shifted lending to less risky counterparts within the non-financial corporations. The findings support the discussion on the short-run costs and provide policy-makers with relevant information to calibrate their policy actions. In terms of policy implications, as mentioned by Gersbach and Rochet (2017), Cappelletti et al. (2019), and Kok et al. (2021) higher capital requirements could have potentially a positive disciplining effect by reducing risk-taking.

Most of the discussed papers address the question of stress test effects by interpreting them as a quasi-experiment, employing a variation of difference-in-differences approaches. However, identifying the effect of the stress tests, which may result in higher capital requirements, on banks' lending and risk-taking is challenging. First, there is the exogenous variation in capital requirements, which is not-observable and stagnant and may impede the causal interpretation of any observed impact. Second, there are bank-specific requirements, not exogenous with respect to banks´ balance-sheets. Third, it is important to disentangle credit supply from credit demand (Aiyar et al., 2014a, Aiyar et al., 2014b, Khwaja and Mian, 2008, Borio and Gambacorta, 2017, and Gropp et al., 2019). The use of micro-data helps in addressing the confounding factors where the main dependent variable is generally specified as bank lending since this is the key transmission channel running from banks to the real economy (Buch and Goldberg, 2016). Using lending growth to different economic sectors as the dependent variable allows disentangling bank credit demand from supply (Aiyar et al., 2014a, Aiyar et al., 2014b).[14] When measuring the effects on banks' lending from changes in capital requirements, it is important to control for bank characteristics, loan demand as well as country characteristics. A further improvement of these identification issues provide variations of difference-in-differences applications that are mostly used in this context. As mentioned, Gropp et al. (2019) use a difference-in-differences matching estimator following Abadie and Imbens (2011) for example, while Georgescu et al. (2017) employ an event study approach. Lastly, Cerulli and Ventura (2019) proposes to estimate a dynamic difference-in-differences, which is employed in this study, as discussed in Section 3.

[13] The financial crisis showed that certain institutions are too systemically important to fail, which may lead to misaligned incentives and greater moral hazard (ESRB 2015). Shocks to these systemically important institutions may lead to losses and liquidity shortages in the financial system, both through direct and indirect channels.

[14] Also, the interaction of bank and time fixed-effects increases efficiency of the estimates, which allows controlling for changes in credit demand (Borio and Gambacorta, 2017.

2 Data

In this section, the background information of our primary data sources is described. Our final dataset is composed of two subsets which both contain confidential supervisory data.

(1) The stress test dataset contains information on 93 (2016) and 87 (2018) participating banks, of which 37 (2016) and 33 (2018) are part of the EBA euro area sample with publicly available results, while 56 (2016) and 54 (2018) banks are part of the SREP sample with undisclosed results. The number of institutions studied in this paper is reduced to 35 (2016) and 33 (2018) banks from the EBA sample since some entities were subject to restructuring (e.g., mergers and acquisitions), ; and 54 (2016 and 2018) banks from the SREP sample. Table 1 provides an overview of the two sub-samples, including the relevant publication dates and the actual count of entities used for this analysis.

(2) The confidential supervisory dataset contains quarterly data between 2015 Q1 and 2019 Q4, with around 3000 entities. However, when considering the presence of several variables around the stress test periods, the effective number of banks reduces to about 1000 with all stress-tested banks still in the sample[15]. A strongly balanced panel for both periods is not required due the use of our dynamic two-way fixed-effects model. Yet, we do require a minimum number of six consecutive observations around the stress test dates to be able to understand its dynamic effects (see Section 3.3). The data includes information on volumes of exposures, risk-weighted assets, assets, impairments, profits and expected losses, as well as indicators of capital, such as the CET1 ratio. Our variables are trimmed at both tails of the distribution by approximately removing observations outside of three standard deviations from the mean (0.3th and 99.7th percentile), in accordance with the inter-quartile outlier detection rule. This procedure is important since reporting errors may impede the sample's actual distributive properties. Since the stress tests are applied to the highest level of consolidation, subsidiaries of stress-tested banks were also removed from our sample to avoid bias in the estimates.

Table 2 reports the descriptive statistics of the sample for the main dependent variables used in our empirical analysis across banks and sectors, computed separately for stress-tested and non-tested banks, as well as "before/after" and "during" treatment periods. Looking at the before/after and during treatment averages among stress-tested and non-tested banks, some heterogeneity among both groups can be observed, with an evident reduction in the mean values for risk-weights of stress-tested banks in the households sector, as well as for return-on-equity. The standard deviation compared to means indicates some dispersion in the log credit changes. In general, the averages of total, before/after and during stress-tested bank variables are similar.

[15] The exact number also depends on the chosen specification.

Table 1: Characteristics of the EBA and SREP samples of banks

	EBA banks	SREP banks (Total)	of which, SREP banks (P2R disclosed)	of which, SREP banks (P2R undisclosed)
2016				
Assets (bn Euros)	523.929	44.405	48.562	41.537
	(518.902)	(25.501)	(23.683)	(26.708)
CET1 ratio	0.144	0.175	0.162	0.185
	(0.056)	(0.124)	(0.102)	(0.139)
Exposures (bn Euros)	441.565	42.221	46.964	38.949
	(386.663)	(23.528)	(21.210)	(24.830)
Return-on-equity ratio	0.013	0.013	0.011	0.013
	(0.009)	(0.021)	(0.017)	(0.023)
Stress tested banks	35	46	21	25
Disclosure	29.07.2016	No	Voluntary	No
2018				
Assets (bn Euros)	533.145	44.164	46.915	40.455
	(503.578)	(26.373)	(25.658)	(27.439)
CET1 ratio	0.156	0.203	0.194	0.215
	(0.063)	(0.115)	(0.116)	(0.116)
Exposures (bn Euros)	479.289	43.195	45.865	39.597
	(406.856)	(24.861)	(23.863)	(26.246)
Return-on-equity ratio	0.017	0.02	0.023	0.017
	(0.008)	(0.019)	(0.022)	(0.013)
Stress tested banks	32	52	30	22
Disclosure	02.11.2018	No	Voluntary	No

Notes: Data refers to the first quarter of the respective year. Assets and total exposures at default refer to bank assets and exposures in billions of euros. Return-on-equity is the ratio between net income and equity. Common-equity tier 1 ratio (CET1 ratio) corresponds to the common-equity tier 1 capital divided by the risk-weighted assets. Stress-tested banks corresponds to the number of banks effectively used in each sample. Due to restructuring/mergers of banks, the sample reduces from 37 to 35 for the EBA sample and from 56 to 54 for the SREP sample in 2016. Further banks are omitted because of insufficient reporting. Standard deviation is reported in parentheses.

Table 2: Descriptive statistics

	Stress-tested banks				Non-stressed banks			
	All	Before/After	During	P-value	All	Before/After	During	P-value
Δ Log Credit								
Non-financial corporations	0.018 (0.218)	0.015 (0.210)	0.024 (0.238)	0.479	0.062 (0.323)	0.061 (0.325)	0.063 (0.316)	0.773
Households	0.012 (0.218)	0.014 (0.229)	0.006 (0.183)	0.565	0.055 (0.226)	0.057 (0.223)	0.052 (0.234)	0.114
Δ Risk-weights								
Non-financial corporations	-0.002 (0.043)	-0.002 (0.040)	-0.003 (0.049)	0.329	0.001 (0.044)	0.001 (0.045)	0.001 (0.042)	0.729
Households	-0.003 (0.036)	-0.002 (0.035)	-0.008 (0.037)	0.003	-0.006 (0.027)	-0.006 (0.027)	-0.005 (0.027)	0.756
Δ Return-on-equity								
Total	-0.002 (0.070)	0.002 (0.067)	-0.011 (0.075)	0.003	-0.001 (0.112)	-0.002 (0.108)	0.001 (0.121)	0.379

Notes: The table presents the mean values for the banks' yearly: i) credit growth as log change of credit volume by sector; ii) risk-taking as change in the average risk-weights by sector; and iii) profitability as change in return-on-equity. Data from 2015 to 2019. Mean values are computed separately for stressed banks and non-stressed banks, as well as all periods, before/after and during the stress test periods. For before/after, we use the periods before the stress test publication and after the SREP exercise, for "during", we use the publication and implementation period. See Section 3.1 for a thorough description of the timing assumptions of the baseline specification. Standard deviations are reported in parenthesis. The p-value is from a t-test with the hypothesis Ho: mean(before/after) - mean(during) = 0.

To identify how banks adjust their balance-sheets in response to higher scrutiny of supervisors, i.e., to estimate the causal effect of a bank being subject to higher capital requirements as a result of the stress tests, different variables are considered. The exposures at default is considered as a measure of total exposures.[16] To measure the changes in levels of banks' lending, the yearly change in the natural logarithm of a bank credit volume is computed. To measure both banks' profitability and risk-taking, the yearly change in the return-on-equity and in the risk-weights (or risk-weighted asset densities), respectively, are studied.[17] The average risk-weights, defined as the ratio of risk-weighted assets to total exposures, is widely used to measure the average risk of exposures held by a bank.

[16] Exposures are also analysed to assess other events, such as the increase of exposures to sovereign debt (Becker and Ivashina (2014) or Ongena et al. (2019)) as a consequence of the longer-term refinancing operations program of the ECB (Van Rixtel and Gasperini (2013))). The exposure at default might be considered as a measure of size, which includes both on-balance-sheet and off-balance-sheet contingent exposures and commitments.

[17] For standard approach (STA) exposures the risk-weights are defined according to external ratings or level of collateralization, as detailed in the Regulation (EU) No 575/2013 ('CRR'). For internal ratings based approach (IRB) exposures the risk-weights are calculated according to Articles 153 and 154 of the CRR. This indicator is also used by the EBA in their annual review of RWA's variability (https://www.eba.europa.eu/-/eba-interim-report-on-the-consistency-of-risk-weighted-assets-in-the-banking-book).

3 Empirical analysis

This section discusses the identification and empirical strategy of the paper and presents the main results for the effect of the 2016 and 2018 stress tests on banks' lending, risk-taking and profitability. It is divided into three subsections. Section 3.1 details our identification strategy and the econometric specification for our baseline setup. Section 3.2 presents our baseline results and Section 3.3 studies the dynamics behind the timing of the stress tests.

3.1 Identification strategy

Our compiled dataset includes two stress test periods (2016 and 2018) for the EBA and SREP banks in the euro area countries, with quarterly supervisory data. The availability of such granular data allows us to implement a dynamic difference-in-differences setting. For that, we assume that in the absence of stress tests, stress-tested banks and non-tested banks will follow a similar trend. Estimating the impact of the stress tests on banks' lending and risk-taking behaviour poses a number of challenges. First, there is an exogenous variation in capital requirements, which is not-observable and stagnant. When regulatory authorities impose higher capital requirement, the adjustment might be for the entire banking system simultaneously, making it practically impossible to identify any casual effect. Second, there are cases where supervisors impose bank-specific requirements, which are related to bank characteristics. Third, to assess the effects of higher capital requirements on banks' lending, it is important to disentangle credit supply from credit demand. These challenges can be overcome by exploiting the two granular datasets and using a dynamic difference-in-differences approach as proposed by Cerulli and Ventura (2019) to examine how banks subject to stress-testing exercises adjust their balance-sheets compared to otherwise similar banks not subject to this scrutiny. The use of micro-data helps in addressing the confounding factors. One main dependent variable is specified as yearly bank lending growth[18] since this is the key transmission channel running from banks to the real economy (Aiyar et al., 2014a, Aiyar et al. (2014b), Buch and Prieto, 2014, and Borio and Gambacorta, 2017). Following the literature, our empirical setup includes lending growth to different economic sectors as dependent variable, as well as bank and quarter fixed-effects. This increases efficiency of the estimates and allows controlling for changes in credit demand. As outcome variables of interest $Y_{i,t}$) our empirical setup also includes the yearly change in sectoral risk-weights, as well as the total yearly change in return-on-equity. The sectors under investigation include non-financial corporations and households. Section 4.3 also includes an extended two-way fixed-effects estimator, adding interacted country-year fixed effects to the country (μ_i) and quarter (τ_t) fixed effects, which further demonstrates the robustness of our estimates and controls for

[18] Defined as yearly log changes.

changes in credit demand.

As an extension to the generalised panel difference-in-differences as discussed by Bertrand et al. (2004) and Athey and Imbens (2006), in our dynamic difference-in-differences an average treatment effect (ATE) is estimated where the treatment is indicated by a binary variable $D_{i,t} = S_{i,t} * T_i$ with $S_{i,t} = 1$ if the bank was treated (i.e., part of the stress tests) and 0 otherwise. $T_i = 1$ during the intervention period (i.e., since the publication of the stress test results and subsequent quarters until the implementation in the supervisory review – SREP, and 0 otherwise. This requires making an assumption on common trends between the outcome variables of treated and non-treated banks which is discussed in more rigour in Section 4. The model takes the following form:

$$Y_{i,t} = \alpha + \beta_1 D_{i,t} + \beta_2 X'_{i,t} + \tau_t + \mu_i + \varepsilon_{i,t}, \tag{1}$$

With $X'_{i,t}$ being a vector of control variables containing the country specific unemployment rate and the banks' voluntary buffer, each lagged by one quarter to avoid contemporaneous interaction. Standard errors are clustered at bank level. α is the constant, μ_i are bank fixed-effects, τ_t are quarterly time fixed-effects and $\varepsilon_{i,t}$ the error term. β_1 is the coefficient indicating the average treatment effect of a stress test.

For our baseline, the treatment period is defined in the most narrow way possible, i.e., from the date of the stress test publication in 2016 Q3 and 2018 Q4 until the implementation (of the impact of the stress tests) during the supervisory review (SREP) in 2017 Q1 and 2019 Q1, respectively. Note that an interim impact was already known to banks in the second and third quarters of the respective years due to the structure of the stress test exercises.[19] At the same time, if additional capital requirements during the SREP were raised, these can be distributed over the following two quarters upon discretion of the supervisory authority. This potential anticipation and phasing-in of stress test outcomes gives way to the possibility to observe a certain dynamic in the effects of the stress tests over several quarters around the publication date. The corresponding results are discussed in the dynamic model in Section 3.3.

Additionally, and to further validate our assumption on common trends between treatment and control groups, we follow Gropp et al. (2019) in evaluating the combination of banks' observables, by defining an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The banks' size is either measured using the size of total assets or risk-weighted assets. The overlap sample are defined as: i) banks larger than the smallest bank of the sample of stress-tested banks (treated sample) and; ii) banks smaller than the largest bank of the sample of non-tested banks (control group).

[19] The stress tests have several cycles, in which banks interact with supervisions regarding their respective impact.

3.2 Effect of the 2016 and 2018 stress tests on banks' lending, risk-taking and profitability: baseline results

Table 3 provides the estimates for the effect of the 2016 and 2018 stress tests on our variables of interest for non-financial corporations and households, with the full and overlapping samples (for bank size).

Table 3: Baseline results

	Full sample	RWA	Assets	Full sample	RWA	Assets
Exposures	**Non-financial corporations**			**Households**		
D_{it}	-0.004	0.005	0.004	-0.016	-0.031	-0.021
(SE)	(0.014)	(0.015)	(0.015)	(0.017)	(0.020)	(0.022)
Observations	13034	7385	9249	12336	6987	8747
Groups	1010	475	963	962	447	920
Risk-weights	**Non-financial corporations**			**Households**		
D_{it}	0	-0.002	0	-0.007*	-0.008*	-0.009**
(SE)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Observations	13030	7309	9205	12375	7017	8793
Groups	1012	473	964	963	450	925
Return-on-equity	**Total**					
D_{it}	-0.019**	-0.018*	-0.021**			
(SE)	(0.007)	(0.008)	(0.008)			
Observations	6778	4298	6571			
Groups	485	290	481			

Notes: This table presents the estimates for the effect of the stress-tests exercises on banks' lending, risk-taking and profitability. The dependent variables are defined as the (i) yearly change of log credit exposures (ii) yearly change in the average risk-weights and (iii) return-on-equity. The estimates are obtained using bank and quarter fixed-effects and control for lagged unemployment and banks' voluntary buffer. The risk-weighted-assets (RWA) and assets reflect the size of banks, which was used to define an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The overlap sample refers to the sample where the untreated banks smaller than the smallest stress-tested bank are removed (in terms of RWA or assets); and stress-tested banks larger than the largest non-tested bank are also removed (in terms of RWA or assets). The standard errors (SE) are reported in parentheses and are clustered by bank. ***, **, and * denote significance at the 0.1, 1 and 5 percent level, respectively.

Our results indicate no significant change in credit extended to either non-financial corporations or households. In every sample variation, the coefficients remain small and insignificant. The number of groups illustrates well how the sample size changes, with the risk-weighted assets (RWA) sample being the most restrictive and a sample size of only around 50 percent of the full sample. Regarding changes in risk-weights, our estimates show a significant (in statistical and economic terms) coefficient for the derisking towards households. The reduction in risk-weights is close to 1 percentage point (pp) for every sample. At the same time, a reduction in banks' profitability – possibly explained by the banks' re-balancing behaviour for risk-taking – is observable in the coefficient estimates. The change in the banks' return-on-equity reaches a reduction of approximately 2 pp and exhibits statistical significance at 5 percent and even 1 percent for the full sample specification.

Overall, results show that after the publication of the stress-testing exercise outcomes, banks subject to the stress tests significantly reduced their risk-taking towards households. This suggests a disciplining effect of the stress tests on bank balance-sheet behaviour through a derisking of the risk-taking towards households, with negative effects on banks' profitability. Following up on these first outcomes, the next section evaluates these dynamics in more depth.

3.3 Effect of the 2016 and 2018 stress tests on banks' lending, risk-taking and profitability: dynamic model

To further investigate the effect of the 2016 and 2018 stress tests and specifically, to evaluate the relevance of the timing, as well as to better understand our baseline results, this section expands the analysis to a dynamic model allowing for anticipatory and lagged effects of the treatment. This specification helps in identifying the dynamic reaction of banks to the publication of the stress test results, illustrating the bank subsequent reaction to additional capital requirements. In particular, it allows us to study the propagation of the treatment over the subsequent quarters, for example whether there are anticipatory or phasing-in effects present. It also allows for possibility to determine whether the effect of a stress test on banks is relevant during the publication of the results or during the supervisory review (SREP).

To study the dynamics behind the timing of the stress tests, our model follows the dynamic difference-in-differences treatment estimator proposed by Cerulli and Ventura (2019), which illustrates the underlying derivations rigorously. For our purposes, we adapt the model as follows:

$$Y_{i,t} = \alpha + \sum_{j=p}^{k} \beta_j D_{i,t+j} + \gamma X'_{i,t} + \tau_t + \mu_i + \varepsilon_{i,t} \tag{2}$$

As in Equation 1, μ_i and τ_t are bank and quarter fixed-effects, respectively, $X'_{i,t}$ is a vector of control variables consisting of the one quarter lag of the country-specific unemployment rate and the banks' voluntary buffer. The novelty enters the equation in the sum of $\sum_{j=p}^{k} \beta_j D_{i,t+j}$. The major difference to the previous setting is $D_{i,t}$, which we now restrict to 1 for treated entities only on the actual treatment event, i.e., the date of publication of the stress test results (2016 Q3 and 2018 Q4). Now, p is the number of lags of $D_{i,t}$ that enter the equation while k represents the number of leads. This allows for a lagged effect as well as an anticipatory effect around the treatment. We set $p = 4$ to cover the period during which the SREP procedure is executed, as well as two additional quarters to observe a possible phasing-in of banks' reaction to higher capital requirements as a result of the stress tests. Similarly, we set $k = 2$ to include the entire stress tests period starting with the first cycle.[20] This specification allows us to study the dynamic propagation of the treatment (stress tests which produce higher capital requirements) over time and for several treatment periods and entities.

Figure 1 graphically represents the effect of the treatment over time for the full sample variation. Most remarkably, Figure 1 confirms our baseline results presented in Subsection 3.2. The risk-weights to households show (almost) no anticipatory response but turns highly significant around two quarters after the publication of the stress tests. The point estimate is now at around 2 pp, which is close to our initial estimate. Along with the significant effects of stress-testing on banks' risk-taking towards households, it is also possible to observe a late lagged significant decrease of lending extended towards non-financial corporations. At the same time, results suggest no anticipatory effects or any other effects for all variables being studied. For return-on-equity, the coefficients display similar outcomes as in the baseline specification, with a short-term decrease by about 3.5 pp one quarter after the publication of the stress test results.

Table 4 summarizes the average treatment effect from the moment of publication of the stress tests until the execution of the SREP exercise on lending, banks' risk-weights and return-on-equity, including the estimated treatment effects for the two overlap samples (relative to bank size).

Overall, Figure 1 and Table 4 support our conjecture that the effect phases in, starting from the publication of the stress test results, continuing to intensify in anticipation of – and during – the SREP exercise.[21] As such, additional to the non-dynamic estimation, our dynamic estimates suggest that stress-tested banks reduced their risk-taking to households. To confirm a decrease on the banks' risk-weights, instead of a possible optimisation of risk-weights under the IRB approach (i.e., potential risk measurement manipulation), another specification considering only portfolios subject to the STA risk-weights is studied. When focusing only on the STA risk-weights, our previous results are confirmed, with a significant estimated coefficient for the reduction of banks' risk-taking to households.[22] At the same time, results show a decrease in banks' return, which could be explained by the banks' derisking behaviour, since a shift in lending to safer assets (lower risk-weights) results in lower profitability.

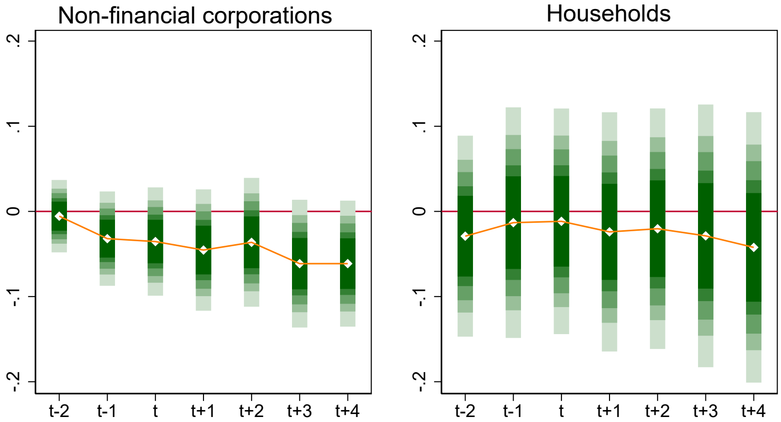
[20] The publication of the stress tests vary over the two exercises, thus 2018 Q4 is included which is usually not considered for phasing-in while, at the same time, 2016 Q1 is also included which is usually reserved for the advance data collection. This ensures symmetry between both treatment periods and also serves as a control to verify whether theoretically non-relevant quarters yield significant results. The selection of leads and lags length cannot be based on a quantitative measure but rather relies on the qualitative assessment of the stress test process. Alternative results when changing the length are provided in the Appendix, Figures 6 and 7.

[21] The choice of the window of leads and lags around the publication relies on our qualitative argumentation. To ensure that results are not stemming from our argumentation only, results with a more restrictive window are also provided in the Appendix, Figure 8.

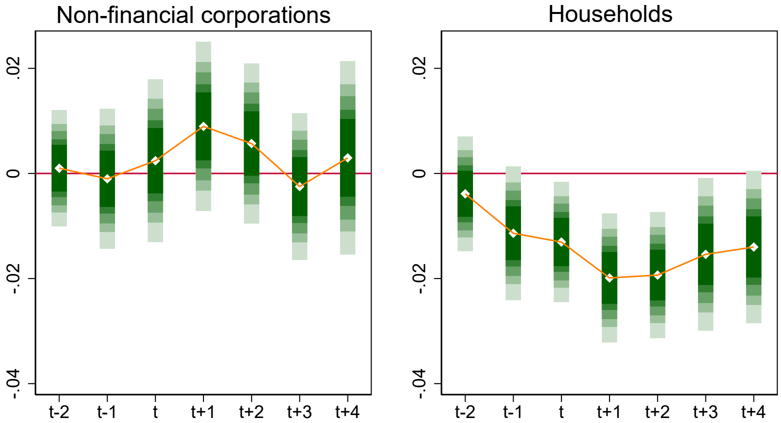
[22] Results are presented in the Appendix, Figure 7, and conserve their qualitative meaning for the IRB and STA risk-weights, but the reaction of the IRB risk-weights is more immediate while the STA risk-weights react slightly more lagged. In magnitude, the responses are also extremely similar with a decrease of around 1.5 percent.

Figure 1: Dynamic effect of stress-testing on lending, risk-taking and profitability

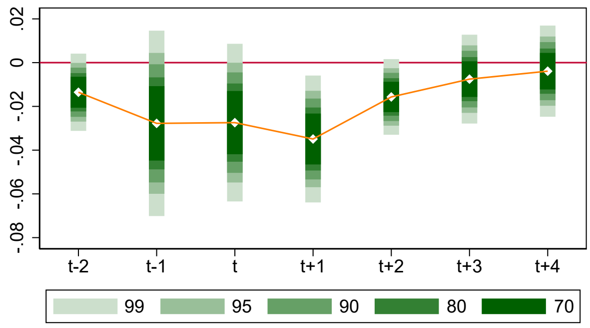
(a) yearly Δ log credit



(b) yearly Δ risk-weights



(c)total yearly Δ return-on-equity



Notes: The figure presents the dynamic evolution of yearly changes in credit exposure amounts (in log terms), risk-weights and return-on-equity, for non-financial corporations and households. The light to dark green shaded areas reflect the respective 99, 95, 90, 80, and 70 percent confidence intervals of the estimated coefficients. The x-axis corresponds to the lead or lag of the treatment quarters with t being the quarter of the treatment (publication of the stress tests). The y-axis corresponds to percentage points impact in the outcome variable.

Table 4: Dynamic effects

	Full sample	RWA	Assets	Full sample	RWA	Assets
Exposures	**Non-financial corporations**			**Households**		
D_{it}	-0.035	-0.020	-0.013	-0.012	-0.018	-0.033
(SE)	(0.025)	(0.027)	(0.031)	(0.051)	(0.059)	(0.062)
D_{it} *One quarter lag*	-0.045	-0.032	-0.039	-0.024	-0.037	-0.047
(SE)	(0.028)	(0.030)	(0.034)	(0.054)	(0.062)	(0.065)
D_{it} *Two quarter lag*	-0.036	-0.030	-0.034	-0.020	-0.036	-0.041
(SE)	(0.029)	(0.032)	(0.034)	(0.055)	(0.062)	(0.065)
Observations	18093	12530	14480	18287	13029	14854
Groups	794	472	734	747	444	698
Risk-weights	**Non-financial corporations**			**Households**		
D_{it}	0.002	0.001	0.007	-0.013**	-0.013*	-0.014**
(SE)	(0.006)	(0.007)	(0.008)	(0.004)	(0.005)	(0.006)
D_{it} *One quarter lag*	0.009	0.009	0.018*	-0.020***	-0.017**	-0.023***
(SE)	(0.006)	(0.007)	(0.008)	(0.005)	(0.005)	(0.006)
D_{it} *Two quarter lag*	0.006	0.007	0.015	-0.019***	-0.017**	-0.023***
(SE)	(0.006)	(0.007)	(0.007)	(0.005)	(0.005)	(0.006)
Observations	18113	12491	14475	18290	13025	14873
Groups	794	470	733	747	447	701
Return-on-equity	**Total**					
D_{it}	-0.027*	-0.021	-0.027			
(SE)	(0.014)	(0.016)	(0.015)			
D_{it} *One quarter lag*	-0.035**	-0.031*	-0.035**			
(SE)	(0.011)	(0.012)	(0.012)			
D_{it} *Two quarter lag*	-0.016*	-0.010	-0.014			
(SE)	(0.007)	(0.007)	(0.007)			
Observations	33208	32970	34954			
Groups	471	288	467			

Notes: This table presents the estimates for the effect of the stress-tests exercises on banks' lending, risk-taking and profitability in a dynamic setting where only the publication quarter is defined as initial treatment. The dependent variables are defined as the (i) yearly change of log credit exposures (ii) yearly change in the average risk-weights and (iii) return-on-equity. The estimates are obtained using bank and quarter fixed-effects and control for lagged unemployment and banks' voluntary buffer. The risk-weighted-assets (RWA) and assets reflect the size of banks, which was used to define an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The overlap sample refers to the sample where the untreated banks smaller than the smallest stress-tested bank are removed (in terms of RWA or assets); and stress-tested banks larger than the largest non-tested bank are also removed (in terms of RWA or assets). The standard errors (SE) are reported in parentheses and are clustered by bank. ***, **, and * denote significance at the 0.1, 1 and 5 percent level, respectively.

4 Validation of the results: parallel trend assumption, placebo dates and alternative specifications

In this Section 4.1 the validity of our identification strategy is discussed by investigating if the main assumption holds. Then, the robustness of our results are studied: i) against placebo dates, in Section 4.2, and ii) upon alternative regression specifications, in Section 4.3.

4.1 Parallel trends assumption

Identifying the effects of higher capital requirements as a result of the stress tests on banks' lending and risk-taking is challenging since there is exogenous variation in capital requirements, which is not-observable. To assess the robustness of our results, testing for a common pre-trend plays an important role in validating the parallel trends assumption underlying the difference-in-differences approach. As the quasi-experimental design uses longitudinal data from treatment and control groups to proxy a counterfactual to estimate a causal effect. The parallel trend test is the most critical assumption to validate the use of our chosen approach, which requires that in the absence of treatment the difference between the 'treatment' and 'control' groups is consistent over time. Beginning with an visual test, Figure 2 displays the evolution of our main dependent variables over the estimation horizon to visually validate the assumption.

Indeed, Figure 2 shows a similar evolution of the main variables between stress-tested banks and non-tested banks outside of stress tests. However, during stress tests (grey shaded areas), it is possible to observe the divergence of stress-tested and non-tested bank risk-weights in the households sector during the 2016 stress test, for example. The risk-weights for non-financial corporations display some variation, also in the inter stress test period, however this might be of lesser relevance given the insignificance of the coefficient estimates displayed in Section 3.2. Nevertheless, to further ensure that our assumptions hold, a formal parallel trends test is also presented below.

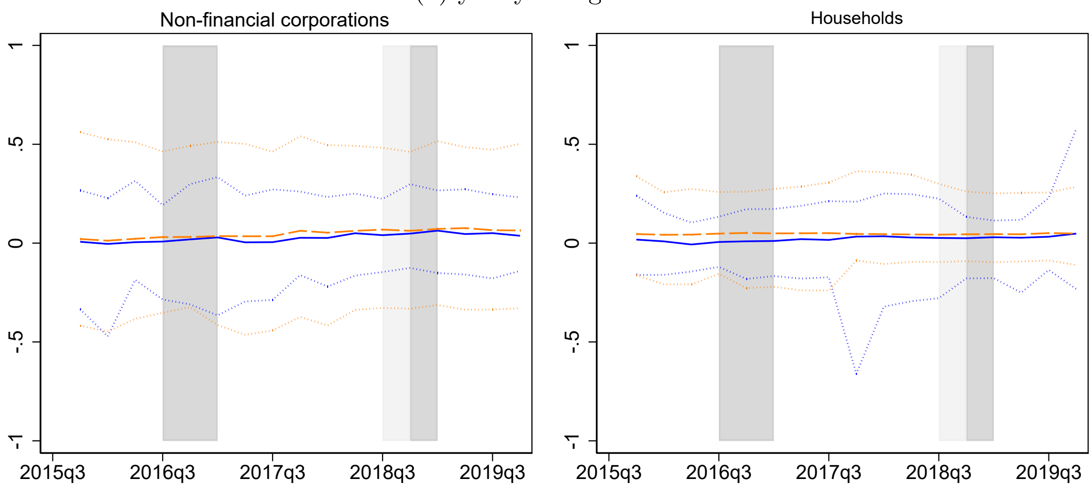
The test uses the (dynamic) difference-in-differences regression augmented with a time trend and the interaction between treatment dummy and time trend variable as implemented by Cerulli and Ventura (2019) following Angrist and Pischke (2008), as below:

$$Y_{i,t} = \alpha + \beta_1 t + \beta_2 (D_{i,t} \times t) + \beta_3 D_{i,t} + \mu_i + \varepsilon_{i,t}, \tag{3}$$

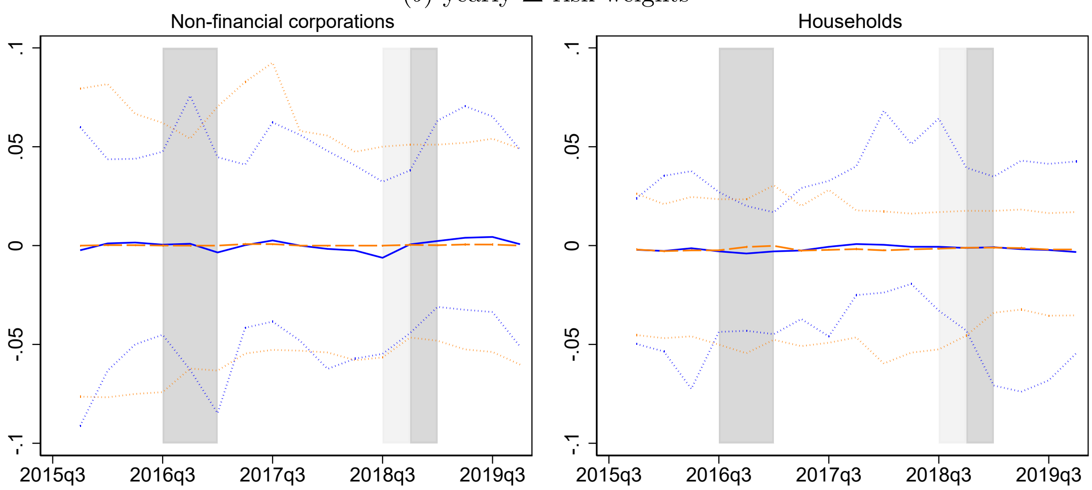
where $Y_{i,t}$ is the outcome variable for bank i at quarter t and t is the time trend. $D_{i,t}$ is again the dummy that takes the value of 1 if bank i was stress-tested at time t and 0 otherwise. The dummy μ_i controls for bank fixed-effects and $\varepsilon_{i,t}$ is the individual error term. Note that τ_t is omitted from the model contrary to

Figure 2: Evolution of credit, risk-weights and return-on-equity

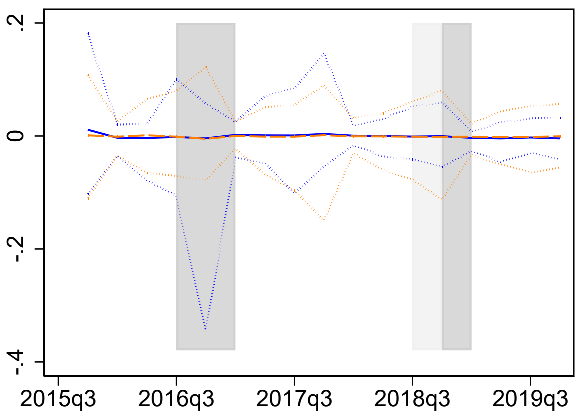
(a) yearly Δ log credit



(b) yearly Δ risk-weights



(c) yearly Δ return-on-equity



Notes: The blue solid line represents the evolution of the median variable of stress-tested banks with the dotted blue line being the 5th and 95th percentile. The dashed orange and dotted orange lines correspond to the same variables for the non-tested banks. The dark shaded area indicates the stress test period, the light grey area indicates the 2018 Q3 stress test where results were already known to banks even before publication. The y-axis corresponds to percentage points.

the baseline since a time trend is now used. If the test fails to reject the null hypothesis that the interaction term (β_2) between the time trend and the treatment dummy is statistically equal to zero, i.e., if (β_2) is statistically insignificant, then the parallel trend is expected to hold. Table 5 reports the p-value for the coefficient of the interaction term (β_2).

Table 5: Parallel trend test by sector (p-value of (β_2))

	Full Sample	RWA	Assets
Δ Log Credit			
Non-financial corporations	0.080	0.195	0.308
Households	0.88	0.853	0.844
Δ Avg. Risk-weights			
Non-financial corporations	0.101	0.080	0.050
Households	0.324	0.578	0.804
Δ Avg. Return-on-equity	0.094	0.137	0.101

Notes: The table reports the p-value for β_2, the coefficient of the interaction between the time trend and treatment dummy. The outcome variables are the banks' log credit and the change in both risk-weights and return-on-equity. The dependent variables are defined as the (i) yearly change of log credit exposures (ii) yearly change in the average risk-weights and (iii) return-on-equity. The risk-weighted-assets (RWA) and assets reflect the size of banks, which was used to define an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The overlap sample refers to the sample where the untreated banks smaller than the smallest stress-tested bank are removed (in terms of RWA or assets); and stress-tested banks larger than the largest non-tested bank are also removed (in terms of RWA or assets).

As observed in Figure 2, the parallel trend test presented in Table 5 confirms that there are indeed comparable trends among all variables, since the test fails to reject the null hypothesis that the interaction term between the time trend and the treatment dummy is statistically equal to zero (i.e., H_0 is accepted, where it is reasonably assumed that the (necessary condition for the) parallel trend assumption is satisfied at a 5 percent confidence level).[23] However, it should be mentioned that this is only a necessary condition that in itself is not sufficient. The parallel trends assumption remains un-testable in principle, which is why the emphasis also lies on the relevance of our overlap sample estimates as it ensures that our results even hold when only similar banks (in size) are analysed. Thus, the robustness of our results when using the overlap sample, the fact that none of the parallel trend tests has been rejected and the visual test from Figure 2 confirm and strengthen the confidence in the validity of our results.

[23] Note that for the non-financial corporations Δ average log credit, the p-value is relatively close to rejection in one case. Therefore, the same test for our dynamic model from Equation 2 is also conducted by adapting it in the same manner as Equation 1 was adapted into Equation 3: by adding a time trend and treatment-trend interaction while omitting the time fixed-effects. Results remain unchanged and the statistical insignificance remains. See the Appendix, Table 11.

4.2 Placebo timing

In the spirit of Heider et al. (2019) and to ensure that our results are not purely driven by the research design, a placebo treatment variable is also introduced. It could be, for example, that so far, our estimations actually reflect an underlying trend towards every year's end (since our relevant stress test period always extends over Q4 and Q1 of the subsequent year) where banks might declare lower profits to pay fewer taxes instead of identifying the causal effect of a stress test. To avoid such confounding factors, the analysis under Equation 1 is extended and a shifted baseline treatment indicator dummy $D_{i,t}$, by one year (or four quarters) backwards, is included, to capture the year ends of 2015 and 2017 and to exclude the designated stress-testing periods. Let this additional variables be $P_{i,t} = 1$ in the quarters 2015 Q3, 2015 Q4, 2016 Q1, 2017 Q4 and 2018 Q1 for banks that were subject to the stress tests in 2016 and 2018, respectively. Our equation now is:

$$Y_{i,t} = \alpha + \beta_1 D_{i,t} + \pi P_{i,t} + \beta_2 X'_{i,t} + \tau_t + \mu_i + \varepsilon_{i,t}, \tag{4}$$

If β_1 and π are both significant (and show the same sign) this could be an indication that our estimates actually do not capture the effects of a stress test but something else and would cast doubt on the validity of our identifying assumptions. On the contrary, if the estimated coefficient of our *actual* treatment indicator β_1 remains significant while the *placebo* coefficient Θ is insignificant (and potentially even takes the opposing sign), it is possible to safely attribute the observed estimates to the effect of stress tests. Table 6 lists the point estimates for the placebo dates and actual stress tests, as well as the corresponding standard errors.

Table 6 shows that for credit exposures all estimated coefficients remain insignificant. More importantly, for risk-weights the coefficients for households remain almost unchanged with significant point estimates just below 1 pp. In contrast, the placebo dummy is insignificant and the coefficient estimates even take on positive values very close to zero. For return-on equity, our results are again confirmed with statistically negative estimates for the actually stress test dates and insignificant positive estimates for the placebo dates. These outcomes provide further strong evidence that our results are robust and valid.

Table 6: Placebo dates

	Full sample	RWA	Assets	Full sample	RWA	Assets
Exposures	**Non-financial corporations**			**Households**		
Placebo dates	-0.003	-0.009	-0.015	-0.007	-0.013	-0.014
(SE)	(0.013)	(0.014)	(0.014)	(0.020)	(0.023)	(0.024)
Actual stress-tests	-0.012	-0.001	-0.005	-0.017	-0.033	-0.027
(SE)	(0.013)	(0.014)	(0.015)	(0.017)	(0.020)	(0.021)
Observations	12018	6735	8726	11383	6377	8261
Groups	1023	477	973	982	455	935
Risk-weights	**Non-financial corporations**			**Households**		
Placebo dates	-0.004	-0.000	-0.002	0.001	0.001	0.002
(SE)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Actual stress-tests	-0.001	-0.001	0.001	-0.007**	-0.007**	-0.008**
(SE)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Observations	12017	6668	8689	11418	6401	8302
Groups	1024	476	976	983	456	939
Return-on-equity	**Total**					
Placebo dates	0.012	0.010	0.011			
(SE)	(0.007)	(0.008)	(0.008)			
Actual stress-tests	-0.011*	-0.010	-0.012*			
(SE)	(0.005)	(0.005)	(0.005)			
Observations	6355	3959	6174			
Groups	976	451	966			

Notes: This table presents the estimates for the effect of the stress-tests exercises on banks' lending, risk-taking and profitability. The dependent variables are defined as the (i) yearly change of log credit exposures (ii) yearly change in the average risk-weights and (iii) return-on-equity. The estimates are obtained using bank and quarter fixed-effects and control for lagged unemployment and banks' voluntary buffer. The risk-weighted-assets (RWA) and assets reflect the size of banks, which was used to define an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The overlap sample refers to the sample where the untreated banks smaller than the smallest stress-tested bank are removed (in terms of RWA or assets); and stress-tested banks larger than the largest non-tested bank are also removed (in terms of RWA or assets). The standard errors (SE) are reported in parentheses and are clustered by bank. ***, **, and * denote significance at the 0.1, 1 and 5 percent level, respectively.

4.3 Alternative specifications

In this Section, another set of alternative specifications is introduced. In Sections 3.2 and 3.3 the variations in the sample and respective dynamics are already presented, which help us understanding the parallel trends assumption better. Nevertheless, alternative specifications in our baseline Equation 1 might also impact the main results.

Table 7: Alternative Specifications

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Exposures	**Non-financial corporates**				**Households**			
$D_{i,t}$	-0.008	0.011	-0.005	0.006	-0.033**	-0.013	-0.015	-0.013
(SE)	(0.020)	(0.012)	(0.014)	(0.012)	(0.015)	(0.015)	(0.017)	(0.016)
Observations	12353	12337	13353	12343	11695	11675	12641	11685
Groups	1020	1020	1025	1020	978	978	984	978
Risk-weights	**Non-financial corporates**				**Households**			
$D_{i,t}$	-0.002	-0.002	0.001	-0.003	-0.001	-0.006**	-0.007**	-0.006**
(SE)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	12343	12327	13352	12331	11732	11711	12678	11722
Groups	1022	1022	1028	1022	979	979	986	979
Retrun-on-equity	**Total**							
$D_{i,t}$	-0.012**	-0.012*	-0.018**	-0.007				
(SE)	(0.005)	(0.006)	(0.007)	(0.005)				
Observations	6552	6063	6308	6548				
Groups	970	970	977	970				
Controls	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Fixed-effects	No	Bank	Bank, Quarter	Bank, Country x Year	No	Bank	Bank, Quarter	Bank, Country x Year

Notes: This table presents the estimates for the effect of the stress-tests exercises on banks' lending, risk-taking and profitability. The dependent variables are defined as the (i) yearly change of log credit exposures (ii) yearly change in the average risk-weights and (iii) return-on-equity. The estimates are obtained by using several specifications: (1) controls for lagged unemployment and lagged banks' voluntary buffer. (2) controls for lagged unemployment and lagged banks' voluntary buffer, with bank fixed-effects. (3) uses bank and quarterly time fixed-effects only. (4) controls for lagged unemployment and lagged banks' voluntary buffer, with bank fixed-effects and interacted year and country fixed-effects. The standard errors (SE) are reported in parentheses and are clustered by bank. ***, **, and * denote significance at the 0.1, 1 and 5 percent level, respectively.

Specifically, we investigate four alternative specifications in this section (Table 7): First (1), time and country fixed-effects are omitted and only controls of our baseline setup – Section 3.2 – are used. Second (2), the time fixed-effects are omitted but the bank fixed-effects are kept to ensure that the use of both time and individual fixed-effects together with clustering does not yield unreliable inference due to over-fitting. Third (3), *only* quarterly time and bank fixed-effects are used as a stark contrast to (1). Fourth (4), the interaction of time and country fixed-effects is included to (2) to account for country and year specific variation.[24] Table 7 discusses the outcomes in the respective order for the full sample variant.

The estimates presented in Table 7 show that the qualitative implications do not change even with a considerable variation across specifications. In general, our main results remain preserved and confirm that our baseline specification is a reasonable setup to uncover the effects of stress-testing on banks' lending, risk-taking and profitability. In detail, specifications (2) and (3) show that there is no substantial change in the quality of our results and specification (4) also preserves the main results on the reduction of banks' risk-taking towards households. When only controls are used, by simply implementing a pooled OLS, there is a change for households. For specification (1) lending to households significantly decreases by about 3 pp while the risk-weights are now insignificant (although with the same sign). However, even if the transmission channel changed, this model should be considered with a grain of salt since does not account for any individual effects and the panel structure of the data. The result on return-on-equity persists nevertheless.

5 The EBA sample vs. the SREP sample: does the disclosure of stress test results matter?

The 2016 and 2018 EU-wide stress testing consisted of a total of 93 and 87 banks, respectively, of which a fraction was directly under the EBA coordination while the larger sample was led by the ECB banking supervision as part of the SREP exercise. In 2016, the EBA to the SREP ratio was 37 to 56 banks and in 2018 was 33 to 54 banks. One defining characteristic between both groups is the non-disclosure of the stress test results to the public for the SREP banks (both in 2016 and 2018). This section exploits this feature. Table 1 already illustrated how both groups (EBA banks versus SREP banks) differ in size.

The following analysis disentangles the effect of disclosure of the stress test results on banks with published results – the EBA banks – from the stress test effect on banks with non-disclosed results – the SREP banks. The control group corresponds to the full-sample of non-tested banks. We employ the following model for estimation:

$$Y_{i,t} = \alpha + \beta_1 D_{i,t} \times EBA_{i,t} + \beta_2 D_{i,t} \times SREP_{i,t} + \beta_3 X'_{i,t} + \tau_t + \mu_i + \varepsilon_{i,t}, \tag{5}$$

Where the meaning of each variable corresponds to the same as in Equation 1. Additionally, $EBA_{i,t}$ is a

[24] Note that introducing an interaction of quarter and individual fixed-effects would yield collinearity and over-fitting – which in turn would impede the meaningfulness of our statistical inference. Therefore, a less restrictive approach is selected to still preserve a reasonable amount of units within the interacted effects.

dummy that takes the value of 1 if bank i is part of the EBA sample (with disclosed results) and 0 otherwise. Analogous to that, $SREP_{i,t}$ is a dummy equalling 1 if bank i is part of the SREP sample (with undisclosed results).

Table 8 reports the estimated results for changes in credit, as a result of the stress tests, in both banks with published results ($Stress \times EBA$) and banks with undisclosed results ($Stress \times SREP$). The first panel displays the impact of the stress tests on lending, showing a significant, only for the overlap sample (in terms of RWA), deleverage by about 5 pp in households for the SREP banks.[25] For the EBA banks, results remain insignificant as before. The second panel displays the impact of the stress tests on banks' risk-weights, indicating the same previous pattern for both groups (EBA and SREP) as each of them decreases risk-taking towards households. Comparing both groups, point estimates are much larger for the SREP banks than for the EBA sample of banks. It becomes evident that the EBA banks, which have their results disclosed do not change their balance-sheet behaviour as much after the stress tests when compared with the SREP banks. This could be explained by the lower intensity of the impact of the stress tests on the EBA sample of banks since they are already very much scrutinised for longer, being therefore more resilient to adverse macroeconomic shocks.

The dynamic version of Equation 5 is also implemented, as for the baseline Equation 1 to study if there is more to learn from the dynamic behaviour of both the EBA and SREP banks. Figure 3 displays the response of both groups of banks on credit to non-financial corporations and households. Table 8 allows to observe heterogeneous treatment effects for credit exposures. The dynamic responses display a significant deleverage in the households sector. This is already observed in Figure 3, being attributed to the SREP sample of banks where lending significantly decreases by about 5 pp (for the overlap sample, in terms of RWA). Figure 4 exhibits also a significant reduction in the risk-weights for households in both groups. However, the SREP banks reduction in risk-weights is twice as large as the effect on the EBA banks. The qualitative results of Table 8 are again confirmed with a notable further increase in the difference between the reduction of risk-weights by the EBA and SREP banks.

To ensure that the measured effects are mainly driven by the actual (non)disclosure and requirements of the stress test results, we proceed to estimate the same regression for more restrictive samples in terms of size overlap. In particular, we restrict the overlap of risk-weighted assets and total assets to be within selected quantiles of the size distributions between stress-tested and non-tested banks. Figure 5 depicts the evolution of the coefficient estimates for an increasingly restrictive overlap sample for total assets making stress-tested and non-tested banks even more comparable[26]. As there is no overlap in the more restrictive

[25] Since the unit is yearly log credit changes, the use of "percentage points" as unit of change is only an approximation.

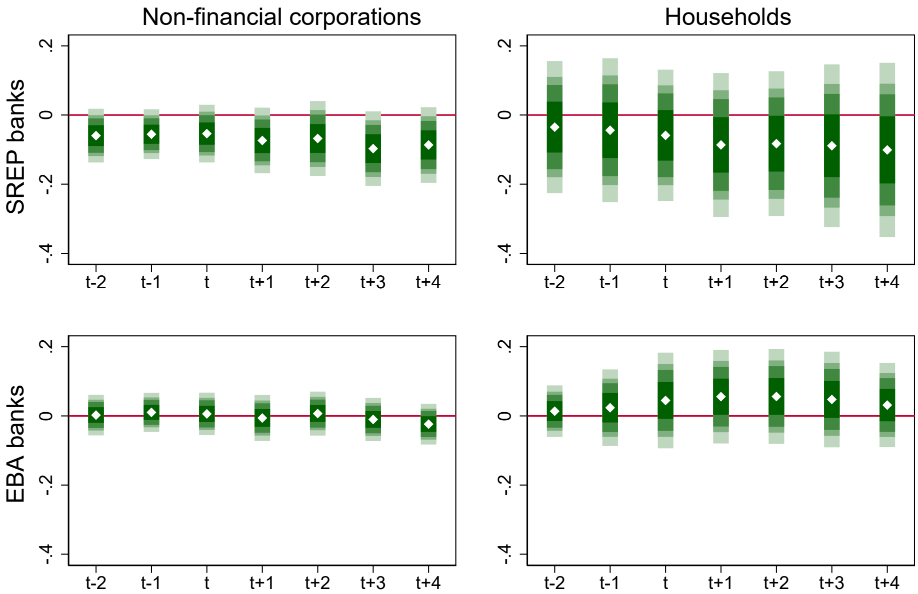
[26] See the Appendix, Figure 9, for the risk-weighted assets overlap sample variation. Results remain qualitatively very similar.

Table 8: Heterogeneous effects

	Full sample	RWA	Assets	Full sample	RWA	Assets
Exposures	**Non-financial corporations**			**Households**		
$D_{i,t}$ *x SREP*	-0.005	0.004	0.004	-0.039	-0.053*	-0.045
(SE)	(0.022)	(0.021)	(0.021)	(0.024)	(0.025)	(0.026)
$D_{i,t}$ *x EBA*	-0.003	0.009	0.008	0.015	0.011	0.019
(SE)	(0.011)	(0.012)	(0.013)	(0.020)	(0.028)	(0.030)
Observations	13034	7385	9249	12336	6987	8747
Groups	1023	477	973	983	456	936
Risk-weights	**Non-financial corporations**			**Households**		
$D_{i,t}$ *x SREP*	-0.002	-0.003	-0.002	-0.009*	-0.009	-0.010*
(SE)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
$D_{i,t}$ *x EBA*	0.003	0.002	0.004	-0.005*	-0.006	-0.008*
(SE)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
Observations	13030	7309	9205	12375	7017	8793
Groups	1025	477	977	984	457	940

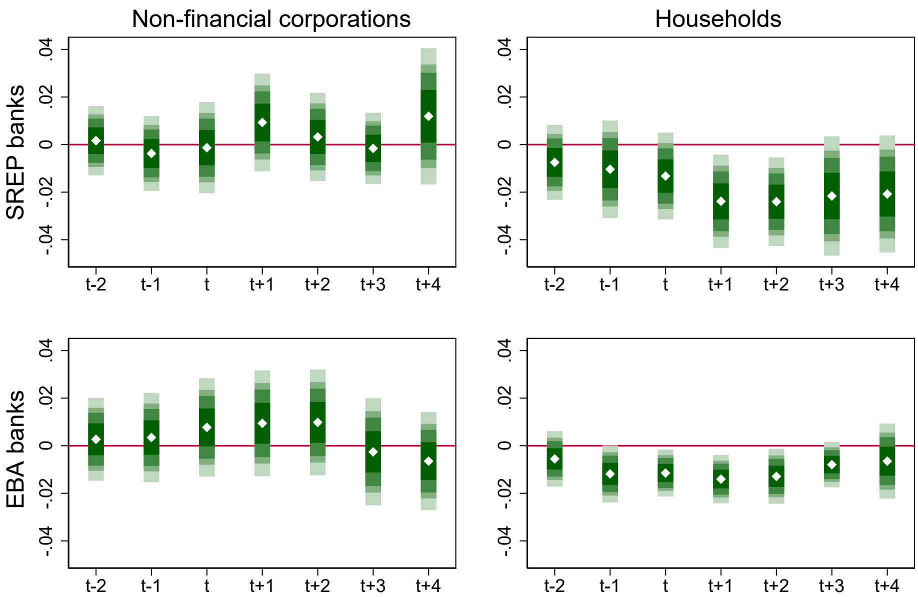
Notes: This table presents the estimates for the effect of the stress-tests exercises on banks' lending and risk-weights. The dependent variables are defined as the (i) yearly change of log credit exposures, and (ii) yearly change in the average risk-weights. The estimates are obtained using bank and quarter fixed-effects and control for lagged unemployment and banks' voluntary buffer. The risk-weighted-assets (RWA) and assets reflect the size of banks, which was used to define an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The overlap sample refers to the sample where the untreated banks smaller than the smallest stress-tested bank are removed (in terms of RWA or assets); and stress-tested banks larger than the largest non-tested bank are also removed (in terms of RWA or assets). The standard errors (SE) are reported in parentheses and are clustered by bank. ***, **, and * denote significance at the 0.1, 1 and 5 percent level, respectively.

Figure 3: Heterogeneous dynamic evolution of credit towards non-financial corporations and households



Notes: The figure presents the dynamic evolution of yearly log change in credit exposure towards non-financial corporations and households. The light to dark green shaded areas reflect the respective 99, 95, 90, and 68 percent confidence intervals of the estimated coefficients. The x-axis corresponds to the lead or lag of the treatment quarters with t being the quarter of the treatment (publication of the stress tests). The y-axis corresponds to percentage points impact in the outcome variable.

Figure 4: Heterogeneous dynamic evolution of risk-weight towards non-financial corporations and households



Notes: The figure presents the dynamic evolution of yearly changes in risk-weights for non-financial corporations and households. The light to dark green shaded areas reflect the respective 99, 95, 90, and 68 percent confidence intervals of the estimated coefficients. The x-axis corresponds to the lead or lag of the treatment quarters with t being the quarter of the treatment (publication of the stress tests). The y-axis corresponds to percentage points impact in the outcome variable.

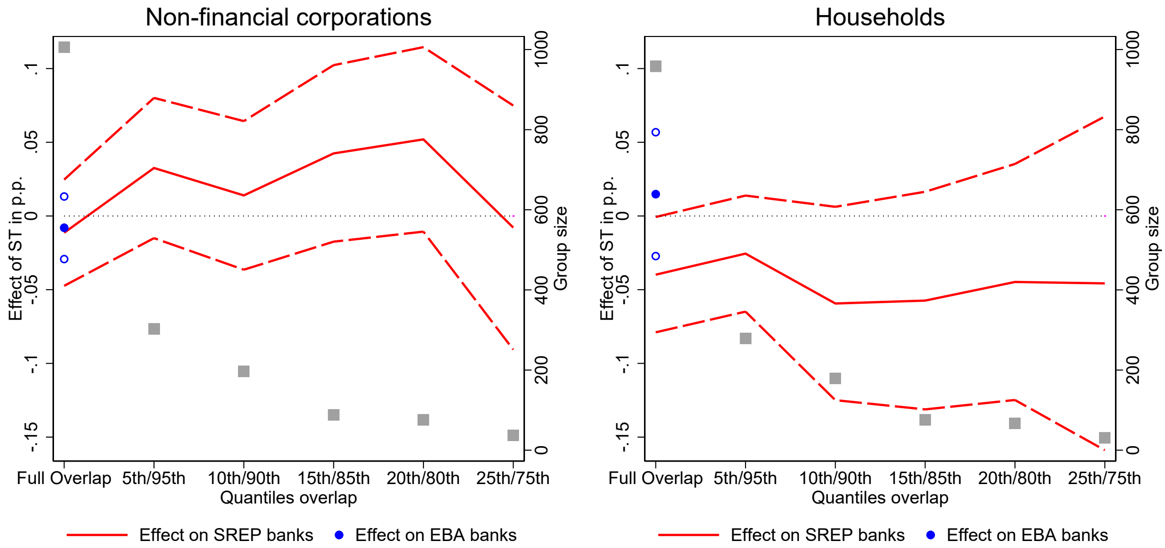
samples, the EBA bank estimates are only depicted in the baseline overlap samples.

Figures 5 and 9 show that results are stable for similar SREP and non-tested banks, in terms of total asset size and risk-weighted assets, respectively. Looking at the increasingly restricted sample (stress-tested and non-tested banks that overlap within their respective asset size distribution - from full min-max-overlap to inter-quartile range) the results remain stable for the SREP banks, even when banks are increasingly similar in size. The estimates align with our baseline results for the full sample, even at a greater overlap (until 10th to 90th for risk-weights to households at a total group size of below 200 control and stress-tested banks.), indicating that the results are driven by the non-disclosing of the stress test results by the SREP banks. As expected, the amount of groups in the sample reduces drastically (represented by the grey squares with the RHS scale), leaving few groups for the inter-quartile range overlap, hence yielding larger standard errors. All other results remain as in the baseline specification (i.e. insignificant, with the exception of log credit growth to households that is again significant at the full overlap like in the baseline heterogeneous results).

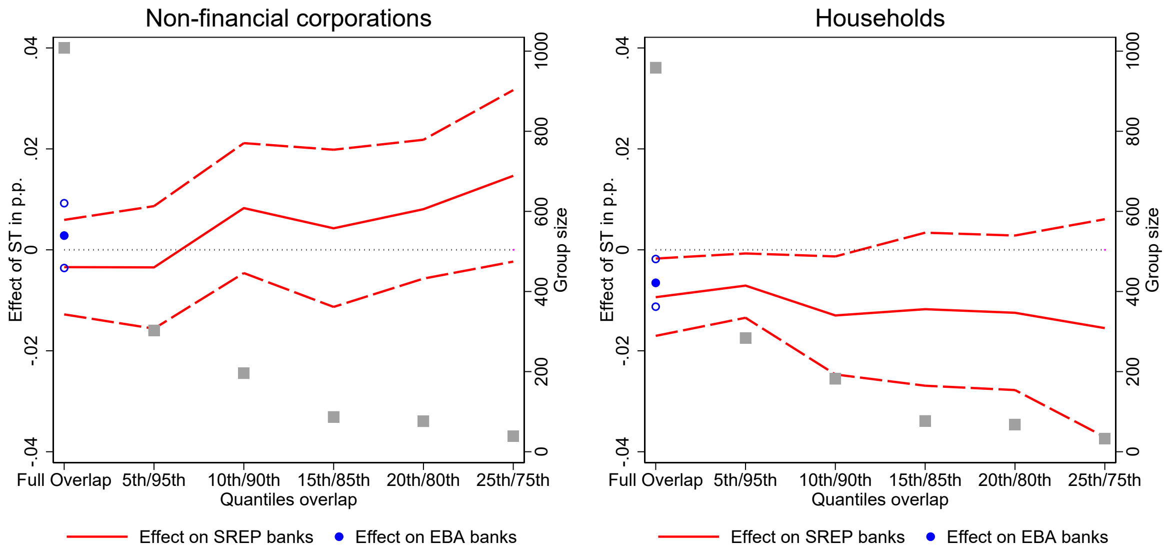
Our results suggest that the EBA banks, with disclosed stress test results, are more robust and are set up to absorb scenario shocks resulting in less additional capital required by the supervisor. This in turn, leads to a moderate derisking in the households sector (i.e., less balance-sheet adjustments when compared with the SREP banks). The EBA banks comprise mainly banks which are under an intensive direct supervision resulting in well capitalised banks thus reducing moral hazard and misaligned incentives by strengthening the resilience of these “too big to fail” banks. This follows Hirtle et al. (2020) and Eisenbach et al. (2016) which find that large banks receive more attention from supervisors and tend to hold less risky loans which are less sensitive to industry-specific fluctuations. Therefore, implying that the average capital depletion as a result of the stress tests is lower in those banks. On the other hand, the SREP banks, which may be subject to higher capital requirements as a result of the stress tests, are more prone to balance-sheet adjustments through a deleverage and derisking (reduction of lending and risk-weights) towards households.

Figure 5: Variations in total assets overlap sample size

(*a*) yearly Δ log credit



(*b*) yearly Δ risk-weights



Notes: LHS scale: The solid red line (blue dot) represents the coefficient estimates of the EBA and SREP tested banks as obtained from the baseline specification 1 but with an increasingly restrictive overlap sample. The dashed red line (hollow blue dot) correspond to the 90 percent confidence intervals. RHS scale: the grey square represent the group size of entities used for the estimation at the respective overlap sample.

As a final step, to further validate the effect of the disclosure of stress test results, we look at the voluntary disclosure of the SREP bank's Pillar 2 Requirements (P2R). Within the SSM, the stress test results for all significant institutions are used to assess the Pillar 2 capital needs of individual banks in the context of the SREP. The qualitative outcomes of the stress tests are included within the scope of risk governance in the SREP, thereby influencing the determination process for the P2R.[27] P2R is a bank-specific capital requirement, which is applied to risks not covered by the minimum capital requirement (known as Pillar 1), and its being published by the ECB banking supervision only since January 2020.[28] Therefore, the bank behaviour for the SREP sample of banks that voluntarily disclosed their P2R in the annual reports of 2016 and 2018 (Pillar 3 disclosure) is studied. The disclosure of P2R is used as a proxy of voluntary disclosure of stress test results for the SREP sample of banks. Our analysis relies on the list compiled by Magnus and De Biase (2021) for banks that disclosed their P2R outcomes in 2018, where we follow their methodology in compiling a corresponding list for 2016. Both groups - the voluntarily disclosing and non-disclosing - share similar mean characteristics in terms of key reported variables as already discussed in 1. With this new data at hand, Equation 5 is extended to the following:

$$\begin{aligned} Y_{i,t} =& \alpha + \beta_1 D_{i,t} \times EBA_{i,t} + \beta_2 D_{i,t} \times SREP_{i,t} \times P2R\_disclosed \\ &+ \beta_3 D_{i,t} \times SREP_{i,t} \times P2R\_undisclosed + \beta_4 X'_{i,t} + \tau_t + \mu_i + \varepsilon_{i,t}, \end{aligned} \tag{6}$$

Where $D_{i,t} \times SREP_{i,t} \times P2R\_disclosed$ corresponds to banks that publicly disclosed their P2R in the respective stress test year (2016 and 2018). Equivalently, $D_{i,t} \times SREP_{i,t} \times P2R\_undisclosed$ corresponds to banks that were not publicly disclosing their P2R in the respective stress test year.

Table 9 clearly indicates that the SREP banks that were not disclosing their P2R in 2016 and 2018 are more prone to balance-sheet adjustments through a deleverage and derisking (reduction of lending and risk-weights) towards households. The set of banks that are part of the SREP sample and do not publish their P2R (which was voluntary until 2019) tend to adjust more their balance-sheet by derisking (reduction of about 1 pp) and deleveraging (reduction of around 7 pp). Regarding changes in risk-weights, our estimates show a significant (in statistical and economic terms) coefficient for banks participating in the stress tests. While both the EBA and SREP groups reduce their risk-weights towards households, the SREP banks that do not publish their P2R decrease them to a larger extent, i.e., the derisking from the EBA sample of banks is half of the impact of the SREP sample of banks that do not publish their P2R. Our results suggest that

[27] The quantitative results of the stress tests are used as a key input for setting the Pillar 2 Guidance (P2G). See `https://www.bankingsupervision.europa.eu/press/pr/date/2021/html/ssm.pr210730_FAQ~d24c9d71b8.en.html`

[28] Before this date banks were disclosing this information on a voluntary basis. The P2R is determined via the SREP. The capital requested by the supervisors to keep is based on the SREP assessment and includes the P2G, which indicates to banks the adequate level of capital to be maintained to provide a sufficient buffer to withstand stress-tested situations. Unlike the P2R, the P2G is not legally binding.

the SREP banks, which were publicly disclosing their P2R voluntarily, are already well capitalised being therefore less prone to balance-sheet adjustments. This confirms that the publication of the stress test results (and P2R) can have a disciplinary effect by reducing banks' risk-taking since banks would publish their P2R if their capital ratios were robust enough. Therefore, the publication of stress test results (and P2R) can be associated with an improvement of market discipline and promotes financial stability.

Table 9: Heterogeneous effects for the EBA and the SREP sample of banks (P2R disclosed and undisclosed)

	Full	RWA	Total Assets	Full	RWA	Total Assets
Exposures	**Non-financial corporations**			**Households**		
D x SREP x undisclosed	-0.034	-0.024	-0.022	-0.068	-0.081*	-0.074*
(SE)	(0.040)	(0.040)	(0.040)	(0.036)	(0.036)	(0.037)
D x SREP x disclosed	0.011	0.019	0.017	-0.015	-0.027	-0.020
(SE)	(0.028)	(0.028)	(0.027)	(0.027)	(0.027)	(0.028)
D x EBA	-0.008	0.002	0.001	0.013	0.005	0.010
(SE)	(0.011)	(0.012)	(0.013)	(0.020)	(0.026)	(0.026)
Observations	12334	7042	9110	11672	6656	8602
Groups	1010	475	963	962	447	920
Risk-weights	**Non-financial corporations**			**Households**		
D x SREP x undisclosed	0.001	-0.001	0.001	-0.017**	-0.016**	-0.017**
(SE)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
D x SREP x disclosed	-0.007	-0.009	-0.007	-0.002	-0.002	-0.003
(SE)	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)	(0.008)
D x EBA	0.002	0.001	0.003	-0.005*	-0.006*	-0.007*
(SE)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
Observations	12318	6959	9062	11712	6690	8655
Groups	1012	473	964	963	450	925

Notes: This table presents the estimates for the effect of the stress tests exercises on banks' lending and risk-weights. The dependent variables are defined as the (i) yearly change of log credit exposures, and (ii) yearly change in the average risk-weights. The estimates are obtained using bank and quarter fixed-effects and control for lagged unemployment and banks' voluntary buffer. The risk-weighted-assets (RWA) and assets reflect the size of banks, which was used to define an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The overlap sample refers to the sample where the untreated banks smaller than the smallest stress-tested bank are removed (in terms of RWA or assets); and stress-tested banks larger than the largest non-tested bank are also removed (in terms of RWA or assets). The standard errors (SE) are reported in parentheses and are clustered by bank. ***, **, and * denote significance at the 0.1, 1 and 5 percent level, respectively.

6 Conclusions

Exposed by the Global Financial Crisis, the supervisory framework's limitations in ensuring the resilience of the banking system to adverse macro-financial shocks had to be overcome. In the euro area, this led to changes in the supervisory institutional setting by moving to a centralised banking supervision, while, at the same time, the EU built up the macroprudential policy toolkit to address risks of a systemic nature. From a financial stability perspective, it was also important to mitigate a potential increase of banks' risk-taking due to monetary policy easing. For this reason, the stress tests have become an important tool in assessing capital shortfalls in the banking sector. As such, the contribution of our paper is to inform policy makers on how stress tests and the implied capital requirements enforced on banks affect the banking system and its resilience as well as the real economy.

In particular, for this paper, we exploited the stress tests framework to identify the causal effect of higher capital requirements on banks' lending and risk-taking behaviour. Banks comply with higher capital requirements by raising new equity (or through the usability of the voluntary buffers – numerator of the capital ratio) or by reducing the denominator (deleveraging and derisking). This paper presents evidence on the latter, i.e., whether banks respond to changes in capital requirements, as a result of the stress test, by deleveraging or derisking their risk-weighted assets.

For identification, our study relies on the centralised SSM stress tests and combined two unique datasets, including a stress-testing data for the 2016 and 2018 exercises with a total of 93 and 87 banks, respectively, and a quarterly confidential supervisory database with around 1000 relevant reporting banks. By using these two unique confidential datasets, we exploit the selection of banks participating in the respective stress tests through a dynamic difference-in-differences approach. The empirical strategy enables us to assess the impact of the stress tests on euro area banks´ lending, risk-taking and profitability. At the same time, we exploit a particular unique feature of our stress test data, comparing two different groups of banks: The EBA sample of banks, for which the test results are published, and the SREP banks, for which the stress test results are not disclosed. This is only possible before the 2021 stress tests where results were also published for SREP banks. To further validate the heterogeneous effect of the disclosure of bank requirements, the publication of P2R is also studied, which was voluntary until 2019. The comprehensive datasets and empirical strategy are crucial to assess the effects of the stress tests and to reinforce the validity of our study.

Three findings are established in this study. First, banks subject to the stress tests reallocate credit away from riskier borrowers and towards safer ones – derisking towards the households' sector with negative consequences for banks' profitability. A reduction in lending to safer assets (decrease in the risk profile) usually results in lower profitability. The results remain stable for different specifications. Second, the EBA banks, which have their stress test results disclosed, do not change their balance-sheet behaviour as much as the SREP banks. While both groups reduce their risk-weights towards households, the SREP banks decrease them to a larger extent. However, when focusing on the SREP banks alone, we find evidence of a reduction in lending to households and non-financial corporates (with a late lagged impact) mainly among risky borrowers. This suggests that the EBA sample of banks are more robust to absorb scenario shocks resulting in less additional capital required by the supervisor. Third, we provide further evidence that the result on heterogeneity between the EBA and the SREP banks is driven by the portion of SREP banks that do not voluntarily disclose their bank requirements, such as the P2R. The SREP banks disclosing their P2R voluntarily are less prone to balance-sheet adjustments. Hence, solidifying the evidence of a clear association between effects of stress testing and the respective disclosure of the results.

As our results show, stress-tested banks reduce lending to risky borrowers and their risk-weights, which results in generally safer banks in terms of capital and risk-weighted asset ratios. This supports the hypothesis that the stress-testing framework and the respective publication has a positive disciplinary effect by mainly reducing banks' risk-taking, while also having an adverse impact on the real economy through a temporary decrease in credit supply (via the SREP banks) and profitability. Having better capitalised banks enhances financial stability by reducing banks' risk-taking incentives and increasing banks' capital against losses. Thus, the stress tests and the publication of bank requirements play an important role in improving financial stability and restoring confidence in the banking system through the market discipline.The combination of both regulatory and market discipline by increasing transparency and disclosure requirements ensures financial stability, where all market participants are able to monitor and influence the bank behaviour and it disciplines bank risk-taking. Our findings follow the consensus in the literature that the stress tests are effective in reducing banks incentives to take risks (Kok et al. (2021), Calem et al. (2020), Pierret and Steri (2020), Cortés et al. (2020), Acharya et al. (2018), among others). The results also square with the literature on higher capital requirements (Cappelletti et al. (2019), Kok et al. (2021), and Gersbach and Rochet (2017)).

Our results support the discussion on the benefits and short-run costs of the stress tests and higher capital requirements (Gropp et al. (2019), Cappelletti et al. (2019) and Gersbach and Rochet (2017)), where banks tend to comply with higher requirements, as a result of the stress tests, by dampening down their risk-weighted assets. Capital requirements can reduce banks' gambling incentives leading to a "prudent equilibrium" (Repullo (2004)), resulting in a positive disciplining effect. In terms of policy action, as suggested by Hanson et al. (2011), Cappelletti et al. (2020) and Gropp et al. (2019), targeting the absolute amount of new capital to be raised instead of the capital ratio could mitigate the temporary adverse impact in the real economy, along with the potential optimisation of the risk-weighted assets.

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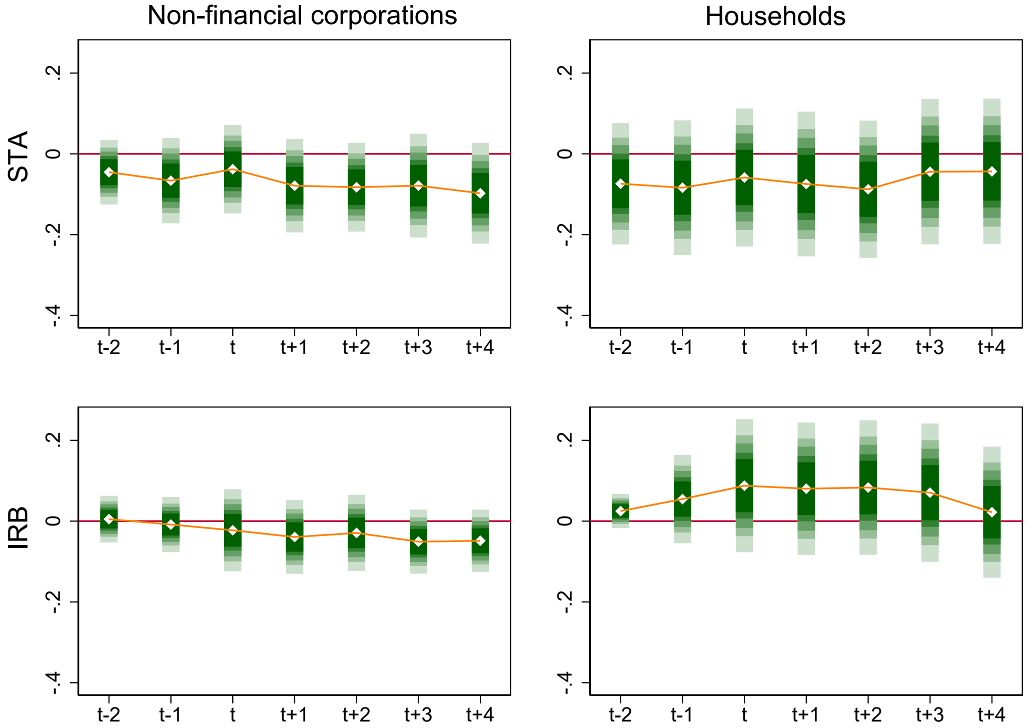
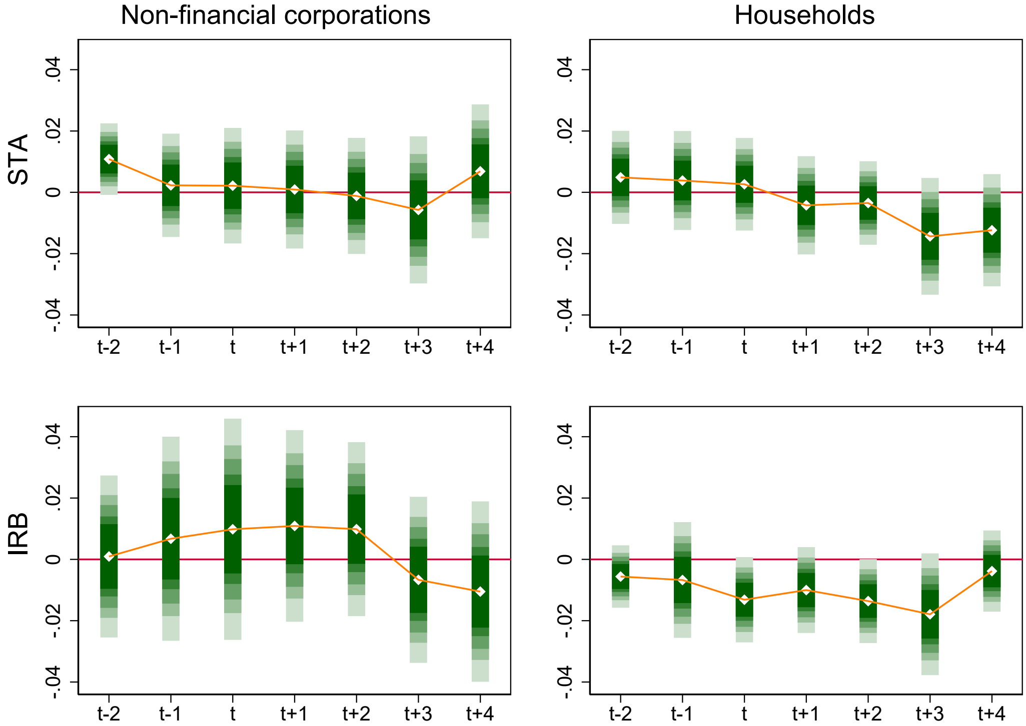
A Additional Tables and Figures

Figure 6: Dynamic evolution of credit for non-financial corporations and households (STA and IRB methods)



Notes: The figure presents the dynamic evolution of yearly changes in credit exposure amounts (in log terms) for non-financial corporations and households. The light to dark green shaded areas reflect the respective 99, 95, 90, 80 and 70 percent confidence interval of the estimated coefficients. The x-axis corresponds to the lead or lag of the treatment quarters with t being the quarter of the treatment (publication of the stress tests). The y-axis corresponds to percentage points impact in the outcome variable. IRB indicates the risk-weights under the internal ratings based approach and STA indicates the risk-weights under the standardized approach.

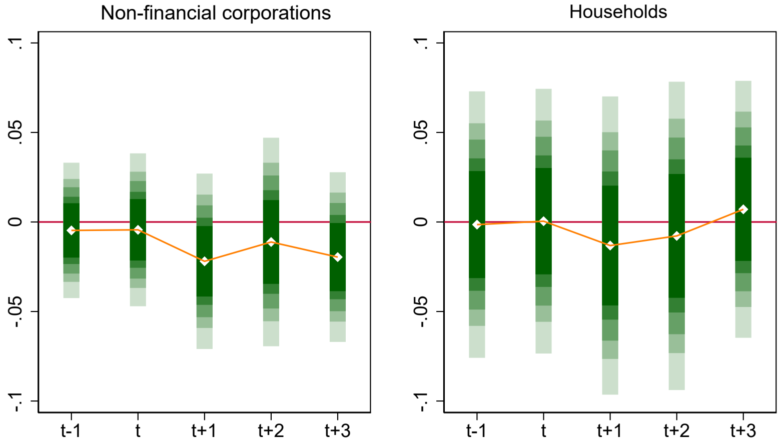
Figure 7: Dynamic evolution of risk-weights for non-financial corporations and households (STA and IRB methods)



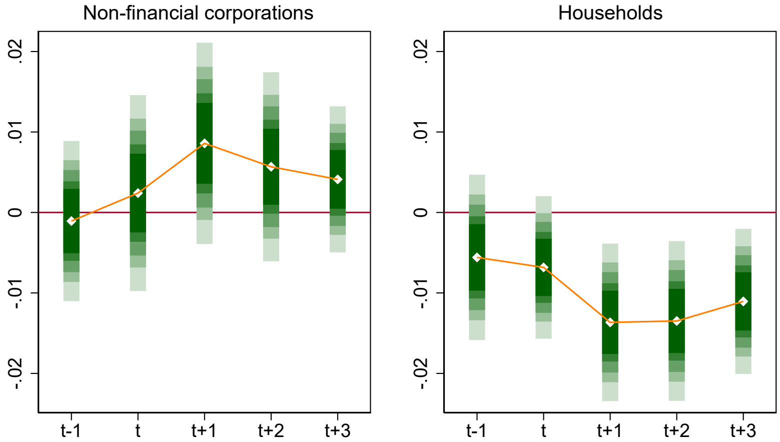
Notes: The figure presents the dynamic evolution of yearly changes in risk-weights for non-financial corporations and households. The light to dark green shaded areas reflect the respective 99, 95, 90, 80 and 70 percent confidence interval of the estimated coefficients. The x-axis corresponds to the lead or lag of the treatment quarters with t being the quarter of the treatment (publication of the stress tests). The y-axis corresponds to percentage points impact in the outcome variable. IRB indicates the risk-weights under the internal ratings based approach and STA indicates the risk-weights under the standardized approach.

Figure 8: Smaller window dynamic effects

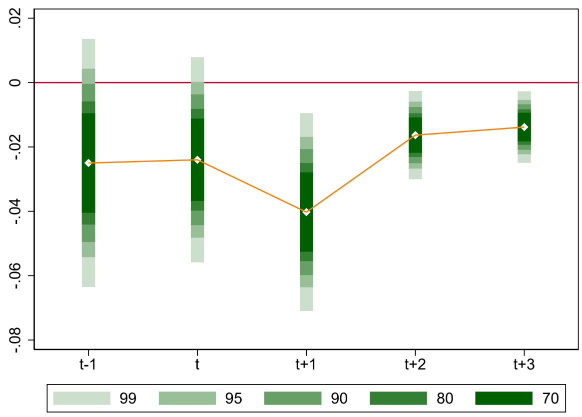
(*a*) yearly Δ log credit



(*b*) yearly Δ risk-weights



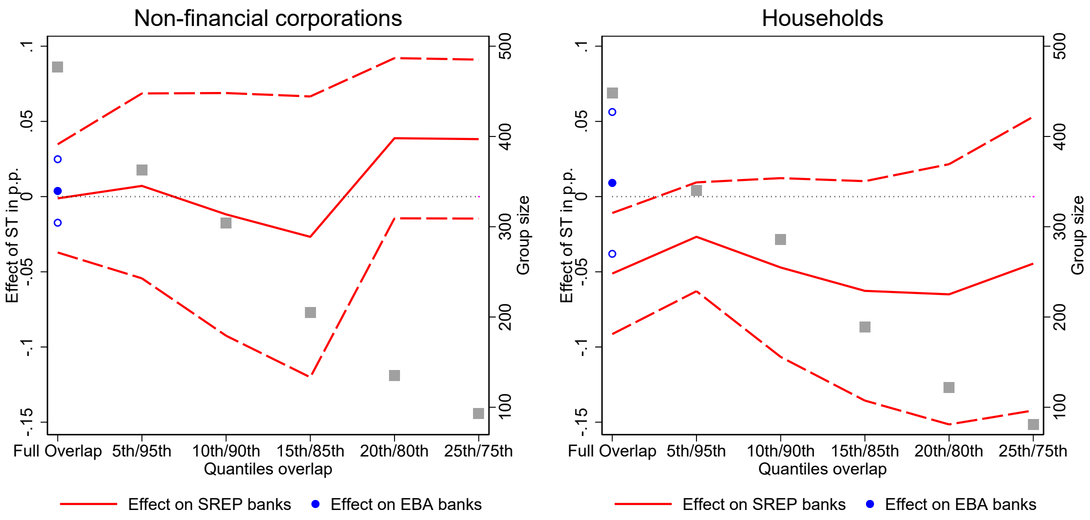
(*c*) yearly Δ return-on-equity



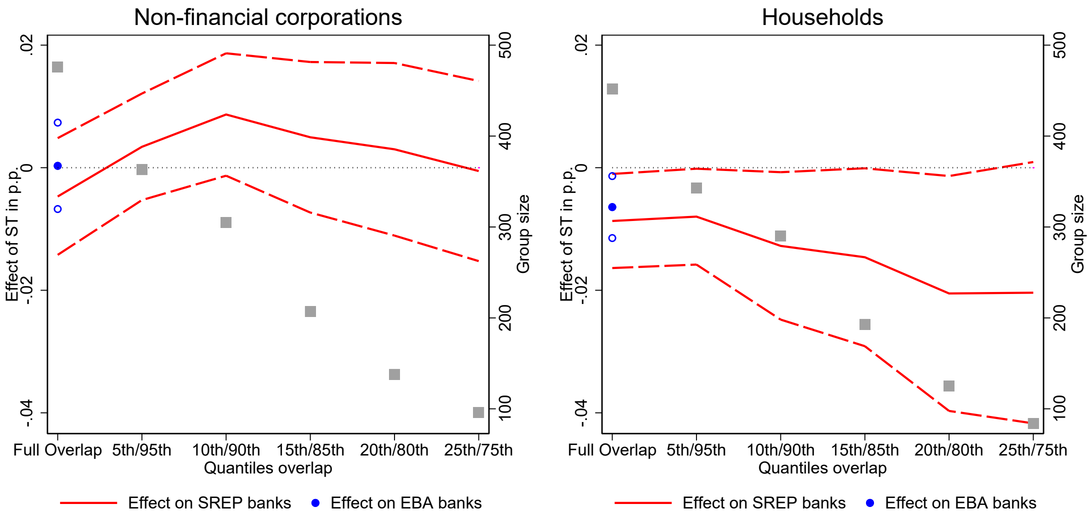
Notes: The figure presents the dynamic evolution of yearly changes in credit exposure amounts (in log terms), risk-weights and return-on-equity, for non-financial corporations and households. The light to dark green shaded areas reflect the respective 99, 95, 90, 80 and 70 percent confidence interval of the estimated coefficients. The x-axis corresponds to the lead or lag of the treatment quarters with t being the quarter of the treatment (publication of the stress tests). The y-axis corresponds to percentage points impact in the outcome variable.

Figure 9: Variations in risk-weighted assets overlap sample size

(a) yearly Δ log credit



(b) yearly Δ risk-weights



Notes: LHS scale: The solid red line (blue dot) represents the coefficient estimates of the EBA and SREP tested banks as obtained from the baseline specification 1 but with an increasingly restrictive overlap sample. The dashed red line (hollow blue dot) correspond to the 90 percent confidence intervals. RHS scale: the grey square represent the group size of entities used for the estimation at the respective overlap sample.

Table 10: Empirical studies estimating the effects of stress tests in the U.S.

Author	Title	Findings
Shahhosseini (2014)	The unintended consequences of bank stress tests	The author investigates (one of the firsts) the impact of stress tests employing a diff-in-diff and a matching method. He finds that banks subject to stress tests managed losses by: reducing net loan charge-offs, increasing provisions, non-performing loans and loss reserves.
Acharya et al. (2018)	Lending implications of U.S. bank stress tests: Costs or benefits?	Authors find evidence that their results are consistent with the "Risky Management Hypothesis", in which the U.S. stress-tested banks reduce lending to risky borrowers, resulting in safer banks in terms of capital and risk-weighted asset ratios.
Connolly (2018)	The real effects of stress testing	The author shows that banks included in the U.S. stress tests altered their lending behaviour in the syndicated loans at the extensive margin, reducing their exposures to risk. Thus, the stress tests improves financial stability and restores confidence in the banking system.
Covas (2018)	Capital requirements in supervisory stress tests and their adverse impact on small business lending	This author finds a decline in holdings of small business loans secured by non-farm non-financial properties at banks subject to the Comprehensive Capital Analysis and Review (CCAR) after 2011, which may be exerting an adverse impact on the U.S. economy.
Bassett and Berrospide (2018)	The impact of post stress tests capital on bank lending	Authors compare banks subject to the CCAR tests relative to the smaller banks, which run their own stress tests, and find no evidence in favour of the risk mitigation. Results suggest that the capital gap implied by the supervisory stress tests is not constraining lending or causing a tightening of the its standards.
Berrospide and Edge (2019)	The effects of bank capital buffers on bank lending and firm activity: What can we learn from five years of stress test results?	Authors use bank-firm matched data from regulatory filings (in the U.S.) and find that banks subject to CCAR from 2012 to 2016, which were vulnerable to higher capital requirements, reduced substantially lending to commercial and industrial segments.
Cortés et al. (2020)	Stress tests and small business lending	This author finds that banks most affected by the stress tests reallocate credit away from riskier markets and towards safer ones. He shows that the stress tests conducted by the Fed does not reduce aggregate lending, however, there is a reduction in lending to small risky business.
Calem et al. (2020)	Prudential policies and their impact on credit in the U.S.	Authors conclude that the 2011 CCAR stress tests had the highest negative effects on the credit originated by banks. There was evidence of a negative impact on market shares and origination of jumbo residential loans, in particular for less capitalised banks.
Pierret and Steri (2020)	Stressed banks	Authors document the effectiveness of supervision in reducing banks' incentives to take risks in the context of the stress tests in the U.S. since 2011.
Shapiro and Zeng (2020)	Stress testing and bank lending	Authors relate the incentives of regulators and banks' lending behaviour in a theoretical model and show that there may be multiple equilibria due to strategic complementary, possibly leading to excess default or insufficient lending to the real economy, i.e., the stress tests may be too soft or too tough.
Bräuning and L. Fillat (2020)	The impact of regulatory stress tests on bank lending and its macroeconomic consequences	Authors indicate that banks experiencing worse results in the stress tests cut lending relative to their peers and specifically in loans that are most sensitive to the stress test scenarios.
Doerr (2021)	Stress tests, entrepreneurship, and innovation	This author argues that stress-tested banks have cut back on lending to entrepreneurs, thereby reducing employment and innovation at young firms. He finds that banks subject to post-crisis stress tests have strongly curbed lending secured by home equity to small businesses.

Table 11: Parallel trend test by sector in dynamic setting (p-value of (β_2))

	Full Sample	RWA	Assets
Δ Log Credit			
Non-financial corporations	0.099	0.207	0.364
Households	0.907	0.881	0.801
Δ Avg. Risk-weights			
Non-financial corporations	0.522	0.435	0.409
Households	0.261	0.435	0.977
Δ Avg. Return-on-equity			
Total	0.931	0.957	0.844

Notes: The table reports the p-value for β_2, the coefficient of the interaction between the time trend and treatment dummy. The outcome variables are the banks' log credit and the change in both risk-weights and return-on-equity. The dependent variables are defined as the (i) yearly change of log credit exposures (ii) yearly change in the average risk-weights and (iii) return-on-equity. The risk-weighted-assets (RWA) and assets reflect the size of banks, which was used to define an overlap sample in terms of bank size, allowing us to evaluate a sub-sample of banks that share key characteristics. The overlap sample refers to the sample where the untreated banks smaller than the smallest stress-tested bank are removed (in terms of RWA or assets); and stress-tested banks larger than the largest non-tested bank are also removed (in terms of RWA or assets).

Acknowledgements

We would like to thank the Editorial Board of the ECB Working Paper Series, the anonymous referee, Carmelo Salleo and the participants of the ECB internal seminar for their useful comments and suggestions. Special thanks to João Silva, Cecilia Melo Fernandes and Giuseppe Cappelletti who contributed to the earliest drafts of the paper. The opinions in this paper are those of the authors and do not necessarily reflect the views of the European Central Bank or the Eurosystem. Steven Ongena acknowledges financial support from ERC ADG 2016 - GA 740272 lending.

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PDF ISBN 978-92-899-5263-7 ISSN 1725-2806 doi: 10.2866/038079 QB-AR-22-044-EN-N