Journal of Banking and Finance 99 (2019) 121–141

Contents lists available at ScienceDirect

Journal of Banking and Finance

journal homepage: www.elsevier.com/locate/jbf

Credit constraints, firm investment and employment: Evidence from survey data☆

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ARTICLE INFO

Article history:
Received 31 October 2017
Accepted 30 November 2018
Available online 8 December 2018

JEL classification:
G30
G31
G32

Keywords:
Credit constraints
Investment
Employment
Inventories
Instrumental variables
TLTRO

ABSTRACT

This paper assesses the impact of credit constraints on investment, inventories and employment using a large sample of firms from 12 European countries for the period 2014–2017. The data come from the Survey on the Access to Finance of Enterprises (SAFE), which contains direct information on the financial constraints faced by non-financial companies. The key identification challenge is a potential omitted variable bias, as firms with poor investment and growth opportunities may have a higher probability of being credit constrained. This problem is addressed by using an instrumental variable that is based on the allocation rule of the ECB's Targeted Longer-Term Refinancing Operations (TLTROs). The main findings suggest that credit constraints have strong negative effects on investment in fixed assets, while they have no impact on employment or inventories. Unconventional monetary policy may spur investment by reducing the incidence of credit constraints, especially in the case of large and old firms.

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1. Introduction

According to the Modigliani–Miller theorem (1958), under certain conditions, a firm's capital structure is irrelevant to its value. This implies that, in perfect capital markets, a firm's financing decisions are independent from its investment decisions. In this case, internal and external funds are perfect substitutes, and real firm decisions, motivated by the maximisation of shareholders' claims, are independent of financial factors such as cash flows, debt leverage or dividend payments. In practice, however, factors such as transaction costs, tax advantages, costs of financial distress, agency costs and asymmetric information lead to an imperfect substitutability between internal and external funds, leading to an external finance premium (Bernanke and Gertler, 1995). As a consequence, financial constraints may have important (negative) effects on real variables such as investment and employment, especially for firms with insufficient internal funds.

This paper aims to test this theoretical prediction. The main findings indicate that credit constraints have strong negative effects on investment in fixed assets, but no significant impact on employment or inventories and other working capital. Therefore investment is particularly sensitive to the availability of external finance.

Most previous research has used *indirect* evidence based on balance sheet data and proxies for credit constraints. In the relevant literature, which started with the seminal work of Fazzari et al. (1988), the standard approach is to use indirect measures of financial constraints such as dividend pay-out behaviour, association with business groups, size, age, ownership form and credit ratings to test whether the sensitivity of investment to cash flows is greater in the group of firms that are more likely to be constrained. Nevertheless, a standard criticism of the studies on investment-cash flow sensitivities is that cash flows proxy for other unobservable determinants of investment such as the profitability of investment. High levels of cash flows signal that the firm has done well and is likely to continue doing well. Thus, firms with more cash flows have better investment opportunities, and it is not surprising that they tend to invest more.

Another study that highlights the limitations of using balance sheet data to measure credit constraints is Farre-Mensa and Ljungqvist (2016). The authors find that firms typically classified as

☆ I am grateful to Nordine Abidi, Mario Alloza, Brindusa Anghel, Geert Bekaert, Thorsten Beck, Roberto Blanco, Olympia Bover, Matthieu Darracq Pariès, Björn Fischer, Dimitris Georgarakos, Victoria Ivashina, Sergio Mayordomo, Enrique Moral-Benito, John Palmer, Tano Santos, João Sousa and Rok Spruk for their useful comments and suggestions. I would also like to thank seminar participants at the European Central Bank, Banco de España and Universidad Carlos III.

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https://doi.org/10.1016/j.jbankfin.2018.11.016
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constrained (on the basis of proxies such as having a credit rating, paying dividends or linear combinations of observable characteristics such as size, age or leverage) do not actually behave as such. In particular, these firms have no difficulty raising debt when tax rates increase (as an increase in tax rates raises the value of tax shields) and they use the proceeds from equity issues to increase payouts to shareholders, implying they have no difficulty in tapping the equity markets either.

Confronted with those issues, there is a new emerging strand of the literature that obtains *direct* measures of financial constraints by asking firms about potential problems in their access to credit markets. Campello et al. (2010) survey 1050 Chief Financial Officers around the world to assess whether their firms were credit constrained during the global financial crisis of 2008. They find that constrained firms planned, on average, more severe cuts in technology expenditures, capital expenditures, marketing expenditures and employment than unconstrained firms. Nevertheless, as acknowledged by the authors, unobserved firm heterogeneity could confound their inferences.

Beck et al. (2005) use a worldwide survey conducted by the World Bank in 1999–2000 to analyse the effect of financial, legal and corruption obstacles on firm growth. While the authors find a negative correlation between these obstacles and firm growth, the lack of firm-level measures of investment opportunities and the potential endogeneity of the firm-level obstacles (firms that are not growing because of internal problems systematically shift blame to the legal and financial institutions and report high obstacles) cast doubt on the causal interpretation of their estimates.

Ferrando and Mulier (2015b) analyse the effect of being a discouraged borrower (i.e., firms that do not apply for a bank loan because they fear that their application will be rejected) on firm investment and growth. To do so they use a unique database that matches firms' answers to the Survey on the access to finance of enterprises (SAFE) with their financial statements for 9 euro area countries between 2010 and 2014. While their estimates suggest that there is a strong negative correlation between discouragement and firm investment and growth, a limitation of their empirical strategy is the endogeneity of discouragement, as discouraged borrowers are likely to have worse investment/growth opportunities than the average applicant.

This paper contributes to the literature that constructs *direct* measures of financial constraints with survey data and assesses their impact on real variables by extending the analysis of Ferrando and Mulier (2015b) on discouraged borrowers to all types of credit constraints. It does so with a large sample of firms from 12 European countries for the period 2014–2017. The data come from the Survey on the Access to Finance of Enterprises (SAFE). The survey, initiated in the middle of the Great Recession, was specifically designed to analyse the problems faced by European non-financial companies in their access to external finance, so it constitutes an ideal source of information about the credit constraints experienced by those firms.

For the purposes of this research a survey-based indicator of credit constraints was developed which encompasses both constraints on the access to bank finance (bank loans, bank overdrafts, credit lines) and constraints on the access to other finance (trade credit, debt and equity securities, informal loans, etc). While bank finance is the predominant source of external funds for non-financial companies in Europe, Casey and O'Toole (2014) find that bank-constrained SMEs substitute trade credit, informal lending and loans from other companies for bank credit. The measure of credit constraints encompasses rejected applications, quantity rationing (a firm only received a limited part of what it applied for), price rationing (a firm refused the lender's proposal for external financing because the borrowing costs were too high) and discouraged borrowers.

The main goal is to identify the causal effect of credit constraints on investment, inventories and employment growth. The key identification challenge is a potential omitted variable bias, as firms with poor investment/growth opportunities are expected to have a higher probability of being credit constrained. To address this issue, an instrumental variable was used, which comes from the Targeted Longer-Term Refinancing Operations (TLTROs), a series of liquidity operations implemented by the ECB between 2014 and 2017 to support bank lending to the euro area non-financial sector. While the TLTROs constituted a shock to the banking sector that relaxed credit constraints, it is also clear that was not an exogenous shock, as banks could freely choose the uptakes in the TLTROs. However, one can exploit an allocation rule on banks' borrowing limits (banks were allowed to borrow up to a certain percentage of their pre-existing stock of eligible loans) to derive an exogenous shock, as in Benetton and Fantino (2017). The predicted TLTRO uptakes constitute the exogenous component of the TLTRO shock, as they are based on exogenous parameters that are common across banks and on pre-determined balance sheet characteristics.

The principal indication from the findings is that credit constraints have strong negative effects on investment in fixed assets, while they have no significant impact on employment or inventories and other working capital. In addition, in order to provide a more granular insight into the real effects of credit constraints, the impact of credit constraints on investment is estimated for different groups of firms. Most of the causal impact of credit constraints on firm investment is driven by large companies and old firms.

Finally, the substitutability between bank and non-bank financing is also explored. In particular, the analysis finds that bank-constrained firms are more likely to consider alternative sources of finance (grant finance, trade credit, informal loans and market financing), but they are not more likely to actually use them. These results suggest that bank-constrained firms wish to diversify their funding sources in an attempt to replace bank financing, but fail to do so, probably because they are also less creditworthy than unconstrained firms.

The rest of the paper is organised as follows. Section 2 describes the sample and the construction of the variables used for the empirical analysis and presents some preliminary evidence. Section 3 explains the identification strategy and the construction of the instrumental variable. Section 4 describes the main results. Finally, Section 5 concludes. Some descriptive statistics and additional results are displayed in the appendices.

2. Sample, construction of variables and some descriptive evidence

2.1. Main characteristics of the sample

The data source for the analysis is the firm-level Survey on the Access to Finance of Enterprises (SAFE), which has been run jointly by the ECB and the European Commission since 2009. The sample contains only non-financial firms and excludes firms in agriculture and public administration. Some of the firms are re-surveyed in subsequent rounds while some of them are interviewed only once. The sample is restricted to the rounds 11–16 of SAFE (from April–September 2014 to October 2016–March 2017) because of the availability of some key variables. After applying these filters, a

Table 1
Variables description.

Variable	Possible values
Country	12 European countries
Sector	Industry, construction, wholesale or retail trade, other services
Size employment	Micro, small, medium, large
Size turnover	1(≤€500,000), 2 (€500,000–€1 million), 3 (€1 million–€2 million) 4 (€2 million–€10 million), 5 (€10 million–€50 million), 6 (>€50 million)
Age	≥10 years, ≥5 and <10 years, ≥2 and <5 years, <2 years
Legal form	Subsidiary or branch, autonomous enterprise
Ownership structure	Listed, family or entrepreneurs, other enterprises, Venture capital enterprises, sole trader, other
Exporter	0,1
Constrained	0,1
Constrained bank	0,1
Constrained other	0,1
Investment growth	Decreased, remain unchanged, increased
Inventories growth	Decreased, remain unchanged, increased
Employment growth	Decreased, remain unchanged, increased
Turnover growth	Decreased, remain unchanged, increased
Enterprise outlook	Improved, remain unchanged, deteriorated
Relevance grants	0,1
Relevance trade credit	0,1
Relevance informal loans	0,1
Relevance market financing	0,1
Use grants	0,1
Use trade credit	0,1
Use informal loans	0,1
Use market financing	0,1
Country TLTRO	Percentage
GDP	Continuous
Consumer confidence	Continuous
Government bond yield	Continuous

sample of 19,375 non-missing observations[1] is left, corresponding to 10,774 non-financial companies from 12 European countries.[2]

Most of the information of the SAFE is qualitative, implying that most of the variables in the sample are categorical. Table 1 lists the names of the variables and the values they can take. A number of variables contain information on the general characteristics of the firms such as country, sector, size (measured by the number of employees[3] or by turnover volume), age (in intervals of years), legal status (whether the firm is an autonomous enterprise or a subsidiary/branch of another enterprise), ownership structure (whether the firm is owned by a single natural person, by a family, by public shareholders, etc) and export activity.

Table A1 of Appendix A shows the breakdown of observations by country. It can be seen that the survey contains more observations from the larger economies in order to be sufficiently representative of these countries. Firms from France, Germany, Italy and Spain account for about 60% of the firms in the sample. Around 56% of observations belong to the "vulnerable countries",[4] i.e., the euro area countries at the epicentre of the sovereign debt crisis (2009–2012).

Table 2 shows the breakdown of observations according to the main firm characteristics. Around 25% of the observations belong to the industry sector,[5] 10% to the construction sector, 25% to wholesale or retail trade and 30% to other services. In order to preserve the anonymity of the survey, the sector of activity of

Table 2
Breakdown of observations by firm characteristics.

	Freq.	Percent	Cum.
Sector			
Industry	5369	27.7	27.7
Construction	2004	10.3	38.1
Wholesale or retail trade	4859	25.1	63.1
Other services	5423	28.0	91.1
Missing (large firms)	1720	8.9	100.0
Total	19,375	100	
Size employment			
Micro	6065	31.3	31.3
Small	5966	30.8	62.1
Medium	5624	29.0	91.1
Large	1720	8.9	100.0
Total	19,375	100	
age			
≥10 years	16,367	84.5	84.5
≥5 and <10 years	2163	11.2	95.6
≥2 and <5 years	670	3.5	99.1
<2 years	175	0.9	100.0
Total	19,375	100	
Legal form			
Subsidiary or branch	2573	13.3	13.3
Autonomous enterprise	16,802	86.7	100.0
Total	19,375	100	
Ownership structure			
Public shareholders	371	1.9	1.9
Family or entrepreneurs	10,162	52.5	54.4
Other entreprises	2475	12.8	67.1
Venture capital enterprises	142	0.7	67.9
Sole trader	5600	28.9	96.8
Other	625	3.2	100.0
Total	19,375	100	
Exporter			
0	8729	45.1	45.1
1	10,646	55.0	100.0
Total	19,375	100	

[1] The actual number of observations used in the estimations varies according to the dependent variable. Descriptive statistics are presented here for the sample used for the baseline regressions of investment growth, as presented in Table 5.

[2] Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands, Portugal, Slovakia.

[3] Micro firms: 1–9 employees; small firms: 10–49 employees; medium firms: 50–249 employees; large firms: 250 employees or more.

[4] Vulnerable countries are Portugal, Italy, Ireland, Greece, Spain, Slovenia and Cyprus.

[5] Industry includes manufacturing, mining and electricity, gas and water supply.

large firms is missing. Micro, small and medium firms each account for about 30% of the sample, while large firms account for 9%. Most firms are more than 10 years old (85%), autonomous enterprises (87%) and owned by a family (53%) or are sole traders (29%). Around half of them are exporters.

2.2. Measures of credit constraints

Another set of variables comprises several measures of credit constraints in bank financing (bank loans and credit lines), trade credit and other financing (equity and debt securities, leasing, factoring, intercompany loans, etc). Following the existing literature (e.g. Ferrando et al., 2017; Ferrando and Mulier, 2015a; Artola and Genre, 2011), these variables equal one if, for each type of financing, any of the following circumstances took place: (a) a firm's application to external financing was rejected; (b) a firm only received a limited part (i.e., less than 75%) of what it applied for (i.e., quantity rationing); (c) a firm refused the lender's proposal for external financing because the borrowing costs were too high (i.e., price rationing); (d) a firm did not apply for external financing because it feared its application would be rejected (i.e., discouraged borrowers). By contrast, a firm is unconstrained if it successfully applied for external financing. Those firms that did not apply for external financing because of sufficient internal funds or for other reasons are excluded from the sample.

As in Ferrando et al. (2017) and Casey and O'Toole (2014), a single credit constraints indicator for bank loans and credit lines (*constrained bank*) is constructed, assuming that a firm is constrained in bank financing if it is constrained in at least one of the two. Hence, the analysis rests on the implicit assumption that these funding sources are imperfect substitutes. This seems a plausible assumption, as loans are more likely to be used to fund large investments in fixed assets and credit lines are more commonly used to finance inventories and other working capital. In analogous fashion, a single credit constraints indicator for trade credit and other financing (*constrained other*) is constructed, assuming that a firm is constrained in non-bank financing if it is constrained in at least one of the two. Finally, a measure of overall credit constraints is built by merging *constrained bank* and *constrained other* into a single variable, *constrained*, which equals 1 if the firm is constrained in at least one of the two financing sources (i.e., *constrained bank* = 1 and/or *constrained other* = 1) and 0 if the firm is constrained in neither of them (i.e., *constrained bank* = *constrained other* = 0). In order to increase the number of non-missing observations, *constrained* equals 1 if, for instance, *constrained bank* equals 1 and *constrained other* is missing, and *constrained* equals 0 if *constrained bank* equals 0 and *constrained other* is missing.

A potential concern regarding the construction of the credit constraints measures is that constrained firms which experience different circumstances (discouraged, price-constrained, quantity-constrained, rejected) are aggregated into a single category. By pooling those four categories of financing constraints the analysis is implicitly assuming that these firms have similar characteristics. To check the plausibility of this assumption, the distribution of each type of constrained firm according to certain key characteristics (sector, size, age and ownership structure) is examined in Figs. B1–B4 of Appendix B. These figures reveal similar distributions across those dimensions for the four types.

A more formal test is carried out in Table B1, which shows the values of Cramer's V between firm characteristics and indicators of credit constraints in loans, credit lines, trade credit and other financing (equity, debt, grant finance, informal loans, etc.) The Cramer's V is a measure of association between two nominal variables, giving a value between 0 and 1. The indicators of credit constraints are categorical variables that take the value 1 (discouraged borrower), 2 (rejected application), 3 (price-constrained) or 4 (quantity-constrained). The values of the Cramer's V are always below 0.2, which suggests weak associations between firm characteristics (rows) and credit constraints indicators (columns). Hence, the available evidence suggests that pooling the four types of credit constraints into one single indicator is warranted.

2.3. Firm characteristics and credit constraints

The distribution of constrained firms differs across firm types, highlighting the role of information asymmetries and credit risk. This is inspected in Fig. 1, which shows the percentage of constrained firms across several categories. Consistent with the literature that finds a negative relationship between the probability of experiencing financial constraints and size,[6] 43% of micro firms are constrained, while this figure goes down to 29%, 19% and 14% in the case of small, medium and large firms, respectively. The same is true when firms are categorised in terms of their turnover: the percentage of constrained firms decreases as size increases. In both cases, the relationship between credit constraints and firm size is statistically significant, as suggested by Pearson Chi-squared tests, and relatively strong, as indicated by Cramer's V values between 0.24 and 0.26. By contrast, the relationship between financial constraints and firm age is non-monotonic and less strong (Cramer's V equal to 0.07). In particular, mature firms (10 or more years old) are 9 percentage points (pp) less likely to experience constraints than new ones (less than 2 years old), in line with previous studies.[7] The incidence of credit constraints is highest in the construction sector (35%) and lowest in industry (27%). Also consistent with the literature that suggests that belonging to a business group relaxes financial constraints,[8] the proportion of constrained firms that are subsidiaries or branches is significantly lower (18%) than that of autonomous enterprises (28%). Ownership structure also matters, although the relationship is not very strong (Cramer's V equal to 0.12) as sole traders and family businesses are more likely (35% and 25%, respectively) to be constrained than publicly-listed firms (17%). There is also a significant proportion of constrained firms among those owned by venture capital enterprises (35%), as venture capital tends to fund new and risky projects for which conventional finance is often not available. Exporting firms are less likely to be financially constrained than non-exporting ones (23% and 30%, respectively) because the former tend to be more competitive and productive (Correa-López and Doménech, 2012). Finally, the proportion of credit constrained firms is higher in "vulnerable" (31%) than in "less vulnerable" countries (21%).

Obviously, as those firm characteristics are correlated between each other, it is useful to run multivariate regression models. In particular, Table 3 shows linear probability models in which the dependent variables are *constrained, constrained bank* and *constrained other*. Country-time fixed effects are included to control for macroeconomic developments (e.g. business cycle). The results show that firm size is a strong predictor of credit constraints, especially when measured in terms of turnover: a very large firm (size 6: turnover greater than € 50 million) has a 27 pp lower probability of experiencing financial constraints than a very small firm (size 1: turnover less than € 0.5 million). In addition, firms between 2 and 5 years old are more likely to experience credit constraints than the rest. By contrast, sector of activity is

[6] See, *inter alia*, Beck et al. (2005), Beck et al. (2006), Artola and Genre (2011) and Schiantarelli (1996) for a review of numerous other studies.

[7] Beck et al. (2005, 2006), Artola and Genre (2011), Ferrando and Griesshaber (2011), Ferrando and Mulier (2015a).

[8] Hoshi et al. (1991), Schiantarelli and Sembenelli (1996), Cho (1995), Elston and Albach (1995), Schaller (1993) and Chirinko and Schaller (1995).

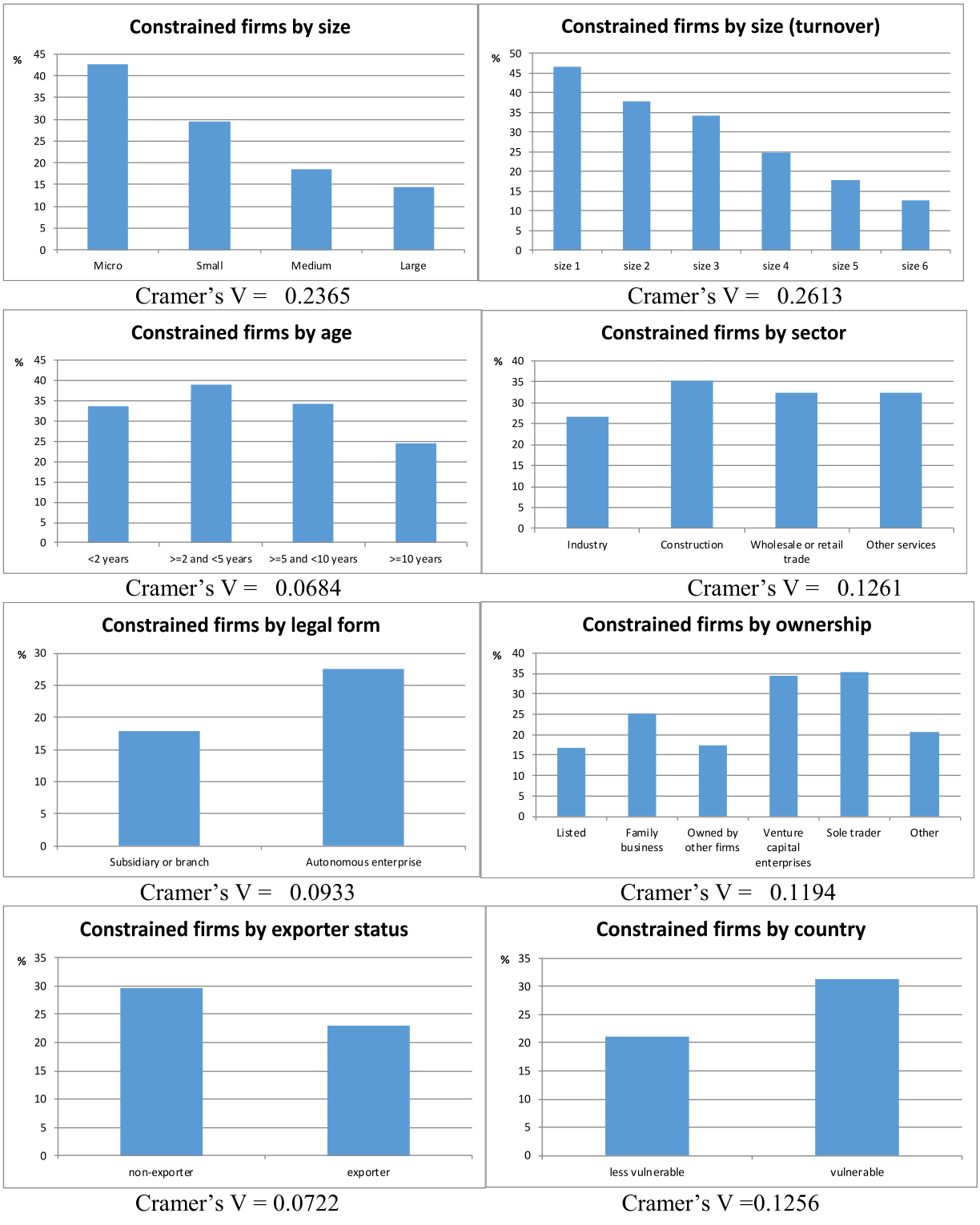


Fig. 1. Percentage of constrained firms by company type.
The charts show the percentage of firms for which the variable *constrained* equals 1. Firm size according to employment is as follows: micro (1–9 employees), small (10–49 employees), medium (50–249 employees), large (250 employees or more). Firm size according to turnover is as follows: size 1(≤€ 500,000), size 2 (€500,000–€1 million), size 3 (€1 million–€ 2 million), size 4 (€ 2 million–€10 million), size 5 (€10 million–€50 million), size 6 (>50 million). Vulnerable countries are Portugal, Italy, Ireland, Greece, Spain, Slovenia and Cyprus, less vulnerable countries are the remaining countries.

rarely significant, and neither is ownership structure. Finally, quite surprisingly, exporters have a higher probability of being financially constrained when the other characteristics are controlled for.

2.4. Dependent variables

Several variables indicate changes in the economic and financial situation of the firm. In particular, firms must answer whether a set of indicators, such as investment, inventories, employment and

Table 3
Firm characteristics correlated with credit constraints.

Dependent variable	(1) Constrained	(2) Constrained bank	(3) Constrained other
Small	−0.010	−0.008	−0.021
	(0.016)	(0.018)	(0.020)
Medium	−0.052***	−0.049**	−0.072***
	(0.020)	(0.023)	(0.025)
Large	−0.051*	−0.052*	−0.085**
	(0.027)	(0.030)	(0.034)
Size 2	−0.076***	−0.082***	−0.060***
	(0.017)	(0.020)	(0.023)
Size 3	−0.106***	−0.103***	−0.138***
	(0.019)	(0.022)	(0.024)
Size 4	−0.174***	−0.190***	−0.152***
	(0.020)	(0.022)	(0.025)
Size 5	−0.226***	−0.253***	−0.202***
	(0.023)	(0.027)	(0.030)
Size 6	−0.270***	−0.313***	−0.220***
	(0.029)	(0.033)	(0.036)
≥5 and <10 years	0.024	−0.000	0.031
	(0.015)	(0.016)	(0.020)
≥2 and <5 years	0.050**	0.100***	−0.031
	(0.024)	(0.029)	(0.026)
<2 years	0.008	0.007	0.002
	(0.041)	(0.043)	(0.056)
Construction	0.025	0.034*	0.027
	(0.017)	(0.020)	(0.022)
Wholesale or retail trade	−0.001	0.005	−0.010
	(0.013)	(0.015)	(0.016)
Other services	−0.022*	−0.017	−0.018
	(0.012)	(0.014)	(0.015)
Autonomous enterprise	−0.018	−0.047***	−0.012
	(0.015)	(0.018)	(0.018)
Family business	−0.008	−0.058	0.052*
	(0.036)	(0.048)	(0.030)
Owned by other firms	−0.022	−0.058	0.028
	(0.035)	(0.047)	(0.031)
Venture capital enterprises	0.091	0.075	0.100
	(0.060)	(0.075)	(0.063)
Sole trader	0.012	−0.031	0.071**
	(0.037)	(0.049)	(0.032)
Other	0.009	−0.046	0.098**
	(0.041)	(0.051)	(0.043)
Exporter	0.021**	0.024**	0.013
	(0.010)	(0.010)	(0.012)
Country-Time Dummies	YES	YES	YES
Observations	20,512	15,638	11,656
R-squared	0.133	0.159	0.123

Estimator: OLS. The omitted categories are: micro firm, turnover less than € 500,000, 10 or more years old, industrial sector, subsidiary or branch, listed, non-exporter. Size is measured in terms of employment (micro, small, medium, large) and in terms of annual turnover (size 1–size 6) as explained in Table 1. Cluster robust standard errors in parentheses. Cluster level: firm.

*** $p < 0.01$.

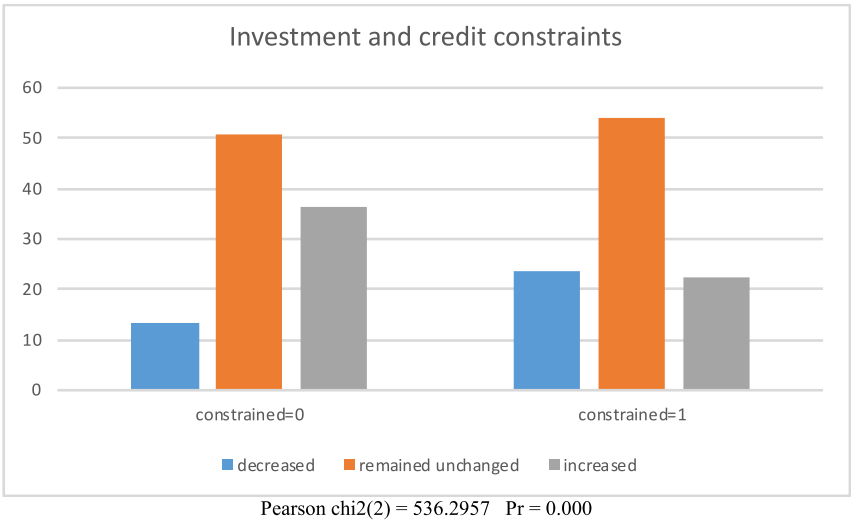
** $p < 0.05$.

* $p < 0.1$.

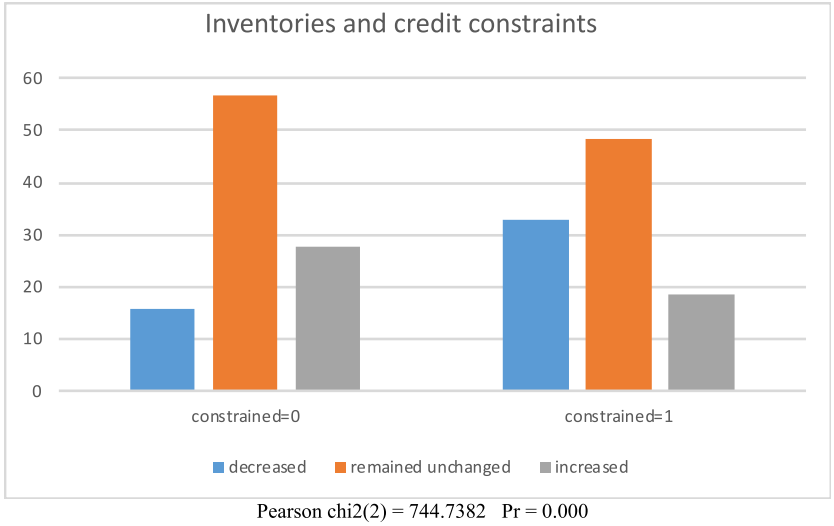
turnover have decreased, remained unchanged or increased over the last six months before the survey.

To inspect a possible link between financial constraints and the dependent variables of the analysis (investment, inventories and employment), Fig. 2 shows the distribution of those variables for constrained and unconstrained firms (considering all funding sources), as well as the Pearson's Chi-squared test of independence and the Cramer's V. The picture that emerges is quite similar in the three variables. In each case, it can be observed that the percentage of firms that report that the variable decreased (blue bar) is substantially larger (between ten and seventeen percentage points) in the group of financially constrained firms (*constrained* = 1), while the percentage of firms that report an increase in the variable (grey bar) is substantially larger (between nine and fourteen percentage points) in the group of firms without credit constraints (*constrained* = 0). In addition, according to the Chi-squared test statistics the null hypothesis of independence is rejected in the three cases. The Cramer's V values indicate moderate associations between credit constraints and the dependent variables.

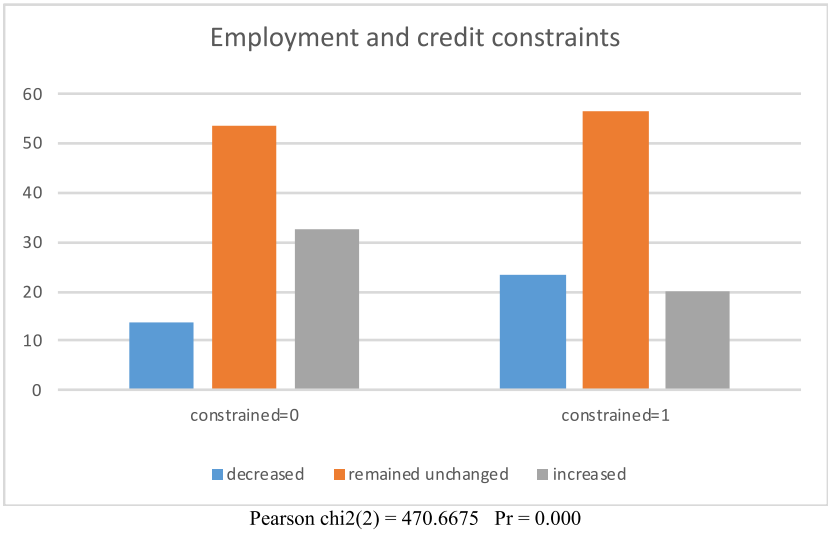
It is also necessary to check whether the distributions of investment, inventories and employment differ from each other. Otherwise, if the same firms that reported falls in investment were the ones that reported declines in inventories and employment, the effective information content of the dataset would be rather limited. However, this is not the case, as the cross-tabulations of Table A3 in Appendix A show that there are a significant number of observations outside the main diagonal of the respective matrices. While Chi-squared tests reject the null hypothesis of independence in the three cases, the values of the Cramer's V (between 0.22 and 0.24) indicate moderate correlations between the dependent variables.



Pearson chi2(2) = 536.2957 Pr = 0.000
Cramer's V = 0.1664



Pearson chi2(2) = 744.7382 Pr = 0.000
Cramer's V = 0.1972



Pearson chi2(2) = 470.6675 Pr = 0.000
Cramer's V = 0.1559

Fig. 2. Conditional distributions of investment growth, inventories growth and employment growth on credit constraints. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 4
Descriptive statistics.

Variable	Obs	Mean	Std. dev.	Min	Max
Dependent variables					
Investment growth: decreased	19,375	0.16	0.37	0	1
Investment growth: unchanged	19,375	0.49	0.50	0	1
Investment growth: increased	19,375	0.34	0.48	0	1
Inventories growth: decreased	19,146	0.19	0.39	0	1
Inventories growth: unchanged	19,146	0.55	0.50	0	1
Inventories growth: increased	19,146	0.26	0.44	0	1
Employment growth: decreased	19,367	0.17	0.38	0	1
Employment growth: unchanged	19,367	0.52	0.50	0	1
Employment growth: increased	19,367	0.31	0.46	0	1
Relevance grants	18,985	0.47	0.50	0	1
Relevance trade credit	19,164	0.52	0.50	0	1
Relevance informal loans	18,962	0.29	0.45	0	1
Relevance market financing	18,886	0.20	0.40	0	1
Use grants	8933	0.40	0.49	0	1
Use trade credit	9213	0.67	0.47	0	1
Use informal loans	5472	0.55	0.50	0	1
Use market financing	3747	0.27	0.44	0	1
Credit constraints variables					
Constrained	19,375	0.26	0.44	0	1
Constrained bank	14,809	0.26	0.44	0	1
Constrained other	11,005	0.24	0.43	0	1
Instrumental variable					
Country TLTRO	19,375	1.14	1.18	0.01	5.25
Other controls					
Turnover growth: decreased	19,375	0.24	0.43	0	1
Turnover growth: unchanged	19,375	0.30	0.46	0	1
Turnover growth: increased	19,375	0.46	0.50	0	1
Enterprise outlook: improved	19,375	0.38	0.48	0	1
Enterprise outlook: unchanged	19,375	0.42	0.49	0	1
Enterprise outlook: deteriorated	19,375	0.21	0.41	0	1
GDP	19,375	0.18	1.02	−7.06	8.83
Consumer confidence	19,375	−8.54	11.79	−69.80	21.48
Government bond yield	19,375	1.50	1.51	−0.02	10.64

In some empirical analyses another set of dependent variables will be used. In particular, a number of variables indicate whether the firm considers a particular type of financing (e.g. trade credit) to be relevant and whether the firm has used it in the past six months (see Table 1).

2.5. Descriptive statistics

Table 4 shows weighted descriptive statistics, constructed with sampling weights, for the dependent variables of the analysis, the measures of credit constraints, the instrumental variable and the remaining controls. As the sample is stratified by country, enterprise size class and economic activity, sampling weights are used in all the statistical analyses. The weights restore the proportions of the economic weight (in terms of number of employees) of each size class, economic activity and country. See Appendix C for the distribution of sampling weights across these dimensions.

Around 30% of firms report increases in investment, inventories and other working capital and employment. The use of non-bank sources of finance is widespread. For instance, 52% of the firms regard trade credit as a relevant source of finance and 67% of those that find it relevant have actually used it in the past six months. With respect to the indicators of credit constraints, 26% of firms are constrained in bank finance (*constrained bank* = 1), 24% are constrained in trade credit or other financing (*constrained other* = 1) and 26% are constrained in some source of financing (*constrained* = 1). The correlation between the indicator of credit constraints in bank financing (*constrained bank*) and the indicator of credit constraints in other financing (*constrained other*) is about 0.6.

3. Empirical methods and identification strategy

To identify the causal impact of credit constraints on investment, inventories and other working capital and employment growth, linear probability models have been used.[9] Let Y be a dummy variable that equals 1 if investment/inventories/employment has increased and 0 if it has decreased or remained unchanged. The econometric model is:

$$Y_{ict} = \rho \cdot constrained_{it} + X_i'\beta + X_c'\gamma + \alpha_c + \alpha_t + \varepsilon_{ict} \quad (1)$$

where i is firm, c is country, t is wave, $constrained_{it}$ is the indicator of credit constraints, X_i' and X_c' are vectors of firm-level and country-level controls, α_c and α_t are country and time fixed effects and ε_{ict} is a regression disturbance.

The key identification challenge is an omitted variable bias, as one may expect firms with poor investment/growth opportunities to have a higher probability of being credit constrained. To tackle this problem two approaches are followed. In a first approach, Eq. (1) is estimated by Ordinary Least Squares (OLS), relying on a comprehensive set of covariates to control for firms' investment opportunities.

The preferred measure of investment opportunities is *enterprise outlook*, an indicator for changes in the enterprise-specific outlook, also used by Ferrando and Mulier (2015b). In particular, the firm is asked to assess the evolution of its own outlook, with respect to its sales and profitability or business plan, i.e., whether this has improved, remained unchanged or deteriorated over the past six months. An indicator for changes in firm's turnover is also included (i.e., whether it has increased, remained unchanged or

[9] For robustness, non-linear models such as probit and bivariate probit have been employed. See Section 4.1.

decreased over the past six months) as a proxy for growth opportunities, as in Gomes (2001). As far as the remaining firm-level controls are concerned, size and age, together with the firm's sector of activity, are traditional determinants of investment opportunities (Petersen and Rajan, 1994). In addition, they are correlated with credit constraints, as discussed in the previous section. The degree of autonomy of the firm (whether the firm is an autonomous enterprise or a subsidiary/branch of another enterprise) is also controlled for, and the ownership structure (whether the firm is owned by a single natural person, by a family, by public shareholders, etc) is also included in the regressions, as those factors are likely to influence investment decisions, and a dummy that equals 1 if the firm is an exporter is included as well.

Nevertheless, a potential caveat to the previous approach is that one cannot perfectly control for firms' investment and growth opportunities, implying that the error term may be correlated with the credit constraint indicator. Hence, in a second approach, an instrumental variable is used in an attempt to isolate the exogenous part of the key regressor. The proposed instrument comes from a monetary shock in the euro area, the Targeted Longer-Term Refinancing Operations (TLTROs).

On the 5th of June 2014, the ECB decided to support bank lending to the euro area non-financial sector through a first set of Targeted Longer-Term Refinancing Operations (TLTRO I). This policy was implemented through eight auctions, one each quarter from September 2014 to June 2016, and participation was open to institutions that were eligible for the Eurosystem open market operations. All TLTRO I matured in September 2018, although early voluntary repayments could be made from 24 months after each TLTRO. In addition, four new Targeted Longer-Term Refinancing Operations (TLTRO II) were conducted between June 2016 and March 2017 at a quarterly frequency. All those operations had a four-year maturity with the possibility of repayment after two years. Hence, the TLTROs can be regarded as a shock to the banking sector that influenced lending behaviour without also directly affecting firm behaviour at the same time.

While the TLTROs constituted a shock to the banking sector that should have relaxed credit constraints, it is also clear that it was not an exogenous shock, as banks could freely choose the uptakes in the TLTROs. Hence it is likely that banks with better lending opportunities or higher credit demand borrowed higher amounts. However, there were certain borrowing limits that could be exploited in order to derive an exogenous shock. In the case of TLTRO I (announced on June 2014), banks were able to borrow an amount equivalent to 7% of their eligible loans (basically, loans to the euro area non-financial private sector, excluding loans to households for house purchase) outstanding on 30 April 2014. After this, additional amounts could be borrowed in further TLTROs depending on the evolution of the banks' eligible lending activities in excess of bank-specific benchmarks.[10] In the case of TLTRO II (announced on March 2016), banks were able to borrow a total amount of up to 30% of their eligible loans outstanding on 31 January 2016. Incentives for banks to lend to the non-financial private sector were provided via a reduction in the interest rate applied in the operations.[11] Crucially, notice that in both TLTROs the stock of eligible loans was measured at a date *prior* to the announcement of the policy.

The proposed instrument is *country TLTRO*, a variable that measures the *predicted* uptake of TLTROs by the banks of each country, scaled by the total assets of each country's banking sector. The instrument is constructed in two steps. In a first step, following the approach of Benetton and Fantino (2017), actual TLTRO uptakes are regressed on the maximum borrowing limits of TLTRO I and TLTRO II (7% and 30% of eligible loans, respectively), plus bank fixed effects and country-time dummies. The predicted values from that regression constitute the exogenous component of the TLTRO shock, as they are based on exogenous parameters that are common across banks and on pre-determined banks' balance sheet characteristics. In a second step, these bank-level predicted uptakes are aggregated at the country level and divided by the sum of the banks' total assets in each country. See Appendix D for details on the construction of the instrumental variable.

An important limitation of this instrumental variable is that it only varies at the country-time level, which prevents the use of country-time fixed effects to control for macroeconomic shocks. Hence, *country TLTRO* may not satisfy the independence assumption (Angrist and Pischke, 2009) because it may be correlated with aggregate demand effects. An ideal dataset would contain information at the bank-firm level. With such data one could link the probability of a firm being financially constrained (the endogenous variable) with the TLTRO uptakes and borrowing limits of its main bank (the instrumental variable), while controlling for macroeconomic shocks with country-time fixed effects.

Nevertheless, to ameliorate those concerns several macroeconomic controls are included. In particular, the economic cycle and the economy-wide investment opportunities are controlled for with the detrended level of real GDP. In addition, other country-level determinants of investment demand are included such as the European Commission's consumer confidence indicator (to measure expectations) and the ten-year government bond yield (to proxy financial conditions). Results are robust to the inclusion of other controls, such as the unemployment rate, aggregate investment growth and firms' perceptions of the general macroeconomic outlook, as reported in the SAFE.

Reassuringly, the instrumental variable is not correlated with basic macro controls, once country and time effects are included. This is shown in Table D3 of Appendix D. The variable *country TLTRO* is regressed on the economic cycle (proxied by GDP, the unemployment rate or aggregate investment growth), the consumer confidence indicator and the ten-year government bond yield, country and time fixed effects. All coefficients are insignificant, suggesting the instrument satisfies the independence assumption.

Finally, cluster-robust standard errors are used to allow for potential heteroscedasticity and serial correlation within groups in the error structure. The clustering group is the country-wave interaction, which is the level of variation of the instrumental variable.

4. Empirical results

4.1. Overall effects

Table 5 presents the results of probability models estimated by OLS, probit and instrumental variable methods, in which the dependent variable is investment growth. All time-varying controls are lagged one period, while the endogenous regressor *constrained* and the instrument *country TLTRO* are included contemporaneously. All specifications include country and time dummies. The first-stage F-statistic is also reported.

Column 1, estimated by Ordinary Least Squares (OLS), shows a strong negative correlation between *constrained* and *investment growth*. However, to establish a causal relationship the use of the

[10] The additional borrowing allowance was limited to three times the difference between net lending since 30 April 2014 and the benchmark at the time it was claimed. See ECB press release for details: https://www.ecb.europa.eu/press/pr/date/2014/html/pr140703_2.en.html.

[11] The interest rate applied to TLTRO II was fixed for each operation at the rate applied in the main refinancing operations (MROs) prevailing at the time of allotment. In addition, counterparties whose eligible net lending in the period between 1 February 2016 and 31 January 2018 exceeded their benchmark were charged a lower rate for the entire term of the operation. See ECB press release for details: https://www.ecb.europa.eu/press/pr/date/2016/html/pr160310_1.en.html.

Table 5
Impact of credit constraints on investment, coefficients and marginal effects.

Dependent variable	Structural equation (1) Investment growth	First-stage (2) Constrained	Reduced form (3) Investment growth	Structural equation (4) Investment growth	Structural equation (5) Investment growth	Structural equation (6) Investment growth
Constrained	−0.085***			−0.863**	−0.091***	−0.198**
	(0.011)			(0.350)	(0.011)	(0.084)
Country TLTRO		−0.023***	0.020*			
		(0.007)	(0.010)			
Estimator	OLS	OLS	OLS	2SLS	Probit	Bivariate probit
Instruments				Country TLTRO		Country TLTRO
Country dummies	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
Macro controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Other firm controls	YES	YES	YES	YES	YES	YES
F-test (First-Stage)		11.81		11.81		
Observations	19,375	19,375	19,375	19,375	19,375	19,375

OLS is Ordinary Least Squares, 2SLS is Two-stage least squares.
Columns 5 and 6 display average marginal effects.
The dependent variable is a dummy that equals 1 if investment has increased and 0 if it has decreased or remained unchanged.
The instrumental variable is country TLTRO.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave.
F-test (first-stage) is the Kleibergen-Paap Wald rk F statistic.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

instrumental variable is required. The first-stage is reported in column 2. According to the first-stage, a percentage point (pp) increase in predicted TLTRO uptake (over total assets) in a country decreases the likelihood of being credit constrained by around 2.3 pp, and the effect is statistically significant at a 1% level. In other words, the TLTROs reduced significantly the incidence of credit constraints among European firms. The instrument does not seem to be weak, as the value of the first-stage F-statistic is above 10, the reference value suggested by Staiger and Stock (1997). The reduced form (i.e., the regression of the outcome variable on the instrument) is reported in column 3. According to the reduced form, a percentage point increase in predicted TLTRO uptake (over total assets) raises the probability that investment will increase by 2 pp.

The Two-Stage Least Squares (2SLS) estimates resulting from the estimation of the first-stage and the reduced form are displayed in column 4. According to these estimates, the presence of credit constraints reduces the probability of increasing investment by 86 pp, and the effect is statistically significant at a 5% level. This is a very strong effect, as it means that the presence of credit constraints reduces to almost zero the probability of increasing investment.

The 2SLS estimates are noticeably larger than the OLS estimates, suggesting that the latter underestimate the causal effect of credit constraints on investment growth. Notice that, following Imbens and Angrist (1994), the 2SLS estimate can be interpreted as the Local Average Treatment Effect (LATE). The LATE is the average treatment effect on the subpopulation of compliers; these being the individuals whose treatment status changes when the value of the instrumental variable changes as well. 2SLS is uninformative for always-takers (the ones that always receive the treatment, irrespective of the value of the IV) and never-takers (the ones that never receive the treatment) because the instrument is unrelated to their treatment status (Angrist et al., 1996). In the present empirical application, compliers are the firms that become financially constrained (unconstrained) when the country's TLTRO uptake decreases (increases), always-takers are the firms that are always financially constrained, regardless of the level of TLTRO, and never-takers are the firms that are never financially constrained. The estimates suggest a very strong causal effect on the subpopulation of complier firms, which is expected to differ from the average causal effect for the entire population (the average treatment effect). In other words, the effect is heterogeneous, and 2SLS captures the average effect for the subpopulation of firms that are especially affected by the presence of credit constraints.[12]

Given the potential heterogeneity of the causal effects (which will be explored in detail in Section 4.3), the previous estimation by OLS/2SLS may be too restrictive, as a linear probability model assumes constant marginal effects across observations. To relax this assumption, a probit model and a bivariate probit (Heckman, 1978) are also estimated. In a bivariate probit both the first stage and the second stage are modelled as probit models and are estimated jointly by maximum likelihood. The motivation for using this non-linear estimator is that, by changing the functional form, one may capture better the heterogeneity of the causal effects. The price to pay is stronger parametric assumptions: one must assume homoskedastic bivariate normal errors. Average marginal effects of probit and bivariate probit are presented in columns 5 and 6, respectively. The marginal effect of the probit model (column 5) is very similar to the OLS coefficient (column 1). However, the average marginal effect of the bivariate probit (column 6) is significantly smaller than the 2SLS coefficient (column 4). In particular, according to column 6, the presence of credit constraints reduces by 20 pp the probability of increasing investment, and the effect is statistically significant at a 5% level. Therefore, the average treatment effect may be substantially lower than the LATE.

The impact of credit constraints on inventory growth is displayed in Table 6. The results are mixed. The OLS coefficient (column 1) and the probit marginal effect (column 5) are significant at a 1% level, suggesting a strong negative correlation between credit constraints and inventory growth. However, the 2SLS coefficient (column 4) reveals a surprising positive association. By contrast, the average marginal effect of credit constraints is negative and statistically significant when using a bivariate probit (column 6).

[12] In general, another reason why 2SLS may yield larger estimates than OLS is measurement error in the endogenous variable.

Table 6
Impact of credit constraints on inventories, coefficients and marginal effects.

Dependent variable	Structural equation (1) Inventories growth	First-stage (2) Constrained	Reduced form (3) Inventories growth	Structural equation (4) Inventories growth	Structural equation (5) Inventories growth	Structural equation (6) Inventories growth
Constrained	−0.029***			0.488***	−0.032***	−0.205***
	(0.007)			(0.174)	(0.008)	(0.040)
Country TLTRO		−0.022***	−0.011**			
		(0.007)	(0.004)			
Estimator	OLS	OLS	OLS	2SLS	Probit	Bivariate probit
Instruments				Country TLTRO		Country TLTRO
Country dummies	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
Macro controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Other firm controls	YES	YES	YES	YES	YES	YES
F-test (First-Stage)		10.780		10.780		
Observations	19,499	19,499	19,499	19,499	19,499	19,499

OLS is Ordinary Least Squares, 2SLS is Two-stage least squares.
Columns 5 and 6 display average marginal effects.
The dependent variable is a dummy that equals 1 if inventories and other working capital have increased and 0 if they have decreased or remained unchanged.
The instrumental variable is country TLTRO.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave.
F-test (first-stage) is the Kleibergen-Paap Wald rk F statistic.
* $p < 0.1$.
*** $p < 0.01$.
** $p < 0.05$.

Table 7
Impact of credit constraints on employment, coefficients and marginal effects.

Dependent variable	Structural equation (1) Employment growth	First-stage (2) Constrained	Reduced form (3) Employment growth	Structural equation (4) Employment growth	Structural equation (5) Employment growth	Structural equation (6) Employment growth
Constrained	−0.052***			−0.118	−0.059***	−0.039
	(0.010)			(0.224)	(0.011)	(0.096)
Country TLTRO		−0.023***	0.003			
		(0.007)	(0.005)			
Estimator	OLS	OLS	OLS	2SLS	Probit	Bivariate probit
Instruments				Country TLTRO		Country TLTRO
Country dummies	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
Macro controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Other firm controls	YES	YES	YES	YES	YES	YES
F-test (First-stage)		12.16		12.16		
Observations	19,778	19,778	19,778	19,778	19,778	19,778

OLS is Ordinary Least Squares, 2SLS is Two-stage least squares.
Columns 5 and 6 display average marginal effects.
The dependent variable is a dummy that equals 1 if employment has increased and 0 if it has decreased or remained unchanged.
The instrumental variable is country TLTRO.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave.
F-test (first-stage) is the Kleibergen-Paap Wald rk F statistic.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Therefore, it can be concluded that the impact of credit constraints on the probability of an increase in inventories is not robust, as its sign and significance depend on the estimation method.

The impact of credit constraints on employment growth is presented in Table 7. The results are also mixed. The OLS coefficient (column 1) and the probit marginal effect (column 5) are negative and statistically significant, suggesting a negative correlation between being constrained and the probability of increasing employment. However, the estimation of the structural equation by 2SLS (column 4) and by a bivariate probit (column 6) reveals no effect.

Therefore, the results of this section suggest a strong causal impact of overall credit constraints on firm investment, while the effects on employment growth and inventories are less robust. These findings suggest that investment is particularly sensitive to the availability of external finance.

Nevertheless, a limitation of the empirical exercise is the fact that the main dependent variables (investment, inventories growth, employment growth) are categorical. The results only indicate that a constrained firm has an X pp lower (higher) probability of increasing (decreasing) investment but do not permit statements regarding the magnitude of the increase/drop in investment.

4.2. Checking the exclusion restriction

A standard concern in any IV estimation is the potential violation of the exclusion restriction, which asserts a single causal channel through which the instrument affects outcomes. In this particular setting, the exclusion restriction amounts to stating that the only channel through which (predicted) TLTRO uptakes may affect firm investment and growth is via their influence on the likelihood of experiencing credit constraints. An alternative channel through which the TLTROs may affect a firm's investment is via their impact on the firm's expectations about the economy. In particular, unconventional monetary policy such as the TLTROs may improve the macroeconomic outlook by supporting aggregate demand and inflation, which in turn may induce firms to invest more in capital goods and other fixed assets.

While the exclusion restriction cannot be tested directly, evidence can be brought to bear on the question by estimating the first stage and reduced form specifications in different subsamples, as in Angrist et al. (2010). It can be shown (see Appendix E) that the reduced-form effect (ρ) is the product of the first stage effect (φ) and the local average treatment effect LATE (λ):

$$\rho = \varphi\lambda \tag{2}$$

From (2) one concludes that, in samples where the first stage φ is zero, the reduced form ρ must be zero as well. On the other hand, a statistically significant reduced-form estimate, with no evidence of a corresponding first stage, signals violations of the exclusion restriction, because it suggests some channel other than the endogenous variable (in this case, credit constraints).

Table 8 presents first-stage estimates (upper table) and reduced form estimates (lower table) for different subsamples of firms according to their size (columns 1–3), their age (columns 4–6), their sector (columns 7–10) and their country, differentiating between vulnerable and less vulnerable countries (columns 11 and 12). According to the upper table (column 1), there is no first-stage in micro firms. This suggests few compliers in this group of firms: many micro firms are likely to be constrained no matter the amount of TLTROs in a country (i.e., they are always-takers). Exclusion implies that this sub-sample should generate zero reduced-form estimates, since the hypothesized causal channel is absent. Indeed, this is the case, as the lower table shows: the coefficient on country TLTRO is insignificant in column 1. The same is true in the case of firms less than 5 years old (column 6), firms from the trade sector (column 9) and firms located in vulnerable and less vulnerable countries (columns 11 and 12): neither the first stage (upper table) nor the reduced-form (lower table) estimates are statistically different from zero (or are only marginally significant, and with the reverse sign, in column 6). Hence, the available evidence suggests that the exclusion restriction is not violated in this empirical setting.

Another important insight that comes from the observation of Table 8 is the first-stage estimates (upper part of the table), which show the effect of unconventional monetary policy (TLTROs) on the probability of facing credit constraints. Regarding large firms (column 3), a 1 pp increase in *country TLTRO* reduces by 5.2 pp the probability that large firms will experience financial constraints. By contrast, the effect is much smaller in the case of SMEs (1.4 pp) and it is insignificant in the case of micro firms. Regarding the breakdown by age (columns 4–6), the effect of *country TLTRO* on the probability of credit constraints is only significant in the case of old firms (10 years old or more; it is marginally significant, but with reverse sign, in the case of firms between 5 and 9 years). Therefore, it seems that unconventional monetary policy may reduce the incidence of credit constraints, but mainly in the case of large companies and old firms. This is a particularly important finding, because those firms face a lower probability of being

Table 8
First-stage and reduced form estimates for different subsamples (to check the exclusion restriction).

First-stage estimates for different subsamples of firms											
Subsample	(1) Micro	(2) Sme	(3) Large	(4) 10 years or more	(5) 5–9 years	(6) Less than 5 years	(7) Industry	(8) Construction	(9) Trade	(10) Other services	(11) Vulnerable	(12) Less vulnerable
Country TLTRO	0.004	−0.014**	−0.052***	−0.030***	0.032*	−0.038	−0.021***	0.040***	−0.003	−0.024**	0.009	−0.013
	(0.011)	(0.007)	(0.012)	(0.006)	(0.017)	(0.039)	(0.008)	(0.012)	(0.013)	(0.010)	(0.008)	(0.030)
Observations	6065	11,590	1720	16,367	2163	845	5369	2004	4859	5423	10,137	9238
Reduced-form estimates for different subsamples of firms												
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Subsample	Micro	Sme	Large	10 years or more	5–9 years	Less than 5 years	Industry	Construction	Trade	Other services	Vulnerable	Less vulnerable
Country TLTRO	0.004	0.025**	0.040*	0.028**	−0.012	−0.056*	0.032***	−0.001	−0.008	0.026**	−0.000	0.014
	(0.007)	(0.011)	(0.021)	(0.011)	(0.019)	(0.031)	(0.009)	(0.014)	(0.011)	(0.010)	(0.009)	(0.043)
Observations	6065	11,590	1720	16,367	2163	845	5369	2004	4859	5423	10,137	9238

Dependent variable: constrained in the upper table, investment growth in the lower table. Estimator: OLS.
All specifications include country and time dummies.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

financially constrained in the first place (see Fig. 1 and discussion in Section 2.3).

4.3. Heterogeneous effects

In order to provide a more granular insight into the real effects of credit constraints, the impact of credit constraints on investment has been estimated by using the previous model (1) for different values of some firm characteristics. Beck et al. (2006) find that firm age, size and ownership are important determinants of firm financing constraints. Therefore the previous regressions are run for different firm groups based on these key characteristics.

Table 9 shows OLS (upper part) and 2SLS (lower part) estimates. According to the OLS estimates, the correlation between credit constraints and investment is negative and strong for all size classes (columns 1–3) and most age classes (columns 4–6). Across ownerships structures (columns 7–11), the correlations are negative and strong in the case of family businesses, subsidiaries and sole traders, while the other ownership categories (listed companies, other) are largely unaffected, which is consistent with asymmetric information problems.

The reading of the lower part of Table 9 (2SLS estimates) must be done with caution, as previous analyses showed that there are some subsamples for which the first-stage is zero or very small (see Table 8). For those samples, the causal chain initiated with the IV does not occur in the first place, implying that a causal relationship cannot be established between the endogenous regressor and the dependent variable. This is likely to be the case in the subsample of micro firms (column 1), in which the first-stage F-statistic is almost zero and the first-stage coefficient is not statistically different from zero (see Table 8). Something similar occurs in the subsample of SMEs (column 2), in which the *F*-test is very low (about 4), implying that the 2SLS coefficient may be severely biased. By contrast, the results reveal a strong effect for the sample of large firms: credit constraints reduce the probability of increasing investment by about 76 pp (column 3, with an associated *F*-test equal to 17). Similar results are found in the case of age (columns 4–6). The estimated impact on old firms (10 years or more) is large and quite precise: the presence of credit constraints reduces by 91 pp the probability of increasing investment (*F*-test equal to 25). By contrast, there is no impact in the case of relatively young firms, but the weak first-stages (as suggested by *F*-tests between 1 and 3) suggest no particular insight is gained from these IV estimates. Finally, regarding different ownership structures (columns 7–11), there is no clear effect in any category, with the exception of family businesses, in which the coefficient of interest is marginally significant. The upshot of the analysis is that most of the causal impact of credit constraints on firm investment is driven by large companies and old firms. As regards the effect on micro firms, SMEs and young businesses, only a negative correlation can be found.

4.4. Substitutability between bank and non-bank financing

The evidence discussed so far suggests that *overall* credit constraints have a strong and negative effect on investment, while their impact on inventories and employment is less clear. However, the previous analysis rests on the implicit assumption that bank financing and other non-bank financing are imperfect substitutes, as a firm is considered to be financially constrained if it is constrained in at least one of the two.

In this section a more formal and granular analysis of the topic is provided. To do so another question of the SAFE, which asks firms about their relevant sources of financing, is employed. A funding source is considered to be relevant if the firm has used it in the past or considers using it in the future. In addition, for

Table 9
Marginal effects of credit constraints for some subsamples.

OLS estimates of the impact of credit constraints on investment growth										
Subsample	(1) Micro	(2) Sme	(3) Large	(4) 10 years or more	(5) 5–9 years	(6) Less than 5 years	(7) Listed	(8) Family business	(9) Subsidiary	(10) Sole trader	(11) Other
Constrained	−0.058***	−0.089***	−0.141***	−0.092***	−0.083***	−0.053	−0.037	−0.095***	−0.091**	−0.077***	−0.062
	(0.014)	(0.011)	(0.037)	(0.010)	(0.025)	(0.042)	(0.107)	(0.014)	(0.040)	(0.016)	(0.056)
Observations	6065	11,590	1720	16,367	2163	845	371	10,162	2617	5600	625
2SLS estimates of the impact of credit constraints on investment growth											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Subsample	Micro	Sme	Large	10 years or more	5–9 years	Less than 5 years	Listed	Family business	Subsidiary	Sole trader	Other
Constrained	1.034	−1.747**	−0.761**	−0.907***	−0.363	1.473	−0.805	−0.922*	−0.817	−0.164	−4.112
	(4.200)	(0.709)	(0.373)	(0.297)	(0.522)	(1.920)	(0.545)	(0.513)	(0.638)	(0.598)	(5.705)
F-test	0.130	3.861	17.375	25.204	3.413	0.953	6.840	8.735	10.714	1.889	0.541
Observations	6065	11,590	1720	16,367	2163	845	371	10,162	2617	5600	625

Dependent variable: investment growth. Estimator: OLS (upper table) and 2SLS (lower table).
Instrumental variable: country TITRO.
All specifications include country and time dummies.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table 10
Relevance and use of non-bank financing: grant finance and trade credit.

Dependent variable	Relevance and use of non-bank financing: grant finance and trade credit					
	(1) Relevance grant finance	(2) Use grant finance	(3) Use grant finance	(4) Relevance trade credit	(5) Use trade credit	(6) Use trade credit
Constrained bank	0.054***	−0.229***	0.285	0.097***	−0.051***	−0.030
	(0.011)	(0.018)	(0.383)	(0.012)	(0.016)	(0.334)
Estimator	OLS	OLS	2SLS	OLS	OLS	2SLS
Country dummies	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
Macro controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Other firm controls	YES	YES	YES	YES	YES	YES
F-test (First-stage)			25.45			21.19
Observations	15,065	7683	7553	15,200	6759	6669

The instrumental variable is country TLTRO.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave.
F-test (first-stage) is the Kleibergen-Paap Wald rk F statistic.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

Table 11
Relevance and use of non-bank financing: informal loans and market financing.

Dependent variable	(1) Relevance informal loans	(2) Use informal loans	(3) Use informal loans	(4) Relevance market financing	(5) Use market financing	(6) Use market financing
Constrained bank	0.142***	0.047	−0.090	0.064***	0.018	−0.918*
	(0.011)	(0.031)	(0.305)	(0.012)	(0.031)	(0.491)
Estimator	OLS	OLS	2SLS	OLS	OLS	2SLS
Country dummies	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
Macro controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Other firm controls	YES	YES	YES	YES	YES	YES
F-test (First-stage)			14.88			10.58
Observations	15,029	4057	3974	14,979	2976	2881

The instrumental variable is country TLTRO.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave.
F-test (first-stage) is the Kleibergen-Paap Wald rk F statistic.
**$p < 0.05$.
*$p < 0.1$.
***$p < 0.01$.

each funding source the firm selects as being relevant, the firm is required to answer whether it has used it the past six months or not.

The survey distinguishes the following sources of funds: retained earnings or sales of assets; grants or subsidised bank loans; credit lines, bank overdrafts or credit cards overdraft; bank loans; trade credit; informal loans (from family and friends, a related enterprise or shareholders); debt securities; equity capital; leasing or hire-purchase; factoring; other sources of financing (e.g. subordinated debt, crowdfunding). Following Casey and O'Toole (2014), this investigation is limited to four groups: a) grant finance, b) trade credit, c) informal loans, d) market financing (debt or equity). As the interest lies in how firms substitute non-bank financing for bank financing, the analysis does not focus on leasing and factoring, as these facilities are often provided by traditional banks. For each of these funding sources, two variables are constructed, a dummy that equals 1 if the firm regards it as relevant (e.g. relevance of trade credit) and another dummy that equals 1 if the firm has used it in the past six months (e.g. use of trade credit). Then linear probability models are estimated in which these variables are regressed on the indicator of bank credit constraints (*constrained bank*) and the same set of firm-level and macro controls as before.

Table 10 displays the results for grant finance and trade credit, while Table 11 focuses on informal loans and market financing. Column 1 of Table 10 reveals a strong and positive correlation between bank credit constraints and the probability of regarding grant finance as a relevant funding source. Therefore, it seems that firms, facing difficulties in their access to bank funds, explore other options, as found by Casey and O'Toole (2014). By contrast, column (2) shows a strong and negative correlation between the actual use of grant finance and bank credit constraints. The negative sign could indicate an endogeneity problem: weak firms are more likely to be bank constrained and they are less likely to obtain public financial support. As one cannot perfectly control for balance sheet strength, the identification of the causal effect relies on an IV strategy to avoid an omitted variable bias. To do so, *constrained bank* is instrumented with *country TLTRO*. Column 3 displays the IV estimation: the coefficient on *constrained bank* is not statistically different from zero. This indicates that bank-constrained firms

Table 12
Relation between constraints in bank and non-bank financing.

Dependent variable	Structural equation (1) Constrained other	First-stage (2) Constrained bank	Reduced form (3) Constrained other	Structural equation (4) Constrained other
Constrained bank	0.533***			0.670***
	(0.015)			(0.155)
Country TLTRO		−0.048***	−0.032***	
		(0.013)	(0.011)	
Estimator	OLS	OLS	OLS	2SLS
Country dummies	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES
Macro controls	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES
Other firm controls	YES	YES	YES	YES
F-test (First-stage)		15.018		15.018
Observations	6573	6573	6573	6573

The instrumental variable is country TLTRO.
Macro controls are detrended real GDP, consumer confidence indicator and the 10 year government bond yield.
Firm controls are dummies for sector, size (in terms of employment and turnover), age, legal form, ownership structure and exporter.
Other firm controls are dummies for increase/decrease in turnover and dummies for improvement/deterioration of enterprise-specific outlook.
Cluster-robust standard errors in parentheses. Cluster level: country-wave-sector.
F-test (first-stage) is the Kleibergen-Paap Wald rk F statistic.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

do not use grants or subsidised bank loans (for instance, support from public sources in the form of guarantees or reduced interest rate loans) more than their unconstrained counterparts, suggesting that no substitution takes place. A similar finding is displayed in columns 4–6 for the case of trade credit. A bank-constrained firm is 9.7 pp more likely to consider trade credit as a relevant funding source (column 4). However, the correlation between actual use and the presence of credit constraints is negative (column 5): business partners are less willing to provide trade credit to weaker firms. Finally, there is no causal impact of bank credit constraints on trade credit use (column 6).

Similar results are displayed in Table 11 for the case of informal loans and market financing. Columns 1 and 4 show that bank-constrained firms are more likely to consider those alternative sources of funding as being relevant. However, columns 3 and 6 reveal no positive impact on credit constraints on the probability of actual use.

The main conclusion of the previous analysis is that constrained firms wish to diversify their funding sources in attempt to replace bank financing, but fail to do so, probably because they are also less creditworthy than unconstrained firms. In fact, most bank-constrained firms are also constrained in non-bank financing (71%). To inspect this issue in more detail, Table 12 shows OLS and IV regressions in which *constrained other* is a function of *constrained bank* and with the same set of control variables as before. Column (1), estimated by OLS, shows a strong and very significant correlation between the two variables. The impact is even stronger when *constrained bank* is instrumented with *country TLTRO* (column 4). According to these estimates, being constrained in bank financing increases the probability of being constrained in other financing by 67 pp. This leaves little room for the substitutability between these two funding sources.

5. Conclusions

In frictionless perfect capital markets, the Modigliani–Miller theorem (1958) implies that a firm's financing decisions are independent from its investment decisions because internal and external funds are perfect substitutes. In practice, however, several factors lead to an imperfect substitutability between internal and external funds, so that financial constraints may have important effects on real variables such as investment, inventories and employment growth.

Existing research that has attempted to test this prediction has generally used *indirect* evidence based on balance sheet data and proxies for credit constraints. This paper is among the first that uses *direct* evidence on firms' access to formal and informal finance from the Survey on the Access to Finance of Enterprises (SAFE), a survey that is specially designed to analyse the problems in the access to external finance faced by European firms. In particular, a large sample of firms from 12 European countries for the period 2014–2017 was used. An indicator of credit constraints that encompasses both constraints in the access to bank finance (bank loans, bank overdrafts, credit lines) and constraints in the access to other finance (trade credit, debt and equity securities, grant finance, informal loans, etc) was developed.

The main goal is to identify the causal effect of credit constraints on investment, inventories and other working capital and employment growth. The key identification challenge is a potential omitted variable bias, as firms with poor investment/growth opportunities are expected to have a higher probability of being credit constrained. To address this problem, the analysis uses an instrumental variable based on banks' uptakes and borrowing allowances in the ECB's Targeted Longer-Term Refinancing Operations (TLTROs).

The findings indicate that credit constraints have strong negative effects on investment in fixed assets, while they have no robust impact on employment growth and inventories and other working capital. In addition, the impact of credit constraints on investment has been estimated for different groups of firms. The upshot of the analysis is that most of the causal impact of credit constraints on firm investment is driven by large companies and old firms. As regards the effect on micro firms, SMEs and young businesses, only a negative correlation could be confirmed as IV estimates for those firms are not informative due a weak first-stage. In other words, while unconventional monetary policy may spur investment by reducing the incidence of credit constraints, this effect may be limited to the case of large companies and old firms.

The substitutability between bank and non-bank financing was also explored. In particular, bank-constrained firms were found

to be more likely to consider alternative sources of finance. However, they were not more likely to actually use them. These results suggest that bank-constrained firms wish to diversify their funding sources in attempt to replace bank financing, but fail to do so, probably because they are also less creditworthy than unconstrained firms.

Finally, note that the results are conservative measures of the total impact of credit constraints in the real economy, as the current analysis ignores the extensive margin, i.e., those businesses that shut down because of a lack of credit and those firms that do not enter the market because they do not obtain financing to undertake their investment projects.

Appendix A. Additional summary statistics

Tables A1 and A2.

Table A1
Breakdown of observations by country.

Country	Freq.	Percent	Cum.
AT	960	4.95	4.95
BE	983	5.07	10.03
DE	1785	9.21	19.24
ES	3245	16.75	35.99
FI	819	4.23	40.22
FR	3134	16.18	56.39
GR	1409	7.27	63.66
IE	1006	5.19	68.86
IT	3410	17.6	86.46
NL	932	4.81	91.27
PT	1067	5.51	96.77
SK	625	3.23	100
Total	19,375	100	

Table A2
Cross-tabulations of dependent variables.

Panel A: investment and inventories				
Inventories				
Investment	Decreased	Remained unchanged	Increased	Total
Decreased	1513	1,121	504	3138
Remained unchanged	1715	6154	2026	9895
Increased	805	3073	2235	6113
Total	4033	10,348	4765	19,146
Pearson chi2(4) = 2.2e + 03 Pr = 0.000 Cramér's V = 0.2390				
Panel B: investment and employment				
Employment				
Investment	Decreased	Remained unchanged	Increased	Total
Decreased	1102	1598	467	3167
Remained unchanged	1560	6111	2330	10,001
Increased	549	2862	2788	6199
Total	3211	10,571	5585	19,367
Pearson chi2(4) = 1.9e + 03 Pr = 0.000 Cramér's V = 0.2224				
Panel C: inventories and employment				
Employment				
Inventories	Decreased	Remained unchanged	Increased	Total
Decreased	1312	2104	614	4030
Remained unchanged	1431	6279	2634	10,344
Increased	426	2068	2270	4764
Total	3169	10,451	5518	19,138
Pearson chi2(4) = 1.9e + 03 Pr = 0.000 Cramér's V = 0.2230				

Appendix B. Analysis of the components of credit constraints

Figs. B1–B4 and Table B1.

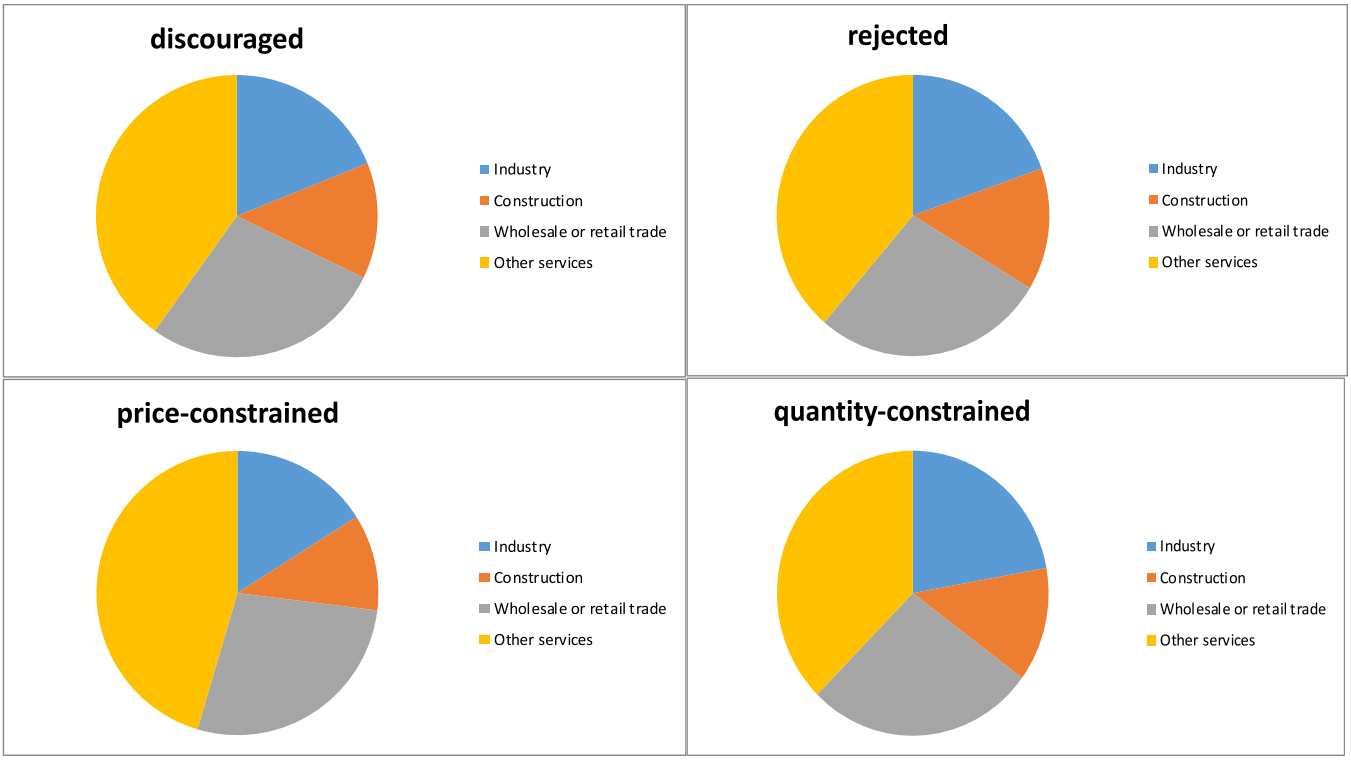


Fig. B1. Sectoral distribution of constrained firms.
This figure examines the sectoral distribution of constrained firms. There are four types of constrained firms: discouraged, rejected, price-constrained and quantity-constrained. A discouraged borrower did not apply because it feared its application would be rejected. A price constrained borrower refused the lender's proposal for external financing because the borrowing costs were too high. A quantity-constrained borrower only received a limited part (i.e., less than 75%) of what it applied for. A firm is classified as constrained if it is constrained in any of the following four funding sources: bank loans; credit lines; trade credit; other financing (equity, debt, grants, informal loans, etc).

Table B1
Relationship between types of credit constraints and firm characteristics according to Cramer's V.

	Loans	Credit lines	Trade credit	Other financing
Sector	0.08	0.06	0.08	0.08
Size	0.11	0.08	0.16	0.09
Age	0.03	0.03	0.04	0.03
Ownership structure	0.05	0.05	0.10	0.08
Legal form	0.02	0.03	0.12	0.07
Exporter	0.09	0.06	0.15	0.04

The table shows Cramer's V values to measure the strength of the association between firm characteristics (rows) and indicators of credit constraints (columns) in bank loans, credit lines, trade credit and other financing (equity, debt, grants, informal loans, etc). The indicators of credit constraints are categorical variables that take the value 1 (discouraged borrower), 2 (rejected application), 3 (price-constrained) or 4 (quantity-constrained). A discouraged borrower did not apply because it feared its application would be rejected. A price constrained borrower refused the lender's proposal for external financing because the borrowing costs were too high. A quantity-constrained borrower only received a limited part (i.e., less than 75%) of what it applied for. Size is measured in terms of number of employees as follows: micro (1–9), small (10–49), medium (50–249), large (250 or more).

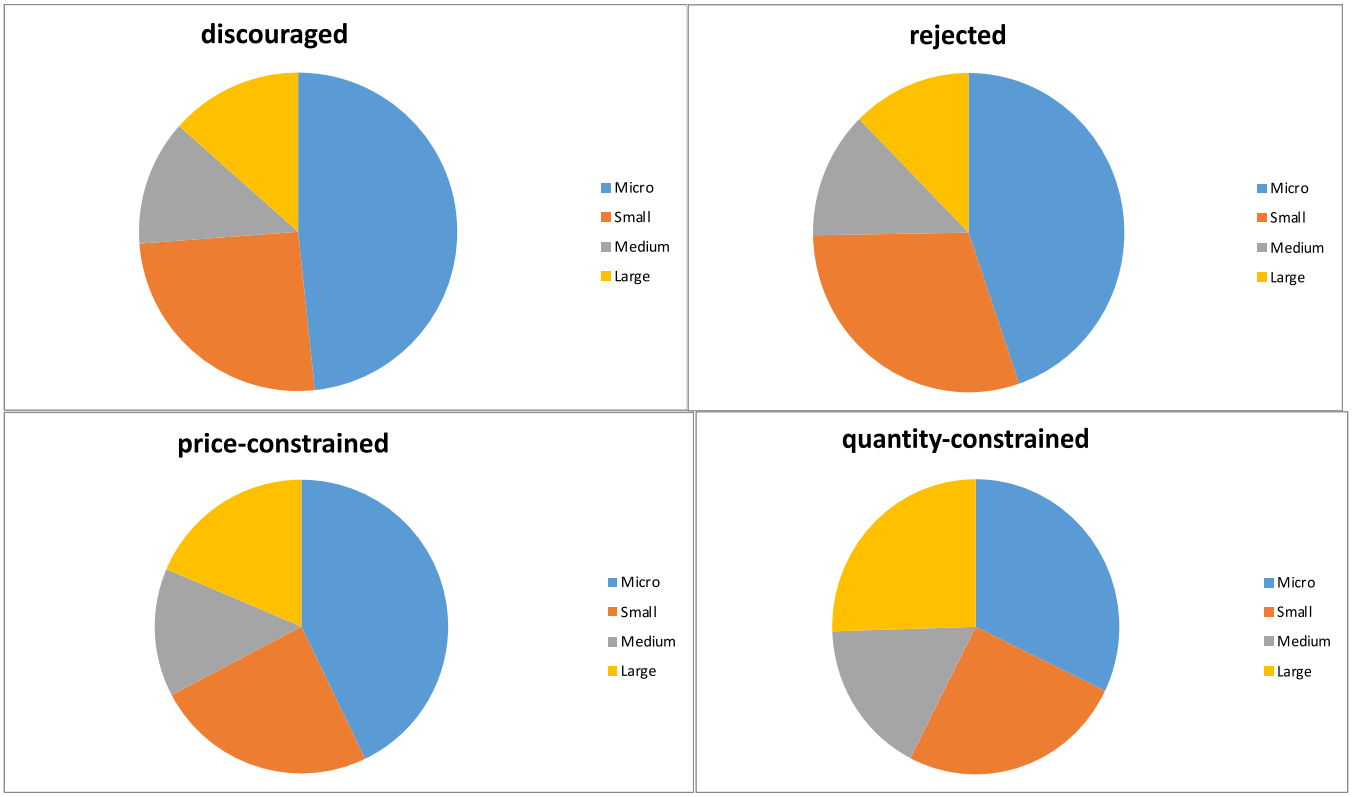


Fig. B2. Size distribution of constrained firms.
This figure examines the size distribution of constrained firms. There are four types of constrained firms: discouraged, rejected, price-constrained and quantity-constrained. A discouraged borrower did not apply because it feared its application would be rejected. A price constrained borrower refused the lender's proposal for external financing because the borrowing costs were too high. A quantity-constrained borrower only received a limited part (i.e., less than 75%) of what it applied for. A firm is classified as constrained if it is constrained in any of the following four funding sources: bank loans; credit lines; trade credit; other financing (equity, debt, grants, informal loans, etc). Size is measured in terms of number of employees as follows: micro (1–9), small (10–49), medium (50–249), large (250 or more).

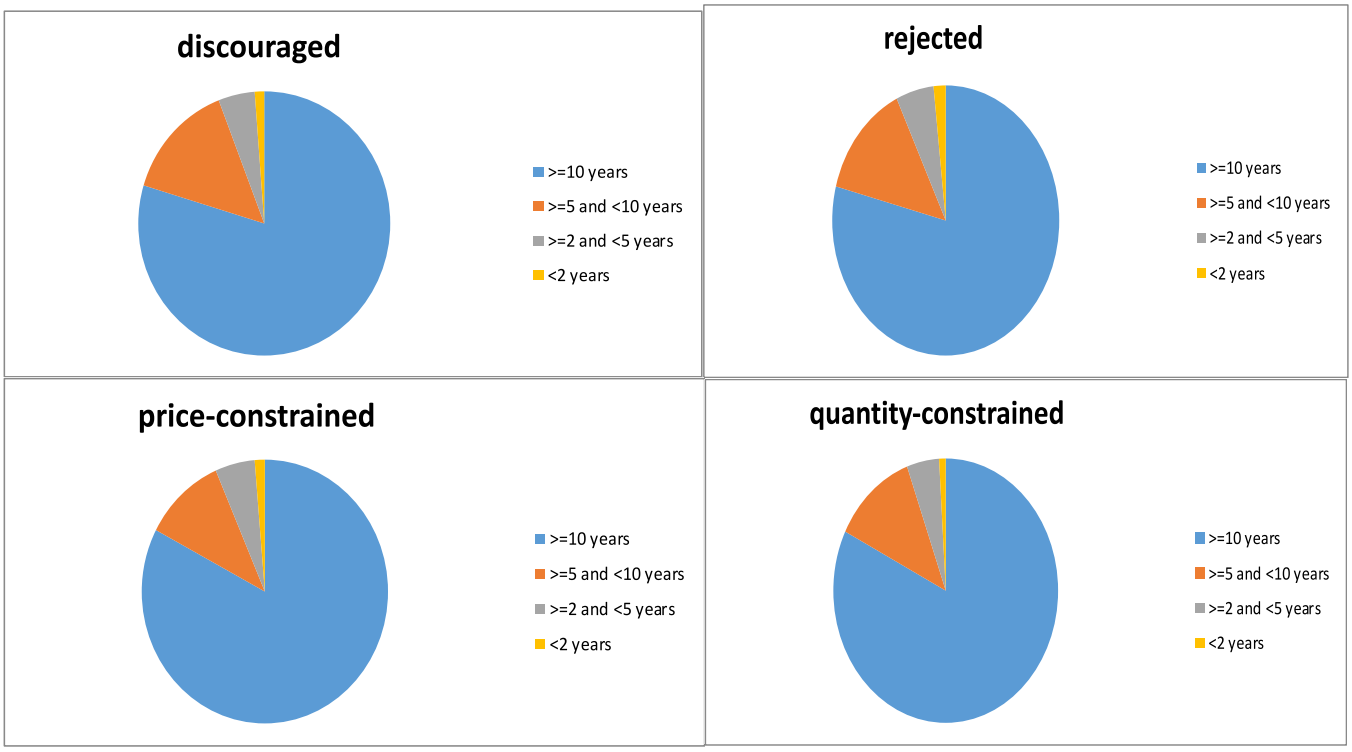


Fig. B3. Age distribution of constrained firms.
This figure examines the distribution of constrained firms according to their age. There are four types of constrained firms: discouraged, rejected, price-constrained and quantity-constrained. A discouraged borrower did not apply because it feared its application would be rejected. A price constrained borrower refused the lender's proposal for external financing because the borrowing costs were too high. A quantity-constrained borrower only received a limited part (i.e., less than 75%) of what it applied for. A firm is classified as constrained if it is constrained in any of the following four funding sources: bank loans; credit lines; trade credit; other financing (equity, debt, grants, informal loans, etc).

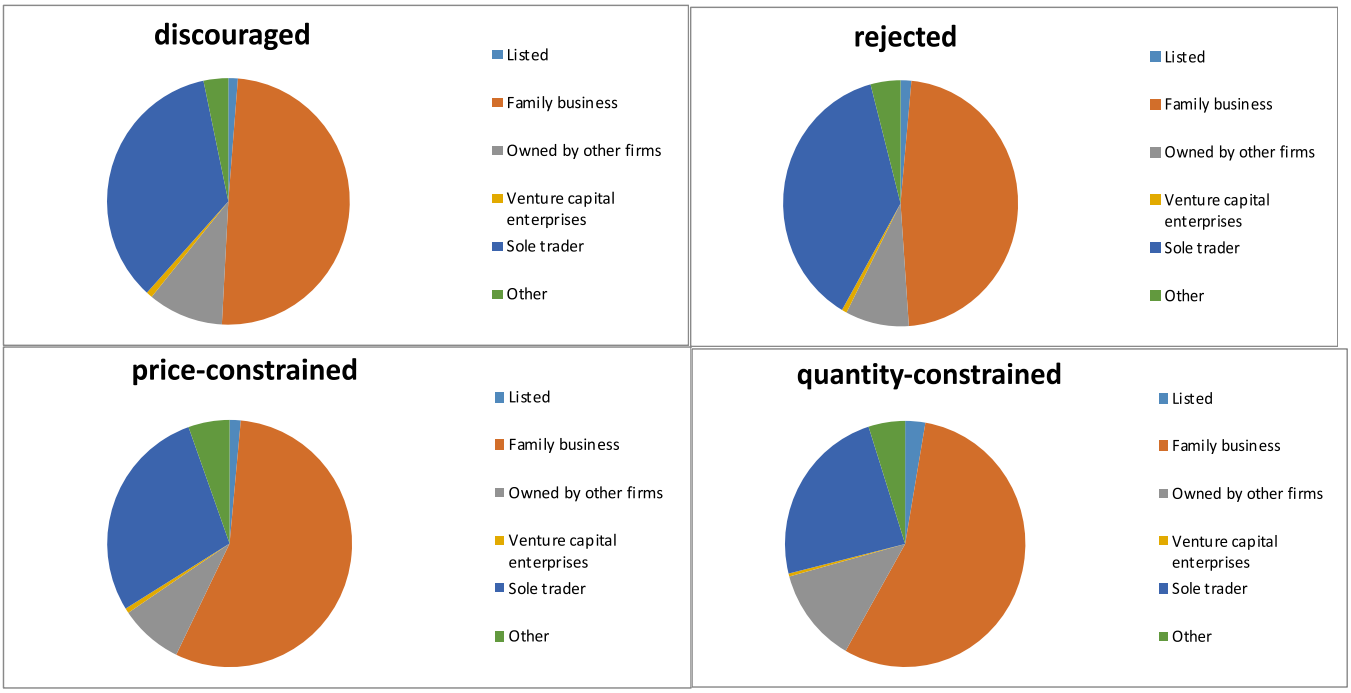


Fig. B4. Distribution of constrained firms according to their ownership structure.
This figure examines the distribution of constrained firms according to their ownership structure. There are four types of constrained firms: discouraged, rejected, price-constrained and quantity-constrained. A discouraged borrower did not apply because it feared its application would be rejected. A price constrained borrower refused the lender's proposal for external financing because the borrowing costs were too high. A quantity-constrained borrower only received a limited part (i.e., less than 75%) of what it applied for. A firm is classified as constrained if it is constrained in any of the following four funding sources: bank loans; credit lines; trade credit; other financing (equity, debt, grants, informal loans, etc).

Appendix C. distribution of sampling weights

Tables C1–C3.

Table C1
Average sampling weights by country.

Country	Mean (sampling weight)
AT	0.57
BE	0.51
DE	2.35
ES	1.00
FI	0.38
FR	1.26
GR	0.46
IE	0.27
IT	1.27
NL	0.78
PT	0.60
SK	0.35

Table C2
Average sampling weights by firm size.

Size	Mean (sampling weight)
Micro	0.84
Small	0.73
Medium	0.69
Large	3.65

Table C3
Average sampling weights by sector of activity.

Sector	Mean (sampling weight)
Industry	0.57
Construction	0.76
Wholesale & retail trade	0.72
Other services	0.96
Large firms	3.65

Appendix D. Instrumental variable

To construct the instrumental variable *country TLTRO* the following regression with bank fixed effects (α_i) and country-time dummies (d_{ct}) has been estimated:

$$\log(TLTRO_{bt}+1) = \alpha_i + d_{ct} + \beta \cdot \log(LIMIT_{bt}+1) + \varepsilon_{bt} \quad (3)$$

where $TLTRO_{bt}$ is the stock of TLTRO funding of bank b in quarter t and $LIMIT_{bt}$ is the maximum borrowing limit for each bank, which is 7% of the eligible loans[13] in April 2014 for the period 2014Q3-2016Q2 (TLTRO I) and 30% of the eligible loans in January 2016 for the period 2016Q2-2017Q1 (TLTRO II).[14]

The data come from the European Central Bank's IBSI (Individual Balance Sheet Items). IBSI contains balance-sheet information of the 300 euro area largest banks, which is individually transmitted on a monthly basis from the national central banks to the ECB since July 2007. The sample accounts for about 70% of the euro area banking sector.

[13] Eligible loans are loans to the non-financial private sector excluding loans to households for house purchase.

[14] The TLTROs I took place between September 2014 and June 2016. The TLTROs II were conducted between June 2016 and March 2017.

Table D1
TLTRO uptakes and borrowing limits.

Variables	(1) log(tltro + 1)	(2) log(tltro + 1)
Log(limit + 1)	0.571***	0.580***
	(0.058)	(0.124)
Size (t−1)		0.040
		(0.209)
Capital ratio (t−1)		0.002
		(0.011)
Liquidity ratio (t−1)		0.009**
		(0.004)
Loan ratio (t−1)		−0.000
		(0.011)
Deposit ratio (t−1)		−0.015
		(0.010)
Market share (t−1)		−0.111*
		(0.063)
Bank fixed effects	YES	YES
Country-time fixed effects	YES	YES
Observations	3912	3248
Period	2014Q3-2017Q1	2014Q3-2017Q1
Number of banks	326	292
R-squared	0.851	0.894

Estimator: OLS. The dependent variable is the natural log of the stock of TLTRO funding plus 1.
Cluster-robust standard errors in parentheses. Cluster level: bank.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table D2
Definition of the bank-level variables.

Variable	Definition
TLTRO	Stock of TLTRO funding (TLTRO-I and TLTRO-II).
LIMIT	Maximum borrowing limit in the TLTRO operations.
Size	Logarithm of the bank's total assets.
Capital ratio	Capital and reserves over total assets (%)
Liquidity ratio	Cash + government securities + Eurosystem deposits over total assets (%)
Loan ratio	Loans to non-financial corporations and households over total assets (%)
Deposit ratio	Deposits by households and non-financial corporations over total assets (%).
Market share	Ratio between a bank's total assets and the total assets of the country's banking sector (%).

Eq. (3) is estimated for a sample of 326 euro area banks for the period between 2014Q3 and 2017Q1. The results, presented in column 1 of Table D1, reveal a strong correlation between the two variables: a 1% increase in the borrowing limit leads to a 0.6% increase in the stock of TLTRO.

Then the exponential function of the fitted values is taken (minus 1) to obtain the predicted participation at the bank level $\widehat{TLTRO}_{bt}$. The variable *country TLTRO* is computed by adding up $\widehat{TLTRO}_{bt}$ for the banks in each country and dividing it by the sum of their total assets. Therefore, it is a weighted average of banks' predicted TLTRO uptakes over total assets (ta_{bt}), where the weights are based on banks' total assets relative to the total assets of the country's banking sector:

$$countryTLTRO_{ct} = \frac{\sum \widehat{TLTRO}_{bt}}{\sum ta_{bt}} = \sum \frac{\widehat{TLTRO}_{bt}}{ta_{bt}} \cdot \frac{ta_{bt}}{\sum ta_{bt}} \quad (4)$$

Nevertheless, one may argue that the coefficient on $LIMIT_{bt}$ is biased due to an endogeneity problem. In particular, as the variable is a multiple of the value of a specific set of pre-existing loans on the banks' books, the importance of these loans in a bank's portfolio may be correlated with the borrowers it is lending to. Therefore, banks that lend more to certain borrowers may have larger shocks than other banks. In other words, banks with better lending opportunities and certain business models may borrow more at the TLTROs and have a greater borrowing limit. This would lead to a classic omitted variable bias.

Table D3
Macro factors correlated with the instrumental variable.

Dependent variable	(1) Country TLTRO	(2) Country TLTRO	(3) Country TLTRO
gdp	0.008		
	(0.060)		
Consumer confidence	0.025	0.026	0.025
	(0.022)	(0.022)	(0.022)
Government bond yield	0.308	0.309	0.307
	(0.306)	(0.302)	(0.300)
Unemployment rate		0.224	
		(0.350)	
Investment growth			0.239
			(0.388)
Country dummies	YES	YES	YES
Time dummies	YES	YES	YES
Observations	72	72	72
R-squared	0.787	0.787	0.787

Estimator: OLS. Cluster-robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

This concern is addressed by adding a large set of controls to Eq. (3). Those controls (size, capital ratio, liquidity ratio, loan ratio, deposit ratio, market share) capture lending opportunities and banks' business models. The definition of those variables is presented in Table D2. For instance, banks with poor lending activities may invest heavily in liquid assets such as treasury bonds. By contrast, a high loan ratio (loans to the non-financial private sector over total assets) may signal good lending opportunities. The country-time dummies also control for aggregate lending opportunities (e.g. business cycle). Size and market share (both in terms of total assets), together with bank fixed effects, are proxies for banks' business models. Hence, if lending opportunities and banks' business models are not the main drivers of the correlation between TLTRO uptakes and borrowing limits, the inclusion of these controls should not affect the coefficient on $LIMIT_{bt}$ substantially. The results, presented in column 2 of Table D1, reveal that this is indeed the case, as the coefficient on $LIMIT_{bt}$ barely changes (0.580 in column 2, 0.571 in column 1) and remains highly significant.

Appendix E. derivation of Eq. (2) (test of the exclusion restriction)

For brevity of exposition, assume a just-identified model with one endogenous regressor, one instrument and no controls.[15] The first stage links the instrument *country TLTRO* (henceforth, $TLTRO_{it}$) and the endogenous regressor $constrained_{it}$:

$$constrained_{it} = \alpha_1 + \varphi TLTRO_{it} + \varepsilon_{it} \quad (5)$$

The reduced form links instrument and outcome variable

$$Y_{it} = \alpha_0 + \rho TLTRO_{it} + u_{it} \quad (6)$$

Finally, the structural equation links the endogenous regressor and the outcome variable:

$$Y_{it} = \alpha_2 + \lambda constrained_{it} + \eta_{it} \quad (7)$$

Consistent estimation of λ (LATE) is carried out via the Indirect Least Squares estimator.[16] In particular, $\widehat{\lambda}$ will be the sample ana-

[15] The following argument can easily be generalised to the case of K control variables. See for instance Angrist and Pischke (2015).
[16] Indirect Least Squares and Two-Stage Least Squares are equivalent in the case of just-identified models.

logue of:

$$\lambda = \frac{Cov(Y_{it}, TLTRO_{it})/Var(TLTRO_{it})}{Cov(constrained_{it}, TLTRO_{it})/Var(TLTRO_{it})} = \frac{\rho}{\phi} \quad (8)$$

Rearranging (8) one obtains (2):

$$\rho = \varphi\lambda \quad (2)$$

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