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BANK BRANCH CLOSURES AND LOCAL SME ECONOMIC ACTIVITY IN SLOVAKIA – GOOD SERVANT BUT A BAD MASTER?

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ABSTRACT

Bank Branch Closures and Local SME Economic Activity in Slovakia – Good Servant but a Bad Master?*

We investigate impact of bank branch closure on labour productivity in SME sector in Slovakia over the period 2013-2019. We use staggered difference-in-difference approach with treatment variable identified by the bank branch closure that occurred in a close (15 km radius) vicinity of a firm. The possible selection bias is addressed by the inclusion of the Mills ratio derived from the nonlinear model estimating the probability of a treatment. We report heterogeneous effect of bank branch closures that is dependent on the measure of firm's creditworthiness approximated by the Altman z-score. In years following the treatment, enterprises with lower z-score experience an increase in labour productivity fuelled by an increase in relative extent of bank financing, and firms with higher z-score report declining labour productivity associated with the decrease in bank financing.

KEYWORDS: bank branch closure, labour productivity, Altman z-score

ABSTRAKT

Zatváranie bankových pobočiek a lokálna ekonomická aktivita na Slovensku – Dobrý sluha, ale zlý pán?

V práci skúmame vplyv zatvárania pobočiek bánk na produktivitu práce v sektore MSP na Slovensku v období 2013 – 2019. Využívame metódu difference-in-differences s postupnou implementáciou opatrenia, ktoré je identifikované ako okamih, kedy došlo k zatvoreniu bankovej pobočky v tesnej blízkosti firmy (v okruhu 15 km). Možné výberové skreslenie sa rieši zahrnutím Millsovho pomeru odvodeného z nelineárneho modelu odhadujúceho pravdepodobnosť výskytu opatrenia. Heterogénny účinok zatvorenia pobočky banky závisí od miery úverovej bonity firmy aproximovanej pomocou Altmanového z-skóre. Na základe výsledkov odhadov je možné skonštatovať, že v rokoch nasledujúcich po výskyte opatrenia podniky s nižším z-skóre zaznamenávajú nárast produktivity práce, ktorý je spojený so zvýšením relatívneho rozsahu bankového financovania. Naopak, podniky s vyšším z-skóre vykazujú pokles produktivity práce spojený s poklesom bankového financovania.

KĽÚČOVÉ SLOVÁ: zatváranie bankových pobočiek, produktivita práce, Altmanovo z-skóre

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1 Introduction

Concentration of bank activities in metropolitan areas and decrease in the physical presence of banking network size have become a trend practically all over the world (Alessandrini et al., 2009; Ho and Berggren, 2020; Galardo et al., 2021). Several studies have recently showed that bank branch closures have had an adverse effect on household financial situations (Tranfaglia, 2018), firm formation (Ho and Berggren, 2020) or loan pricing Bonfirm et al. (2020). However, with the exception of Nguyen (2019) and Duquerroy et al. (2022), the impact of reduction in bank branch network on SMEs sector's labour productivity has been a relatively under-studied phenomenon. This is all the more intriguing, since the ultimate role of bank credit is to serve as a source of external financing that enables accumulation of capital, hence resulting in improving economic performance of companies.

We complement the recent literature on the effects of bank branch closures on local economies (Nguyen, 2019; Ho and Berggren, 2020; Rafaj and Siranova, 2020) by developing an innovative approach to specification of treatment effect, that allows us to apply the difference-in-differences methodology in fashion of Gopalakrishnan et al. (2021). In our model design, the firms subject to the treatment are those companies that have experienced a bank branch closure in the close geographical vicinity (i.e., 15 km radius). This idea traces bank to the regional literature arguing that geographical distance still matters as spatial structure of local bank market represents a unique element affecting the local firms' economic behaviour (Papi et al., 2015).

One usually argues that bank branch closure is not an exogenous managerial decision but reflects overall economic environment populated by firms shaping the local demand for credit (Nguyen, 2019; Bonfirm et al., 2020). In order to tackle endogeneity issue in our treatment variable, we adopt approach utilized by Fisera et al. (2019). In the first step, we model probability of treatment by random effect panel logit model. Once the associated Mills ratio is calculated, our main model is modified by this ratio in order to control for the selection bias in underlying data structure.

Our contribution to the relevant literature is therefore threefold. We extend the relevant literature on effects of bank branch closures by i) constructing the treatment variable based on the concept of geographical vicinity of affected firms, ii) investigating the effect of bank branch closure conditional on a proxy variable for creditworthiness of a firm (Altman z-score) as a treatment group criterion, iii) focusing on change in labor productivity of affected firms. In order to achieve these objectives we construct a novel, geo-coded micro-level dataset for Slovak small and medium enterprises linked to the precise location of individual bank branches.

Slovak banking sector is strongly oriented on traditional business activities. Slovak SMEs also relies heavily on bank funding due to practically non-existent efficient financial markets. These two features preclude Slovakia to serve as a good natural experiment to analyse how reduction in such an important distributional channel might affect local economic landscape. Recently, Rafaj and Siranova (2020) investigated how local bank market characteristics affect regional output productivity in Slovakia. According to the results, while there is no observable effect of bank branch presence on regional productivity, local bank market characteristics do matter. Siranova and Rafaj (2021) argued that the impact of bank branch presence needs to viewed through the concept of under- and over-saturation of local credit markets. While the bank branch closure may be associated with positive benefits if it serves to consolidate ineffective size of bank branch network, in case of under-saturated local credit markets, the bank branch closures leave SME sector facing the higher costs of debt.

Our results suggest that the impact of bank branch closures varies significantly with respect to the level of (perceived) creditworthiness of affected firms. Companies that may have suffered from possible 'lock-in' effect in relationship banking in the past (Sharpe, 1990; Rajan, 1992), positively benefit from bank branch closures through an increase in relative bank borrowing. Contrary, we report decline in labor productivity among firms with higher credit rating that may be interpreted as work of the standard information asymmetry theory (Bonfirm et al., 2020) as the search for a new financial intermediary likely brings about short-term transaction costs associated with loss of incumbent information. On top of that we find no evidence that the non-bank external sources of financing have served as substitutes for the bank credit in our sample.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature, section 3 outlines the empirical methodology and introduces our data. The findings and policy implications are discussed in section 4, and final section concludes the paper.

2 Literature review

From conceptual point of view, two competing theoretical approaches aims at addressing the question whether the level of proximity between companies and banks generates more costs or profits for SMEs in the long run.

The first strand of literature hypothesises that the long-run relationship between borrower (company) and lender (formal bank institution) is conducive to decreasing information asymmetry, hence benefiting both sides by increasing lending volumes and decreasing costs of borrowing (Berger and Udell, 1992; Petersen and Rajan, 1994). Since the incumbent banks own private information collected on firms with which they are in a long-term relationship, in case of bank branch closure this information is irredeemably lost and a local information pool shrinks (Bonfirm et al., 2020).

On the other hand, Sharpe (1990) and Rajan (1992) argue that the long-term banking relationship may result in the 'hold-up' situation because each additional information gathered by lender only serves to lock the borrower into the existing relationship. This monopolistic power over intrinsic information provided by the lender may prevent the captured company from changing its lender, since an outside bank will not be willing to finance the project that might have been rejected by the relationship bank in the first place. The bank branch closure may therefore provide a positive incentive to firms 'locked-in' an unsatisfactory long-term relationship contract to search for a more effective ways to finance their investment needs.

Most of the studies approaching this issue empirically focus on investigating the credit conditions of firms experiencing a closure of their primary bank provider. So far the empirical evidence has been inconclusive. Some studies suggest that bank branch closures can be detrimental to access to credit, especially for small and medium enterprises (Nguyen, 2019; Duquerroy et al., 2022). In Duquerroy et al. (2022), the decline in credit volumes materializes even if the firm is reallocated to a new bank branch belonging to the original lender. In contrast, Bonfirm et al. (2020) report no decrease in credit supply after reduction in local bank branch network which could be attributed to a still sufficient level of local credit market saturation post-closure. In a similar vein, Siranova and Rafaj (2021) argue that adverse effects of bank branch closures materialize only in under-saturated local credit markets. In other words, one should look at the state of a local credit market disequilibria when assessing the effects of bank branch closures.

The most recent evidence also points to an important role played by bank branch specialization and firm information transparency. Regarding the former, Duquerroy et al. (2022) document that decline in total credit to small enterprises is two times higher when firm's account is reallocated from a branch that specializes in its industry to a branch that does not. The results are strongly suggestive of banks operating in segmented bank credit markets. Regarding the latter, while Bonfirm et al. (2020) report no decrease in loan volumes in areas affected by bank branch closures, they show that banks tend to have a tendency to prefer information transparent firms over their competitors when initiating a new banking relationship.

Second stream of literature focuses on pricing conditions. At first sight, general findings document a substantial average discount when firms switch from one bank to another (Ioannidou and Ongena, 2010; Stein, 2010), as banks aims at partially offsetting firm's switching costs Barone et al. (2011). These studies, however, look at the bank pricing decision when the switching is a result of typical competitive behaviour. Bonfirm et al. (2020) show that even if there exists an alternative to a closed bank branch and local markets remain competitive, firms that were forced to transfer receive no discount in interest rate compared to firms switching banks during normal times. Loss of incumbent information is offered as one plausible explanation of this empirical finding.

Few studies use firm-level data to investigate effect of credit constrains faced by the SME sector on firm productivity. Using the micro level data, Gatti and Love (2008) found evidence that that firms that are unable to access effective credit usually have lower productivity. Financing from formal financial institutions also greatly enhances productivity of SMEs (Ayyagari et al., 2010), while financial constraints hamper productivity in China (Lu et al., 2018). In European context, Ferrando and Ruggieri (2018) report that firms with higher systemic financial frictions have lower productivity.

To our knowledge, with primary attention being paid to change in credit conditions offered by formal banking institutions, only a few studies focus on investigating the response of firm's economic activity to changing credit market conditions stemming from the geographical element, i.e. physical presence of commercial banks.

When bank branch closes, credit rationing may adversely affect territories with already under-saturated markets (Siranova and Rafaj, 2021), creating infamously coined 'banking deserts' (Kashian et al., 2018)). Discussing the wider economic consequences, Garmaise and Moskowitz (2006) links mergers among major US banks accompanied by bank branch network rationing to deteriorating economic development and increase in crime. Nguyen (2019) shows how bank branch closures negatively affect employment growth in affected areas. At municipality level, an increase in the distance to the nearest bank branches in Sweden is shown to affect new firm formation negatively (Ho and Berggren, 2020). However, Rafaj and Siranova (2020) does not find any impact of change in bank presence on growth of city regions. Interestingly, bank branch expansion rather then reduction has had an adverse effect on local economic growth in Italy (Bernini and Brighi, 2018). (Greenstone et al., 2020) conclude that while predicted negative lending shock did induce decline in small business loan originations, the both small firm and overall employment remained unaffected, notwithstanding whether during normal times or during Great Recession.

Methodologically, our design is closest to the study by Nguyen (2019) who focus on physical aspect of bank branching, i.e. spatial distance to a nearest credit provider. In the use of firm-level data linking the credit rationing hypothesis to labour productivity, our study also partially resembles recent study by Yu and Fu (2021). However, while Yu and Fu (2021) uses firm survey-based data on presence of credit rationing in external funding, we hypothesise that bank branch closing directly affects access to credit in an adverse way.

3 Model and data

We aim to assess the effect of a bank branch closure (i.e., treatment) on a firm labour productivity. Given this objective, we utilize the Cobb-Douglas production function, similar to Nemethova et al. (2019), where we incorporate hypothesised effect of a treatment.[1] In our setup, the bank branch closure in a close vicinity of a firm i is considered a negative treatment that will primarily affect accumulation of physical capital K_i.[2]

$$Q_{it} = A_i[K_{it}(1 + \gamma D_{it})]^{\beta_1} L_{it}^{\beta_2} \tag{1}$$

where Q_{it} represents the total production, A_i the total factor productivity, K_{it} level of capital stock, L_{it} labor input of a firm i at time t, β_1 total output elasticity of capital, β_2 total output elasticity of labor, D_{it} treatment variable with 1 signalling bank branch closure and zero otherwise, and γ the factor measuring change in capital accumulation in treated firms in comparison to non-treated firms.

After simple algebraic manipulation (Appendix 5), the equation [1] can be expressed as follows:

$$ln(Q_{it}/L_{it}) = C_i + \beta_1 ln(K_{it}/L_{it}) + \beta_1\gamma D_{it} + (\beta_2 - 1)lnL_{it} \tag{2}$$

Combining the theoretical foundation laid out in equation [2] into econometric specification, the benchmark equation of interest can be specified as follows:

$$Y_{it} = \alpha_0 + u_i + \beta_1 ln(K_{it}/L_{it}) + \omega_1 lnL_{it} + \omega_2 L(.)Closing_{it} + \lambda X_{it} + \tau_t + \epsilon_{it} \tag{3}$$

where Y_{it} stands for labor productivity $ln(Q_{it}/L_{it})$ of a firm i at time t, $X_{i,t-1}$ vector of firm-specific control variables, u_i firm fixed effects, and τ_t time dummies. $Closing_{it}$ is a dummy variable that takes a value of 1 for all the years after a firm experienced a bank branch closure in its close vicinity, and 0 otherwise. Mathematically, $\omega_1 = (\beta_2 - 1)$ and $\omega_2 = \beta_1\gamma$.

In our approach we implement methodology by Gopalakrishnan et al. (2021) for difference-in-differences (DiD henceforth) analysis with staggered implementation since we are able to observe firm's productivity over a period of few years following the treatment. We also specify the treatment group of firms that were affected by the treatment according to their credibility score $ALTFirm_{it}$. The key equation of interest is therefore specified as follows:

[1] We do not impose any restriction on returns to scale specification. We include a battery of fixed effects into our baseline specification, so that most of the industry, firm and county specific features will be captured by them.

[2] Firms usually use bank loans to cover their liquidity needs (short-term business lines of credit) or to finance their long-term investment needs. In our approach we focus on effects of investment funding that should, be default, lead to changes in long-term firm productivity and value added.

$$Y_{it} = \alpha_0 + u_i + \omega_2 L(.)Closing_{it} + \omega_3 ALTFirm_{it-4} \times L(.)Closing_{it} + \lambda_1 ALTFirm_{it-4} + \beta_1 ln(K_{it}/L_{it}) + \omega_1 lnL_{it} + \lambda X_{it} + \tau_t + \epsilon_{it} \quad (4)$$

where $ALTFirm_{it-4}$ stands for dummy variable identifying treatment group of firms. The credit rating is lagged four years before the treatment in order to address possible endogeneity between change in accounting-based credibility metric and underlying economic performance of firms (Brown et al., 2012).

We include interactive fixed effects to account for the unobserved variables that may contribute to the firm-level outcomes; such as time-varying regional characteristics, and constant and time-varying industry characteristics. We also control for size of a firm by inclusion of three dummies representing micro, small and medium enterprises based on their size of total assets. This is to reduce the omitted variable bias (Gormley and Matsa, 2014). Standard errors are clustered at firm level as well as at 'treatment group*year' level.

Similar to Gatti and Love (2008) we use two different concepts in order to measure labour productivity, one based on total sales-per-employee (Nemethova et al., 2019), one on the value-added-per-employee indicator (Gatti and Love, 2008).

In our selection of fundamental variables included in vector $X_{i,t-1}$ we draw upon the relevant literature analyzing determinants of firm's productivity, e.g. Gatti and Love (2008); Lalinsky (2013); Nemethova et al. (2019). List of control variables is summarized in Table A1.

The choice of radius length measuring the 'close vicinity' of a firm to bank branch is driven by findings in Halas and Klapka (2015). For Slovakia, the average radius of influence for medium-sized cities if approximately 15 km. As part of the $X_{i,t}$ vector, we also control for change in number of bank branches in a wider radius (up to 30 kilometers) that coincides with the maximum value of the mean distance of labour commuting for a particular centre, as reported by Halas and Klapka (2015). This is to purify the effect of bank branch closure from magnifying effects of change in credit access in neighboring regions that may still affect economic prospects of a firm.

3.1 Identification of treatment group

Bank branch closures are likely to affect different firm groups heterogeneously given their perceived credit worthiness. In this context, literature usually reports that the phenomenon of credit rationing occurs in a situation when banks, unwilling to increase interest rates, limit credit provisioning to specific firms in order to curb excessive credit demand (Yu and Fu, 2021). In most of the cases, the credit rationing therefore affects firms rated as less creditworthy.

In order to approximate the creditworthiness of a firm we use the Altman z-score provided (and calculated) by the FinStat company. We take the classification of firms based on the Altman z-score in our database as a purely exogenous, sort of 'black-box' metric that serves to capture (and approximate) the opinion of practitioners about the probability of a company's bankruptcy. In other words, we classify firms as if they were rated by practitioners, i.e. users of the database, without our expertise interfering with the assessment.[3]

[3] This also partially addresses the concern raised by the literature regarding the endogeneity of credit ratings used by researchers as proxies for credit rationing, see (Yu and Fu, 2021)

Thanks to its simplicity in terms of replicability and interpretation, the Altman z-score has remained widely popular among both, practitioners as well as academics (Altman, 2018). Not only that, association between the use of Altman z-score and credit-scoring bank models has been discussed in few contributions (Gordy, 2000, 2003). Agarwal and Taffler (2008) argues that while similar in their bankruptcy prediction properties, the z-score approach leads to significantly greater bank profitability, if applied to assess the creditworthiness of a customer, based on comparison of performance of traditional simple accounting-ratio-based and market-based approaches.[4]

We define $ALTFirm_{it-4}$ in equation (5) with:

- ALT1 = 1 for firms at the lower part of distribution (higher probability of credit rationing) and zero otherwise;
- ALT3 = 1 for firms at the upper part of distribution (lower probability of credit rationing) and zero otherwise;

Boucher et al. (2009) distinguishes five categories of borrowers in credit market: a) unconstrained borrowers or price rationed borrowers, b) unconstrained non-borrowers or price rationed non-borrowers, c) quantity rationed borrowers, d) risk rationed borrowers, and e) transaction cost rationed borrowers. We hypothesise that firms in treatment group ALT3, i.e. high credit scoring, will belong predominantly to quantity unconstrained borrowers that are not affected with credit limit by formal institutions. On the other hand, constrained quantity borrowers found in treatment group ALT1 will be affected by the credit limit to a higher extent.[5]

From a different perspective, the Altman z-score collected from external sources reflects only the 'hard information'; i.e., the assessment of a company is based solely on a booking value of a company, rather than some insight gained from accumulation of 'soft information'. Ultimately, if we observe a tendency to form bank lending relationship among the ALT1 group of firms it may indicate that SMEs in this category are able to overcome their negative economic outlook through higher transparency and positive signalling. In this respect, the standard assessment of their creditworthiness may lead to under-estimation of their credit prospects.

3.2 Dataset description

For our analysis, we combine a few datasets from different sources.

The information regarding the number of bank branches operating in a close vicinity to a firm's location is obtained from a survey sent to individual banks actively present in Slovak banking system. Altogether, we were able to collect historical data about the bank branch locations for all the major bank

[4]In our text we use the Altman z-score and credit rating interchangeably. While the Altman z-score aims, by its construction, to primarily measure the probability of a firm's default, we argue that for our purposes this metric is also closely associated with lower or higher ranking in credit scoring framework used by a commercial banks; as a consequence, it can be used to approximate the decision of a commercial bank regarding the credit conditions.

[5]We focus on quantity rather than price constrains due to the availability of data in firm level balance sheet items on bank volumes as well as volumes of other type of external financing.

brands operating in Slovakia during the period 2015-2019.[6] The closing of a bank branch, i.e. the treatment, is observed if there is a change in the bank branch presence compared to a previous year.

Firm-level data are gathered from the private FinStat database that contains data for majority of Slovak enterprises.[7]

The quality of the data varies from year to year since several indicators for individual enterprises were not available due to the lack of submitted financial statements. The representative sample of small and medium enterprises from the FinStat database was selected by the process closely following Bauwhede et al. (2015); Siranova and Rafaj (2021). In this we exclude firms with incomplete data, SMEs located in Bratislava and Kosice LAU1 regions, focus on joint stock and limited liabilities companies and trim resulting dataset at three standard deviations for employee costs variable. More details on cleaning procedure are available upon request.

We also select only those firms that experienced a bank branch closure exactly once per period analyzed (treated group) and firms that remained unaffected by a treatment over the entire period (control group), similar to Bonfirm et al. (2020). In other words, we avoid dealing with multiple treatment effects, even on the expenses of reducing our sample of firms substantially. We also exclude firms with no bank branches located in their close vicinity at the beginning of analyzed period in order to satisfy the assumption of possible treatment.

In order to create a 'radius of influence' around a firm that allows us to collect information about the presence of a bank branch in close vicinity of a firm we geo-locate the official address of a firm and bank branch by the QGIS software. Extracted information about the localization is once externally (blindly) verified.

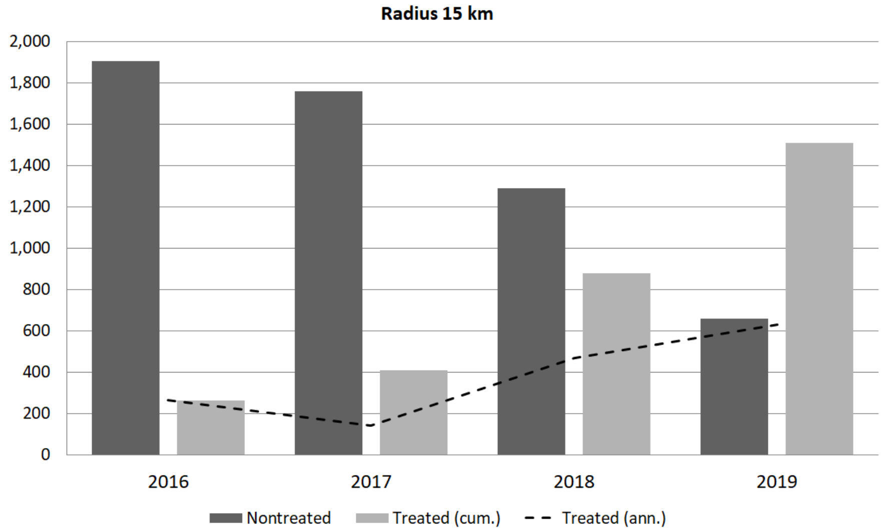
After performing these steps, we ended with a representative sample of a total of 2169 enterprises along with the bank branch localization information in their 15 km vicinity radius.[8] The implementation timeline, as given in Figure 1, shows that majority of the bank branch closure happened to the end of our sample, in years 2018 and 2019. However, a non-significant portion of firms experienced the bank bank closure as early as 2016. While the underlying reasons for bank branch network reduction and re-design in Slovakia are yet to be explored, the usual suspects include the flourishing fintech industry supported by recent legislative changes (Rafaj and Siranova, 2020), advent of new e-banking services (Petersen and Rajan, 2002), or increasing low operating efficiency as a way to address prolonged period of highly accommodative monetary policy inserting further pressure on profit-generating strategy of individual banks (IMF, 2016). This trend is not unique to the Slovak economic conditions, as concentration of banks in metropolitan areas (Alessandrini et al., 2009) and a decrease in banking network size due to ongoing redesign of their local banking networks (Ho and Berggren, 2020; Galardo et al., 2021) have become a trend practically all over the world.

[6]OTP Bank, Postova Bank, Prima Bank, ERSTE Bank, TATRA Bank, Unicredit Bank, VUB Bank, CSOB Bank. These banks constitute more than 90 percent of Slovak banking sector measured by their share on total assets, total loans or total capital. The remainder of other banks is usually located in city of Bratislava or Kosice, which are excluded from our analysis by definition.

[7]FinStat company was funded in 2012 with the key objective to create a freely available tool that would help in assessing the financial health of Slovak companies. It integrates many of the publicly available information about health of private firms (e.g., the Commercial Register, the Trade Register, the Trade Licensing Register, the Register of Financial Statements, the Register of Bankrupts, lists of court decisions) into one comprehensive database. Several analytical reports prepared by FinStat's analysts are available, usually as a form of pre-paid service.

[8]This is broadly similar to Bauwhede et al. (2015) or Siranova and Rafaj (2021). We have at least one SME represented in each of the 72 LAU1 regions.

Figure 1: Staggered bank branch closures across firms in the sample



Notes: The figure shows the trends in the bank branch closures across firms. Non-treated denotes number of firms that did not experience bank branch closure in their close vicinity (up to 15 km). Treated (ann.) denotes number of firms that experienced bank branch closure in a particular year. Treated (cum.) denotes cumulative volume of firms that experienced bank branch closure over the given period starting from year 2016.

Descriptive characteristics of our sample are provided in Table 1. On average, the treatment and control group of firms report almost identical pre-treatment statistical properties calculated for list of dependent as well as explanatory variables. Only in case of the change in number of bank branch closures calculated for a wider radius (15-30 km) we report slightly lower minimum for treated than non-treated companies signifying that some of the companies were exposed to more drastic bank branch network reduction than the rest of the population. Firms associated with better creditworthiness (Altman Group 3) are characterized by higher average labour productivity, but (surprisingly) lower capital-labor shares, as well as smaller relative exposure towards bank funding. As expected, companies with lower Altman score are also relatively more inclined to rely on other, non-bank, sources of financing.

3.3 Addressing the endogeneity in treatment variable

We control for possible selection bias by introducing the Mills ratio into the regression, in line with Fisera et al. (2019). This is due to the possibility that some firms may have a higher probability of being localized in a region where bank branch closures occur more systematically (i.e. treatment is not random), see Table 1. The widely-used two-step or correction method, proposed by Heckman, uses simple least squares estimation on a nonrandomly selected sample while avoiding sample specification bias (Heckman, 1979).

We employ random effect logit model in the first stage regression in order to model probability of having experienced a bank branch closure in a close vicinity of a firm.

Aside from firm-level data used in the main benchmark regression, we also add list of explanatory variables that are gathered from the relevant literature on location factors of on-site bank branches. This is to address the common "exclusion restriction" (Wolfolds and Siegel, 2019).[9] Literature lists local business

[9] Note, that our list of explanatory variables unique for the selection equation contains vector of county-specific regressors.

Table 1: Descriptive statistics of treated and non-treated firms

	Treatment = 1					Treatment = 0				
Variable	Obs	Mean	St.D.	Min	Max	Obs	Mean	St.D.	Min	Max
Panel A - Altman Group 1										
VA/Emp	173	9.61	0.90	5.28	12.32	527	9.58	0.80	6.56	12.46
Sales/Emp	173	10.93	0.83	9.17	13.38	532	10.82	0.76	8.48	13.41
Bank Loans/Emp	173	7.10	5.02	0.00	13.64	532	6.74	5.08	-8.04	14.02
Non-bank Funding/Emp	173	4.51	5.21	0.00	14.37	532	4.88	5.28	-8.43	14.72
ln(K/Emp)	173	10.94	1.27	6.72	14.38	532	10.81	1.34	2.85	14.71
ln(Emp)	173	2.62	1.00	1.39	5.40	532	2.61	1.03	1.39	5.40
ln(Age)	173	2.76	0.39	1.39	3.78	532	2.76	0.37	1.61	3.76
Change in # branches (15-30 km)	146	-1.63	1.60	-8.00	3.00	532	-1.14	1.53	-5.00	3.00
Panel B - Altman Group 3										
VA/Emp	790	9.98	0.63	7.50	12.35	2,249	9.92	0.67	5.86	12.62
Sales/Emp	793	11.28	0.96	8.78	15.04	2,254	11.19	0.92	6.21	15.50
Bank Loans/Emp	793	3.46	4.38	-0.56	12.59	2,254	3.01	4.23	-5.12	13.45
Non-bank Funding/Emp	793	1.96	3.68	-10.05	11.25	2,254	2.06	3.70	-9.39	11.19
ln(K/Emp)	793	8.94	1.42	3.37	12.76	2,253	8.92	1.44	2.51	13.90
ln(Emp)	793	2.48	0.96	1.39	5.40	2,254	2.49	0.94	1.39	5.40
ln(Age)	793	2.65	0.42	1.39	3.37	2,254	2.69	0.41	1.39	3.37
Change in # branches (15-30 km)	652	-1.87	1.53	-9.00	3.00	2,254	-1.19	1.59	-6.00	3.00

Note: The definition of the variables is given in Table A1. Descriptive statistics for treated firms are calculated for one year before the treatment.

Table 2: Probability of treatment

Treated=1	(1)	(2)	(3)	(4)	(5)
ln(K/Emp)	0.228*	0.221*	0.254*	0.228*	0.246*
	(0.062)	(0.068)	(0.051)	(0.060)	(0.057)
Ln(Emp)	-0.096	-0.083	-0.072	-0.067	-0.069
	(0.614)	(0.659)	(0.728)	(0.724)	(0.735)
Ln(Age)	-1.271**	-1.179**	-1.403**	-1.266**	-1.351**
	(0.014)	(0.022)	(0.013)	(0.015)	(0.017)
Reg. centrum	0.035***	0.039***	0.043***	0.047***	0.044***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ln(Pop)	-0.146	-0.187		-0.054	-0.176
	(0.279)	(0.158)		(0.695)	(0.242)
Young	-93.38***	-89.85***	-114.7***	-138.7***	-114.3***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HHI	-20.09***	-17.24***	-29.86***		-29.91***
	(0.000)	(0.000)	(0.000)		(0.000)
Pop/Branch	0.000***		0.000***	0.000	0.000***
	(0.008)		(0.001)	(0.266)	(0.001)
UR		0.115	0.066	0.093	0.074
		(0.102)	(0.423)	(0.198)	(0.374)
Constant	6.875*	6.977*	7.947*	8.945*	9.517*
	(0.031)	(0.034)	(0.028)	(0.011)	(0.014)
Firm-year obs.	6 507	6 507	6 507	6 507	6 507
# Firms	2 169	2 169	2 169	2 169	2 169

Note: Robust standard errors clustered at the firm levels. P-values in parentheses. $***$, $**$ and $*$ indicate p-values at the 1%, 5%, and 10% significance levels. The definition of variables is given in Table A1. Random effect panel logit model used for estimation. Year fixed effects are included, but not reported.

environment, socio-demographic attributes and level of existing bank competitions among the standard determinants (Leyshon et al., 2008; Hasan et al., 2021; Siranova and Rafaj, 2021). In our specification, vector of control variables includes bank concentration (Herfindahl-Hirchman) index (Hasan et al., 2021), unemployment rate (Alama and Tortosa-Ausina, 2012; Jackowicz and Kozlowski, 2016), population size (Leyshon et al., 2008; Cohen and Mazzeo, 2010), share of young population (Siranova and Rafaj, 2021) at LAU1 level, and year time dummies. We also introduce a dummy to control for special role played by regional centers observed in the recent years (Siranova and Rafaj, 2021), identified at NUTS3 level. Level of bank market saturation is indirectly controlled for by the ratio of population to number of bank branches (Hasan et al., 2017).

Table 2 summarizes the regression results modelling the probability of individual treatment. All of the specifications include the basic fundamental determinants measured at firm level. In columns (1)-(4) we also alternate among different combinations of selected regional characteristics. Our preferred model (column 5) incorporates all of the relevant indicators into one specification. As reported, younger firms with higher capital/labor ratio located in regional centers prone to operate in over-saturated bank markets (Pop/Branch) are more likely to suffer from the bank branch closure in their closer vicinity. In the opposite direction, a higher concentration of bank services in local credit markets (HHI) that are located in regions with higher share of young population positively contributes to decreasing probability of treatment. These findings are broadly in line with the recent empirical evidence that hints at the emerging presence of banks' strategic behaviour characterized by concentration of on-site branches into their dominant local markets whilst exiting markets deemed to be too competitive or over-saturated (Siranova and Rafaj, 2021).

3.4 Parallel trend assumption

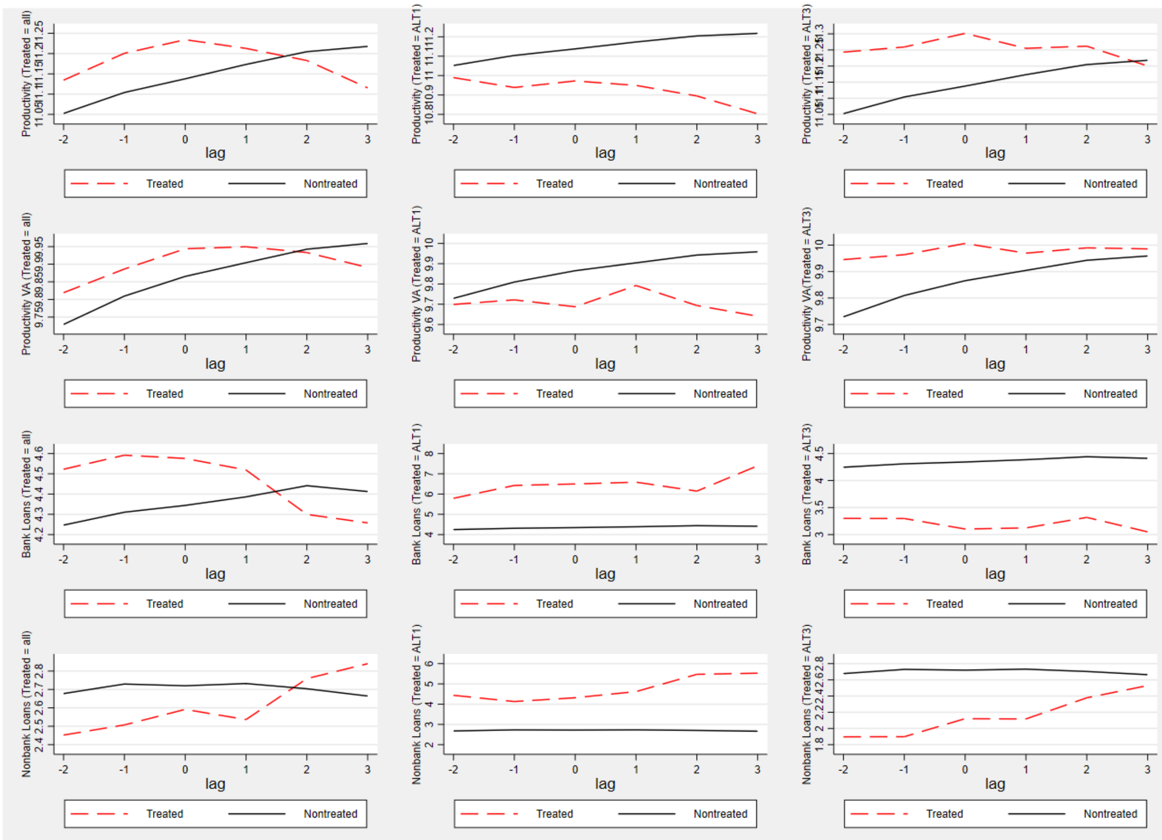
The trends for the key dependent variables for a 5-year time window around the bank branch closures, i.e. treatment, for full sample as well as grouped by ALT1 and ALT3 firms, are given in Figure 2.

The figure suggests that the treatment had a significant impact on the firms. For instance, the trends of both measures of productivity (first and second rows) were almost parallel for the treated and non-treated firms in the years before bank branch closures. In the post-treatment period, however, they show considerable divergence with a noticeable fall in labour productivity for the treated firms. In case of bank debt financing, the divergence, i.e. fall in bank credit volumes in treated firms, is also observed, albeit being characterized by a less pronounced similarity in the pre-treatment period development. The reliance on non-bank funding has increased for the treated firms compared to a stagnation for the control group. In case of low-scoring firms (second column, ALT1 group), the parallel trend assumption is likely to be satisfied in case of bank and non-bank financing (third and fourth row), where we observe a significant divergence in the post-treatment periods. On the other side, high-scoring firms show similar trend in labour productivity in the pre-treatment periods, but report a stagnation in their post-treatment years, contrary to the positive growth in labour productivity in control group.

In order to provide a formal test of parallel trend assumption in dependent variable, we follow Gopalakrishnan et al. (2021). In particular, we regress dependent variable Y_{it} using the pre-implementation

Thus, we assume that the selection bias can potentially occur at the LAU1 level. In other words, banks do not specifically target individual firms, but also pre-determined local markets. In order to satisfy the exclusion restriction, our outcome equation does not contain county-specific regressors; however, we use county-year fixed effects in their stead.

Figure 2: Trends in the key dependent variables in pre- and post-treatment periods



Notes: The figure shows the trends of the key dependent variables for a time window around the year of the bank closure (t-2 to t+3). The two lines in each figure represent the mean values of the dependent variable for the treated and non-treated firms. The dependent variables listed from top to bottom are: Sales/Emp, VA/Emp, Bank loans/Emp, and Non-bank funding/Emp. The definition of each of the variables is given in Table 1.

period from up to 4 years before a firm experienced a bank branch closures, i.e. treatment, until the year before treatment.

$$Y_{it} = \alpha_0 + \alpha_1 ALTFirm_{it-4} \times Year_{t-4} + \alpha_2 ALTFirm_{it-3} \times Year_{t-3} + \alpha_3 ALTFirm_{it-2} \times Year_{t-2} + \alpha_4 ALTFirm_{it-1} \times Year_{t-1} + u_i + \epsilon_{it} \quad (5)$$

The treated and non-treated firms are on parallel trends for a dependent variable if the coefficients α_1, α_2, α_3, and α_4 in the pre-implementation period are not statistically different from zero. As in the case of 4 we include interactive fixed effects to account for the unobserved heterogeneity. We also present graphic illustration of parallel trend assumption by depicting the α_1, α_2, and α_3 coefficients with associated confidence intervals over the pre-treatment years.

Table 3: Test for parallel trend assumption

Dependent variable	(1) Sales/Emp	(2) VA/Emp	(3) Loan/Emp	(4) NBLoan/Emp	(5) Sales/Emp	(6) VA/Emp	(7) Loan/Emp	(8) NBLoan/Emp
Year(-4)*Treatment (ALT1 group)	-0.049	-0.093	0.007	1.011*				
	(0.402)	(0.161)	(0.989)	(0.013)				
Year(-3)*Treatment (ALT1 group)	-0.023	-0.037	-0.629	0.263				
	(0.758)	(0.656)	(0.282)	(0.610)				
Year(-2)*Treatment (ALT1 group)	-0.025	-0.006	-0.377	0.495				
	(0.754)	(0.948)	(0.543)	(0.364)				
Year(-1)*Treatment (ALT1 group)	-0.010	0.090	-0.980*	0.375				
	(0.894)	(0.271)	(0.084)	(0.454)				
Year(-4)*Treatment (ALT3 group)					-0.016	0.007	0.346	0.487*
					(0.690)	(0.889)	(0.285)	(0.087)
Year(-3)*Treatment (ALT3 group)					0.020	0.030	0.572	-0.095
					(0.663)	(0.558)	(0.110)	(0.764)
Year(-2)*Treatment (ALT3 group)					-0.061	-0.014	0.282	0.052
					(0.225)	(0.803)	(0.474)	(0.880)
Year(-1)*Treatment (ALT3 group)					-0.047	-0.076	0.154	0.092
					(0.328)	(0.156)	(0.683)	(0.782)
Constant	11.13***	9.873***	4.644***	2.723***	11.148***	9.881***	4.284***	2.745***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm-year observations	3 214	3 214	3 214	3 214	3 214	3 214	3 214	3 214
Adj. R2	0.906	0.799	0.811	0.814	0.906	0.799	0.811	0.814
Firm-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
County (LAU1)-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm Size-Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors clustered at the firm levels and treatment group*year cluster. P-values in parentheses. $***$, $**$ and $*$ indicate p-values at the 1%, 5%, and 10% significance levels. Definition of variables is given in Table A1.

The parallel trend tests for the pre-treatment period (Table 3) suggest that the baseline results for all of the dependent variables and different treatment groups can be interpreted as causal in nature at 10% confidence level. One should, however, still note the declining (increasing) pre-treatment trend, although statistically insignificant, in few instances (column 1-3).

4 Findings and discussion

4.1 Impact on labour productivity

First, in order to motivate our approach that focuses on differences in creditworthiness of SMEs based on their calculated probability of default, we estimate baseline specification in eq. [4] without interaction term and treatment group dummy variable. We perform this exercise to corroborate the simple intuition presented in Figure 2. The declining trend in sales-based measure of productivity observed Figure 2 was not confirmed once controlling for set of explanatory variables. However, we report continuous decline in value-added based productivity (Table A2), albeit statistically significant only in the second year following the treatment. As the heterogeneity in firms characteristics can potentially conceal the differences in response to treatment, we now proceed to key element of our analysis, the dis-aggregation analysis based on Altman z-score ranking.

The results from the estimation of Equation 4 on the impact of bank branch closure on labor productivity (measured by ratio of sales and value added on labour stock) across firms that report low (ALT1) credit scoring are presented in Table 4.

The results in Table 4 indicate that relative to the control group, our treatment group of companies experiences significantly higher growth in labour productivity following the bank branch closure. This is apparent especially over the longer time horizon in case of total sales (column 1-4). For the value-added based indicator, the highest economic impact is attained one year after the treatment. As indicated by the coefficient of interacted term ($ALTFirm_{it-4} \times L(.)Closing_{it}$), the impact on labour productivity measured by sales-based (value-added-based) indicator ranges between 0.23 to 0.87 (0.31 to 0.91) percentage points for the ALT1 firms compared to that for the control group. The bank branch closure, in general, is reported to have a negative impact on all firms' productivity when focusing on value-added performance (column 5-8), one to two years after the bank branch closure took place.

All firm-level control variables obtain expected, although sometimes statistically insignificant, coefficients. As expected from simple comparison of descriptive statistics (Table 1), companies identified as less creditworthy report lower labour productivity, on average. Presence of potential endogeneity bias is mitigated by the inclusion of Mills ratio that enters regressions with statistically significant values in few specifications (column 1-2, 6).

In similar fashion, results from the estimation of eq. [4] on the impact of bank branch closure labor productivity (measured by ratio of sales and value added on labour stock) across firms that are associated with high (ALT3) credit scoring are presented in Table 5.

The results in Table 5 indicate that relative to the control group, our treatment group of companies experiences significantly lower growth in labour productivity shortly after the bank branch closure. As indicated by the coefficient of interacted term ($ALTFirm_{it-4} \times L(.)Closing_{it}$), the impact on labour productivity measured by sales-based (value-added-based) indicator ranges between -0.34 to -0.19 (-0.52 to

-0.08) percentage points for the ALT3 firms; a smaller value in magnitude than the ones reported for ALT1 firms. The adverse impact of treatment is, however, sometimes reversed over longer time horizons (column 8) with slight increase in value-added based productivity reported in the third year following the bank branch closure.

The bank branch closure, in general, is reported to have statistically insignificant impact on all firms' productivity, as the previously indicated negative impact of treatment (Table 4) has been taken over by observed stagnating (deteriorating) trend in firm's productivity in the ALT3 group (depicted in Figure 2).

All firm-level control variables obtain expected, although sometimes statistically insignificant, coefficients. Presence of potential endogeneity bias is mitigated by the inclusion of Mills ratio that enters regressions with statistically significant values in few specifications (column 1-2, 6).

Table 4: Determinants of Labour Productivity (Treatment Group ALT 1)

	Altman Group 1							
	Sales/Employees				VA/Employees			
	(1) Lag 0	(2) Lag 1	(3) Lag 2	(4) Lag 3	(5) Lag 0	(6) Lag 1	(7) Lag 2	(8) Lag 3
Panel A - Difference-in-Difference								
Treatment	0.003	-0.006	0.011	-0.013	0.019	-0.033*	-0.039***	-0.016
	(0.854)	(0.376)	(0.266)	(0.778)	(0.459)	(0.054)	(0.004)	(0.727)
L4.Treatment group	-0.007	-0.004	-0.003	0.000	-0.035**	-0.053**	-0.040**	-0.037**
	(0.494)	(0.802)	(0.852)	(0.977)	(0.018)	(0.015)	(0.015)	(0.010)
Treatment * L4. Treatment group	0.023*	0.027	0.046*	0.087***	-0.004	0.091*	0.054	0.031***
	(0.068)	(0.211)	(0.091)	(0.002)	(0.909)	(0.057)	(0.274)	(0.009)
Panel B - Firm-specific determinants								
ln(K/Emp)	0.049***	0.050***	0.050***	0.050***	0.083***	0.084***	0.084***	0.083***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.015)	(0.015)	(0.014)	(0.015)
ln(Emp)	-0.766***	-0.766***	-0.766***	-0.767***	-0.687***	-0.687***	-0.687***	-0.688***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Age)	0.021	0.002	0.028	-0.007	0.298**	0.308**	0.316***	0.357**
	(0.868)	(0.988)	(0.832)	(0.935)	(0.016)	(0.010)	(0.009)	(0.035)
Panel C - Other determinants								
Mills ratio	0.002**	-0.002**	-0.001	0.001	0.001	0.003***	-0.001	-0.003
	(0.043)	(0.013)	(0.154)	(0.790)	(0.679)	(0.000)	(0.334)	(0.351)
Change in # branches (15-30 km)	0.000	0.001	0.002	0.002	0.001	0.003	0.003	0.003
	(0.903)	(0.795)	(0.518)	(0.498)	(0.825)	(0.623)	(0.629)	(0.595)
Constant	12.63***	12.67***	12.60***	12.70***	10.07***	10.07***	10.02***	9.93***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm-year observations	6,507	6,506	6,504	6,503	6,507	6,506	6,504	6,503
# clusters (treatment group*year)	4	4	4	4	4	4	4	4
Firm-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
County (LAU1)-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm size-Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors clustered at the firm levels and treatment group*year cluster. P-values in parentheses. $***$, $**$ and $*$ indicate p-values at the 1%, 5%, and 10% significance levels. Definition of variables is given in Table A1.

These findings on the increase in productivity of the ALT1 firms and decline in productivity of the ALT3 firms seem to point to rejection of the credit rationing hypothesis. Contrary, firms possibly facing severe credit constraints due to their higher probability of bankruptcy (low Altman z-score) report an increase

Table 5: Determinants of Labour Productivity (Treatment Group ALT 3)

	Altman Group 3							
	Sales/Employees				VA/Employees			
	(1) Lag 0	(2) Lag 1	(3) Lag 2	(4) Lag 3	(5) Lag 0	(6) Lag 1	(7) Lag 2	(8) Lag 3
Panel A - Difference-in-Difference								
Treatment	0.005	0.014	0.024***	0.001	0.015	0.003	-0.031	-0.025
	(0.677)	(0.367)	(0.007)	(0.987)	(0.548)	(0.903)	(0.143)	(0.595)
L4.Treatment group	0.018**	0.026**	0.020*	0.019*	0.014	0.029	0.018	0.016
	(0.045)	(0.024)	(0.056)	(0.052)	(0.174)	(0.153)	(0.273)	(0.278)
Treatment * L4. Treatment group	0.000	-0.034*	-0.019	-0.019**	0.005	-0.052	-0.008	0.019**
	(0.963)	(0.072)	(0.173)	(0.011)	(0.804)	(0.113)	(0.716)	(0.034)
Panel B - Firm-specific determinants								
ln(K/Emp)	0.049***	0.049***	0.049***	0.049***	0.083**	0.083**	0.083**	0.083**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.014)	(0.014)	(0.014)	(0.015)
ln(Emp)	-0.766***	-0.767***	-0.766***	-0.767***	-0.687***	-0.687***	-0.688***	-0.688***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Age)	0.028	0.005	0.034	-0.007	0.300**	0.304**	0.315***	0.355**
	(0.823)	(0.968)	(0.798)	(0.934)	(0.011)	(0.011)	(0.007)	(0.030)
Panel C - Other determinants								
Mills ratio	0.002*	-0.002**	-0.001	0.001	0.000	0.003***	-0.001	-0.003
	(0.057)	(0.014)	(0.176)	(0.732)	(0.705)	(0.000)	(0.381)	(0.370)
Change in # branches (15-30 km)	0.000	0.001	0.002	0.002	0.002	0.003	0.003	0.003
	(0.859)	(0.832)	(0.486)	(0.453)	(0.793)	(0.650)	(0.610)	(0.590)
Constant	12.61***	12.65***	12.58***	12.69***	10.05***	10.06***	10.02***	9.93***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm-year observations	6,507	6,506	6,504	6,503	6,507	6,506	6,504	6,503
# clusters (treatment group*year)	4	4	4	4	4	4	4	4
Firm-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
County (LAU1)-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm size-Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors clustered at the firm levels and treatment group*year cluster. P-values in parentheses. $***$, $**$ and $*$ indicate p-values at the 1%, 5%, and 10% significance levels. Definition of variables is given in Table A1.

in their labour productivity following the bank branch closure. Our findings may therefore indicate that the ALT1 group may have suffered from possible 'lock-in' effect in relationship banking (Sharpe, 1990; Rajan, 1992); a situation which has been distorted by an exit of bank branch from local credit market. Since the ALT1 group also reports higher relative share of bank credit compared to the rest of the sample (Table 1), overall benefits from changing the bank credit provider may be therefore magnified.

In case of the ALT3 group, as they could be viewed as already highly efficient and profitable (higher credit rating), even the loss of some hidden 'intrinsic' information through the bank branch closure should not adversely impact their credit assessment by remaining incumbent banks. As a result, reported decline in labor productivity may be interpreted as work of the standard information asymmetry theory (Bonfirm et al., 2020). The search for a new financial intermediary thus brings about short-term transaction costs that are, ultimately, mitigated over longer-term, once the new relationship is brokered.

4.2 Channels of transmission - Role of bank and non-bank financing

In the previous section we provide evidence that while the high credit rated firms (ALT3 group) may have faced increasing costs of bank branch closures, the ALT1 firms benefited from the exit of bank branch from local credit market, possibly due to the distortion of the established relationship with leaving bank branches. In this section we look at the behaviour of bank and non-bank financing following the treatment of bank branch closure. This allows us to further investigate whether the loss of bank credit funding was replaced by provision of new bank credit, or whether the firms were more likely to substitute the financing from other, informal sources. Role of informal external financing has been at the center of finance literature for a longer time, see Ayyagari et al. (2010).

As previously, we firstly estimate baseline specification in eq. [4] without interaction term and treatment group dummy variable in order to corroborate the simple intuition presented in Figure 2. The presence of declining trend in bank financing (Figure 2) was confirmed even after controlling for set of explanatory variables; however, statistical significant outcome is reported only for two years time lag. We also report continuous decline in non-bank funding (Table A2), again statistically significant only in the second year following the treatment. The sudden increase in non-bank funding three years after the treatment is reported also in our regression output, however, this outcome is highly statistically insignificant.

We now continue our analysis by discussing the findings reported for the AL1 group. According to the results in Panel A (Table 6), we observe that after the initial decline in bank funding (column 1-2), firms experiencing bank branch closure were able to obtain additional monetary resources by significantly increasing their relative share of bank financing in comparison to non-treated firms (column 3-4). Interestingly, although these companies also strongly rely on non-bank funding (Table 1), they did not use the non-bank funding as an alternative channel of external financing (column 5-8). This further corroborates the presence of 'hold-up theory' hypothesis in our data by providing the evidence that increase in bank funding followed by a bank branch closure has brought about new benefits likely stemming from the incentive to search for a new bank loans provider.

Situation substantially differs in the ALT3 group of companies (Panel A, Table 6. Not only these firms report medium-term decline in their relative bank loans positions (column 3-4), they do not substitute the external sources of financing through Non-bank funding either (column 7-8). Once again, this evidence support the increasing 'information asymmetry' hypothesis occurring due to the loss of incumbent information.

Table 6: Channels of transmission

	Bank Loans / Employees				Non-bank Funding / Employees			
	(1) Lag 0	(2) Lag 1	(3) Lag 2	(4) Lag 3	(5) Lag 0	(6) Lag 1	(7) Lag 2	(8) Lag 3
				Treatment group = Altman 1				
Panel A - Difference-in-Difference								
Treatment	0.190	-0.103	-0.176*	-0.504	-0.099	-0.065	-0.437**	0.142
	(0.213)	(0.282)	(0.063)	(0.189)	(0.330)	(0.166)	(0.030)	(0.824)
L4.Treatment group	0.017	0.001	-0.082	-0.053	0.343***	0.230	0.275*	0.251*
	(0.909)	(0.990)	(0.567)	(0.663)	(0.007)	(0.147)	(0.094)	(0.063)
Treatment * L4. Treatment group	-0.154	-0.178*	0.596**	1.099***	-0.284	0.083	-0.364	-0.316***
	(0.345)	(0.085)	(0.045)	(0.000)	(0.122)	(0.708)	(0.303)	(0.005)
				Treatment group = Altman 3				
Panel A - Difference-in-Difference								
Treatment	0.210*	-0.094	-0.043	-0.203	-0.150	-0.053	-0.337**	0.141
	(0.087)	(0.438)	(0.409)	(0.525)	(0.275)	(0.177)	(0.034)	(0.824)
L4.Treatment group	0.278*	0.249	0.250*	0.253*	-0.097	-0.078	-0.049	-0.079
	(0.080)	(0.102)	(0.071)	(0.061)	(0.372)	(0.327)	(0.507)	(0.276)
Treatment * L4. Treatment group	-0.117	-0.073	-0.178	-0.512***	0.042	0.010	-0.216**	-0.021
	(0.290)	(0.618)	(0.114)	(0.000)	(0.629)	(0.899)	(0.013)	(0.294)
Panel B - Firm-specific determinants	YES	YES	YES	YES	YES	YES	YES	YES
Panel C - Other determinants	YES	YES	YES	YES	YES	YES	YES	YES
Firm-year observations	6,507	6,505	6,504	6,503	6,507	6,505	6,504	6,503
# clusters (treatment group*year)	4	4	4	4	4	4	4	4
Firm-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
County (LAU1)-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm size-Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors clustered at the firm levels and treatment group*year cluster. P-values in parentheses. $***$, $**$ and $*$ indicate p-values at the 1%, 5%, and 10% significance levels. Definition of variables is given in Table A1.

4.3 Robustness checks

We perform few robustness checks. All results are available upon request.

First, our benchmark regressions (Table 4, Table 5) do not distinguish whether the exit of a bank branch resulted in a complete exit of an incumbent bank from the local credit market, or happened as a natural outcome of a efficiency-driven re-design within the bank branch network owned by one commercial bank. In order to address this interesting question, we re-estimate eq. [4] with treatment identified only for those cases where we observe a complete exit of a commercial bank form local credit market, i.e. this particular bank has had no bank presence after the bank branch closure. Similar to the baseline findings, the low credit rating firms benefit from increasing their bank loan financing and report higher post-treatment labour productivity; whilst, highly rated SMEs experience a significant decline in their productivity materializing shortly after the bank branch closure that dissipates only very slowly over the longer time horizon.

We then re-estimate the baseline specification in eq. 4 for all the dependent variables with a sample where the credit scoring of the treated firms remains constant during the treatment period (post-closure) at the pre-treatment values. The estimation results are consistent with those for the baseline sample, with low-rated firms experiencing increase and high-rated firms reporting decline in their labour productivity. We also observe increase (decrease) in relative levels of bank funding in the ALT1 (ALT3) group. We can therefore argue that our results are attributable to our treatment variable, rather than deteriorating economic performance of treated firms reflected in worsening of their credit-scoring levels.

Lastly, we also investigate the impact of Mills ratio inclusion on our findings. After removing the Mills ratio from the specification [4], the positive effect of bank branch closure among the ALT1 group of firms becomes even more pronounced, with sales-based (VA-based) productivity achieving peak after 3 (1) years lag. As in the baseline regressions, ALT3 group of firms report negative impact of bank branch closure, with the exception of lag 3 for VA-based productivity measure. Additionally, we interact Mills ratio with our interaction term (i.e., triple interaction). Once again, positive (negative) impact of treatment is preserved in case of lower (higher) rated firms.

5 Conclusions

We investigate the impact of the 'brick-and-mortar' bank branch closures over the period of 2015-2019 on labour productivity of SME sector in Slovakia. We consider the experience of a bank branch closure as a negative treatment endogenously imposed on a firm located in its close vicinity. This approach allows us to adopt the difference-in-differences method with staggered implementation, in fashion of Gopalakrishnan et al. (2021). Possible endogeneity bias in treatment variable is addressed by introducing the Mills ratio, derived from the nonlinear regression specification modelling the probability of a treatment on set of control variables, into our baseline specification.

As an additional novelty, we construct two treatment groups of small and medium enterprises characterized by their Altman z-score calculated and reported by external data provider. More financially constrained firms, i.e. SMEs with lower z-score, are hypothesised to face a more severe credit rationing once we observe reduction in bank branch network.

Our results reveal few intriguing findings. We find that ALT1 group (lower credit rating) reports both, the increase in relative bank borrowing as well as labour productivity in the post-treatment periods. This may indicated that this group of firms may have suffered from a possible 'lock-in' effect in relationship banking in the past; a situation which has been distorted by an exit of bank branch from local credit market. Contrary, decline in relative levels of bank credit associated with lower labour productivity in ALT3 group (higher credit rating) may be viewed as a confirmation of a work of the standard information asymmetry theory that postulates that the bank branch closures result in a loss of incumbent information, hence imposing additional transaction costs to affected firms.

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Appendix

A5.1 Bank Branch Closure as Treatment in Cobb-Douglas Production Function

Our functional form of the Cobb-Douglas Production Function closely follows Nemethova et al. (2019). We do not impose any restriction on returns to scale specification.

$$Q_{it} = A_i K_{it}^{\beta_1} L_{it}^{\beta_2} \tag{A1}$$

where Q_{it} represents the total production, A_i the total factor productivity, K_{it} level of capital stock, L_{it} labor input of a firm i at time t, β_1 total output elasticity of capital, β_2 total output elasticity of labor, D_{it} treatment variable with 1 signalling bank branch closure and zero otherwise, and γ the factor measuring change in capital accumulation in treated firms in comparison to non-treated firms.

The treatment D_{it} is hypothesised to affect accumulation of physical capital. Affected firms will therefore report differences in the accumulated capital in the magnitude of γ. In this approach, the change in bank credit used for investment funding should result in changes in long-term firm productivity.

$$Q_{it} = A_i [K_{it}(1 + \gamma D_{it})]^{\beta_1} L_{it}^{\beta_2} \tag{A2}$$

The specification [A2] can be further reformulated as follows:

$$\frac{Q_{it}}{L_{it}} = \frac{A_i [K_{it}(1 + \gamma D_{it})]^{\beta_1} L_{it}^{\beta_2}}{L_{it}} \tag{A3}$$

$$ln(Q_{it}/L_{it}) = ln(A_i/L_{it}) + ln(\frac{[K_{it}(1 + \gamma D_{it})]^{\beta_1}}{L_{it}^{\beta_1}} \frac{L_{it}^{\beta_2}}{L_{it}} L_{it}^{\beta_1}) \tag{A4}$$

$$ln(Q_{it}/L_{it}) = ln(A_i/L_{it}) + ln(K_{it}^{\beta_1}/L_{it}^{\beta_1}) + ln(\frac{(1 + \gamma D_{it})^{\beta_1}}{L_{it}^{\beta_1}}) + ln(L_{it}^{\beta_2+\beta_1-1}) \tag{A5}$$

$$ln(Q_{it}/L_{it}) = ln(A_i/L_{it}) + \beta_1 ln(K_{it}/L_{it}) + ln(1 + \gamma D_{it})^{\beta_1} - \beta_1 ln(L_{it}) + (\beta_2 + \beta_1 - 1) lnL_{it} \tag{A6}$$

$$ln(Q_{it}/L_{it}) = ln(A_i/L_{it}) + \beta_1 ln(K_{it}/L_{it}) + \beta_1 ln(1 + \gamma D_{it}) + (\beta_2 - 1) lnL_{it} \tag{A7}$$

$$ln(Q_{it}/L_{it}) = ln(A_i/L_{it}) + \beta_1 ln(K_{it}/L_{it}) + \beta_1 \gamma D_{it} + (\beta_2 - 1) lnL_{it} \tag{A8}$$

Table A1: Variables and their definitions

Panel A	**Dependent variables**
Sales/Emp	Total sales to # of employees
Value added/Emp	Value added to # of employees
Bank loans/Emp	Long-term and short-term bank loans to # of employees
Non-bank Funding/Emp	Sum of other financial assistance, liab. to subsidiary and parent company, liab. within the consolidated entity and issued bonds to # of employ.
Panel B	**Firm characteristics**
K/Emp	Ratio of fixed assets to # of employees
Emp	Number of employees, centered according to the reported size category of company
Age	Age of company (years)
Firm size	Dummy variables for 3 size categories according to value of total assets
Change in # of branches (15-30 km)	Calculated YoY change in number of bank branches within the 15-30 km radius
Panel C	**Regional characteristics (LAU1)**
Pop	Total population
Young	Ratio of population between 20-29 years on total population
UR	Unemployment rate
HHI	Herfindahl-Hirschman index. Based on number of individual bank groups present in local markets (LAU1)
Pop/Branch	Population divided by number of branches
Reg. centrum	Dummy variable, 1 = regional centrum for NUTS3 region

Table A2: Determinants of Labour Productivity

	Sales/Employees				VA/Employees			
	(1) Lag 0	(2) Lag 1	(3) Lag 2	(4) Lag 3	(5) Lag 0	(6) Lag 1	(7) Lag 2	(8) Lag 3
Panel A - Difference-in-Difference								
Treatment	0.006	-0.003	0.014	-0.010	0.018	-0.023	-0.034**	-0.016
	(0.708)	(0.732)	(0.135)	(0.828)	(0.426)	(0.157)	(0.013)	(0.737)
L4. Treatment group	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
Treatment *L4. Treatment group	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
Panel B - Firm-specific determinants								
lnK/Emp	0.049**	0.050**	0.050**	0.050**	0.083**	0.084**	0.084**	0.083**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.015)	(0.014)	(0.014)	(0.015)
lnEmp	-0.766***	-0.766***	-0.766***	-0.766***	-0.687***	-0.687***	-0.687***	-0.688***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
lnAge	0.020	0.003	0.024	-0.015	0.293**	0.305**	0.308**	0.347**
	(0.871)	(0.984)	(0.851)	(0.849)	(0.015)	(0.010)	(0.010)	(0.035)
Panel C - Other determinants								
Mills ratio	0.002**	-0.002**	-0.001	0.001	0.001	0.003***	-0.001	-0.003
	(0.047)	(0.013)	(0.194)	(0.743)	(0.671)	(0.000)	(0.377)	(0.375)
Change in # branches (radius 15-30 km)	0.000	0.001	0.002	0.002	0.001	0.003	0.003	0.003
	(0.934)	(0.763)	(0.486)	(0.476)	(0.826)	(0.596)	(0.617)	(0.602)
Constant	12.63***	12.67***	12.62***	12.72***	10.07***	10.07***	10.04***	9.95***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm-year observations	6,507	6,506	6,504	6,503	6,507	6,506	6,504	6,503
# clusters	4	4	4	4	4	4	4	4
Firm-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
County (LAU1)-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm size-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
β_1	0.049	0.050	0.050	0.050	0.083	0.084	0.084	0.083
β_2	0.234	0.234	0.234	0.234	0.313	0.313	0.313	0.312
γ	0.122	-0.060	0.280	-0.200	0.217	-0.274	-0.405	-0.193

Note: Robust standard errors clustered at the firm levels and treatment group*year cluster. P-values in parentheses. $***$, $**$ and $*$ indicate p-values at the 1%, 5%, and 10% significance levels. Definition of variables is given in Table A1.

Table A3: Channels of transmission

	Bank Loans / Employees				Non-bank Funding / Employees			
	(1) Lag 0	(2) Lag 1	(3) Lag 2	(4) Lag 3	(5) Lag 0	(6) Lag 1	(7) Lag 2	(8) Lag 3
Panel A - Difference-in-Difference								
Treatment	0.167	-0.124	-0.131*	-0.470	-0.134	-0.050	-0.465**	0.134
	(0.227)	(0.175)	(0.075)	(0.230)	(0.210)	(0.191)	(0.015)	(0.832)
L4. Treatment group	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
Treatment * L4. Treatment group	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
Panel B - Firm-specific determinants								
lnK/Emp	0.609***	0.607***	0.608***	0.609***	0.348*	0.352*	0.356*	0.353*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.051)	(0.052)	(0.052)	(0.050)
lnEmp	0.448***	0.445***	0.445***	0.442***	-0.075	-0.076	-0.076	-0.074
	(0.002)	(0.002)	(0.002)	(0.002)	(0.386)	(0.408)	(0.407)	(0.427)
lnAge	0.667	0.820	0.728	0.199	-0.191	-0.530	-0.916	-0.171
	(0.587)	(0.506)	(0.574)	(0.836)	(0.810)	(0.494)	(0.275)	(0.798)
Panel C - Other determinants								
Mills ratio	-0.009	0.008**	0.002	0.028	0.033**	0.001	0.020***	-0.016
	(0.108)	(0.011)	(0.668)	(0.184)	(0.040)	(0.714)	(0.004)	(0.669)
Change in # branches (radius 15-30 km)	0.015	0.016	0.019	0.019	-0.017	0.000	0.005	0.003
	(0.773)	(0.736)	(0.669)	(0.665)	(0.686)	(0.992)	(0.904)	(0.936)
Constant	-4.132	-4.353	-4.157	-2.818	0.248	1.017	2.120	0.059
	(0.244)	(0.228)	(0.271)	(0.325)	(0.884)	(0.521)	(0.213)	(0.980)
Firm-year observations	6,507	6,506	6,504	6,503	6,507	6,506	6,504	6,503
# clusters	4	4	4	4	4	4	4	4
Firm-level controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
County (LAU1)-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Firm size-Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors clustered at the firm levels and treatment group*year cluster. P-values in parentheses. ∗∗∗, ∗∗ and ∗ indicate p-values at the 1%, 5%, and 10% significance levels. Definition of variables is given in Table A1.