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Amount of credit and its variability as labor productivity determinants: Evidence from Hungary and Poland

MICHAŁ BRZOZOWSKI*

Faculty of Economic Sciences, University of Warsaw, Długa 44/50, 00-241, Warsaw, Poland

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ABSTRACT

Using annual sectoral data for Hungary and Poland covering the period of 2005–2016, this paper assesses the impact of credit market characteristics on labor productivity in manufacturing. Apart from the amount of loans extended to non-financial corporations, which has been extensively studied in the literature, it focuses on credit market stability and tightness. The main results are that the volatility of credit originating from the supply side of the market has a negative influence on labor productivity, while credit market tightness is insignificant. There is no robust evidence that the stock of credit is a critical productivity determinant.

KEYWORDS

financial development, credit variability, labor productivity, Hungary, Poland

JEL CLASSIFICATION INDICES

E44, G21, J24

1. INTRODUCTION

There seems to be a consensus among scholars that the level of financial development, measured by the ratio of credit to the private sector as a percentage of GDP, stimulates economic growth, although its impact eventually becomes negative at high levels of financial sector expansion.

* Corresponding author. E-mail: brzozowski@wne.uw.edu.pl

There is also an agreement that financial turbulence has negative effects on the real economy. The aim of this paper is to jointly analyze the influence of the amount and variability of bank loans to non-financial corporations on labor productivity.

The main hypothesis of the paper is that the variability in the volume of credit impairs labor productivity growth. Credit instability impedes planning and discourages long-term investment in physical capital and innovation. Productivity improvements require not only wide but also continuous access to credit. The corollary hypothesis states that when credit fluctuations are overlooked, an empirical analysis of the relationship between credit market depth and growth is likely to overestimate the benefits of financial development. It has to be stressed that the analysis is not confined to the consequences of turmoil in the credit markets, but it covers overall variability, i.e., all changes in the credit stock regardless of their range.

To confirm these conjectures, I used sectoral data on labor productivity of two Central European (CE) countries, Hungary and Poland. These economies offer a promising testing ground for assessing the role of financial markets which have been quickly growing at a steady pace. Figure 1 shows (see the left panel) that the stock of credit extended by banks to the private sector in CE doubled over the decade preceding the global financial crisis, after which it stalled and slightly declined. Although for the region as a whole, the growth before the crisis was not rapid enough for it to catch up with other middle-income or high-income countries (see the right panel of Fig. 1), it was considered to be excessive and likely to lead to unsustainable credit boom (IMF 2015).

Poland largely followed this trend, except for the post-crisis period, when it did not witness a reduction. The credit market has been more turbulent in Hungary: the stock of loans in the last years has sharply fallen to the level observed at the beginning of the 2000s, when it was significantly higher than in other countries in the region. This fall can be attributed to the behaviour of foreign banks which hold a larger share of bank assets in Hungary than in Poland and reduced their lending during and after the global financial crisis (Allen et al. 2017). In addition, after the global financial crisis the demand for loans in Hungary decreased due to

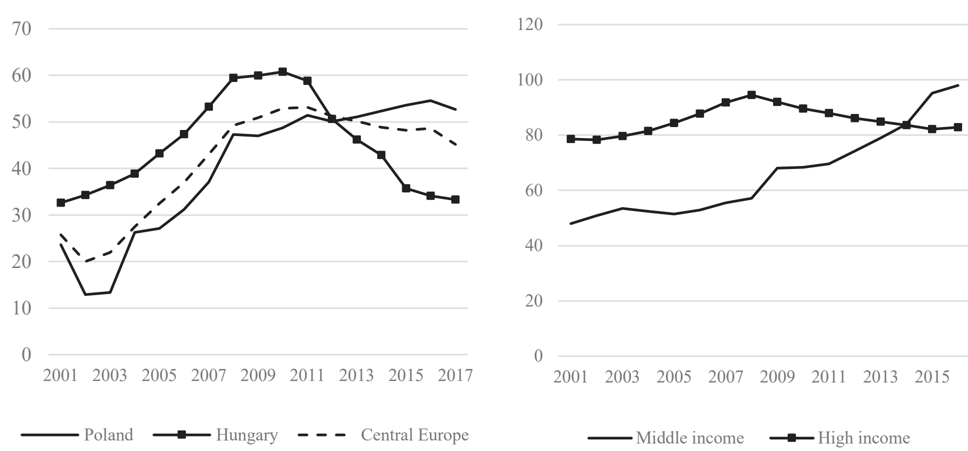

Fig. 1. The stock of credit (% of GDP) extended by banks to the private sector
Source: World Bank. *Note:* Central Europe includes the Baltics.

historically low investment rates and the supply of loans was constrained by the government's strategy towards financial sector, such as bank levy introduced in 2009 (Kovács 2013).

This brief overview of data reveals the lag in development of the Polish and Hungarian credit markets and their marked instability. The pattern of credit growth in Poland was typical of other CE countries, while it was distinct in Hungary. This is why valuable insights can be gained from studying the impact of the volume and variability of credit on productivity in both countries. Moreover, the central banks in both countries started to run Senior Loan Officer Opinion Surveys as early as at the beginning of the 2000s, which provides a unique opportunity to estimate a measure of excess demand for credit. This is an important control variable in the main regression model which explains the impact of the amount and variability of credit on productivity. Including the measures of variability and excess demand for credit in the set of independent variables improve the accuracy of estimates of the impact of the size, instability and tightness of the credit market.

The objective of the paper is to reassess the importance of financial development for labor productivity by jointly considering the volume of credit and its variability in Poland and Hungary. The main results are that the volatility of the supply credit extended to non-financial corporations had a negative influence on labor productivity (measured at the 2-digit level of ISIC Rev. 4 classification) in 2005–2016 in the Polish and Hungarian manufacturing, while credit market tightness was insignificant. Moreover, the effect of credit stock becomes weaker or zero when credit volatility is also taken into consideration as a determinant of productivity.

The detailed presentation of my finding is contained in *Section 4*, preceded in *Section 3* by a description of the data and methodology. In *Section 2*, I review the related literature, focusing on the impact of financial development and financial crises on productivity. *Section 5* offers conclusions and policy implications.

2. REVIEW OF RELATED LITERATURE

2.1. Credit and growth

The relationship between the level of financial development and economic growth has been studied extensively in the literature. This review concentrates on two aspects of the finance – growth nexus, i.e., the role of the credit market and its impact on productivity. It suffices to mention that the research on the relationship between finance and economic growth in general is abundant enough to have been subjected to a meta-analysis by Arestis et al. (2015) and Bijlsma et al. (2018). In the former article, the credit-to-GDP ratio was found to be statistically insignificant in all specifications. Bijlsma et al. (2018) concluded that although the literature has exaggerated the size of the finance – growth effect in the past, a 10% increase in credit to the private sector increased economic growth by 0.09 percentage points. This positive effect was found to be decreasing, as postulated by the '*too much finance*' hypothesis put forward by Rioja – Valev (2004), Shen – Lee (2006), Cecchetti – Kharroubi (2012), Arcand et al. (2015), Fagerberg – Srholec (2016), and Bolek et al. (2021).

Labor productivity, can be explained by fixed investment, the accumulation of human capital and technological progress. In light of the analysis by Madsen – Ang (2016), it seems that financial development influenced growth through all these channels. Using a panel data set for 21 OECD countries over the past 140 years, the authors found that the production of knowledge, from which technological progress stems, was the most important channel through which financial development affects growth. Financial development was also a powerful force behind increases in the investment rate. This result was robust to the use of different measures of (and instruments for) financial development and econometric techniques, to which earlier estimates by Beck et al. (2000) were sensitive.

Innovative activities are a prerequisite of advancing technology. The idea that financial development is essential for innovation can be traced back to Schumpeter (1911). Pradhan et al. (2016) studied the short- and long-run relations between domestic credit and the intensity of innovative efforts measured by patents, research personnel and spending. Using data on the Eurozone countries, they failed to find Granger causal relationships that were uniform across various periods and innovation measures. Hsu et al. (2014) investigated the impact of financial development on several measures of innovative efforts in 32 countries. Their general conclusion was that the development of credit markets appears to discourage innovation in industries that are more dependent on external finance and are more high-tech intensive. This finding is consistent with the hypothesis that banks are more risk-averse and less able than equity markets to overcome information and agency problems in the high-tech industries. Law et al. (2018) challenged this view on the basis of the results obtained from non-linear panel data regression analyses of innovation in 75 countries. They found an inverted U-shaped relationship between financial development on the one hand and patent applications and patents granted on the other hand. Regarding the number of patents granted, Ho et al. (2018) argued that it was positively associated with banking market deepening only when political institutions are sufficiently democratic.

Research on the link between financial development and improvements in technology is less abundant than research on the growth – finance nexus. Beck et al. (2000) used a cross-country instrumental variable estimator and panel techniques to show that financial intermediaries exert a large, positive impact on total-factor productivity (TFP) growth. Arizala et al. (2009) estimated that an increase in the ratio of private credit to GDP can accelerate industry-level TFP growth in sectors more dependent on external finance. The share of resources allocated to sectors more dependent on external finance was found by Fisman – Love (2004) to be positively associated with financial development only in the long-run. The authors hypothesized that these sectors are more likely to invest in R&D, thereby contributing to TFP growth.

The results of micro-level studies of the relation between finance and productivity are mixed. Dabla-Norris et al. (2012), using data from the World Bank survey covering over 14,000 firms in 63 countries, concluded that the strength of the effect of innovation on productivity is weakly dependent on financial development. Counterevidence was provided by Gorodnichenko – Schnitzer (2013), who, using data from the same source, found that domestically owned firms in the countries that were developing or in transition innovated less intensively than the foreign-owned companies. The latter were likely to face less severe financial constraints.

Hassan et al. (2017) explored the short- and long-run relations between credit and productivity in the French, German and Italian firms. They found significant and negative contemporaneous correlations between credit and productivity, and a positive correlation between credit and future productivity (after two subsequent years). Italy was an exception as it had a positive contemporaneous correlation and a positive, although small, correlation in the subsequent periods. A positive impact of credit supply on the productivity of Italian corporations was confirmed by Manaresi – Pierri (2018). They showed that an expansion in credit supply led firms to increase both their inputs and their output (value-added and revenues) for a given level of inputs and that a credit crunch would be followed by a productivity slowdown.

The negative influence of excessive financial development, consistent with the 'too much finance' hypothesis, was corroborated by Coricelli et al. (2012) at the firm level. Estimates of the threshold regression model for a sample of CEE countries confirmed that TFP growth increased with book leverage until the latter reached a critical threshold beyond which leverage became excessive and reduced TFP growth.

Indirect evidence on the importance of financial development for productivity improvements is offered by Amore et al. (2013). They looked at firms' innovative performance and found that the deregulation of banking activities across the US states during the 1980s and 1990s had significant beneficial effects on the quantity and quality of innovation by public firms. As shown by Chava et al. (2013), who studied young private firms and made a distinction between interstate and intrastate banking deregulation, this result does not hold for all firms and all types of banking deregulation. Interstate banking deregulation, contrary to its intrastate counterpart, increased the local market power of banks and decreased the level and risk of innovation by young private firms. In contrast, Cornaggia et al. (2015) found that the deregulation of interstate bank branching laws increased innovation among private firms that were dependent on external finance and reduced innovation by public corporations headquartered within the deregulating states.

The research reviewed so far suggests that access to credit spurs capital accumulation and innovation that impact labor productivity. Our first hypothesis states that there exists a link between financial development and labor productivity.

Hypothesis 1: Credit stock has a positive effect on the value added per employee in Hungary and Poland in all sectors of economy.

2.2. Access to external finance and innovation

The second strand of the literature to which this paper is related analyzes the interaction between the financial cycle and sources of productivity: spending on R&D. Instability of credit supply impinges on smoothing expenditures on R&D and adoption of technology. Transitory shocks to finance may entail significant costs of firing and hiring highly trained R&D personnel and disrupt teamwork on long-term innovative projects. In other words, R&D investment has high adjustment costs (Hall et al. 1986; Lach – Schankerman 1989; Bernstein – Nadiri 1989).

Evidence on the importance of liquidity constraints as a cause of R&D cyclicality in the U.S. manufacturing industries was provided by Ouyang (2011) and in the French firms by Aghion et al. (2012) Firms tend to smooth their R&D spending over time in order to avoid having to lay off knowledge workers and preserve acquired skills and routines. Brown – Petersen (2011) reported that the U.S. firms relied heavily on cash reserves to smooth R&D spending during the 1998–2002 boom and bust in stock market returns. For Korea, Shin – Kim (2011) documented that firms, in particular, the young ones, used more cash holdings to smooth R&D investment during a bear market than during a bull market.

A transitory external finance shock that cannot be cushioned by the firm's own financial resources can lead to the erosion of innovation capacity. Lööf – Nabavi (2016) examined the link between innovation and negative financial shocks in a sample of exporting firms in Sweden that are assumed to be less credit constrained. Only innovative firms were found to exploit cash reserves to offset the effects of negative financial shocks on their patent activities during recessions. Low- and medium-tech exporters were not found to face significant financial constraints during the economic slowdowns.

Intangibility is another characteristic of innovation expenditures that makes them particularly vulnerable to credit volatility. Costs of investment in intangible goods, such as knowledge and new technology, are not recoverable once the investment is made. Since investment in innovation is irreversible, it is negatively affected by uncertainty, as argued by Caballero – Pindyck (1996). Waiting for new information is the opportunity cost of investing, which represents a real option and can encourage firms to postpone irreversible investment in new technology. The negative effect of uncertainty on investment has been confirmed by Goel – Ram (2001) and Czarnitzki – Toole (2013) in the case of R&D expenditures and by Bontempi (2016) in a more general case of intangible goods.

The impact of financial shocks on TFP growth was examined by Estevão – Severo (2010). Financial shocks, defined as increases in the costs of funds, had a statistically significant and economically meaningful negative impact on TFP growth in the U.S. and Canadian industries. The authors suggested that financial shocks distort the allocation of factors of production across firms. A negative effect of the banking crises on labor productivity and TFP that was larger in developing than in the developed countries was discovered in a wider sample of 61 countries by Oulton – Sebastiá-Barriel (2016). There are also studies which proved the existence of a permanent, depressing effect of the global financial crisis of 2007–2009 on productivity (e.g., Redmond – Van Zandweghe 2016; Duval et al. 2017).

To the best of my knowledge, the impact of credit market instability that does *not* culminate in a crisis has not been examined. This paper aims to fill this gap in the literature. Investment in innovation has high adjustment costs and needs to be smoothed. Additionally, it is irreversible and is likely to be delayed in an uncertain environment. Provided that variability in access to credit generates uncertainty and undermines smoothing of R&D spending, I want to test the following hypothesis.

Hypothesis 2: Variability in credit stock has a negative effect on the value added per employee in Hungary and Poland, in general, and in more R&D-intensive manufacturing firms, in particular.

3. DATA AND METHODOLOGY

In research on the impact of financial development on growth, particular attention has to be paid to the issue of reverse causality. To deal with this problem, Rajan – Zingales (1998) computed a measure of the dependence of manufacturing sectors on external financing which is exogenous to the proxies for financial development and other determinants of growth. The following modified version of their model constitutes the framework for the regression analysis in this paper:

$$y_{ijt} = \varphi y_{ijt-1} + \beta (ExtDep^{*}Fin)_{ijt-1} + u_{ijt}$$

$$u_{ijt} = \alpha_{ij} + e_{ijt}$$

where i stands for industry at 2-digit level of ISIC Rev.4 classification, j for country (i.e., Poland or Hungary), and t denotes year. The dependent variable y is the real value added divided by the number of persons engaged, both of which were retrieved from the OECD STAN Industrial Analysis dataset. The vector *ExtDep*Fin* contains three variables that capture the characteristics of the financial market (*Fin*) multiplied by the dependence on external financing (*ExtDep*). All of these variables were lagged one year because financial conditions can have a delayed effect on the real economy. Furthermore, using lagged values helped dissipate doubts about the exogeneity of the financial variables. The regression equation did not include an industry's initial share in total value added, which was one of the covariates in the original model of Rajan – Zingales (1998), because I used annual data and estimated a dynamic model with the lagged dependent variable included among the explanatory variables; this made it possible to capture the process of convergence.

I used the end-of-year stock of bank loans to non-financial corporations as a measure of banking sector development. Statistical information on assets and liabilities of banks compiled by the National Bank of Poland (NBP) and detailed financial accounts of non-financial corporations released by the Hungarian National Bank (MNB) were the sources of data. Both series included credit extended by domestic financial institutions in domestic and foreign currencies. The explanatory variable labelled *amount of credit* is equal to the stock of loans to non-financial corporations divided by the total value added of all sectors.

To obtain a measure of credit variability, labelled *variability*1, I used the annual standard deviation of the rate of growth of the end-of-quarter stock of credit series deflated by the CPI index. The last element of vector *Fin* is a proxy for credit market tightness, labelled *tightness*, which was defined as excess demand for credit equal to the difference between the rate of growth of real values of demand for and supply of credit. Amounts of credit demanded and supplied were estimated in a credit market disequilibrium model, similar to the models used in the literature on credit cycles (e.g., Ghosh – Ghosh 1999; Čeh et al. 2011; Everaert et al. 2015).

The model is composed of two continuous regression equations and a switching equation, I_i, which classifies observation, i on a dependent variable z into either the demand or supply regime:

$$I_i = 1 \quad if \quad \gamma W_i + u_i > 0$$

$$I_i = 0 \quad if \quad \gamma W_i + u_i \leq 0$$

Demand regime: $z_{Di} = \beta_D X_{Di} + \varepsilon_{Di} \quad if \quad I_i = 1$

Supply regime: $z_{Si} = \beta_S X_{Si} + \varepsilon_{Si} \quad if \quad I_i = 0$

Here, the dependent variable z stands for the rate of growth of real value of credit; X_{Di} and X_{Si} are the vectors of weakly exogenous variables, W_i is a vector of all exogenous variables specified in the continuous equations and a set of instruments that help identify the model. The symbols β_D, β_S, γ represent the vectors of parameters; u, ε_D, ε_S denote the error terms which have trivariate normal distribution with the zero-mean vector. The full information maximum likelihood algorithm used in this paper to fit this kind of endogenous switching regression model was implemented by Lokshin – Sajaia (2004).

Potential determinants of demand for and supply of credit in Hungary and Poland were selected on the basis of a review of literature on the determinants of domestic credit in the emerging markets (Guo – Stepanyan 2011; Voghouei et al. 2011; Gozgor 2014; Alkhuizen et al. 2018). Among the many covariates considered, only a few were found to affect the quantities demanded and supplied in the credit market. The list of variables and data sources are specified in the *Additional material* in *Table A1*[1]. Quarterly data from 2004 to 2016 were used for estimation.

The model belongs to the class of switching regression models with known sample separation, i.e., it is known whether z is generated by the demand regime or the supply regime equation. This information was retrieved from the Senior Loan Officer Opinion Survey run by the central banks in both countries. The differences between the percentage of responses "eased considerably" and "eased somewhat" and the percentage of responses "tightened considerably" and "tightened somewhat" were used to create the index of credit terms and standards. A negative value of the index was interpreted as an indicator of the supply regime corresponding to I_i equal to 0. There were minor differences between the survey questionnaires in Hungary and Poland. To ensure comparability across countries, answers to two questions pertaining to credit standards for approving applications for loans and the terms on which banks granted loans were averaged in Poland. In Hungary, the question about credit standards also comprised the terms of loans.

The selection equation for I_i was estimated based on all variables used in the demand and supply equations and one additional instrument, i.e., the VIX index. The value of excess demand for credit is presented in Figure 2. It shows that before the global financial crisis there was an excess supply of credit in both countries and afterwards the demand regime prevailed. It is also visible that the degree of credit market disequilibrium is larger in Hungary than in Poland.

Figure 2 demonstrates that most of the time the credit markets were not in equilibrium. It was therefore justified to construct a second measure of credit variability. Instead of the rate of growth of the raw credit series, I employed the supply of credit derived from the disequilibrium model estimates. Thus, *variability*2 is defined as the annual standard deviation of the rate of

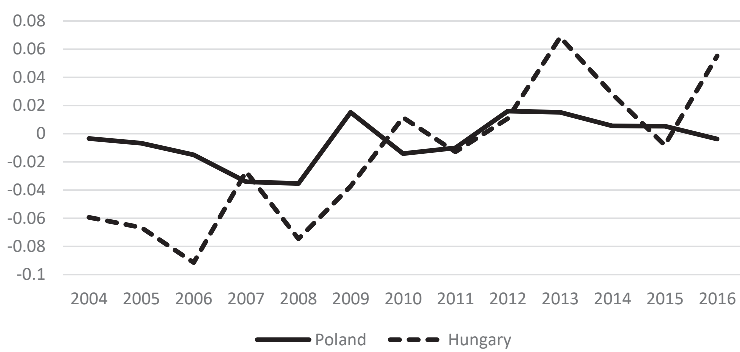

Fig. 2. Excess demand for credit (variable *tightness*)
Notes: Excess demand is defined as the difference between the rate of growth of demand for credit and supply of credit (both in real terms) estimated in the disequilibrium model presented above.
Source: NBP and MNB.

[1]The Additional material is available on request from the author and online at https://drive.google.com/file/d/1imHcYtpCxIkDcZC1we6FqNc7pc4Av7Hh/view?usp=sharing.

growth of the supply of credit. The variability of credit originating from the demand side of the market could be the outcome of optimizing the behavior of firms, whereas instability of the supply of credit can interfere with long-term investment and pose a more severe obstacle to labor productivity growth.

All of the elements of vector *Fin* presented above entered the main regression model and were multiplied by the dependence on external financing *ExtDep*. This measure was not different from the one used by Rajan – Zingales (1998), because they used US data for the 1980s and used a different industry classification. Moreover, as shown by von Furstenberg – von Kalckreuth (2007), there is no support for attributing fundamental features to indexes of dependence on external finance in the U.S. that would justify applying them to other countries. Therefore, I constructed a new measure on the basis of data from the Bank for the Accounts of Companies Harmonized (BACH) database, which covers firms from Belgium, France, Italy, Portugal and Spain[2]. The dependence on external finance was defined as:

$$1 - \frac{net\ profit + depreciation\ and\ amortization\ of\ fixed\ assets}{acquisitions\ less\ sales\ and\ disposal\ of\ tangible\ fixed\ assets}$$

where the numerator was a proxy for cash flow, which is not available in the BACH dataset.

To avoid the business cycle variability of investment expenditures and profits being transmitted to the measure of external dependence, I calculated its average value over two periods. The first period for which the average value of *ExtDep*1 was computed excluded the pre-crisis boom of 2005–2007 and the years 2008–2011, when global financial and sovereign European crises occurred, i.e., it extended from 2000 to 2015 with an interval in 2005–2011[3]. The second period for which *ExtDep*2 was constructed started in 2000 and ended in 2004[4]. In comparison with *ExtDep*1, it excluded the years 2012–2015, which witnessed the still incomplete recovery of the European financial system, evidenced by the unconventional monetary policy measures taken by the European Central Bank. The sectors included in the analysis and their external dependence are enumerated in *Table A2* in the *Additional material*. Construction of two measures of external dependence facilitated the establishing of robust results of estimation of the main regression model of labor productivity.

The model for labor productivity was fitted on annual data on Hungarian and Polish branches (40 in each country) in the years of 2005–2016. Three different techniques were applied to eliminate the “small T” bias (Nickell bias), i.e., to solve the problem arising from a correlation between the lagged dependent variable and the error which arises when a dynamic panel data model is estimated by the fixed effects estimator.

To remove the “small T” bias, the bootstrap-corrected fixed-effects (BCFE) estimator of Everaert – Pozzi (2007) uses a bootstrap-based numerical method to obtain the value of the bias instead of analytical approximations based on a strict set of assumptions which are often violated in practice. I used the algorithm proposed by De Vos et al. (2015) for unbalanced

[2]Only for those countries necessary data was available.

[3]The concern for cyclical distortions in funding needs of the Euro area firms in 2004–2007 led European Commission (2013) to exclude these years from the calculation of external dependence.

[4]For sector 19 (Coke and refined petroleum products) the data is not available for the period of 2000–2004. As a result, *ExtDep*1 is averaged over 2012–2015 and *ExtDep*2 is missing.

panels and generated bootstrap samples under the assumption that the error terms were from the normal distribution with cross-section specific variance[5]. The number of bootstrap samples used for inference was set to 100.

Quasi-maximum likelihood (QML) estimation was the second strategy used to cope with the bias peculiar to the dynamic panel data covering short time periods. Unlike the BCFE procedure, the QML approach does not consist in estimating and removing the bias; instead, it is designed to avoid it by modelling the unconditional likelihood function. The maximum likelihood estimation procedure of Kripfganz (2016) employs the representation proposed by Hsiao et al. (2002) for the initial observations of the first-differenced dynamic model. The initial observations were estimated using all the time-varying right-hand-side variables in the model and as many forward-looking periods as were available for the shortest panel.

The QML estimator is inconsistent if the explanatory variables are not strictly exogenous. Although the methodology of Rajan – Zingales (1998), which combines the amount and variability of credit at the national level with sectoral dependence on external finance, was conceived to address the issue of endogeneity, the assumption of strict exogeneity of regressors might not have been met. To deal with this potential problem, I used the System Generalized Method of Moments (GMM) of Arellano – Bover (1995), and Blundell – Bond (1998) which relies on the instrumental variables technique. This estimator suffers from poor small sample properties, finite sample bias due to the weak instrument problem, and sensitivity of results to the number and choice of instruments. Despite its flaws, it has been very popular in applied work; therefore, it will be used in this paper alongside the BCFE and QML estimators, which are underrepresented in empirical work.

4. EMPIRICAL RESULTS

The panel data approach described in the previous section was preceded by the application of the original Rajan – Zingales (1998) method, which uses the Ordinary Least Squares (OLS) estimator and cross-sectional data. The dependent variable is the average annual growth rate in value added in each industry during the period of 2005–2016. Independent variables are industries' shares in total value added at the beginning of the sample in 2005, the interaction between the dependence of industries on external financing and credit stock in 2005, the interaction between the dependence of industries on external financing and credit variability in the period of 2005–2016, and indicator variables for each industry. The variability of the credit stock was calculated as the standard deviation over the period of 2005–2016 of the rate of growth of the end-of-quarter stock of credit series deflated by the CPI index. The descriptive statistics of all variables and the correlation coefficients are presented in *Tables A3* and *A4* in the *Additional material.*

It should be stressed that there are serious limitations of the original methodology applied to the sample composed of only two countries. The number of observations is small (80) when the time dimension of the sample is reduced to 1. Additionally, the lack of variability over time of the interaction terms led to the problem of multicollinearity. The variance inflation factor exceeded 10 if the interaction terms between the dependence of industries on external financing

[5]Under assumption of cross-sectional heteroscedasticity, the error term was resampled over time within cross-sections.

Table 1. OLS estimates of the impact of credit stock and its variability on the average annual growth of labor productivity, 2005–2016

Measure of external dependence	*ExtDep1*		*ExtDep2*	
	(1)	(2)	(3)	(4)
Share of total value added in 2005	−0.459**	−0.459**	−0.502**	−0.502**
	(0.211)	(0.211)	(0.221)	(0.221)
Amount of credit * *ExtDep*	0.044***		0.052***	
	(0.016)		(0.018)	
Variability * *ExtDep*		−0.654***		−0.760***
		(0.239)		(0.268)
Constant	0.026***	0.050***	0.028***	0.053***
	(0.007)	(0.011)	(0.008)	(0.011)
Observations	80	80	78	78
R-squared	0.649	0.649	0.640	0.640
F statistic (P-value)	30.578 (0.0)	30.578 (0.0)	19.135 (0.0)	19.135 (0.0)

Notes: Robust standard errors are shown in brackets; stars indicate significance level: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Sector dummies were included.

and the credit stock and its variability were included in the set of regressors. Therefore, Table 1 reports the estimation results obtained for two model specifications, one in which the interaction between the dependence of industries on external financing and the credit stock in 2005 is included (columns 1 and 3) and another in which the interaction between the dependence of industries on external financing and the variability of credit is among the regressors (columns 2 and 4).

The original findings of Rajan – Zingales (1998) are confirmed in columns (1) and (3) of Table 1, i.e., financial development spurs the growth in value added per worker. This main conclusion holds for both measures of external dependence used in this paper. Additionally, the results presented in columns (2) and (4) reveal that credit variability hampers labor productivity growth. The cross-sectional analysis provides evidence supporting both hypotheses posed in this paper. To test the corollary hypothesis that R&D intensive sectors are more vulnerable to variability of credit stock, the Rajan – Zingales (1998) methodology was applied to a sample composed of manufacturing industries and the results are shown in Table 2.

The small number of observations implies caution when interpreting the results presented in Table 2. The value of the estimated coefficients on financial development (columns 1 and 2) are similar to those presented in Table 1 regardless of the measure of external dependence. By contrast, the variability of credit seems to have a stronger negative effect on labor productivity growth in manufacturing than in all sectors of the economy. The value of coefficients on credit variability in columns (2) and (4) of Table 2 are, respectively, 30% and 20% larger than their counterparts reported in Table 1.

Table 2. OLS estimates of the impact of credit stock and its variability on the average annual labor productivity in manufacturing industries, 2005–2016

Measure of external dependence	*ExtDep1*		*ExtDep2*	
	(1)	(2)	(3)	(4)
Share of value added in 2005	–0.698	–0.698	–0.859*	–0.859*
	(0.400)	(0.400)	(0.456)	(0.456)
Amount of credit * *ExtDep*	0.058***		0.061**	
	(0.018)		(0.022)	
Variability * *ExtDep*		–0.851***		–0.904**
		(0.266)		(0.326)
Constant	0.010***	0.039***	0.011**	0.038***
	(0.003)	(0.009)	(0.004)	(0.009)
Observations	34	34	32	32
R-squared	0.767	0.767	0.748	0.748
F statistic (P-value)	69.046 (0.0)	69.046 (0.0)	6.158 (0.0)	6.158 (0.0)

Notes: Robust standard errors are shown in brackets; stars indicate significance level: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Sector dummies were included.

The limitations of cross-sectional analysis applied to a sample composed of two countries can be overcome when annual data are used instead of averages computed over the sample period. The three panel data techniques outlined above were first applied to estimate the sole impact of financial development on labor productivity. The descriptive statistics of all variables and the correlation coefficients are presented in *Tables A5* and *A6* in the *Additional material*. The results in columns (1), (3), and (5) in Table 3 do not unequivocally confirm that the stock of credit enhances labor productivity growth; the System GMM estimator produced insignificant estimates.

The set of covariates was extended to include other characteristics of the credit market in columns (2), (4) and (6) in Table 3. The coefficient on the amount of credit loses its statistical significance in 2 out of 3 cases. Tightness of the credit market does not seem to affect value added per employee. Credit market variability hinders labor productivity, but the significance of this result does not hold when the QML estimator is applied. As argued above, the effect of credit volatility could be stronger when it is generated in the supply side of the market. Therefore, Table 4 presents estimates of the models with all the characteristics of the credit market as covariates, among which *variability2* was used as a measure of instability.

Contrary to the expectations, the association between labor productivity and volatility of the supply of credit is weaker. The coefficients on *variability*2 weighted by the indexes of dependence on external finance were smaller and barely significant when 2 estimation methods were used. The lack of a strong negative relation between variability of credit supply and labor productivity in a sample covering all sectors of economic activity comes as a no surprise if one recalls that the long-term investment and R&D spending are most susceptible to unstable

Table 3. Variability of stock of credit and value added per employee in all sectors of economic activity

Estimator	(1) BCFE	(2) BCFE	(3) QML	(4) QML	(5) GMM	(6) GMM
Lagged VA/empl	0.963***	0.965***	0.853***	0.856***	0.763***	0.799***
	(0.070)	(0.076)	(0.052)	(0.052)	(0.092)	(0.078)
Amount of credit * *ExtDep1*	4.245***	2.630**	2.322**	1.599	1.863	–0.157
	(1.189)	(1.328)	(1.095)	(1.416)	(1.327)	(1.245)
Variability1 * *ExtDep1*		–2.203*		–1.492		–2.960**
		(1.162)		(1.675)		(1.381)
Tightness * *ExtDep1*		–0.210		–0.228		–0.644
		(0.636)		(0.521)		(0.463)
Observations	843	843	763	763	843	843

Notes: Robust standard errors are shown in brackets (a small sample correction was applied in (5) and (6)); stars indicate significance level: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Year dummies were included. Country dummies were added in (5) and (6). Hansen J. statistic: 24.797 ($P = 0.209$) in (5), 26.372 ($P = 0.606$) in (6). Number of instruments: 35 in (5), 46 in (6). AR1 test statistic: –2.627 ($P = 0.009$) in (5), –2.594 ($P = 0.009$) in (6). AR2 test statistic: 1.103 ($P = 0.270$) in (5), 1.133 ($P = 0.257$) in (6).

Table 4. Variability of the supply of credit and value added per employee in all sectors of economic activity

Estimator	(1) BCFE	(2) QML	(3) GMM
Lagged VA/empl	0.964***	0.853***	0.843***
	(0.065)	(0.051)	(0.070)
Amount of credit * *ExtDep1*	4.544***	2.538*	–0.111
	(1.370)	(1.386)	(1.170)
Variability2 * *ExtDep1*	–1.218*	–0.931	–1.209*
	(0.671)	(0.606)	(0.626)
Tightness * *ExtDep1*	–0.099	–0.091	–0.483
	(0.465)	(0.443)	(0.424)
Observations	843	763	843

Notes: Robust standard errors are shown in brackets (a small sample correction was applied in (3)); stars indicate significance level: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Year dummies were included. Country dummies were added in (3). Hansen J. statistic: 32.516 ($P = 0.298$) in (3). Number of instruments: 46 in (3). AR1 test statistic: –2.582 ($P = 0.010$) in (3). AR2 test statistic: 1.122 ($P = 0.262$) in (3).

external financing. The bulk of expenditures on R&D is performed by manufacturing sectors in general and high-tech industries in particular. Therefore, the negative influence of credit variability on value added per worker should be more easily detected in manufacturing sectors than in agriculture or services. To test this prediction, I re-estimated the parameters of the model, retaining only manufacturing sectors in the sample. The results are shown in Table 5.

Columns (1)–(3) in Table 5 report estimates with the standard deviation of the rate of growth of the stock of credit, while in columns (4)–(6) the standard deviation of the rate of growth of credit supply was the proxy for credit market instability. The conclusion that the credit market variability and tightness have respectively depressing and non-significant effects on value added per employee in manufacturing is evidenced in Table 5. Regardless of the measure of instability of external financing, its statistical significance was established by all the applied estimators. The negative effect of credit market tightness was significant at the 10% level only when the System GMM estimator was used. Including the measures of credit market variability and the tightness in columns (1)–(3) and (6) removes the statistical significance of the proxy for credit market depth. The key conclusion which can be drawn from Table 5 is that credit variability is a more prominent determinant of labor productivity in manufacturing than the amount of credit.

To strengthen the validity of these findings, I conducted a robustness check by using the alternative measure of dependence on external finance *ExtDep*2. The results for all sectors of economic activity are shown in Table 6, with variability of stock and supply of credit in the respective columns (1)–(3) and (4)–(6).

Table 5. Variability of the stock and supply of credit and value added per employee in manufacturing

Measure of variability	**Variability1 (stock)**			**Variability2 (supply)**		
Estimator	**(1) BCFE**	**(2) QML**	**(3) GMM**	**(4) BCFE**	**(5) QML**	**(6) GMM**
Lagged VA/empl	0.924***	0.817***	0.822***	0.916***	0.815***	0.876***
	(0.124)	(0.054)	(0.050)	(0.112)	(0.059)	(0.040)
Amount of credit * *ExtDep1*	1.901	1.816	–1.542	6.819***	4.935**	0.368
	(2.036)	(1.766)	(1.370)	(2.308)	(2.341)	(1.409)
Variability * *ExtDep1*	–4.863***	–3.805*	–6.157***	–4.143***	–3.459***	–4.209***
	(1.772)	(2.184)	(1.872)	(1.189)	(1.285)	(1.283)
Tightness * *ExtDep1*	–0.533	–0.610	–1.111*	–0.356	–0.377	–0.900*
	(0.795)	(0.588)	(0.589)	(0.656)	(0.458)	(0.509)
Observations	357	323	357	357	323	357

Notes: Robust standard errors are shown in brackets (small sample correction was applied in (3) and (6)); stars indicate significance level: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Year dummies were included. Country dummies were added in (3) and (6). Hansen J statistic: 20.778 ($P = 0.753$) in (3), 26.283 ($P = 0.448$) in (6). Number of instruments: 42 in (3) and (6). AR1 test statistic: –2.6748 ($P = 0.007$) in (3), –2.701 ($P = 0.007$) in (6). AR2 test statistic: 0.781 ($P = 0.435$) in (3), 0.532 ($P = 0.595$) in (6).

Table 6. Sensitivity of results for all sectors of economic activity to the method of measurement of sectoral dependence on external finance

Measure of variability	Variability1 (stock)			Variability2 (supply)		
Estimator	(1) BCFE	(2) QML	(3) GMM	(4) BCFE	(5) QML	(6) GMM
Lagged VA/empl	0.986***	0.837***	0.824***	0.986***	0.835***	0.866***
	(0.050)	(0.054)	(0.068)	(0.047)	(0.053)	(0.059)
Amount of credit * *ExtDep2*	3.122**	1.638	0.397	4.438***	2.311*	0.199
	(1.489)	(1.199)	(0.684)	(1.469)	(1.362)	(0.664)
Variability * *ExtDep2*	-1.736	-1.385	-2.528**	-1.248*	-0.771	-0.989
	(1.181)	(1.560)	(1.140)	(0.719)	(0.657)	(0.599)
Tightness * *ExtDep2*	-0.095	-0.244	-0.434	-0.106	-0.135	-0.309
	(0.714)	(0.502)	(0.482)	(0.581)	(0.500)	(0.475)
Observations	822	744	822	822	744	822

Notes: Robust standard errors are shown in brackets (small sample correction was applied in (3) and (6)); stars indicate significance level: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Year dummies were included. Country dummies were added in (3) and (6). Hansen J statistic: 31.978 ($P = 0.321$) in (3), 34.530 ($P = 0.220$) in (6). Number of instruments: 46 in (3) and (6). AR1 test statistic: -2.465 ($P = 0.014$) in (3), -2.441 ($P = 0.015$) in (6). AR2 test statistic: 1.226 ($P = 0.220$) in (3), 1.201 ($P = 0.230$) in (6).

The estimates with the index of dependence on external finance calculated over the period of 2000–2004 revealed that the results were not sensitive to the way in which this variable was measured. In Table 6, variability of credit is rarely statistically significant. Credit market depth was significant only when the BCFE or the QML estimator was used, in the latter case at only 10%. I did not find any evidence that credit market tightness affects labor productivity. In the second robustness test, presented in Table 7, the index *ExtDep*2 again replaces *ExtDep*1, but the sample encompasses only manufacturing sectors.

The results in Table 7 in columns (4)–(6) largely accord with the estimates shown in Table 5, i.e. they point to a negative impact of variability of the supply of credit on labor productivity in manufacturing. This finding cannot be generalized to the overall variability of the stock of credit rooted in either the demand or supply side of the market because it is significant only in the model estimated by System GMM. Financial development is only statistically significant in column (4) in Table 7, while credit market tightness is statistically significant only when System GMM is used.

The statistical significance of the amount of loans depends on the estimation method and the inclusion of other characteristics of the credit market in the model; credit market tightness is not significant. It should be stressed that the lack of robust evidence on the growth enhancing effect of financial development is not new in the literature. Iwanicz-Drozdowska et al. (2019) found that an increase in the bank credit-to-GDP ratio hampers growth in the countries of Central, Eastern and South-eastern Europe; the evidence of the negative impact of financial depth on

Table 7. Sensitivity of results for manufacturing to the measurement of sectoral dependence on external finance

Measure of variability	Variability1 (stock)			Variability2 (supply)		
Estimator	(1) BCFE	(2) QML	(3) GMM	(4) BCFE	(5) QML	(6) GMM
Lagged VA/empl	0.974***	0.755***	0.711***	0.975***	0.750***	0.779***
	(0.046)	(0.037)	(0.064)	(0.054)	(0.036)	(0.064)
Amount of credit * *ExtDep2*	3.118	1.440	0.259	6.276**	3.871	0.413
	(2.236)	(1.879)	(0.736)	(2.556)	(2.518)	(0.554)
Variability * *ExtDep2*	−3.374	−3.403	−5.612***	−4.155***	−3.031**	−3.784***
	(2.158)	(2.088)	(1.907)	(1.423)	(1.182)	(0.937)
Tightness * *ExtDep2*	−0.293	−0.826	−1.128*	−0.471	−0.644	−1.066*
	(0.784)	(0.547)	(0.644)	(0.561)	(0.519)	(0.528)
Observations	336	304	336	336	304	336

Notes: Robust standard errors are shown in brackets (a small sample correction was applied in (3) and (6)); stars indicate significance level: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. Year dummies were included. Country dummies were added in (3) and (6). Hansen J statistic: 21.345 ($P = 0.724$) in (3), 21.206 ($P = 0.731$) in (6). Number of instruments: 42 in (3) and (6). AR1 test statistic: −2.587 ($P = 0.010$) in (3), −2.597 ($P = 0.009$) in (6). AR2 test statistic: 1.370 ($P = 0.171$) in (3), 1.174 ($P = 0.241$) in (6).

growth in a wider group of countries is provided by Arcand et al. (2015). Cecchcetti – Kharroubi (2019) examined the negative relation between the rate of growth of credit and the rate of growth in output per worker in the developed countries. Brown et al. (2011) showed in turn that credit constraints do not affect revenue growth of firms in Central Europe; however, the credit constrained firms are less likely to invest in R&D and introduce new products.

The key contribution of this paper is in providing the evidence that credit supply variability reduces value added per employee in manufacturing. This finding is novel and extends the literature on the role of financial stability in promoting economic growth. However, this literature is focused on the crises episodes and not on the overall volatility of credit which does not culminate in a collapse of bank lending. Summing up, evaluation of the sensitivity of results with respect to the estimation techniques, the methods of measurement of credit market variability and the dependence on external finance proved that the main conclusion of this paper is based on solid evidence.

5. CONCLUSION

The aim of this paper was to scrutinize the impact of credit market characteristics on labor productivity. Apart from the amount of loans, which has been extensively studied in the literature, I focused on credit market stability and tightness. I assumed that credit variability hampers long-term investment planning, including R&D spending, thereby leading to a decrease in value added per employee. I verified this prediction using sectoral data at 2-digit level of aggregation for Hungary and Poland, covering the period of 2005–2016. To attenuate the problem of endogeneity of the financial variables, I adopted a popular methodology which is based on weighting them by the indexes of dependence on external finance.

I did not find hard evidence that the stock of credit in the economy boosts labor productivity. The results were sensitive to the estimation method, the measurement of dependence on external finance, and, more importantly, to the inclusion of credit variability in the model. By contrast, the variability of the supply of loans extended to non-financial corporations turned out to reduce labor productivity, regardless of which the estimator and index of dependence on external finance were used. Credit market tightness, defined as excessive demand for credit, computed from the estimates of a credit market disequilibrium model, did not seem to affect value added per employee.

Focusing on the depth of the credit market is too narrow an approach to reveal the true relationship between financial development and labor productivity. The main message of this paper is that wide credit availability and relaxing of financial constraints are far less important stimulants of labor productivity than the stability of credit supply. Policymakers should promote the least volatile level of lending by banks because not just financial crises but any volatility of the supply of loans hurts the real economy.

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