Innovation and SME finance: Evidence from developing countries

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ABSTRACT

This paper explores the relationship between firm-level innovation and external finance for small and medium enterprises (SMEs). Our sample consists of 13,430 firms from Eastern Europe and Central Asian countries. A propensity score matching approach reports a positive relationship between formal finance and product and process innovations, which is greater for early-stage SMEs than for mature counterparts. However, informal finance has more significant impact on mature firms' product innovation. Our empirical evidence highlights policy implications for countries desiring to enhance the innovation of their SMEs by improving the external finance of these SMEs.

JEL Classification: O30; 031; G20; G21

Keywords: Developing countries; External finance; Innovation; SMEs; Propensity score matching methods.

1. Introduction

The literature has recognised the importance of innovation as a critical factor of the firm and economic development (Howells, 2005; Szirmai, Naudé, & Goedhuys, 2011). There is also a growing consensus that external finance plays a significant role in firm-level innovation (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011; Brown, Martinsson, & Petersen, 2012; Fernandez, 2017; Gorodnichenko & Schnitzer, 2013; Jie Wu, Si, & Wu, 2016). In particular, the availability of external finance is seen to be more beneficial to the development of small firms, which usually face cash constraints (Aghion, Fally, & Scarpetta, 2007; Guiso, Sapienza, & Zingales, 2004). However, accessibility to financing for small and medium enterprises (SMEs) is not uniformly available in all economies (Hewa Wellalage, Locke, & Samujh, 2019; HewaWellalage & Reddy, 2018; Lee, Sameen, & Cowling, 2015) and the type of finance options available to SMEs may vary according to the phase of their respective life cycle (Berger & Udell, 2006).

Related research by Fernandez (2017) examines the finance pattern of innovative and non-innovative private firms in Latin America. Her work seeks to determine the relationship between finance types and their effect on the firm's level of product and process innovation during different phases of their lifecycles. The expectation that the external financing opportunities of firms do evolve is thus crucial to firm level innovation for two reasons. First, it is essential to determine if there is a different level of financial friction based on firm age. Second, significant policy opportunities emerge if lowering financing costs or constraints and promoting sustainable balanced growth makes a key difference in ensuring firm level innovation for all SMEs. Even though some studies consider firm age to understand the financial behaviour of SMEs (Berger & Udell, 2006), little is known of the mechanism behind firm level innovation. In fact, the debate regarding costs and benefits of formal and informal finance receives mixed coverage in the literature (Degryse, De Jonghe, Jakovljević, Mulier, &

Schepens, 2016; Ullah & Wei, 2017). In this paper, we use the Business Environment and Enterprise Performance Surveys (BEEPS)[1], which provide cross-country firm-level data for Eastern Europe and Central Asian countries. Based on the surveys, we find that formal finance is associated with a higher firm-level product and process innovations for young firms compared to mature firms. In regarding formal finance sources, bank financing has the most significant effect on firm level innovation compared to non-bank finanincing. Also, we find that trade credit plays and important role as an informal financial source in firm level innovation.

This study makes a threefold contribution to the literature. First, we are contributing new evidence to the growing literature on SMEs and innovation by analysing SMEs' firm level innovation and firm external finance using micro-data. Growing evidence in research on capital markets and innovation stresses the significant impact of external financing in firm-level innovation activities (Rajan & Zingales, 1998). However, the channel through which access to finance affects firm-level innovation remains underdeveloped in the literature. Our paper, as far as we aware is the first to document how firm age matters in external financing and innovation dynamics. Start-ups firms face difficulties in accessing external finance because they are ''the most informationally opaque'' type of firms (Berger & Udell, 1998; Nunes, Gonçalves, & Serrasqueiro, 2013). Since the cost of funds increases with information asymmetry, innovative young firms are often excluded from a creditworthy category by financial institutions (Mina, Lahr, & Hughes, 2013; Schneider & Veugelers, 2010), which

[1] The World Bank and the European Bank develop the Business Environment and Enterprise Performance Surveys (BEEPS) jointly for Reconstruction and Development. BEEPS covers firms in 29 Eastern Europe and Central Asian countries. Based on face-to-face interviews with firm managers and owners, BEEPS reports firm characteristics, firm owners/managers demographic information, and business/institutional environment (http://www.enterprisesurveys.org/).

restricts their firm level innovation. We contribute to the literature by showing that the firm age is a relevant factor in the financing behaviour of SMEs and their firm level innovation.

Second, this study employs two direct measures of innovation for product and process, following the recommendation of the Oslo Manual[2]. The use of direct proxies differs from earlier works measuring innovation via indirect proxies such as R&D expenses and patents (Lööf & Nabavi, 2016; Mancusi & Vezzulli, 2010), which do not adequately capture the innovation of SMEs' behaviour in developing economies. Innovation in technologically developed countries typically involves R&D activities; however, in transitional and developing economies, it often involves imitation (Acemoglu, Aghion, & Zilibotti, 2006). Doubts concerning the propriety of using R&D as an innovation proxy for emerging markets and small firms are beginning to appear in the literature for several reasons. These include the fact that not all innovations are generated by R&D disbursement (Gorodnichenko & Schnitzer, 2013), formal R&D measurers are favourable for large firms (Archibugi & Sirilli, 2001) and, R&D is input rather than output oriented and not all R&D necessarily leads to innovation. We focus on core-innovation, such as product and process innovation, following the perspective of the European Bank for Reconstruction and Development (2014), that access to external credit has a discernible impact only on core-innovation but no distinct effect on soft innovation (marketing and organisations) for SMEs.

Third, the micro-econometric robustness of the analysis outdoes prior studies by dealing directly with causality and other endogeneity biases. We employ a propensity score matching (PSM) method to calculate the average treatment effects of external credit on firm

[2] The *Oslo Manual* is the leading universal source of guidelines for the collection and use of data on innovation activities in industry. This third edition in 2005 emphasizes the economic impact of the innovation process, and the experience gained from recent rounds of innovation surveys in OECD member and non-member countries (www.oecd.org/sti/oslomanual). The *Oslo Manual i*ntroduces four types of innovation: product, process, organisational and marketing.

level innovation activities. A PSM method allows non-randomised studies similar to randomised experiments to be designed (Rubin, 2001). The underlying concept of propensity scoring is matching treated with untreated participants. We examine the observable characteristics of firms with and without external finance and then compare the innovation levels between firms with external finance and firms without external finance that have the same external finance propensity. The estimated effect is given by the post-treatment variable, external finance.

The remainder of the paper consists of five sections. Section 2 reviews prior research while Section 3 described the data, variables, methods and procedures used in the empirical section. The estimation results are presented and discussed in Section 4. Lastly, Section 5 concludes the discussion.

2. External finance and innovation

Most developing markets are characterized by a bank-based formal financial system with weak equity and debt markets. In particular, Beck, Demirgüç-Kunt, and Maksimovic (2008) report that bank finance is the most dominant external funding source for SMEs in developing countries. Therefore, the development of the formal finance sector is positively related to the firm-level innovation (Chava, Oettl, Subramanian, & Subramanian, 2013; Cornaggia, Mao, Tian, & Wolfe, 2015). For instance, Benfratello, Schiantarelli, and Sembenelli (2008) relying on the data for Italian firms, report a positive effect of banking development on firm-level innovation. Cornaggia et al. (2015) in turn, find that small innovative firms depend mainly on bank financing, more so than publicly-traded companies. Furthermore, Amore, Schneider, and Žaldokas (2013) and Chava et al. (2013) find that banking industry deregulation has a significant positive impact on the quantity and quality of firm-level innovation activities.

Access to formal financing may have a significant positive impact on firm-level innovation in several ways. First, innovation is a long-term process with a coherent design of planning, designing, testing and process development. Consequently, long-term or medium-term maturity loans offered by formal financing providers should allow innovative firms to enjoy an opposite repayment period; hence, encouraging a positive relationship between formal financing and firm-level innovation activities. Second, formal financial institutions provide loans at an affordable interest rate due to regulatory monitoring and control, restricting inappropriately high rates, all of which forms part of the license for acquiring formal banking status. Therefore, formal financial institutions reduce the financial burden for innovative firms, and this, in turn, promotes innovation.

Another strand of the literature reports the role of informal financing in supporting innovation and firm growth. Innovative firms often face difficulties in accessing formal finance, in particular, credit from banks (Freel, 2007). Innovative UK medium-sized enterprises were more likely to be turned down for finance than other firms during 2007–2012, and this effect worsened during the financial crisis Lee et al. (2015). Such financial barriers can be observed more frequently for innovative SMEs in developing economies, characterized by underdeveloped financial markets and limited alternatives for capital. In such an environment, innovative firms must rely on informal finance (Buyinza & Bbaale, 2013). Although bank financing is critical to firm-level innovation, bank financing is more appropriate for large and mature firms' innovation (Kerr, Nanda, & Rhodes-Kropf, 2014). A bank loan, in these circumstances, may be costlier for entrepreneurs than informal financing.

Informal finance leads to the innovation for entrepreneurs in several ways. It provides greater flexibility (Jie Wu et al., 2016), high accessibility (Lin & Sun, 2006), and short processing time and lower transaction costs (Armendariz & Morduch, 2007). In order to minimise the consequences of asymmetric information, banks require a premium to

compensate for adverse selection, and borrowers use collateral to signal the quality of their project (Hanedar, Broccardo, & Bazzana, 2014). However, the usual exclusion of intangible assets as collateral for formal funding excludes some innovative firms from the formal credit market since limited sized loans or a higher rate are not available.

In contrast, informal debt providers offer finance through relationships and enable innovative firms to acquire finance with limited or no tangible collateral (Degryse et al., 2016). Such informal loans can be reasonably priced, as such lending is a local activity that depends on informal finance providers' superior knowledge of their borrowers (Madestam, 2014). Also, Ghate (1992) reports that informal lenders are competent to monitor borrowers by lending to a group of known borrowers where social ties and relationships play an important role in their lending.

Close monitoring by informal lenders serve to reduce the agency problems of SMEs', which allows formal finance providers to lend to bank-sanctioned innovative firms. Based on an SME sample, Dybvig, Shan, and Tang (2016) find formal financial institutions outsource the screening and monitoring for informal lenders. Banks usually screen firms carefully before providing bank loans to avoid type I (reject sound lending proposals) and type II (consent poor lending proposals) errors. Screening and monitoring are costly, and it may be simpler to reject innovative firms. However, informal finance providers are better in monitoring their clients (Andersen & Malchow-Møller, 2006), and thus, their monitoring helps formal finance providers to provide credit for innovative firms at a lower cost.

Empirical evidence suggests that external financing for SMEs is extremely important, especially for young firms (Berger, Espinosa-Vega, Frame, & Miller, 2011; Berger & Frame, 2007; Berger & Udell, 1998). However, obtaining external financing is difficult for young firms for two reasons: information asymmetry and the moral hazard problem (Denis, 2004).

Start-up firms are ‘‘the most informationally opaque’’ type of firms (Berger & Udell, 1998; Nunes et al., 2013) and it may be difficult for investors to comprehend the firm’s value (Nofsinger & Wang, 2011).

Additionally, extremely limited information on innovation in young firms exacerbates the asymmetric information problem. Limited information prevents external lenders from evaluating the quality of funding applications, failing to produce equilibrium prices and efficient transactions (Stiglitz, 2000). Therefore, information asymmetry will limit a firm’s external credit accessibility and affect its financing and investment decisions (Tang, 2006). This information friction leads to high loan costs pricing the risk of high loan default rates. Since the cost of funds with information asymmetry, young firms are often excluded from a creditworthy category by financial institutions (Mina et al., 2013; Schneider & Veugelers, 2010) and that may restrict funds for their firm level innovation. Therefore, the positive relationship between formal finance and firm level innovation may be greater in early stage firms than in later stage firms.

3. Data

Data are assembled from the Business Environment and Enterprise Performance Survey (BEEPS) 2013. The BEEPs are jointly produced by the World Bank and the European Bank for Reconstruction and Development and comprise representative random samples of firms across 29 Eastern European and Central Asian economies[3] of which 14 countries are from the former Soviet Union[4]. We have selected the 29 economies for our study. The surveys employ stratified random sampling techniques with identical questionnaires across all countries. This

3 Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Mongolia, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Tajikistan, Turkey, Ukraine, and Uzbekistan.

4 Former Soviet Union countries are Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Ukraine, and Uzbekistan.

stratified random sampling ensures a representative sample, which minimises sample selection biases in data analysis. The strata are firm size, business sector, and geographic region within a country.

Our study utilises 13,430 SMEs. The Enterprise Surveys are undertaken by the World Bank in 2013 (www.enterprisesurveys.org) categorise Eastern European and Central Asian firms having 5 to 99 employees as SMEs, and that is the definition used in this study[5]. Firms with fewer than five employees (micro firms) and, those with more than 100 employees (large firms) are excluded from this study sample.

3.1 Variables

We use product innovation, process innovation (Gorodnichenko & Schnitzer, 2013; Mahagaonkar, 2010) and product and process innovation as main dependent variables in our study The *Product_Inno* and *Process_Inno, Product& Process* variables were derived from the following survey question(s):

> *During the last three years, has this establishment introduced new or significantly improved products or service methods of manufacturing products or offering service?*

The *Product_Inno* dummy variable takes the value one if the firm introduced new or significantly improved products or service products during the last three years and zero otherwise.

The *Process_Inno* dummy variable takes the value one if the firm introduced new or significantly improved methods of manufacturing products during the last three years and zero otherwise.

[5] There is no universal definition for SMEs. The most frequent upper limit designating an SME is 250 employees, as in the European Union. The United States in turn considers SMEs to include firms with fewer than 500 employees.

The *Product & Process* dummy variable takes the value one if the firm introduced new or significantly improved products or service products and if the firm introduced new or significantly improved methods of manufacturing products during the last three years and zero otherwise.

The stream of literature on emerging markets has recently shifted towards direct measures of innovation for several reasons (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2014; Gorodnichenko & Schnitzer, 2013). Most obviously, the traditional measures of innovation, such as R&D expenditure and patents, are less likely to be observable in domestically owned small firms (Acemoglu et al., 2006) and emerging markets (Gorodnichenko & Schnitzer, 2013). Some doubts have been expressed in the literature concerning the propriety of using R&D as an innovation proxy for SMEs in emerging markets because not all innovations are generated by R&D disbursement (Gorodnichenko & Schnitzer, 2013), formal R&D measures are favourable for large firms (Archibugi & Sirilli, 2001) and, R&D is input rather than output oriented and not all R&D necessarily leads to innovation. Also, measures of innovation in developed markets are relatively tightly defined, as it does not include firms to adopt innovation from elsewhere (Lee et al., 2015). However, capturing the catching up process of innovation is important for SMEs in emerging markets firm (Acemoglu et al., 2006; Ayyagari et al., 2011, 2014). Therefore, the proxies above adequately capture both the innovations that are new to the firm and those that are new to the world.

Nevertheless, we acknowledge that self-reported measures of innovations are more prone to measurement errors and biases than more objective measures such as R&D and patents. Prior research also acknowledges the subjectivity of these self-reported measures of innovation (see (Gorodnichenko & Schnitzer, 2013). Nevertheless, in a given context, the majority of the sampled SMEs are not engaged in R&D and patents.

Independent variables capture formal and informal finance for working capital. Formal finance includes loans from banks (state-owned and private) and non-bank institutions. Informal finance includes trade credits and loans from friends, families and money lenders. The definition of informal finance varies across the studies. As an example, Allen, Qian, and Qian (2005) define informal finance as all finance beside bank loans. In a cross-country study, Ayyagari, Demirgüç-Kunt, and Maksimovic (2010) include internal financing in the informal category.

Table A1 in the Appendix presents definitions and metrics for the dependent variable: Product_Inno; Process_Inno; Product & Process), independent variables: dummy variables for formal (Formal) and informal (Informal) financing and control variables: dummy variables for firm size (Small and Medium), firm age (firm Age), firm ownership (female Owner and Foreign Own%), collateral availability (Collateral), R & D expenses (R & D), manager experience (Mgr_Exp) and senior manager time dealing with regulations (Regulations), industry (30 sub-industry categories), and country (29 countries) dummies.

The control variables chosen for the analysis are standard in the literature (See Lee et al., 2015). Firm size- This is an important control variable. Smaller firms are less likely to benefit from economies of scale, which results in a lower level of innovation. Literature report that firm size has a positive relationship with the propensity of firm level innovation (Gorodnichenko & Schnitzer, 2013). Firm age- Theory and empirical evidence show that young firms invest more in R&D than incumbents when the task is to enter new markets. In a similar vein, Ayyagari et al. (2011) and Gorodnichenko and Schnitzer (2013) find that young firms tend to engage with more product innovation than older firms. Foreign_Own % - This factor has been evidenced to significant positive effect on frim level innovation, because of foreign ownership transfer superior technologies, which is required to product and process

innovation of their subsidies (Guadalupe, Kuzmina, & Thomas, 2012). Female - Several studies show that gender diversity has an impact to firm level innovation (Díaz-García, González-Moreno, & Jose Sáez-Martínez, 2013; Sastre, 2016; Teruel & Segarra-Blasco, 2017; Tonoyan & Strohmeyer, 2006). Two hypotheses are plausible: One suggests that women are risk-averse than men, which would be detrimental to innovation, given that innovation is inherently a risky procedure. On the other hand, several scholars argue that female participation improves firm innovation because they bring different skills to the firms. Collateral- The importance of collateral value that a firm can use to secure funds for innovation is an important factor for firm level innovation. Studies find that higher collateral value increases the quantity, quality and novelty of innovation (See Mao, 2017). R & D- Prior studies report that R & D expenditures can have a significant impact on firm level innovation, there following (Jie Wu, 2013) and (Jie Wu et al., 2016) we controlled SME's R & D expenditure. Mgr_Exp- Balsmeier and Czarnitzki (2014) report positive relationships between the industry-specific experience of the top-manager and the decision to innovate. Therefore, we include manager experience as a covariant of our study, which may impact on firm level innovation. Regulations- Innovative frims in developing and emerging economies with heavily regulated industries (Djankov, McLiesh, & Shleifer, 2007) may face bureaucratic barriers to get licenses, permits and certifications (D'Este, Iammarino, Savona, & von Tunzelmann, 2012; Hadjimanolis, 2000), which can restrict SMEs innovation (Anokhin & Schulze, 2009). Therefore, we controlled regulation complexity as well. Also, following prior innovation studies, we controlled country and industry affect using dummy variables (See Ayyagari et al., 2011, 2014; Jie Wu et al., 2016).

Descriptive statistics for the data are presented in Tables 1 (individual countries) and 2 (whole sample). Table 1 reports a number of firms, product innovation, process innovation and both product and process innovation percentages for individual countries. Additionally, the percentage of firms with the bank, non-bank, supplier credit and informal funds (funds from

friends and family) are also reported in Table 1. On average, 21% of the sampled firms were product innovators, and 17% of sample firms introduced new processes. Approximately 11% of SMEs are engaged in both product and process innovation. The highest innovation is reported from Serbia, which indicates that above 35% of Serbian SMEs introduced new products, while 28% introduced new processes. Interestingly above, 22% of SMEs introduced both new product and processes in Serbia in the last three years. The lowest innovation rate is reported by Latvia, where only 9% and 7% of SMEs introduced new products or processes, respectively. The main external financing source is bank financing, which indicates that approximately 28% of sample firms have bank financing. This is aligned with the idea that bank finance is the most dominant external financing provider for small firms in developing and transition economies (Beck et al., 2008). Also, Table 1 report that the second major source of external financing for SMEs is trade credit. Further, we can see non-bank loans, trade credit, and informal credit are, on average, 9, 26, and 12%, respectively. That is, over 40% of financing for the sampled SMEs come from non-bank sources.

Table 2, in turn, shows that most sampled firms belong to the retail and wholesale sectors (23 and 16%, respectively). The percentage of foreign ownership of this study sample is low (average foreign ownership is 4%). Small firms predominate as almost 58 % of the sample, and 42 % of medium size firms contributed. The average age of sample firms is 14 years.

<<Insert Table 1 here >>

<<Insert Table 2 here>>

4. Model Specifications

4.1 Endogeneity of the innovation and external finance relationship

Endogeneity of innovation and external finance occurs when a predictor variable correlates with the error term (Antonakis, Bendahan, Jacquart, & Lalive, 2010)[6]. Endogenous sample selection biases are a common problem in survey data, which is stem from three sources (Härkänen, Kaikkonen, Virtala, & Koskinen, 2014). First, missing data by design: only part of the finite population is selected in the sample. Second, unit-non-response: not all individuals in the sample respond and third, item non-response: some survey participants do not respond to one or more individual question. Selection models, fixed-effects models, and instrumental variables are heavily used in the literature as techniques to deal with endogeneity; however, those techniques have their own limitations (Ayyagari et al., 2010, 2011, 2014).

Although field experiments are used to correctly estimate causal effects, they are impractical. This has encouraged researchers to rely on observational data, which makes it difficult for scholars to measure unbiased causal effects (Li, 2013). In recent times, the propensity score matching (PSM) technique has increased the ability of researchers to draw causal inferences using observational data. PSM control self-selection biases and causal interferences by placing them into a non-random assignment (Rosenbaum & Rubin, 1983). Further, PSM analysis does not impose any specific linearity assumptions on the treatment effects that are intrinsic in the regression-based modelling (Böckerman & Ilmakunnas, 2009). This method has been widely applied in cross-sectional studies.

4.2 Methodology

The direct comparison of firms having external credit and others that do not leads to an identification problem. External credit accessibility may be correlated with both observable

[6] Apart from reverse causality or simultaneity, omitted variable biases, measurement errors, and unobservable heterogeneity are the main types of endogeneity problems which occur in the innovation and credit constraints relationship. In the robustness section, using a recursive probit model, we control both simultaneity and unobservable heterogeneity.

and unobservable factors of firms. If the study fails to correct for this bias, the estimates will give naïve and overestimated results of the impact. Following Rosenbaum and Rubin (1983), we perform PSM to pair firms that have external credit with other firms that are similar but without external credit. It is then assumed that the matched firms would have non-systematic differences in response to the treatment, so they provide valid counterfactual evidence. We estimate the probability of having external finance as a function of observed characteristics and rank firms with and without external finance by their propensity scores. We then pair individual firms with external finance and firms without external finances with similar propensity scores and calculate the average difference in innovation across them.

In this study, we are comparing the propensity of innovation of firms who exposed to no treatment T=0 (no external finance) and the propensity of innovation of firms that are exposed to treatment T=1 (external finance). The PSM method will construct a control group with observed characteristics that are as similar as possible to the treated group, except for the external finance. Technically, the sample population comprises of treated firms (external finance) and untreated firms (no external finance).

Specifically, we estimate the average treatment on the treated (ATT), that is the difference in innovation between those treated and their corresponding counterfactuals determined by a matching method (Cox-Edwards & Rodríguez-Oreggia, 2009; Ichino, Mealli, & Nannicini, 2008).

Following Becker and Ichino (2002), we use four matching methods: stratification matching, nearest-neighbor matching, kernel matching, and radius matching. The standard error for the ATT is calculated using a bootstrapping procedure. For instance, under nearest-neighbor matching (M), ATT is given by

$$ATT^{M} = \frac{1}{N^{T=1}} \sum_{i \in T=1} \left[Y_i^{i \in T=1} - \sum_{j \in T=0} \omega_{ij} Y_j^{j \in T=0} \right]$$

where $\omega_{ij} = 1/N_i^{T=0}$ if $j \in C(i) = \min_j ||p_i - p_j||$; and 0 otherwise, where C is the set of control units, and p is the propensity score.

5. Results

Formal Financing: Table 3A (Panel A), includes all matching models and shows that the ATT is statistically significant and positive for product and process innovations. Through a comparison of the different matching models for product, innovation indicates that the magnitude of the ATT ranges from 0.043 with the stratified matching technique to 0.076 with the radius matching method. The magnitude of the ATT for process innovation ranges from 0.028 with the stratified matching technique to 0.063 with the radius matching method. Therefore, the estimated positive average effect of formal finance on product innovation and process innovation outcomes for firms that have formal finance is between 4 and 8 percent, and 3 to 6 percent, respectively.

Informal Financing: Table 3A (Panel B) reports that, with the exception of nearest neighbour matching, the ATT is positive for product and process innovation. Under nearest neighbour matching, some of the matches between treated (firms with informal finance) and non-treated (firms without informal finance) may be poor because, for some treated firms, the nearest neighbour may have a very different propensity score, but it contributes to the estimation of the ATT (Morris, 2007). Although stratification matching shows a positive ATT, it is not statistically significant (i.e., small t-value). When the nearest neighbour and stratified matching methods are excluded, the results indicate that the estimated positive ATT of informal finance on product innovation and process innovation for firms that have informal finance is between 3 and 4 percent, and 2 and 4 percent, respectively

The descriptive statistics showed that approximately 10% of sampled firms were engaged in both product and process innovation. Therefore, Table 3B reports external financing (Panel A- Formal financing and Panel B- Informal financing) for joint product and process innovation. The estimated ATT of formal finance is between 3 (stratified matching) and 7 percent (radius matching). Also, the estimated ATT of informal finance on both product and process innovation is between 2 (stratified matching) and 4 percent (kernel matching).

Overall our results indicate that both formal and informal finance have a positive impact on firm level innovation, which is consistent with the findings in the vast majority of studies on innovation discussed in Section 2. However, extending prior studies, our study reports that formal finance has a more significant impact on firm level innovation than informal finance. As documented in the extant literature discussed in the Introduction, formal financial institutional loans with long-term maturity and affordable interest rates may encourage a positive relationship between formal financing and firm-level innovation activities.

<<Insert Table 3 here>>

5.2 Firm level product innovation and external financing types

Table 4A reports that the estimated PSM results of product innovation for formal financing sources (bank and non-bank financing) and informal financing sources (trade credit and funds from friends and family)

The ATT of bank finance and trade credit on product innovation outcome is between 3 to 7 percent and between 3 to 4 percent, respectively. However, small t-values indicate that non-bank financing and informal funds from friends and families do not have a statistically significant impact on firm level product innovation. In fact, bank finance has the most significant effect on firm level product innovation.

5.3 Firm level process innovation and external financing types

Table 4B reports the ATT of process innovation for formal financing sources (bank and non-bank financing) and informal financing sources (trade credit and funds from friends and family). The results indicate that trade credit has the most significant effect on firm level process innovation. In particular, the positive ATT of trade credit on process innovation outcome is between 3 and 4 percent.

<< *Insert Table 4 in here*>>

5.4 Firm age, external finance and innovation relationship

Formal finance: The estimated ATT of formal finance on product innovation and process innovation outcomes for young firms is 7-10 percent and 3-4 percent, respectively (Table 5 Panel A). In turn, the estimated ATT of formal finance on product innovation and process innovation outcomes for mature firms is 3-5 percent and 2-3 percent, respectively (Table 6 Panel A). This demonstrates that the positive relationship between formal finance and firm level product and process innovation is greater in young firms than mature ones.

Informal finance: Informal finance has no statistically significant impact on firm level innovation for young firms (Table 5 Panel B). However, Table 6 Panel B illustrates that the ATT of informal finance on product innovation for mature firms is 3-5 percent. Unlike formal finance, these results indicate that the positive relationship between informal finance and firm level product innovation is greater in mature firms than in young firms.

Overall, our results indicate that formal finance has a more significant effect on the firm level innovation of young firms; whereas informal finance plays a more role in the innovation level of older firms than young ones.

5.5 Validity of the method

Following Li (2013), we check the covariate balance summary and overlap distribution to confirm the validity of the PSM model.

Covariate balance summary: this reports the model-adjusted difference in the mean and ratio of variances between the treated and untreated groups for each covariate. For every reported case, the differences in weighted means are negligible, and the variance ratios are all near one. This indicates that the covariate balance is met. We report Covariate balance summary in Appendix 1 Table A2.

Overlap in the distribution: we also checked the overlap and common support assumptions for formal and informal finance for product and process innovation using the graph. Figure 1 shows the kernel densities of the propensity score, including all control variables. Our matching satisfies the overlap and common support assumptions for formal and informal finance. Indeed, the figure illustrates a substantial overlap in the distribution.

<<Insert Figure 1 here>>

6. Robustness check

This study tests the robustness of results against three scenarios:

6.1 Probit and IV probit analysis of external finance and firm level innovation

Table 7A and 7B report the relationship between innovation and external finance for SMEs using probit and IV probit models. Estimating relationships between innovation and external finance (formal and informal) by probit model may lead to biased estimates due to the problem of endogeneity. According to the traditional view, the direction of causality runs from finance to innovation; for example, a high level of external funds may force firms to make optimal investment decisions and engage in innovation activities. This interpretation is consistent with the accepted strategic relevance of forms of seed funding in stimulating firm level innovation activities. Nevertheless, the possibility of causality running in the opposite direction is worth testing. Innovative projects may have more demand for external finance because innovative firms need capital to finance their activities. Reverse causation, following Smith and Blundell

(1986), checks endogeneity between external finance (formal and informal) and innovation. The null hypothesis assumes the model is appropriately specified with all explanatory variables being exogenous.

Our finding does not support the null hypothesis that the innovation and external finance proxies are exogenous at a significance level of one percent. An instrumental variable (IV) probit model corrects for this endogeneity bias. We report IV probit estimation with *Avg_Formal* and *Avg_Informal* instrument variables. The instrument for firm external finance (formal and informal finance) is location-size-industry averages. We use the average values of formal and informal finance, and index by firms in a specific industry in a similar-sized location within a country. The location-size-industry averages should also serve to mitigate the effects of measurement error since these errors are idiosyncratic to the firm. The F-test for instrument relevance calculates *Avg_Formal* as 34.15 and *Avg_Informal* as 36.78, suggesting instruments are relevant. The statistics are well beyond the rejection range for the null, enhancing confidence that the instrument set is appropriate, the proposed instruments are well specified, and the econometric findings are robust.

Table 7A reports the relationship between product and process innovations and formal finance. The results suggest that formal finance is related positively to the firm-level innovations of Central Asian and Eastern European SMEs. In the IV probit model, Avg_Formal (the instrument for formal) increase the standardised IV probit index by .0167 and .0155 standard deviations of product and process innovations respectively and is statistically significant at the one percent level. When considering the marginal effect, our results show that the probability of product (process) innovation increase by 0.6% (0.4%) for firms' formal finance percentage goes up by one. This result is also consistent with prior empirical evidence that suggests a positive relationship between bank financing and innovation (Benfratello et al., 2008; Herrera & Minetti, 2007). Therefore, following Ayyagari et al. (2011), this study can

conclude that there is a positive relationship between product and process innovations and the level of formal finance in the firm.

Table 7B provides probit estimation results for the relationship between informal finance and product and process innovations. *Avg_informal* (the instrumental variable for informal finance) is positively correlated with SMEs' innovation level and is significant at a one percent level. Considering the marginal effect, our results show that the probability of product (process) innovation increase by 0.8% (0.5%) for firms' informal finance percentage goes up by one.

<<Insert Table 7 in here>>

6.2 Average Treatment Effect (ATE)

We report the average treatment effect (ATE) in the whole population of firms (Hirano & Imbens, 2004). Unlike ATT, ATE is the average effect of treatment (external finance) on the innovation level of the whole population of firms (i.e., those that get external finance and those that do not). ATT and ATE will not necessarily be equal because of selection bias. (ATT = ATE only in randomized controlled trials.)

In line with our main results, ATE estimates show that external financing has a positive impact on firm level innovation. Furthermore, Table 8 indicates that the ATE of formal financing is higher than the ATE of informal financing for firm level innovation.

<<Insert Table 8 here>>

6.3 Sub-sample analysis

As a second robustness check, we divided the full sample into three groups based on their capital market development indicator using the ratio of their market capitalisation to gross domestic product. Larger values represent broader stock markets, characterised by less volatility, less information asymmetry, greater liquidity, and more vigorous information

discourse requirements. Even in this sub-sample, the results confirm our main study results of a positive relationship between innovation and external finance. Further, this sub-sample analysis shows that external finance has a significant effect on firm-level innovation of SMEs. However, the magnitude of innovation varies according to the level of capital market development[7].

7. Conclusion and policy implications

We investigated the relationship between external financing and firm-level innovation of SMEs in Central Asia and Eastern Europe by assessing the impact of external finance and innovation. We concluded that having formal finance is positively associated with firm level product innovation (4-8%) and process innovation (3-6%). That effect is higher for young firms' product innovation (7-10%) and process innovation (3-4%) compared to mature firms' product innovation (3-5%) and process innovation (2-3%). Although informal finance has no significant impact on the firm level innovation of young firms, informal finance has a significant positive impact on the firm level product innovation of mature firms (3-5%).

Our study has several significant policy implications. First, it is important to have a broader formalised financial system that is capable of taking care of entrepreneurs and the different stages of the life cycle of small firms. Formal finance providers, such as banks and micro-finance institutions, need to expand their ability to serve SMEs, in particular, young firms at the community level, in order to provide business growth. Formalising the activities of informal financial institutions will not just make it easier to access finance for SMEs, but also will expose the banks to the competition. This increases the availability of low-cost finance for innovative SMEs.

[7] This result is available upon request.

There are demand and supply side forces requiring the application of an appropriate theory. From an agency-theory perspective, incentives for formal financial institutions to increase returns to their stakeholders, or more effectively manage risk, are missing. Bonding to either or to both of these objectives is needed to improve the flow of funds to innovative SMEs. Monitoring and enforcement cost money, and inducement payments to encourage change are not free.

On the demand side, there is an issue that SMEs, in some regions, see significant benefits from not being part of the formal sector. Where it is possible to remain "hidden", there are at least two advantages. First, there is the avoidance of government regulations that might impede SME owners from attaining their goals. Payment of taxation, licences, and registration fees present an unnecessary impediment to success where avoidance at low risk is available. It does, however, mean no access to formal sector finance which, in turn, may result in a higher cost through moneylenders. Yet this cost may still be lower than the disadvantage of paying taxes.

Integration of the informal sector into the formal sector provides opportunities for expanding innovation. Inducements and penalties are not dichotomous choices. Moneylenders who are encouraged to bring themselves under central banking controls can expand their businesses with a supply of inexpensive central bank funds, make more profit and reposition their social standing. Theory suggests that cultural and social context is an essential component of achieving congruence with a goal of more finance for innovative SMEs.

Further research is necessary for several areas. Consideration of whether the results are limited to Eastern Europe and Central Asia or are more generally applicable will guide policy. The institutional environment of the country may have a significant impact on firm-level

innovation, and access to finance and further comparative work investigating this nexus will make a useful contribution to understanding the issues involved.

Appendix 1

Table A1: Variable description

Variable Name	Description	Measurement
Dependent variables		
Product_Inno	This takes the value of 1 if the firm introduced new or significantly improved products or service, otherwise 0.	*1=yes; 0=otherwise*
Process_Inno	This takes the value of 1 if the firm introduced new or significantly improved methods of manufacturing products or methods of offering service, otherwise 0.	*1=yes; 0=otherwise*
Product & Process	This takes the value of 1 if the firm introduced new or significantly improved products or service and if the firm introduced new or significantly improved methods of manufacturing products or methods of offering service, otherwise 0.	*1=yes; 0=otherwise*
Independent variables		
Formal	This takes the value of 1 if the firm level formal financing percentage is >0, otherwise 0.	*1=yes; 0=otherwise*
Informal	This takes the value of 1 if the firm level informal financing percentage is >0, otherwise 0.	*1=yes; 0=otherwise*
Small	The firm has 5 to 19 employees	*1=yes; 0=otherwise*
Medium	Firm has between 20 and 99 employees.	*1=yes; 0=otherwise*
Foreign_Own%	Percentage of private foreign individuals, companies or organizations	Range from 0% to 100%.
Female	The firm has at least one female owner	*1=yes; 0=otherwise*
Firm_age	A number of years from the date of establishment.	Years
Mgr_Exp	A number of years' experience of the firm's manager.	*Year(s)*
R&D	This takes the value of 1 if the firm has allocated funds for R & D, otherwise 0.	*1=yes; 0=otherwise*
Collateral	This takes the value of 1 if the financing required collateral for most recent loan or line of credit, otherwise 0.	*1=yes; 0=otherwise*
Regulations	Percentage of total senior management's time spent on dealing with requirements imposed by government regulations in a typical week over the last year.	Percentage
Industry	Dummy variables representing 30 sub-industries: Manufacturing industries dummies: Food; Tobacco, Textiles, Garments, Wood, Paper, Publishing & Printing, Chemical, Plastic & rubber; Non-metallic mineral; Basic metals; Fabricated Metals; Machinery & equipment; Electronics; Precision instruments; transport machines, Furniture Retail industry dummy: Retail	

	Other Services industry dummies: Wholesales, IT; Hotel & restaurant; Services for motor vehicles; Construction Section; Post; Tanning; Communication; Office management; IT support; Other Services	
Country	Dummy variables representing 29 countries Country dummies: Albania; Armenia; Azerbaijan; Belarus; Bosnia-Herzegovina; Bulgaria; Czech Republic; Estonia; Georgia; Hungary; Kazakhstan; Kosovo; Kyrgyzstan; Latvia; Lithuania; Macedonia; Moldova; Mongolia; Montenegro; Poland; Romania; Russia; Serbia; Slovakia; Slovenia; Tajikistan; Turkey; Ukraine; Uzbekistan.	

Table A2: Covariate balance summary

Covariate balance summary for formal finance and firm level innovation

	Raw	Matched
Number of obs =	12,854	25,708
Treated obs =	4,278	12,854
Control obs =	8,576	12,854

	Standardized differences		Variance ratio	
	Raw	Matched	Raw	Matched
medium	-.6931712	.0587968	.6553401	1.016817
small	.6931712	-.0587968	.6553401	1.016817
foreign_own	.0025152	.0331112	.948528	1.095781
female	.0162337	-.0210293	1.011363	.9848041
firm_age	.1399886	-.005473	1.098061	.6871328
mgr_exp	.0959822	-.0081163	.9452109	.8527352
R&D	-.100192	-.0290512	.5223606	.8367153
Collate	-.0325415	.0029733	.8198154	1.018146
Regulation	-.0338913	.0154693	.8177806	1.095355

**Twenty nine countries and 30 industries also included this covariate balance summary*

Covariate balance summary for Informal finance and firm level Innovation

Covariate balance summary

	Raw	Matched
Number of obs =	12,854	25,708
Treated obs =	3,780	12,854
Control obs =	9,074	12,854

	Standardized differences	Variance ratio

	Raw	Matched	Raw	Matched
medium	-.0518013	-.0127876	.9815532	.9956144
small	.0518013	.0127876	.9815532	.9956144
foreign_own	.0504593	.0080658	1.215148	.9870232
female	.066526	-.0154892	1.045372	.9892559
firm_age	.0814286	.0231531	1.134588	.9482746
mgr_exp	-.0210789	.0071296	.8750968	.8904564
R & D	-.0199039	.0118599	.8874031	1.070742
Collat	-.0086254	-.0074953	.9495799	.9552709
Regulation	-.0644685	.0051622	.6728718	1.029819

**Twenty nine countries and 30 industries also included this covariate balance summary*

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Table 1

Individual countries

Country	No. firms	Product Innov %	Process Innov %	Product & process Innov %	Firms with bank loan %	Firms with non-bank loan %	Firms with trade credit %	Firms with informal credit %
Albania	348	0.213	0.167	0.086	0.155	0.080	0.305	0.144
Armenia	342	0.149	0.149	0.064	0.228	0.146	0.307	0.178
Azerbaijan	358	0.196	0.154	0.095	0.204	0.137	0.291	0.184
Belarus	297	0.249	0.178	0.118	0.185	0.121	0.259	0.175
Bosnia-Herzegovina	314	0.159	0.131	0.061	0.156	0.089	0.274	0.140
Bulgaria	237	0.186	0.135	0.084	0.160	0.105	0.316	0.165
Czech	212	0.198	0.151	0.094	0.090	0.066	0.278	0.104
Estonia	244	0.164	0.111	0.070	0.135	0.082	0.254	0.086
Georgia	319	0.179	0.150	0.103	0.185	0.132	0.235	0.166
Hungary	447	0.168	0.181	0.110	0.159	0.087	0.197	0.121
Kazakhstan	516	0.140	0.093	0.056	0.143	0.076	0.180	0.114
Kosovo	199	0.106	0.055	0.045	0.131	0.070	0.211	0.121
Kyrgyzstan	234	0.132	0.094	0.073	0.141	0.051	0.167	0.068
Latvia	292	0.089	0.065	0.034	0.123	0.068	0.192	0.089
Lithuania	234	0.115	0.068	0.051	0.150	0.098	0.222	0.115
Macedonia	321	0.150	0.131	0.084	0.150	0.069	0.153	0.100
Moldova	313	0.188	0.147	0.086	0.118	0.048	0.169	0.061
Mongolia	118	0.144	0.144	0.051	0.186	0.051	0.169	0.068
Montenegro	129	0.326	0.264	0.194	0.535	0.140	0.341	0.186
Poland	449	0.261	0.225	0.165	0.486	0.105	0.325	0.116
Romania	459	0.316	0.257	0.181	0.538	0.098	0.296	0.115
Russia	3790	0.277	0.228	0.154	0.364	0.066	0.269	0.124
Serbia	291	0.354	0.282	0.220	0.498	0.065	0.271	0.117
Slovakia	233	0.305	0.197	0.146	0.532	0.052	0.283	0.103
Slovenia	230	0.313	0.261	0.187	0.483	0.048	0.313	0.065
Tajikistan	315	0.225	0.194	0.108	0.556	0.108	0.340	0.124
Turkey	1075	0.224	0.167	0.114	0.467	0.077	0.253	0.092
Ukraine	844	0.275	0.211	0.141	0.456	0.072	0.289	0.111
Uzbekistan	270	0.293	0.200	0.133	0.404	0.115	0.296	0.144
Total	13,430							
Average		0.210	0.165	0.107	0.280	0.087	0.257	0.121

Table 2

Whole sample: Descriptive statistics

Variable	Obs	Mean	Std.Dev	Min	Max
Product Innovation	13,430	0.210	0.421	0	1
Process Innovation	13,430	0.165	0.388	0	1
Product & Process Inno	13,430	0.107	0.327	0	1
Formal	12,758	0.299	0.458	0	1
Informal	12,744	0.260	0.439	0	1
Foreign Ownership %	13,309	3.923	17.83	0	100
Mgr_Exp	13,050	16.32	9.862	1	70
Firm age	13,297	13.88	9.740	0	148
Regulations	11,959	15.51	20.69	0	100
R & D	9,513	.1086	.3111	0	1
Small-sized	13,430	.5812	.4934	0	1
Medium-sized	13,430	.4188	.4934	0	1
Female owner	13,430	.3333	.4714	0	1
Collateral	4,215	.7808	.4138	0	1

Manufacturing Industry	Obs	Share
Food	829	6.1%
Tobacco	17	0.1%
Textiles	228	1.7%
Garments	458	3.4%
Wood	291	2.1%
Paper	291	2.1%
Publishing & Printing	344	2.5%
Chemical	330	2.4%
Plastics & rubber	277	2.0%
Non Metallic mineral	540	4.0%
Basic metals	64	0.5%
Fabricated metal	530	3.9%
Machinery & equipment	445	3.3%
Electronics	183	1.3%
Precision instruments	154	1.1%
Transport machines	266	2.0%
Furniture	301	2.2%
Retail	3,098	22.8%
Other Services		
Wholesales	2,184	16.1%
IT	207	1.5%
Hotel & restaurants	563	4.1%
Services for motor vehicles	365	2.7%
Construction Section	1,115	8.2%
Post	137	1.0%
Tanning	58	0.4%
Communication	20	0.1%
Office management	17	0.1%
IT Support	248	1.8%
Other Services	34	0.3%

Table 3 A

The impact on external financing on innovation: propensity score matching (PSM)-Full Sample

Panel A: Formal Finance	Product Innovation					Process Innovation				
	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	2162	650	0.065	0.022	2.969	2162	650	0.057	0.019	3.080
Kernel matching	2162	805	0.053	0.018	2.938	2162	805	0.044	0.016	2.763
Radius matching (radius=0.01)	2156	805	0.076	0.020	3.805	2156	805	0.063	0.018	3.474
Stratification matching	2162	805	0.043	0.022	1.931	2162	805	0.028	0.019	1.435
	Product Innovation					Process Innovation				
Panel B: Informal finance	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	1091	780	-0.003	0.024	-0.112	1091	780	-0.019	0.022	-0.860
Kernel matching	1091	1871	0.027	0.017	1.590	1091	1871	0.019	0.016	1.245
Radius matching (radius=0.01)	1090	1871	0.041	0.016	2.489	1090	1871	0.042	0.016	2.684
Stratification matching	1091	1871	0.017	0.018	0.922	1091	1871	0.005	0.017	0.306

Note: an ATT means average treatment effect on the treated.

Following covariates are included in all model: firm size (Small and Medium), firm age (firm age), firm ownership (female Owner and Foreign own%), collateral availability (Collateral), R & D expenses (R & D), manager experience (Mgr_Exp) and senior manager time dealing with regulations (Regulations), industry (30 sub-industry categories), and country (29 countries).

The standard error used to compute the t statistics is the standard deviation of the ATT after 100 bootstrap replications.

Table 3 B

The impact on external financing on innovation: propensity score matching (PSM)-Full Sample

Panel A: Formal Finance	Product & Process Innovation				
	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	2162	650	0.042	0.019	2.206
Kernel matching	2162	805	0.050	0.014	3.667
Radius matching (radius=0.01)	2156	805	0.072	0.013	5.506
Stratification matching	2162	805	0.034	0.013	2.600
	Product & Process Innovation				
Panel B: Informal finance	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	1091	781	0.032	0.017	1.861
Kernel matching	1091	1871	0.036	0.015	2.445
Radius matching (radius=0.01)	1091	1877	0.027	0.014	1.965
Stratification matching	1090	1877	0.016	0.013	1.192

Note: an ATT means average treatment effect on the treated.

Following covariates are included in all model: firm size (Small and Medium), firm age (firm age), firm ownership (female Owner and Foreign own%), collateral availability (Collateral), R & D expenses (R & D), manager experience (Mgr_Exp) and senior manager time dealing with regulations (Regulations), industry (30 sub-industry categories), and country (29 countries). We dropped Slovenia to achieve balancing property in PSM.

The standard error used to compute the t statistics is the standard deviation of the ATT after 100 bootstrap replications.

Table 4 A

The impact on external financing types on product innovation: propensity score matching (PSM)-Full Sample

	Product Innovation									
Panel A: Formal Finance	Bank					Non-Bank				
	No. treated	No. contr.	ATTa	Std.Err	t	No. treated	No. contr.	ATTa	Std.Err	t
Nearest neighbour matching	2109	656	-0.013	0.022	-0.569	238	237	0.015	0.043	0.358
Kernel matching	2109	858	0.049	0.018	2.655	238	2575	0.014	0.029	0.466
Radius matching (radius=0.01)	2100	854	0.074	0.021	3.573	238	2574	0.020	0.030	0.612
Stratification matching	2109	858	0.034	0.017	1.937	238	2575	0.005	0.034	0.143
	Product Innovation									
	Trade credit					Others (Money lenders, friends and family)				
Panel B: Informal finance	No. treated	No. contr.	ATTa	Std.Err	t	No. treated	No. contr.	ATTa	Std.Err	t
Nearest neighbour matching	983	2022	0.035	0.019	1.845	337	441	0.038	0.040	0.958
Kernel matching	986	20122	0.028	0.019	1.503	337	2612	0.000	0.027	0.015
Radius matching (radius=0.01)	983	2022	0.035	0.018	1.919	337	2601	0.017	0.028	0.611
Stratification matching	985	2023	0.018	0.016	1.141	337	2612	-0.018	0.029	-0.616

Note: an ATT means average treatment effect on the treated.

Following covariates are included in all model: firm size (Small and Medium), firm age (firm age), firm ownership (female Owner and Foreign own%), collateral availability (Collateral), R & D expenses (R & D), manager experience (Mgr_Exp) and senior manager time dealing with regulations (Regulations), industry (30 sub-industry categories), and country (29 countries). We dropped Slovenia to achieve balancing property in PSM.

The standard error used to compute the t statistics is the standard deviation of the ATT after 100 bootstrap replications.

Table 4 B

The impact on external financing types on innovation: propensity score matching (PSM)-Full Sample

	Process Innovation									
Panel A: Formal Finance	Bank					Non-Bank				
	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	337	441	-0.000	0.039	-0.011	238	237	0.036	0.044	0.825
Kernel matching	337	2612	0.003	0.025	0.115	238	2575	0.021	0.029	0.741
Radius matching (radius=0.01)	337	2601	0.020	0.028	0.698	238	2574	0.027	0.030	0.898
Stratification matching	337	2612	-0.017	0.026	-0.641	238	2575	0.010	0.029	0.330
	Process Innovation									
	Trade credit					Others (Money lenders, friends and family)				
Panel B: Informal finance	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	986	867	0.021	0.023	0.935	337	441	-0.000	0.038	-0.011
Kernel matching	986	2022	0.024	0.016	1.500	337	2612	0.003	0.024	0.119
Radius matching (radius=0.01)	983	2022	0.038	0.017	2.305	337	2601	0.020	0.025	0.781
Stratification matching	985	2023	0.013	0.019	0.699	337	2612	-0.017	0.026	-0.652

Note: an ATT means average treatment effect on the treated.

Following covariates are included in all model: firm size (Small and Medium), firm age (firm age), firm ownership (female Owner and Foreign own%), collateral availability (Collateral), R & D expenses (R & D), manager experience (Mgr_Exp) and senior manager time dealing with regulations (Regulations), industry (30 sub-industry categories), and country (29 countries). We dropped Slovenia to achieve balancing property in PSM.

The standard error used to compute the t statistics is the standard deviation of the ATT after 100 bootstrap replications.

Table 5

The impact on external financing types on innovation: propensity score matching (PSM)-Young Firms

Panel A: Formal Finance	Product Innovation					Process Innovation				
	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	658	257	0.097	0.036	2.727	664	196	0.053	0.035	1.503
Kernel matching	664	261	0.073	0.031	2.321	664	261	0.033	0.028	1.175
Radius matching (radius=0.01)	658	257	0.097	0.035	2.822	658	257	0.049	0.030	1.632
Stratification matching	664	261	0.079	0.036	2.205	664	261	0.049	0.030	1.466
	Product Innovation									
	Product Innovation					Process Innovation				
Panel B: Informal finance	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	301	217	0.049	0.045	1.096	301	217	0.009	0.039	0.226
Kernel matching	301	599	0.002	0.031	0.073	301	599	0.012	0.031	0.382
Radius matching (radius=0.01)	296	593	0.019	0.032	0.604	296	593	0.023	0.029	0.768
Stratification matching	301	599	0.001	0.032	0.021	301	599	0.009	0.029	0.300

Note: an ATT means average treatment effect on the treated.

Following covariates are included in all model: firm size (Small and Medium), firm age (firm age), firm ownership (female Owner and Foreign own%), collateral availability (Collateral), R & D expenses (R & D), manager experience (Mgr_Exp) and senior manager time dealing with regulations (Regulations), industry (30 sub-industry categories), and country (29 countries). We dropped Slovenia to achieve balancing property in PSM.

The standard error used to compute the t statistics is the standard deviation of the ATT after 100 bootstrap replications.

Table 6

The impact on external financing types on innovation: propensity score matching (PSM)-Old Firms

Panel A: Formal Finance	Product Innovation					Process Innovation				
	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	1498	432	-0.002	0.0035	-0.048	1498	432	0.010	0.028	0.352
Kernel matching	1498	543	0.037	0.026	1.428	1498	543	0.043	0.022	1.918
Radius matching (radius=0.01)	1492	540	0.054	0.028	1.944	1492	540	0.041	0.025	3.254
Stratification matching	1498	543	0.031	0.024	1.257	1498	543	0.034	0.024	1.454
	Product Innovation									
	Product Innovation					Process Innovation				
Panel B: Informal finance	No. treated	No. contr.	ATT[a]	Std.Err	t	No. treated	No. contr.	ATT[a]	Std.Err	t
Nearest neighbour matching	790	529	0.026	0.028	0.927	790	529	-0.012	0.0031	-0.376
Kernel matching	790	1249	0.027	0.024	1.148	790	1249	0.009	0.018	0.475
Radius matching (radius=0.01)	787	1249	0.048	0.024	1.991	787	1249	0.038	0.020	1.891
Stratification matching	790	1246	0.039	0.022	1.887	789	1250	-0.006	0.021	-0.273

Note: an ATT means average treatment effect on the treated.

Following covariates are included in all model: firm size (Small and Medium), firm age (firm age), firm ownership (female Owner and Foreign own%), collateral availability (Collateral), R & D expenses (R & D), manager experience (Mgr_Exp) and senior manager time dealing with regulations (Regulations), industry (30 sub-industry categories), and country (29 countries). We dropped Slovenia to achieve balancing property in PSM.

The standard error used to compute the t statistics is the standard deviation of the ATT after 100 bootstrap replications.

Table 7A

Probit and IV probit regression for formal finance and firm level innovation

Variables	*Probit*	*Margins (dy/dx)*	*IV Probit*	*IV Probit (dy/dx)*	*Probit*	*Margins (dy/dx)*	*IV Probit*	*IV Probit (dy/dx)*
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
	Product Innovation				*Process Innovation*			
Formal	.0029*** (.0007)	0008*** (.0009)	.0167*** (.00175)	.0003*** (.0005)	.0030*** (.0008)	.0006*** (.0002)	.0155*** (.0021)	.0003 (.0004)
Avg_Formal				.0055*** (.0002)				.0035*** (.0001)
Small	.0036 (.0382)	.0010 (.0106)	-.2213*** (.0458)	.0178 (.0132)	.0009 (.0437)	.0018 (.0087)	-.1978*** (.0528)	.0121 (.0108)
Foreign_Own	.0050*** (.0008)	.0014*** (.0002)	.0047*** (.0008)	.0014*** (.0002)	.0020** (.0009)	.0004** (.0002)	.0018** (.0374)	.0005** (.0002)
Female	.0921*** (.0339)	.0257*** (.0095)	.0978*** (.0331)	.0256*** (.0094)	.1274*** (.0383)	.0254*** (.0076)	.1318*** (.0374)	.0254*** (.0004)
Firm_Age	.0044** (.0017)	.0012*** (.0005)	.0033*** (.0016)	.0012** (.0005)	.0049*** (.0018)	.0010** (.0004)	.0038** (.0018)	.0009** (.0004)
Mgr_Exp	.0060*** (.0017)	.0017*** (.0005)	.0053*** (.0017)	.0016*** (.0005)	.0049** (.0019)	.0009*** (.0004)	.0044** (.0019)	.0009** (.0004)
R&D	1.180** (.0469)	.3296*** (.0115)	1.059*** (.0515)	.3246*** (.0122)	1.779*** (.0495)	.3550*** (.0081)	1.650*** (.0584)	.3520*** (.0080)
Regulations	.0021** (.0009)	.0006** (.0002)	-.0011 (.0009)	.0005** (.0003)	.0009 (.0010)	.0002 (.0002)	-.0020** (.0584)	.0001 (.0002)
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cons	-1.181*** (.0492)		-1.082*** (.0517)		-1.519*** (.0565)		-1.421*** (.0606)	
Summary statistics								

Log likelihood	-3908.17		-38950.34		-2859.56		-37912.77	
LR chi2/Wald chi2	803.19		950.52		1515.22		1548.25	
P value	0.0000		0.0000		0.0000		0.0000	
Sample Size	12783	12783	12783	12783	12833	12833	12833	12833
Corr(e.formal,e.product)			-.3342				-.3039 (.0463)	
Sd(e.formal)			21.29				21.30 (.1701)	
Wald test of exogeneity Chi2(1)			60.05***				37.80***	

Table 7B

Probit and IV probit regression for informal finance and firm level innovation

Variables	*Probit*	*Margins (dy/dx)*	*IV Probit*	*IV Probit (dy/dx)*	*Probit*	*Margins (dy/dx)*	*IV Probit*	*IV Probit (dy/dx)*
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
	Product Innovation				*Process Innovation*			
Informal	.0009 (.0006)	.0003 (.0002)	.0228*** (.0035)	.00016 (.0012)	.0013*** (.0007)	.0002** (.0001)	.0217*** (.0004)	.0002 (.0010)
Avg_Informal				.0076*** (.0007)				.0049*** (.0005)
Small	.0504 (.0362)	.0151 (.0109)	.0002 (.0350)	.0158 (.0105)	.0559 (.0417)	.0116 (.0083)	.0086 (.0399)	.0122 (.0085)
Foreign_Own	.0050*** (.008)	.0015*** (.0002)	.0035*** (.0008)	.0014*** (.0002)	.0019** (.0009)	.0003** (.0001)	.0010 (.0009)	.0004** (.0002)
Female	.0903*** (.0339)	.0275*** (.0104)	.0396 (.0332)	.0242** (.0098)	.1229*** (.0384)	.0246*** (.0077)	.0715** (.0383)	.0237*** (.0078)
Firm_Age	.0045*** (.0017)	.0014*** (.0005)	.0024 (.0016)	.0012** (.0005)	0049** (.0018)	.0010*** (.0004)	.0029 (.0018)	.0009** (.0003)
Mgr_Exp	.0062*** (.0017)	.0019*** (.0005)	.0060*** (.0016)	.0016*** (.0005)	.0049** (.0019)	.0010** (.0003)	.0050** (.0018)	.0009* (.0004

R&D	1.187*** (.0470)	.4311*** (.0172)	.9161*** (.0929)	.3295*** (.0166)	1.784*** (.0494)	.3550*** (.0081)	1.463*** (.1357)	.3548*** (.0092)
Regulations	.0027** (.0008)	.0008*** (.0003)	.008** (.0008)	.0009*** (.0002)	.0014 (.0009)	.0003 (.0019)	.0008 (.0009)	.0004** (.0002)
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cons	-1.196*** (.0496)		-1.203*** (.0582)		-1.537*** (.0569)		-1.511*** (.0772)	
Summary statistics								
Log likelihood	-3911.46		-4001.79		-2862.07		-3896.47	
LR chi2/Wald chi2	788.17		1191.69		1504.42		1895.93	
P value	0.0000		0.0000		0.0000		0.0000	
Sample Size	12728	12728	12782	12783	12782		12783	
Corr(e.formal,e.product)			-.5439 (.0890)				-.5075 (.1069)	
Sd(e.formal)			24.42 (.1952)				24.41 (.1952)	
Wald test of exogeneity Chi2(1)			23.24***				15.10***	

Notes: Table 7A and 7B report probit, marginal probit, IV probit and IV marginal probit results of innovation and external finance relationship. Table 7A reports probit results for the relationship between product and process innovations and formal finance relationship. Table 7B reports probit results for the relationship between product and process innovation and informal finance relationship. (*) dy/dx is for discrete change of dummy variable from 0 to 1. ***p<0.001;**p<0.05; *p<0.1. *Avg_Formal* is an instrumental variable in the *Formal* variable. *Avg_Informal* is an instrumental variable for the *informal* variable. These models provide standard errors, which are in parentheses. The Wald test of exogeneity is reported in the last row as a chi-squared statistic with 1 degree of freedom. This study sample consists of small and medium firms. The medium variable is used as a base variable. Product and process Innovations are a dichotomous dependent variable. Formal and Informal are main explanatory variables which are continuous variables.

Table 8

Average treatment effect (ATE) estimation

	Coef.	AI Robust Std. Err	Z	P>|z|	[95% Conf. Interval]
ATE -Product Formal | (1 vs 0)	.0310769	.0112548	2.76	0.006	.0090179 .053136
ATE -Process Formal | (1 vs 0)	.0373542	.0105666	3.54	0.000	.0166441 .0580644
ATE -Product Informal (1 vs 0)	.0036564	.0094736	0.39	0.070	-.0149114 .0222243
ATE -Process Informal (1 vs 0)	.0158208	.008927	1.77	0.076	-.0016758 .0333174

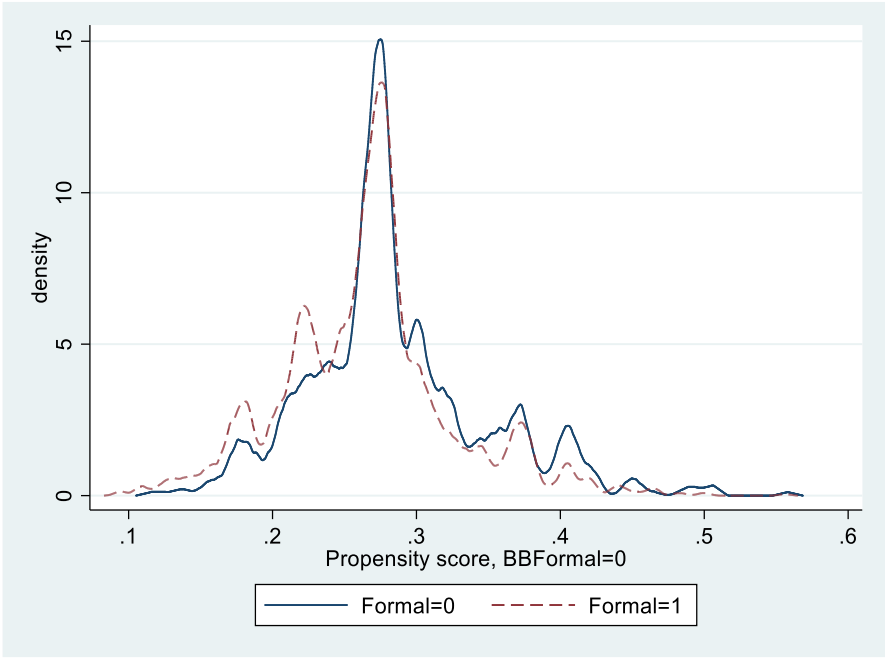

Figure 1A: Kernel densities of the Propensity scores for firms with formal financing and firms without formal financing

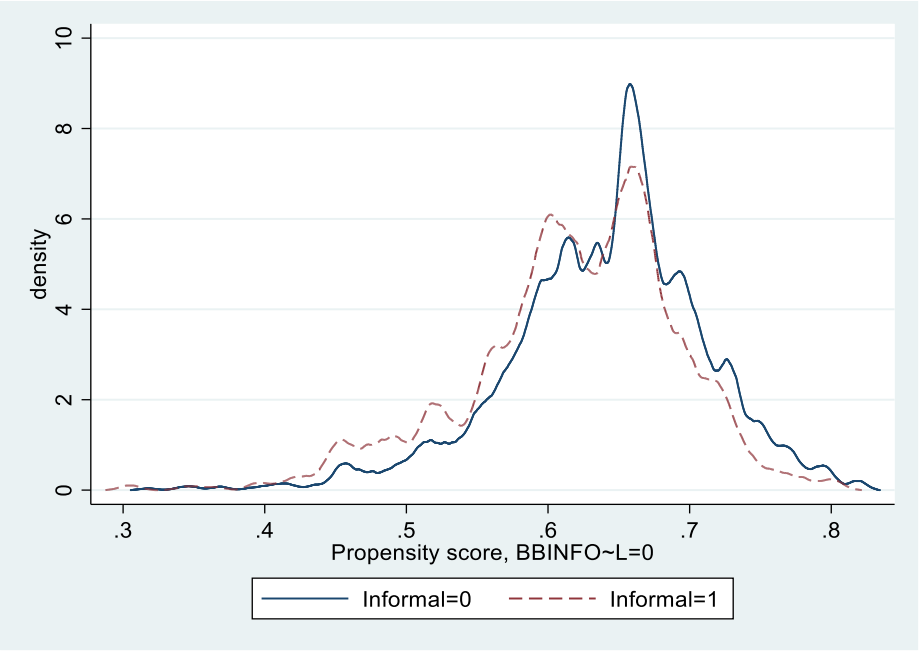

Figure 1B: Kernel densities of the Propensity scores for firms with informal financing and firms without informal financing

Figure 1: Kernel densities of propensity score for firm level innovation and external financing