

Formal Credit and Innovation: Is there a uniform relationship across types of innovation?

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Abstract

We investigate the formal credit effect on firm level innovations of small and medium enterprises in developing economies. Using the instrumental regression method, we control for potential endogeneity in innovation and credit relationships. Results indicate that formal credit availability boosts all four types of innovations. However, this impact is more significant for soft innovations compared to hard innovations. The results also point to the importance of informal finance as a source of external finance for firms where capital markets suffer from imperfections. Our study encourages the development of policy based on financing for various types of innovation, which is especially suited for developing economies.

Keywords: *Innovation; SMEs; formal credit; endogeneity; instrumental probit regression, developing economies*

JEL classification: *O1; G2; G28*

1. Introduction

This paper explores the relationship between firm level innovations and formal credit availability for small and medium enterprises (SMEs)¹, using World Bank data for Central Asia

¹ Firms with 5 to 19 employees are categorised as small firms, and those with 20 to 99 employees are defined as medium-sized.

and Eastern Europe. Specifically, we analyse four direct proxies of innovations: product, process, organisational and marketing, as recommended in the *Oslo Manual*². The phase of introducing a new product, process, organisational or marketing method is the most critical in the firm's lifecycle. During this period, uncertainty and finance requirements are at maximum level (Giudici & Paleari, 2000). Thus, accessibility of external finance is one of the critical factors which have a significant impact on a SME's innovation (Hajivassiliou & Savignac, 2008) as SMEs lacking internal funds may choose to seek external funds (Beck, Demirgüç-Kunt, & Maksimovic, 2008; Schneider & Veugelers, 2010). However, SMEs undertaking innovation tend to have high idiosyncratic risk resulting in a higher cost of finance to compensate for this risk (Mina et al., 2013) or simply a denial of finance for their innovative projects by financial providers.

Alternative sources of capital such as venture capital, crowdfunding, seed and angel finance are changing the landscape, bank-based formal financial system, according Freedman & Click (2006) continues as the primary financial intermediary of developing economies In particular, debt finance, specifically formal bank finance is the most dominant external funding source for firms of all sizes in developing countries (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011) and small innovative firms depend mainly on bank financing (Cornaggia, Mao, Tian, & Wolfe, 2015). Giudici and Paleari (2000) discussing capital requirements for small firms operating in the high-tech sector face more constraints than larger firms and present empirical findings suggesting informal finance is more important than formal sector finance.

² The Oslo Manual 2018 provides guidelines for collecting, reporting and using data on innovation. The 4th edition emphasises the economic impacts of the innovation process, and the experience gained from recent rounds of innovation surveys in OECD member and non-member countries (<http://www.oecd.org/innovation/oslo-manual-2018-9789264304604-en.htm>).

Nevertheless, scholars focused on the trade-off between formal and informal finance on firm level innovations report several striking differences (See Wellalage & Fernandez, 2019; Wu, Si, & Wu, 2016). Formal finance may provide a cheap source of financing with longer term maturities (R. Chen, 2010). Longer repayment periods provide sufficient time to engage in design, testing and implement the new product for firm innovations (Eisenhardt & Tabrizi, 1995). Informal finance providers, in contrast, charge high interest rates and short maturities to gain quick profits and reduce risk (Hu, 2010). Nonetheless, informal debt may provide a quick source of funding for innovative firms (R. Chen, 2010; Hu, 2010) with lower transaction costs (Armendariz & Morduch, 2007), and low or no collateral requirement (Wu et al., 2016). This ambiguous empirical evidence leads to the role of formal and informal financing for firm level innovation remains inconclusive. Also, government policies in developing economies often aim to promote formal financing even if informal financing plays an important role in the private sector (Kan, 2000). Thus, the role of formal financing for SMEs innovation needs to be further analysed. Several theories, including agency theory (Jensen & Meckling, 1976), pecking order theory (Myers, 1984) and signalling theory (Myers & Majluf, 1984) provide explanations of the formal or informal finance accessibility in small innovative firms.

The Business Environment and Enterprise Performance Surveys (BEEPS)³ provide cross-country firm-level data for 29 developing economies. After controlling for endogeneity, we find that formal credit availability increases SMEs' product and process innovations (hard innovations) by approximately 0.55 % and 0.35 %, respectively. Alongside this, formal credit availability increases SMEs' organisational and marketing innovations (soft innovations) by approximately 2 % and 1.3 % respectively. In most of cases, soft innovations are difficult to

³ The Business Environment and Enterprise Performance Surveys (BEEPS) was developed jointly by the World Bank and the European Bank for Reconstruction and Development. BEEPS include 4,000 plus firms in emerging countries. Based on face-to-face interviews with firm managers and owners, BEEPS report firm characteristics, including firm owners/managers, demographic information and business/institutional environment (<http://www.enterprisesurveys.org/>)

identify compared to hard innovations, given that they are less visible to investors. This increases the opaqueness and information asymmetry in soft innovative firms' loan applications and consequently limits access to external finance. Hard innovations, such as the number of new product ideas (Cooper & Kleinschmidt, 1993) and patents, can directly or partially be evaluated by loan providers. Thus, we can argue that, favourably effect by formal credit availability is high in soft innovation than hard innovation. Furthermore, our results point to the relevance of informal credit as a source of short-term external finance for innovative SMEs, regardless of their types of innovation. We also find that the impact of firm characteristics and owner characteristics differs on innovation types.

Our study offers important contributions to existing literature. First, we deepen the understanding of firm level innovation by examining external credit availability on both hard and soft innovations. The different impact between hard and soft innovation comes from the different characteristics of the innovation types. Although some recent studies distinguish between different types of innovations (See Herrera & Minetti, 2007; Qi & Ongena, 2019), only a few studies have intimately examined the relations between four dimensions of innovation types and credit aspect. We add to empirical evidence of SME finance by examining the interaction of formal and informal credit, an informal credit topic that has largely been ignored. Therefore, the main contribution of this study is the comprehensive innovation-finance analysis based on empirical data. In addition to this, we add robust empirical evidence on the growing literature on finance-innovation studies of innovation activities in small firms from developing economies. The role of formal credit availability for innovation remains a matter of debate because many studies fail to address the likely endogenous nature underlying the financing and innovation relationship. Our research is significant in dealing with causality and other endogeneity biases in the relationship between external credit availability and innovation.

Finally, our study provides a framework for the development and promulgation of policy based on financing for various types of innovation that is suited for weak institutional environments.

The following sections of this paper are organised as follows. Section 2 presents the literature review, section 3 describes the data and section 4 explains the model specifications. Section 5 discusses our empirical findings, and section 6 reports on the robustness studies. Finally, section 7 provides discussion and policy implications.

2. Literature review

The pecking order theory of finance suggests that firms prefer to finance new investments by first using internally stored retained earnings, then seeking external debt and finally, as a last resort, external equity (Myers, 1984; Myers & Majluf, 1984). However, limited information or information opaqueness of small innovative firms means that external finance providers are unable to evaluate the quality of funding applications which results in financial institutions failing to produce equilibrium prices and efficient transactions (Stiglitz, 2000). Additional opaqueness emerges when innovative firms intentionally maintain information asymmetries to avoid revealing information to competitors (Hall & Lerner, 2010; Mancusi & Vezzulli, 2010). These information asymmetries deal with adverse selection and moral hazards affecting agency costs. The consequence, resulting from these agency costs, produces constraints in the credit market whenever lenders cannot observe the risk type of borrowers, as lenders will need to reject credit to both high and low-risk types.

The innovation capabilities and priorities of firms are different. A firm may be engaged in the introduction of a new product or process, new organisational and marketing practices, or administrative systems simultaneously (Azadegan & Wagner, 2011). Battisti and Stoneman (2010) report that hard innovations (product or process) are not adequate to gain competitive advantage and thus, the far-reaching benefits of hard innovations can only be reached if they

are accompanied by soft innovations. On the other hand, the types of innovations are interconnected. As an example, Lam and Society (2005) report that organisational innovation could be a necessary foundation for technological process and product innovations.

Finance is an important factor influencing the growth of SMEs with both equity and debt financing, presenting trade-offs over matters such as control and ownership of the firm (Wu et al., 2016). Equity financing is more appropriate for risky and long maturity investment, such as innovations (Giudici & Paleari, 2000). Small innovative firms bear high financial distress costs due to their limited size, pointing toward equity finance as more appropriate for innovative firms than debt financing. Other than lending money (Alexy, Block, Sandner, & Ter Wal, 2012) some equity financing providers, such as venture capitalists, engage in active monitoring (Hall & Lerner, 2010), firm development strategy and marketing (Denis, 2004; Kortum & Lerner, 2000) and provision of network resources. These enhancements provide for the governance and managerial needs of innovative SMEs (De Clercq, Fried, Lehtonen, & Sapienza, 2006). Prior research provides evidence that the presence of venture capital may partially mitigate the high costs of capital in SMEs innovations (Hall & Lerner, 2010), leading to increased innovations (Kortum & Lerner, 2000).

Unlike debt funders equity funders dilute the SMEs ownership rights (Hall & Lerner, 2010; Wu et al., 2016). Venture capital searches for potentially high increases in enterprise value and success is very dependent on selection on right type of firm selection (Dutta & Folta, 2016). For smaller businesses engaging in innovation it is not clear that venture capital can find the high rates of return required (X. Lin, Xu, Zhang, & Yang, 2019).

An emerging literature discussing the role of debt financing, in firm level innovation, continues to debate the costs and benefits of formal versus informal finance (See Ayyagari et al., 2011; Gorodnichenko & Schnitzer, 2013; Wellalage & Fernandez, 2019). Both formal and

informal finance have their strengths and weaknesses and SME may benefit through a co-existence of two financing modes in their capital structure (Degryse, Lu, & Ongena, 2013). A perspective supportive of informal financing proposes it reduces moral hazard and adverse selection problems because informal capital providers have superior information through personal relationships with the borrower (Allen, Qian, & Xie, 2018). However, the informational advantage of informal finance may lead to rent extraction (Allen et al., 2018) and expose innovators to conflicts and entanglements (Wu et al., 2016). Also, high interest rates and short-term maturity offered through informal financiers may impose an additional burden on long-term innovation activities (Armendariz & Morduch, 2007). In contrast, when SMEs access formal finance they may benefit from longer terms of repayment, benefitting innovation with longer horizons (Wu et al., 2016). Some scholars report that formal financing is the most suitable funding source for innovation because banks are well equipped to deal with information asymmetries and risk associated with innovation activities (Rajan & Zingales, 2001). Based on developing economies formal finance is associated with higher firm growth than not informal finance (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2010). Nevertheless, as both formal and informal finance sources depend on agent effectiveness in dealing with information asymmetry (Allen et al., 2018) the co-existence, and potential complementarity, of formal and informal finance is important for SME innovation.

Qi and Ongena (2019) report that hard innovations, such as product and process innovations, are more capital intensive and would thus be more sensitive to external finance than soft innovations. Access to formal finance may reduce the cash flow sensitivity of fixed investment spending, particularly for small firms, increasing the probability that they will engage in product and process innovation (Fombang & Adjasi, 2018). Nevertheless, studies report that, similar to product and process innovations, finance is a critical enabler that can promote SMEs' organisational and marketing innovations (Ajayi & Morton, 2015). Formal

financing may have a positive impact on firm-level innovation in two ways. First, formal financing providers offer long-term or medium-term maturity loans, which allow innovative firms to have a sufficient repayment period. Second, formal financial institutions provide loans at an affordable interest rate. Since formal finance institutions are monitored and controlled by regulators, they cannot set unreasonably high-interest rates. Although formal finance access is less important to some innovation activities due to the absence of cash-flow sensitivity to innovation (H. J. Chen & Chen, 2012), overall, this aligns with a widely accepted view that the availability of finance is the key to driving innovation (Ayyagari et al., 2011; Freel, 2007).

We expect that:

H₁: There is a positive relationship between formal credit availability and the innovation performance of SME, irrespective of the type of innovation.

Prior studies have shown that the informal financial sector⁴ plays a significant role in financing firms in most developing economies (Ayyagari et al., 2010; Mullineux & Murinde, 2014) and small firms (Denis, 2004; Wilson, 2015). This study proposes that the accessibility to informal finance by SMEs will strengthen the relationship between formal debt and its innovation.

Informal money lenders have a unique opportunity for proximity, which promotes SMEs' lending by trading on soft information. This soft information, due to the grass-roots presence of informal money lenders, establishes reputations, extensive knowledge networks and relationships with the SMEs in an area, enabling them to utilise social collateral and personal relationships as a valid means of control. This increases the accessibility and

⁴ Informal finance is vaguely defined in literature by referencing sources of finance apart from formal financing institutions (banks) and stock markets. There are many sources of informal credit, including friends, family and relatives, moneylenders, rotating savings and credit organisations (ROSCAs), loan sharks, credit clubs, saving collectors and informal credit unions.

availability of informal finance for innovative SMEs. According to the signalling theory, these low-cost signals can also be used to reduce information asymmetries between borrowers and financial institutions (Almazan, Banerji, & Motta, 2008; Payne, Moore, Bell, & Zachary, 2013). This leads financial providers to avoid type I (reject sound lending prospects) and type II (accept poor lending prospects) errors.

This increases the accessibility and availability of formal finance, consequently increasing firm level innovation.

We expect that:

H₂: The accessibility of informal finance positively moderates the relationship between formal credit availability and SMEs' innovation performance

3. Data

All firm level data are collected from the World Bank Enterprise Surveys⁵ (BEEPS) in the Eastern Europe and Central Asia 2013-2014 version. These BEEPS are co-produced by the World Bank and the European Bank for Reconstruction and Development. The distinct advantage of BEEPS is its broad coverage. BEEPS include firm level performance, financing activities, innovation activities, ownership information, and business environment. This enables us to use direct proxies of innovations and financing activities. The surveys employ stratified random sampling techniques with identical questionnaires across all countries. The strata for Enterprise Surveys are firm size, business sector, and geographic region within a country.

⁵ The World Bank's Enterprise Surveys offer an expansive array of economic data on 130,000 firms in 135 countries. The World Bank's Enterprise Survey website provides details as to how the surveys are conducted. (<http://www.enterprisesurveys.org>). An Enterprise Survey is a firm-level survey of a representative sample of an economy's private sector.

Our study utilises data from 13,430 SMEs from 29 Eastern European and Central Asian economies,⁶ of which 14 countries are from the former Soviet Union⁷. Russian (3,790) firms dominate the sample constituting 28%, and the inclusion of all ex-Soviet Union countries escalates the ratio to 62%. Most firms are engaged with organisational innovation (23.29%), followed by product innovation (21%). Table 1 lists the full study sample base for each country, indicating product, process, organisational and marketing innovations percentages. Table 1 also reports the percentage of firms with a bank loan, non-bank financing, firms with trade credit, and firms with informal financing. Appendix A presents definitions and metrics for variables included in the models.

A look at the various forms of innovation shows variability between countries. It is interesting to see the individual innovation activities of the firms as well as the degree of overlap among the different types of innovation. The *Innovation* column in Table 1 reports that approximately 47% of firms engaged with at least one type of innovation. Serbia shows the highest percentage of innovative firms (56.01%), while Lithuania shows the lowest percentage of innovative firms (30.77%). This is not surprising, because following the Oslo manual, we defined innovation in terms of it being “new to the firm”, not only “new to the world”. Also, we report the overlap between product and process innovation in two ways. First, the *Core Innovation* column reports the country level average of firms engaged with either product or process innovation, or both. In a total sample, 26.87% of firms engaged with core innovation. The highest *Core Innovation* is reported by Serbia, which indicates that approximately 42% of

⁶ 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.

⁷ Former Soviet Union countries are Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Ukraine and Uzbekistan.

Serbian firms are engaged with either product or process innovation, or both. Second, the *Product & Process* column reports the percentage of firms engaged with both product and process innovation. In a total sample, 10.72% of firms are engaged with both product and process innovation.

Table 1
Study Sample

Country	No. of firms	Product Innov %	Process Innov %	Org_ Inno%	Market_ Inno%	Product & process Innov%	Core_ Inno%	Innovation	Firms with bank loan %	Firms with non- bank loan %	Firms with trade credit %	Firms with informal credit* %
Albania	348	21.26%	16.67%	28.45%	14.99%	8.62%	29.31%	54.31%	15.52%	8.05%	30.46%	14.37%
Armenia	342	14.91%	14.91%	25.59%	12.87%	6.43%	23.39%	47.95%	22.81%	14.62%	30.70%	17.84%
Azerbaijan	358	19.55%	15.36%	21.63%	8.99%	9.50%	25.42%	43.02%	20.39%	13.69%	29.05%	18.44%
Belarus	297	24.92%	17.85%	21.28%	10.88%	11.78%	30.98%	49.49%	18.52%	12.12%	25.93%	17.51%
Bosnia- Herzegovina	314	15.92%	13.06%	25.00%	8.33%	6.05%	22.93%	43.63%	15.61%	8.92%	27.39%	14.01%
Bulgaria	237	18.57%	13.50%	32.91%	15.02%	8.44%	23.63%	52.74%	16.03%	10.55%	31.65%	16.46%
Czech Republic	212	19.81%	15.09%	25.47%	20.28%	9.43%	27.49%	51.89%	8.96%	6.60%	27.83%	10.38%
Estonia	244	16.39%	11.07%	30.58%	19.26%	6.97%	20.49%	52.87%	13.52%	8.20%	25.41%	8.61%
Georgia	319	17.87%	15.05%	20.00%	6.03%	10.34%	22.57%	40.44%	18.50%	13.17%	23.51%	16.61%
Hungary	447	16.78%	18.12%	25.11%	8.31%	10.96%	23.94%	44.74%	15.88%	8.72%	19.69%	12.08%
Kazakhstan	516	13.95%	9.30%	20.82%	8.79%	5.62%	17.64%	37.21%	14.34%	7.56%	18.02%	11.43%
Kosovo	199	10.55%	5.53%	17.68%	7.04%	4.52%	11.56%	27.14%	13.07%	7.04%	21.11%	12.06%
Kyrgyzstan	234	13.25%	9.40%	27.90%	14.16%	7.27%	15.38%	46.15%	14.10%	5.13%	16.67%	6.84%
Latvia	292	8.90%	6.51%	24.91%	8.65%	3.42%	11.99%	35.96%	12.33%	6.85%	19.18%	8.90%
Lithuania	234	11.54%	6.84%	18.03%	4.82%	5.13%	13.25%	30.77%	14.96%	9.83%	22.22%	11.54%
Macedonia	321	14.95%	13.08%	24.45%	8.44%	8.41%	19.63%	42.06%	14.95%	6.85%	15.26%	9.97%
Moldova	313	18.85%	14.70%	19.81%	4.79%	8.63%	24.92%	40.26%	11.82%	4.79%	16.93%	6.07%
Mongolia	118	14.41%	14.41%	21.19%	6.03%	5.08%	23.73%	41.53%	18.64%	5.08%	16.95%	6.78%
Montenegro	129	32.56%	26.36%	22.22%	4.69%	19.38%	39.53%	55.81%	53.49%	13.95%	34.11%	18.60%
Poland	449	26.06%	22.49%	15.80%	10.38%	16.48%	32.07%	46.33%	48.55%	10.47%	32.52%	11.58%
Romania	459	31.59%	25.71%	20.13%	6.58%	18.08%	39.22%	53.81%	53.81%	9.80%	29.63%	11.55%
Russia	3790	27.70%	22.85%	17.68%	5.69%	15.41%	35.15%	48.31%	36.39%	6.57%	26.86%	12.43%
Serbia	291	35.40%	28.18%	21.99%	7.59%	21.99%	41.58%	56.01%	49.83%	6.53%	27.15%	11.68%
Slovakia	233	30.47%	19.74%	20.78%	10.73%	14.59%	35.62%	51.93%	53.22%	5.15%	28.33%	10.30%

Slovenia	230	31.30%	26.09%	20.52%	7.05%	18.70%	38.70%	53.04%	48.26%	4.78%	31.30%	6.52%
Tajikistan	315	22.54%	19.37%	25.64%	13.78%	10.79%	31.11%	51.11%	55.56%	10.79%	33.97%	12.38%
Turkey	1075	22.42%	16.74%	22.99%	11.12%	11.44%	27.72%	47.63%	46.70%	7.72%	25.30%	9.21%
Ukraine	844	27.49%	21.09%	21.58%	12.71%	14.10%	34.48%	52.25%	45.62%	7.23%	28.91%	11.14%
Uzbekistan	270	29.26%	20.00%	35.16%	14.21%	13.33%	35.93%	51.85%	40.37%	11.48%	29.63%	14.44%
Total	13430	21.01%	16.52%	23.29%	10.08%	10.72%	26.87%	46.56%	27.99%	8.70%	25.71%	12.06%

Descriptive statistics for the data are presented in Table 2. The average formal finance percentage for the firm is 11.37%, which ranges from 0 to 100. This indicates that in heavily regulated environments, small firms have less access to formal financing (Gerlach-Kristen, O'Connell, & O'Toole, 2015; J. Y. Lin & Sun, 2006). Table 2 also indicates that the average informal finance percentage for the firm is 11.39 %. This is in alignment with Allen, Qian, and Qian (2005), who report that informal finance is an important factor for private sector development in countries with an underdeveloped capital market and a weak institutional environment. The percentage of foreign ownership of this study sample is low at a 4% average. Small firms predominate at almost 58 % of the sample, and 42 % of medium size firms contributed. The average age of sample firms is 13.9 years, and managers of the sample firms have approximately 16 years of experience. Only 10% of firms have research and development (R&D) expenses. The variable *Petty_Corruption*⁸ reveals approximately 32 % of SMEs in the sample make informal payments to get things done. Widespread petty corruption faces a largely amoral cohort of stakeholders much more accepting of this reality, attributing it as an endemic consequence of a weak institutional environments in developing economies. The *Regulations* variable points to senior managers spending approximately 16 % of their time dealing with government rules and regulations and some businesses indicate 100 % of time of their managers goes into dealing with regulation. High values for the *Regulation* point toward an institutional environment not supportive of firms.

⁸ Some authors classify corruption as grand vs petty based on scale (See Hewa Wellalage, Locke, & Samujh, 2019; Nguyen, Doan, Nguyen, & Tran-Nam, 2016), with firms engaging in grand corruption trying to gain market advantages, while firms engaging in petty corruption are trying to 'get things done'. Grand corruption, is generally seen as detrimental to economic development (Luo, 2005; Nguyen et al., 2016), the impact of petty corruption, often associated a small amounts of money can be positive in firm growth and development in developing economies (Huntington, 2006).

Table 02
Descriptive statistics

Variable	Obs	Mean	Std.Dev	Min	Max
Formal	12758	11.37	22.83	0	1
Informal	12744	11.39	24.19	0	1
Small	13430	.5812	.4934	0	1
Medium	13430	.4188	.4934	0	1
Foreign_Owned	13309	3.923	17.83	0	100
Female	13430	.3333	.4714	0	1
Firm_age	13297	13.88	9.740	0	148
Mgr_Exp	13050	16.32	9.862	1	70
R & D	9513	.1086	.3111	0	1
Regulations	11959	15.51	20.69	0	100
Corruption	9215	.3208	.4138	0	1
Country					
Albania	13430	.0259	.1589	0	1
Armenia	13430	.0254	.1575	0	1
Azerbaijan	13430	.0266	.1611	0	1
Belarus	13430	.0221	.1471	0	1
Bosnia-Herzegovina	13430	.0234	.1511	0	1
Bulgaria	13430	.0176	.1317	0	1
Czech Republic	13430	.0158	.1246	0	1
Estonia	13430	.0182	.1336	0	1
Georgia	13430	.0238	.1523	0	1
Hungary	13430	.0333	.1794	0	1
Kazakhstan	13430	.0384	.1922	0	1
Kosovo	13430	.0142	.1208	0	1
Kyrgyzstan	13430	.0174	.1308	0	1
Latvia	13430	.0217	.1458	0	1
Lithuania	13430	.0174	.1308	0	1
Macedonia	13430	.0239	.1527	0	1
Moldova	13430	.0233	.1509	0	1
Mongolia	13430	.0088	.0933	0	1
Montenegro	13430	.0096	.0975	0	1
Poland	13430	.0334	.1798	0	1
Romania	13430	.0342	.1817	0	1
Russia	13430	.2822	.4501	0	1
Serbia	13430	.0217	.1456	0	1
Slovakia	13430	.0173	.1306	0	1
Slovenia	13430	.0171	.1297	0	1
Tajikistan	13430	.0234	.1513	0	1
Turkey	13430	.0801	.2714	0	1
Ukraine	13430	.0628	.2427	0	1
Uzbekistan	13430	.0201	.1403	0	1
Manufacturing Industry					
Food	13430	.0617	.2405	0	1

<i>Tobacco</i>	13430	.0013	.0366	0	1
<i>Textiles</i>	13430	.0170	.1292	0	1
<i>Garments</i>	13430	.0341	.1815	0	1
<i>Wood</i>	13430	.0217	.1456	0	1
<i>Paper</i>	13430	.0217	.1456	0	1
<i>Publishing & Printing</i>	13430	.0256	.1580	0	1
<i>Chemical</i>	13430	.0246	.1550	0	1
<i>Plastics & rubber</i>	13430	.0206	.1419	0	1
<i>Non Metallic mineral</i>	13430	.0402	.1966	0	1
<i>Basic metals</i>	13430	.0048	.0694	0	1
<i>Fabricated metal</i>	13430	.0395	.1949	0	1
<i>Machinery & equipment</i>	13430	.0331	.1790	0	1
<i>Electronics</i>	13430	.0136	.1159	0	1
<i>Precision instruments</i>	13430	.0115	.1065	0	1
<i>Transport machines</i>	13430	.0198	.1393	0	1
<i>Furniture</i>	13430	.0224	.1480	0	1
<i>Retail</i>	13430	.2307	.4212	0	1
<i>Other Services</i>					
<i>Wholesales</i>	13430	.1626	.3690	0	1
<i>IT</i>	13430	.0154	.1232	0	1
<i>Hotel & restaurants</i>	13430	.0419	.2004	0	1
<i>Services for motor vehicles</i>	13430	.0272	.1626	0	1
<i>Construction Section</i>	13430	.0830	.2759	0	1
<i>Post</i>	13430	.0102	.1005	0	1
<i>Tanning</i>	13430	.0043	.0656	0	1
<i>Communication</i>	13430	.0015	.0386	0	1
<i>Office management</i>	13430	.0013	.0366	0	1
<i>IT Support</i>	13430	.0185	.1349	0	1
<i>Other Services</i>	13430	.0025	.0502	0	1

4. Model Specifications

We estimate the relationship between Innovation and formal credit using probit regression.

$$\begin{aligned}
Innovation_i = & \beta_0 + \beta_1 Formal_i + \beta_2 (Owner\ manager\ characteristics) \\
& + \beta_3 (Firm\ characteristics)_i + \beta_4 (Institutional\ environment)_i \\
& + Country\ dummies + \gamma_s + Error
\end{aligned}$$

Here, $Innovation_i$ is a binary variable set equal to one if the firm reported an innovation activity in the last three years (product, process, organisation or marketing

innovation) and zero otherwise. *Formal*_{*i*} is a vector of the variable indicating the percentage of formal credit in the firm⁹. We have included owner manager characteristics, firm characteristics and institutional environment. The baseline regressions include country and industry (γ_s) control variables.

Endogenous covariates

The most common complication in innovation and finance studies is endogeneity (See Gorodnichenko & Schnitzer, 2013). Other than measurement errors, endogeneity in the relationship between innovation and finance can arise in three main ways: (i) Omitted variables bias; (ii) Unobservable heterogeneity (See Efthyvoulou & Vahter, 2016; Savignac, 2008); (iii) Reverse causality or simultaneity problem (See Savignac, 2008). The instrumental variables method is widely used to control for endogeneity that occurs from reverse causality/simultaneity and measurement errors. Studies now also use instrumental variable methods to overcome an omitted variable problem (Angrist & Krueger, 2001; Wellalage, Locke, & Samujh, 2018). In this study, we use instrumental probit regression to control for endogeneity biases in our regression.

We use instrumental variables which affect innovation but do not directly influence formal credit in firms. Following prior studies¹⁰, we use the modified version of the locality-sector average of formal credit (*Sec_Avg_Credit*) as an instrument for the firm level formal credit. Formal credit constraints tend to be more severe in developing markets with weak institutions. Therefore, the locality-sector average of formal credit captures the business environment in the locality, and institutional weakness, which are factors exogenous to the firm

⁹ The *formal* variable refers to the percentage of formal credit in the last year while innovation (*Innovation*) measures are reported over the last three years. Since innovation is likely to lead to formal financing constraints (see Canepa & Stoneman, 2008 and Hajivassiliou & Savignac, 2007), this difference in timing may bias our estimates up. However, following (Gorodnichenko & Schnitzer, 2013), our estimates provide a lower bound of the true causal effect.

¹⁰ To avoid concerns of endogeneity, prior studies used locality-sector average as a valid instrument (See Hewa Wellalage et al., 2019).

(Wellalage et al., 2018). The other advantage of a locality-sector average of the formal credit instrument variable is that this eliminates the unobservable biases correlated with credit constraints at the firm level (Qi & Ongena, 2018). Furthermore, we tested for weak exogeneity of the limited dependent variable model using the R. J. Smith and Blundell (1986) test, which rejects the hypothesis that the Innovation variable is exogenous at a significance level of 1 %. We also test the validity of the instrument by using a transformed F-test. The test showed that our instrument variable *Sec_Avg_Credit* was greater than 10¹¹.

5. Results

5.1 Firm level innovations and formal financing relationship

Formal financing and innovation results are reported in Table 4A and Table 4B. The Wald test in IV probit regression indicates that the correlation parameter rho is equal to zero. This indicates that the error terms in the structural equation and the reduced-form equation for the endogenous variable are correlated (Wooldridge, 2002). Therefore, we use the IV probit to explain the formal financing and innovation relationship.

Sec_Avg_Credit indicates that formal finance could predict with statistical significance firm level product and process innovation. In particular, product innovation and process innovation reveal that the probability of product innovation increased by 0.55 % and process innovation increased by 0.35 % when the formal finance (*Sec_Avg_Credit*) variable goes up by one. Table 4B reports formal financing and organisation and marketing innovation results. Formal finance is positively predicting, with statistical significance, firm level organisation and marketing innovation. Organisational and marketing innovations reveal that the probability of organisational innovation increased by 1.98 % and marketing innovation by 1.26 % when the

¹¹ If the F-test is greater than 10, the selected instruments are valid (Stock & Yogo, 2002).

formal finance (*Sec_Avg_Credit*) variable goes up by one. This aligns with a widely accepted view that access to finance is key to driving innovation (Ayyagari et al., 2011; Freel, 2007). Consequently, we accept hypothesis 1, which indicates there is a positive relationship between formal financing and firm level innovation of SMEs. Furthermore, we report that the impact of formal financing is highest for organisational innovations, followed by marketing innovations. This means the impact of formal financing on firm level innovation is higher in soft innovation than in hard innovation.

The impact of explanatory variables on firm level innovation differs between types of innovations. The marginal effects of product and process innovation with respect to *Foreign_Owned* reveals that the probability of product innovation (process innovation) increased by 0.14% (0.05%) when foreign ownership goes up by one. This supports the argument that foreign ownership transfers superior knowledge, which is required for product and process innovations of their subsidiaries (Guadalupe, Kuzmina, & Thomas, 2012). However, we did not find a significant impact on foreign ownership in firm level marketing innovations. We also found that an increase in foreign ownership leads to reduce organisational innovation in SMEs. Therefore, we can conclude that foreign ownership has more impact on hard innovations than soft innovations. Firms with female owners tended to engage more with product and process innovations. The marginal effects of product and process innovation with respect to the *Female* variable reveals that the probability of product innovation (process innovation) increased by 2.56% (2.54%) for firms with at least one female owner compared to firms with no female owners. According to social feminist theories, women and men perform differently (Farhat & Mijid, 2016) and gender difference in innovation activity is to be expected.

The marginal effects of hard innovations with respect to *Firm_age* reveals that the probability of firm level innovation is increased by 0.12 % and 0.09 % for product and process

innovations respectively when the firm's age goes up by one year. This demonstrates that the positive relationship between formal finance and firm level hard innovations are greater in later-stage firms than in early-stage firms. In contrast, we report that the marginal effects of hard innovations with respect to *Firm_age* reveal that the probability of firm level innovation is decreased by 0.07 % and 0.02 % for organisational and marketing innovations respectively when the firm's age goes up by one year. This indicates that formal financing opportunities for young firms are crucial to their firm level soft innovation. As with existing literature, we find evidence that firms with more experienced managers (Balsmeier & Czarnitzki, 2014) and firms with more R&D are more engaged with hard innovation.

The use of firm-level data focuses the study on petty corruption rather than grand corruption and our findings point to petty corruption having a positive pay-off. This aligns with literature on the 'grease the wheels' hypothesis (Huntington, 2006; Leff, 1964; Leys, 1965), which report that corruption can be innovation-enhancing. Potentially, petty corruption can expedite the typically slow moving queue in obtaining permits when hard innovation activities are undertaken (Luo, 2005), enabling licenses to be issued easily and quickly (Huntington, 2006). In turn, this reduces the transaction costs associated with new product or process development. However, petty corruption has no significant effect on firm level soft innovation (See Table 4B). Similar to the findings of (Ayyagari et al., 2011), our results indicate that all industries are not equally innovative. Unreported results indicate that across 30 industries, firms from manufacturing industries are, in this sample, the most innovative.

Table 4 A

Probit and IV probit regression on formal financing and firm level product and process innovation

<i>Variables</i>	<i>Probit</i>	<i>Margins (dy/dx)</i>	<i>IV Probit</i>	<i>IV Probit (dy/dx)</i>	<i>Probit</i>	<i>Margins (dy/dx)</i>	<i>IV Probit</i>	<i>IV Probit (dy/dx)</i>
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
	<i>Product Innovation</i>				<i>Process Innovation</i>			
<i>Formal</i>	.0029*** (.0007)	.0008*** (.0009)	.0167*** (.0017)	.0003*** (.0005)	.0030*** (.0008)	.0006*** (.0002)	.0155*** (.0021)	.0003 (.0004)
<i>Sec_Avg_Credit</i>				.0055*** (.0002)				.0035*** (.0001)
<i>Small</i>	.0036 (.0382)	.0010 (.0106)	-.2213*** (.0458)	.0178 (.0132)	.0009 (.0437)	.0018 (.0087)	-.1978*** (.0528)	.0121 (.0108)
<i>Foreign_Owned</i>	.0050*** (.0008)	.0014*** (.0002)	.0047*** (.0008)	.0014*** (.0002)	.0020** (.0009)	.0004** (.0002)	.0018** (.0374)	.0005** (.0002)
<i>Female</i>	.0921*** (.0339)	.0257*** (.0095)	.0978*** (.0331)	.0256*** (.0094)	.1274*** (.0383)	.0254*** (.0076)	.1318*** (.0374)	.0254*** (.0004)
<i>Firm_age</i>	.0044** (.0017)	.0012*** (.0005)	.0033*** (.0016)	.0012** (.0005)	.0049*** (.0018)	.0010** (.0004)	.0038** (.0018)	.0009** (.0004)
<i>Mgr_Exp</i>	.0060*** (.0017)	.0017*** (.0005)	.0053*** (.0017)	.0016*** (.0005)	.0049** (.0019)	.0009*** (.0004)	.0044** (.0019)	.0009** (.0004)
<i>R&D</i>	1.180** (.0469)	.3296*** (.0115)	1.059*** (.0515)	.3246*** (.0122)	1.779*** (.0495)	.3550*** (.0081)	1.650*** (.0584)	.3520*** (.0080)
<i>Regulations</i>	.0021** (.0009)	.0006** (.0002)	-.0011 (.0009)	.0005** (.0003)	.0009 (.0010)	.0002 (.0002)	-.0020** (.0584)	.0001 (.0002)
<i>Petty_Corruption</i>	.0027 (.0008)	.0008*** (.0003)	.0008** (.0008)	.0009*** (.0002)	.0014 (.0009)	.0003 (.0019)	.0008 (.0009)	.0004** (.0002)
<i>Industry dummy</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Country dummy</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Cons</i>	-1.181*** (.0492)		-1.082*** (.0517)		-1.519*** (.0565)		-1.421*** (.0606)	
<i>Summary statistics</i>								
<i>Log likelihood</i>	-3908.17		-3895.34		-2859.56		-3791.77	
<i>LR Chi2/Wald chi2</i>	803.19		950.52		1515.22		1548.25	
<i>P value</i>	0.0000		0.0000		0.0000		0.0000	
<i>Sample Size</i>	12783	12783	12783	12783	12833	12833	12833	12833
<i>Corr(e.formal, e.product)</i>			-.3342				-.3039 (.0463)	
<i>Sd(e.formal)</i>			21.29				21.30 (.1701)	
<i>Wald test of exogeneity Chi2(1)</i>			60.05***				37.80***	

Note: Dependent variables (product and process innovations) are dummy variables. We report probit, probit margins (dy/dx), IV probit and IV Probit (dy/dx): marginal effects measure discrete change. The main explanatory variable is Formal, a continuous variable. The instrumental variable for Formal is Sec_Avg_Credit. 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. * Significant at 10% level, **Significant at 5% level, ***Significant at 1% level.

Table 4 B

Probit and IV probit regression on formal financing and firm level organisational and marketing innovation

Variables	Probit	Margins (dy/dx)	IV Probit	IV Probit (dy/dx)	Probit	Margins (dy/dx)	IV Probit	IV Probit (dy/dx)
	<i>Organisational Innovation</i>				<i>Marketing Innovation</i>			
Formal	-.0004 (.0007)	-.0001 (.0002)	.0440*** (.0004)	-.0003 (.0035)	-.0004 (.0009)	-.0001 (.0001)	.0439*** (.0004)	-.0002 (.0024)
Sec_Avg_Credit				.0198*** (.0048)				.0126** (.0057)
Small	.0873** (.0382)	.0257** (.0112)	-.6841*** (.0264)	.0301 (.0573)	.0592 (.0485)	.0099 (.0081)	-.6849*** (.0265)	.0061 (.0391)
Foreign_Owned	-.0014** (.0008)	-.0004* (.0003)	-.0004 (.0006)	-.0004** (.0002)	-.0015 (.0011)	-.00002 (.0002)	-.0005 (.0006)	-.0003 (.0002)
Female	.0540 (.0336)	.0159 (.0098)	.0318 (.0241)	.0041 (.0095)	.0433 (.0419)	.0072 (.0070)	.0322 (.0241)	.0005 (.0067)
Firm_Age	-.0024 (.0017)	-.0007 (.0005)	-.0028** (.0012)	-.0007** (.0005)	.0001 (.0021)	-.0001 (.0003)	-.0029** (.0012)	-.0002** (.0004)
Mgr_Exp	-.0024 (.0017)	-.0007 (.0005)	-.0015 (.0012)	-.0006 (.0005)	-.0031 (.0021)	-.0005 (.0004)	-.0014 (.0012)	-.0004 (.0004)
R&D	-.0568 (.0515)	-.0167 (.0152)	-.2046*** (.0362)	-.0016 (.0217)	-.0900 (.0661)	-.0149 (.0110)	-.2001*** (.0362)	-.0035 (.0152)
Regulations	-.0006** (.0008)	-.0001 (.0002)	-.0094*** (.0006)	.0005 (.0008)	-.0050*** (.0012)	-.0008*** (.0002)	-.0096*** (.0006)	-.0007 (.006)
Petty_Corruption	.0062 (.0017)	.0019 (.0005)	.0060 (.0016)	.0016 (.0005)	.0049 (.0019)	.0010 (.0003)	.0050 (.0018)	.0009 (.0004)
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cons	-.7473*** (.0482)		.0919*** (.0378)		-1.227*** (.0609)		.0848*** (.0417)	
Summary statistics								
Log likelihood	-4056.6		-38734.34					
LRchi2/Wald chi2	21.44		15137.96					
P value	0.000		0.0000					
Sample Size	12736		12736	12736			12736	12736
Corr(e.formal,e.p roduct)			-.9996 (.0005)				-.9997 (.0004)	
Sd(e.formal)			22.70 (.1823)				22.73 (.1805)	
Wald test of exogeneity Chi2(1)			26.31***				24.05***	

Note: Dependent variables (organisational and marketing innovations) are dummy variables. We report probit, probit margins (dy/dx), IV probit and IV Probit (dy/dx): marginal effects measure discrete change. The main explanatory variable is Formal which is a continuous variable. The instrumental variable for Formal is Sec_Avg_Credit. 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. * Significant at 10% level, **Significant at 5% level, ***Significant at 1% level.

5.2 Firm level innovations formal and informal financing interaction

The interaction term on (*Sec_Avg_Credit* X Informal) is positive and statistically significant, suggesting that informal finance increases the effects of formal finance on firm level innovation. This implies that the higher the level of formal and informal financing, the more innovative the firm. Accordingly, we can accept *H2: The accessibility of informal finance moderates the relationship between formal credit constraints and SMEs' innovation performance*. This result is consistent with prior empirical evidence, suggesting a positive relationship between informal finance and firm growth in developing economies (Degryse, De Jonghe, Jakovljević, Mulier, & Schepens, 2016; Wu et al., 2016).

Table 5

Firm level innovation, interaction of formal financing and informal financing

Variables	IV Probit	IV Probit (dy/dx)	IV Probit	IV Probit (dy/dx)	IV Probit	IV Probit (dy/dx)	IV Probit	IV Probit (dy/dx)
	<i>Product Innovation</i>		<i>Process Innovation</i>		<i>Organisational Innovation</i>		<i>Marketing Innovation</i>	
<i>Sec_Avg_Credit</i>	.0332** (.0128)	.0008** (.0053)	.0005** (.0360)	.0006 (.0071)	.0441*** (.0003)	.0196*** (.003)	.0440*** (.0004)	.0126*** (.0034)
<i>Informal finance</i>	.0029** (.0011)	.0006** (.0004)	.0001** (.0026)	.0003 (.0005)	.0020*** (.0009)	.0002** (.0005)	.0021*** (.0009)	.0001 (.0004)
<i>Sec_Avg_Credit</i> <i>* Informal</i>	.0020** (.0007)	.0010** (.0004)	.0001** (.0001)	.0002 (.0002)	.0007*** (.0001)	.0006** (.0002)	.0022*** (.0006)	.0018*** (.0002)
<i>Control variables</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Summary Stat</i>								
Log likelihood	-39422		-38374		-38671		-37071	
/Wald chi2	1856.41		1367.08		1478.78		14995.22	
<i>P value</i>	0.000		0.000		0.000		0.000	
<i>Sample Size</i>	12826	12726	12826		12729	12729	12715	12715
<i>Corr(e.formal, e.product)</i>	-.7035 (.3121)		.0841 (.8110)		-.9989 (.0011)		-.999287 (.0007)	

<i>Sd(e.formal)</i>	22.65 (.1810)		22.64 (.1811)		22.62 (.1819)		22.66 (.1822)	
<i>Wald test of exogeneity Chi2(1)</i>	35.7**		39.71*		51.69***		51.09***	

Note: Four dependent variables (Product, Process, Organisational and Marketing Innovations) are dummy variables. We report IV probit and IV Probit (dy/dx): marginal effects measure discrete change. The interaction variable (Sec_Avg_Credit Informal) is used to check the impact of informal credit on formal credit of innovation. 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. * Significant at 10% level, **Significant at 5% level, ***Significant at 1% level.*

6. Robustness

In order to assess the robustness of our results, we conduct the following robustness analysis.

(i) *Propensity score matching models and firm level innovation*

In recent times, the propensity score matching (PSM) technique has increased the ability of researchers to draw causal inferences using observational data. PSM controls self-selection biases and causal interferences by placing them into non-random assignment (Rosenbaum & Rubin, 1983). In this study, we are comparing the propensity for innovation in firms that are exposed to no treatment $T=0$ (no formal finance) and the propensity for innovation in firms that are exposed to treatment $T=1$ (formal finance). We use four matching methods: stratification matching; nearest neighbour matching; kernel matching; and radius matching, following (Becker & Ichino, 2002).

Table 6 includes all matching models and shows the ATT is significant and positive for product and process innovations. Through a comparison of the different matching models, 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 to 8 % and 3 to 6 % respectively. Panel B includes all matching models; the estimated positive average effect of formal finance on organisation and marketing innovation outcomes for firms that have formal finance is between 23 to 26 % and between 8 to 9 % respectively. Although the PSM coefficients are significantly larger than our IV probit, the PSM results align with our main probit and /IV probit results. This upward biases in PSM model indicates the importance of controlling for all types of endogeneity.

Covariate Choice: The covariates chosen for the PSM are standard in the literature (See Lee, Sameen, & Cowling, 2015; J. A. Smith & Todd, 2005), reflecting economic theory and the institutional settings. Omission of significant variables can result in a surge bias in estimates (Heckman, Ichimura, & Todd, 1997). Only variables that simultaneously, influence the decision of participation and the outcome variable, need to be included (Caliendo & Kopeinig, 2005). We use a statistical significance approach to select covariates¹² by iteratively adding variables to the specification and retaining those that are statistically significant (Heckman, Ichimura, & Todd, 1997). The covariates included in the PSM models are: firm size (Small and Medium), firm ownership (Foreign and Female), firm age (Firm_age), manager experience (Mgr_Exp), R & D expenses (R & D), senior manager time dealing with regulations (Regulations), paying bribes to get things done (Petty_Corruption), industry (30 sub-industry categories), and country (29 countries).

¹² Three common strategies for the selection variables are 1. Hit or Miss Method 2. statistical significance approach (Heckman et al., 1997) 3. Leave-one-out cross-validation (Black & Smith, 2004).

Overlap and common support: We report the overlap and common support assumptions between treatment and compression group. From the several approaches¹³ available we parsimonious, adopting the straightforward visual analysis of the density distribution of the propensity scores in treatment and compression group (Caliendo & Kopeinig, 2005; Michael Lechner, 2008). 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 finance innovations.

Table 6

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

<i>Panel A:</i>	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
	Organisation Innovation					Marketing Innovation				
<i>Panel B</i>	No. treated	No. contr.	ATT ^a	Std.Err	t	No. treated	No. contr.	ATT ^a	Std.Err	t
Nearest neighbour matching	1286	999	0.253	0.020	12.77	1286	994	0.084	0.018	4.623
Kernel matching	1286	2044	0.257	0.021	12.49	1286	2044	0.088	0.013	6.739
Radius matching (radius=0.01)	501	2002	0.234	0.023	10.34	-	-	-	-	-

¹³ Minima and Maxima compression of the propensity score in treatment and comparison groups (See Michael Lechner, 2002) and trimming procedure to determine the common support (See J. A. Smith & Todd, 2005) are the other methods of ensure the common support condition observed in the treatment and control group.

Stratification matching	1286	2044	0.238	0.016	14.63	1286	2044	0.086	0.011	7.552
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Note: an ATT means the average treatment effect on the treated. All covariates used in the probit model is included in here. The standard error used to compute the t statistics is the standard deviation of the ATT after 100 bootstrap replications.

The following covariates are included in PSM models: firm size (Small and Medium), firm ownership (Foreign and Female),firm age (firm_age),manager experience (Mgr_Exp), R & D expenses (R & D), senior manager time dealing with regulations (Regulations), paying bribes to get things done (Petty_Corruption), industry (30 sub-industry categories), and country (29 countries).

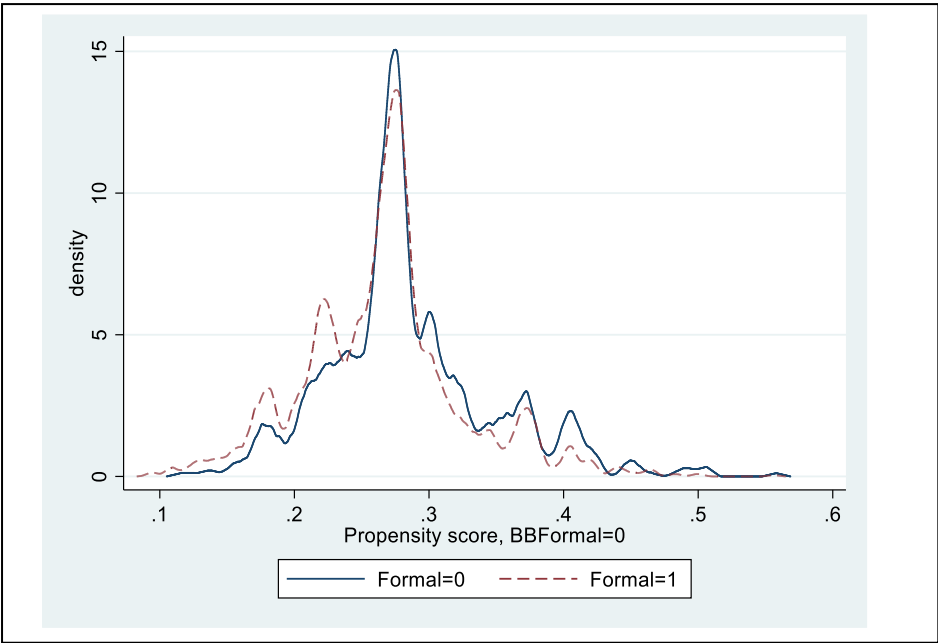


Figure 1: Kernel densities of propensity score for firm level innovation and formal financing

(ii) Treatment effects estimation

In our Table 7 results, the ATT indicates the average effect when everyone in the treated group receives the treatment, vis à vis no-one in the treated group receiving the treatment. ATE is the average effect that would be seen if all participants (both treated and comparison groups) received the treatment compared to if none of these participants (treated and comparison) received the treatment. The ATT and ATE will not necessarily be equal because the treatment effect varies across participants and varies across participants in the treated and

comparison groups¹⁴. We now report the ATE of formal finance, which provides an idea about how formal finance impacts on firm level innovation in the whole population. Overall, ATE results align with our primary findings, which indicates that formal financing has a positive outcome to all type of innovation, and that effect is highest for organisational innovation.

Table 7
Treatment effects 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 -Organisational Formal (1 vs 0)	.0848746	.0091987	41.84	0.000	.3668454	.4029038
ATE -Marketing Formal (1 vs 0)	.0504398	.0072612	20.72	0.000	.1362081	.1646715

(iii) Resampling

Russian firms represent approximately 28% of the total sample. Exclusion of the Russian firms removes the dominant effect of Russian institutional factors if they exist when rerunning the probit and IV probit models. The results are consistent with the primary results, discussed above, confirming that formal finance has a significant positive impact on firm level innovation, and this impact varies across innovation types.

6. Discussion and Policy Implications

This study extends the existing literature by exploring the relationship between formal credit availability and four types of firm level innovation for SMEs. An appreciation of how

¹⁴ The ATT and ATE values are equal in randomised controlled trials.

innovation, formal and informal finance affect SMEs is essential when formulating efficacious public policy. Our first hypothesis of a positive relationship between formal credit availability and innovation is confirmed for all four types of innovation, and the effect of formal financing on firm level innovation is higher in soft innovation than in hard innovation. Results also indicate that using informal credit is common in our sample firms. Our second hypothesis, which concerns how accessibility to informal finance moderates the relationship between formal credit accessibility and SMEs' innovation performance, is confirmed.

An increase in access to finance is the key outcome necessary, but it is not a sufficient condition — the formal sector, when lending to smaller businesses, suffers from an information asymmetry problem. Consequently, the prudent action is to ameliorate the risk while maintaining profitability. Through the proximity of communication and interaction, the Error type 1 is lowered as there is less information asymmetry, more monitoring, which reduces agency costs, and strong collection processes.

The informal financial sector operates in a very different manner. Typically, it is not a bricks and mortar-based establishment but rather a diffuse set of money lenders. Crowdfunding is a contemporary example, and business angels and venture capitalists fall along the spectrum of informal lenders, dependent upon the regulatory regime in the prospective country. Venture capitalists predominantly want an equity stake, rather supplying debt capital, in firms that are likely to produce significant increases in value realisable through trade sale or initial public offering. Venture capital offers the potential to increase innovative activity and governments recognising this potential encourage this through regulatory processes. At the smaller business end venture capital is less important for most businesses, excepting those with high flying potential of which only a few actually succeed. The forms of innovation relating to process, product marketing innovation do not produce the large increases in enterprise value that venture

capitals are looking to back. The formal and informal sector debt providers are the major external source of capital to this genre of innovation.

Support and encouragement for the informal financial sector tend to be anathemas for public policy analysts and advisors. Informal finance is typically structured, such as crowd funding and peer to peer lending underground sponsored by loan sharks with gang and crime syndicate affiliations. Nevertheless, development and implementation of policy to enhance informal sector financing is a challenge in developing economies. As an example, petty corruption, which relates to the firm level is common in many countries. Bribes are a form of low cost signalling, indicating to a prospective lender the business can afford the loan and pay additional money to secure such a loan. In this instances the probability of type 1 and 2 errors are increased.

In summary, public policy issues are clear, and potential policy formulation requires a research analysis in situ. Most importantly, a recognition that more of the same regulatory and compliance weakness, coupled with low level contractual certainty and corruption, means no progress and lost opportunities to improve a nation's overall wellbeing. Our research indicates that there is a way forward.

Appendix 1

Definition and measurement of variables

Variable	Definition	Measurement
Dependent variable		
<i>Product_Inno</i>	This takes value 1 if the firm introduced new or significantly improved products or service, otherwise 0.	<i>1=yes; 0=otherwise</i>
<i>Process_Inno</i>	This takes value 1 if the firm introduced new or significantly improved methods of manufacturing products or offering service, otherwise 0.	<i>1=yes; 0=otherwise</i>
<i>Org_Inno</i>	This takes value 1 if the firm introduced new or significantly improved organisational structures or management practices, otherwise 0.	<i>1=yes; 0=otherwise</i>
<i>Market_Inno</i>	This takes value 1 if the firm introduced new or significantly improved marketing methods, otherwise 0.	<i>1=yes; 0=otherwise</i>
<i>Explanatory variables</i>		
<i>Formal</i>	Percentage of formal finance (finance from bank and nonbank)	Percentage
<i>Informal</i>	Percentage of informal finance (finance from trade credits and funds from friends and family)	Percentage
<i>Small</i>	Firm has 5 to 19 employees.	<i>1=yes; 0=otherwise</i>
<i>Medium</i>	Firm has between 20 and 99 employees.	<i>1=yes; 0=otherwise</i>
<i>Foreign</i>	Percentage of private foreign individuals, companies or organisations	Continuous variable, take range from 0% to 100%.
<i>Female</i>	Firm has at least one female owner	<i>1=yes; 0=otherwise</i>
<i>Firm_age</i>	Number of years since firm has been established	<i>Year(s)</i>
<i>Mgr_Exp</i>	Number of years' experience of the firm's manager.	<i>Year(s)</i>
<i>R&D</i>	Firm allocated R&D expenses	<i>1=yes; 0=otherwise</i>
<i>Regulations</i>	Percentage of senior management's time spent on dealing with requirements imposed by government regulations.	Continuous variable, take range from 0% to 100%.
<i>Petty_Corruption</i>	This variable determines the existence of a bribe. This takes value 1 if the firm answers yes to the below question: It is said that establishments are sometimes required to make gifts or informal payments to public officials to 'get things done' about customs, taxes, licenses, regulations, services, etc. On average, what percentage of total annual sales, or estimated total annual value, do establishments like this one pay in informal payments or gifts to public officials for this purpose?	<i>1=yes; 0=otherwise</i>
<i>Industry</i>	30 Industry dummies are included	
<i>Country</i>	29 Country dummies are included	

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