

Financial Constraints and Innovation: Is there a uniform relationship across types of innovation?

Nirosha Hewa Wellalage

The University of Waikato

Abstract

An analysis of the extent to which formal credit constraints affect firm level innovation of small medium enterprises in transitional economies finds informal finance plays an important role. Formal credit constraints impede marketing innovation and stimulates product and organisational innovation. Access to informal finance increases the four types of innovation, investigated in this study, using propensity score matching to control unobservable determinants of the credit constraints-innovation relationship. Several robustness tests provide supportive findings. The results point to the importance of informal finance as a source of external finance for firms where capital markets suffer from multiple imperfections.

Keywords: *Innovation; SMEs; emerging markets; endogeneity; propensity score matching method (PSM), transition economies*

JEL classification: *O1; G2:G28*

1. Introduction

Research, in this paper, explores the relationship between innovation and formal credit constraints for small and medium enterprises (SMEs)¹, using World Bank data for Central Asia and Eastern Europe. In particular we analyse following the recommendation of, four direct proxies of innovations - product, process, marketing and organisational as recommended in the *Oslo Manual*². Smaller business innovation differs in many instances from the activities of larger corporations where Research and Development expenditure is a predominant metric used in studies and often combined with stock market data. In addition to concentrating on the non-corporate sector we scrutinise the moderating effects of informal sector financing³ on firm-level innovation and causality in the relationships.

Within the extant research we observe three features which motivate the current study. First, evidence supporting the conjecture that innovation boosts economic growth and private sector development is not new (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2011; Baumol, 2002). Second firm level innovation and credit constraint studies are attracting more attention recently (Ayyagari et al., 2011; Gorodnichenko & Schnitzer, 2013). Third these works rarely

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

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 has emphasis the economic impacts 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).

³ 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.

attempt to distinguish between various types of innovation or its components ((Habiyaemye & Raymond, 2013). The significant issue constraining research concerning how innovation activities in small firms impact and are impacted by accessibility of finance is the absence of firm-level data (Ayyagari et al., 2011).

Motivation to investigate the role of innovation in smaller entrepreneurial businesses and channels of finance are encourage the use of new data sources and robust analytic methods. To date public policy development directed toward growth and increasing wellbeing remains ill-informed ignoring the consequences of financing constraints differentially affect investment and economic growth depending on the specific institutional, social and geographical context, the structural characteristics of the firms, and the economic sectors in which they operate (Dosi, Pavitt, & Soete, 1990). We articulate the effect of formal credit constraints on different types of firm level innovation for SMEs in transitional economies and there is a clear need to be specific concerning the credit constraints and its effect on different types of innovation when formulating policy.

Informal investment as the primary source of external risk capital for innovation in SMEs is a second best outcome and cause of distortions in the economy. As a consequence of the formal financial sector's unresponsiveness to excess credit demand, the informal credit market tends to develop and become an integral component of financial intermediation in transition economies.

The Business Environment and Enterprise Performance Surveys (BEEPS)⁴ provide cross-country firm-level data for 29 transition economies. We observe some formal financial

⁴ The Business Environment and Enterprise Performance Surveys (BEEPS) was developed jointly by the World Bank and the European Bank for Reconstruction and Development. BEEPS includes 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/>)

constraints firms and others that do not, but a direct comparison between them leads to an identification problem because formal credit constraints may correlate with unobserved determinants of firms. To overcome this potential bias, we use propensity score matching (PSM) to find a comparison group for individual firms in the financial constraints group. After controlling for firm characteristics and taking care of firms' observable factors typically linked to innovation decisions, we find systematic difference in the firm level innovation activities associated with credit constraints.

In particular, formal credit constraints will increase SMEs' product innovation and organisational innovation by approximately 11 percent and 3 percent respectively. However, credit constraints will decrease SMEs' marketing innovation by approximately 4 percent and credit constraints do not have significant impact on process innovation. Further, the 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. Additionally, robustness testing of regression results with bivariate probit, alternative proxies and average treatment effects (ATE) produce predominantly consistent findings, and the overall interpretation of the results does not alter, lending support to the conclusion of our main findings.

Our study contributes three novel insights into literature. First, we are contributing new evidence to the growing literature on SMEs and innovation by analysing SMEs' firm level innovation and credit constraints using micro-data (Hult & Ketchen, 2001; Lööf & Nabavi, 2016; Mancusi & Vezzulli, 2010). To our knowledge, this is the first analysis distinguishing between various types of innovation and show credit constraints impact differently between types of innovation. While the impact of credit constraints on SMEs innovation has been the

subject of previous studies, the hypotheses typically test single types of innovation, and predominantly focusing upon product or process innovation.

Second, most prior studies, using micro-data, select firms in developed markets (Hajivassiliou & Savignac, 2008; Hult & Ketchen, 2001; Savignac, 2008). Policy, derived from such mature market studies, may prove problematic for SMEs in transition economies given the effects of control variables capturing size, cultural and various institutional differences. For many transitional economies the financial system is dominated by state-owned banks, which do not necessarily allocate credit to firms with the highest rate of return on capital due to multiple levels of corruption. Access to credit does not guarantee growth when credit markets suffer from systemic allocative inefficiency. Our study, provides a framework, encouraging the development and promulgation of policy based on financing for various types of innovation, specifically suited for weak institutional environments. Third, our methodology advances previous studies in several respects. We use direct measures of innovation and credit constraints; following the recommendation of the *Oslo Manual* - product, process, marketing and organisational metrics are engaged. This differs from earlier works measuring innovation via indirect proxies such as R&D expenses and patents (Löf & Nabavi, 2016; Mancusi & Vezzulli, 2010), which do not adequately capture the innovation behaviour of SMEs in transition economies. Innovation in technologically developed countries typically involves R&D activities; however, in transitional and developing economies innovation it often involves limitation (Acemoglu, Aghion, & Zilibotti, 2006). Doubts concerning the propriety of using R&D as an innovation proxy for emerging markets small firms appearing in the literature because, 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.

The micro-econometric robustness of the analysis advances prior studies, dealing directly with causality and other endogeneity bias. We employ a propensity score matching (PSM) method to calculate the average treatment effects of credit constraints on firm level innovation activities. A PSM method allows non-randomised studies similar to randomised experiments to be designed (Rubin, 2001). The underlying concept of propensity score is matching treated with untreated. We include matching treated with untreated (i.e. credit constrained and non-credit constrained) firms regarding their observable characteristics. Then we compare the innovation level of credit constrained firms and non-credit constrained firms that have the same credit constrained propensity. The estimated effect is provided by the post-treatment variable - credit constraint.

The paper is organised as follows. Section 2 presents the literature review and hypothesis development, while section 3 describes the data and the section 4 explains the model specifications. Section 5 discusses our empirical findings, and section 6 reports robustness studies. Section 7 provides discussion and policy implications.

2. Literature Review and Hypothesis Development

Empirical evidence concerning the relationship between innovation and credit constraint continues to accumulate since the early studies of Arrow (1962) through Mulkay, Hall, and Mairesse (2001) and more recently Hall and Lerner (2010), and Hottenrott and Rexhäuser (2015). An interest in firm level studies has also gained more traction (Ayyagari et al., 2011; Gorodnichenko & Schnitzer, 2013). Both information asymmetry, including moral hazard and adverse selection (Hall & Lerner, 2010), and signalling theory (Hottenrott & Rexhäuser, 2015) are emerging as important theoretical lenses for analysis.

Myers (1984), and Myers and Majluf (1984) suggest firms prefer to finance new investments by first using internally stored retained earnings and only then seeking external

debt and finally, external equity. Information asymmetry suggests that the shadow cost of funds increases with the degree of severity of the asymmetric information problem. It appears cheaper to finance innovation with internal funds than sourcing external markets. Additional opaqueness emerges where innovative firms intentionally maintain information asymmetries to avoid the revealing information to competitors, which may reduce the prospective value of innovation (Hall & Lerner, 2010; Mancusi & Vezzulli, 2010).

An explanation of the bias resulting from an asymmetric information problem suggests that information frictions lead to high loan costs and high loan default rates. Lack of information or limited information means external finance providers are unable to evaluate the quality of funding applications resulting in financial institutions failing to produce equilibrium prices and efficient transactions (Stiglitz, 2000). As Stiglitz argues:

because of these [...] problems of information [...] the exchange process is intertwined with the process of selection over hidden characteristics and the process of providing incentives for hidden behaviours. (p. 1447)

From an agency theory perspective, moral hazard results from the inability of principals to monitor agents' actions, and adverse selection emanates from failure of principals to observe agents' private information. The consequence, resulting from these agency theory issues, produces constraints in the credit market whenever lenders cannot observe a borrower's risk type, as lenders will need to reject credit to both high- and low-risk types.

2.1 Hypothesis development

A firm's decision to innovate depends on many factors encompassing internal and external conditions (Kim, Park, & Roy Song, 2017). Accessibility of external finance is one of the key factors which has a significant impact on firm's level of innovation (Hajivassiliou & Savignac, 2008). SMEs lacking internal funds may seek external funds (Beck & Demirguc-

Kunt, 2006; Schneider & Veugelers, 2010). Empirical evidence concerning innovation and formal credit⁵ constraints is mixed. One strand of literature argues that innovative SMEs face limited formal credit availability and/or high costs of credit (Schneider & Veugelers, 2010). An alternative approach aligned with signalling theory, posits that innovation may signal a firm's quality and monopolistic power, eliminating information asymmetries in external financing and positively encouraging market participants (Heil & Robertson, 1991; Schatzel & Calantone, 2006). This line of thinking suggests innovation may stimulate access to external credit. However, little research is available connecting formal financial constraints in SMEs' innovation and signalling, and none that we are aware of exploring causality effects.

Beck, Demirgüç-Kunt, and Maksimovic (2008), report that bank finance is the most dominant external financing provider for small firms in developing and transition economies. A well-developed formal finance sector can alleviate financial constraint faced by innovative SMEs. On the other hand, availability of formal financial institutions will lead to interbank competition which stimulates formal financial institutions to finance riskier innovation projects. Having 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 set of planning, designing, testing and process development. Therefore, loans with short maturity impose financial pressure on innovative firms. However, formal financing providers usually offer long-term or medium-term maturity loans which allows innovative firms to have enough repayment period. This may lead to a positive relationship between formal financing and firm-level innovation activities. 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. This indicates that formal financial institutions

⁵ Loan form formal financial institutions, such as banks and other formally registered financial institutions

reduce the financial burden for innovative firms and this promotes innovations. Therefore, formal financial constraints may negatively impact on firm level innovation for SMEs. We expect that:

H_{1a}: There is a negative relationship between formal credit constraints and product innovation performance of SMEs.

H_{1b}: There is a negative relationship between formal credit constraints and process innovation performance of SMEs.

H_{1c}: There is a negative relationship between formal credit constraints and organisation innovation performance of SMEs.

H_{1d}: There is a negative relationship between formal credit constraints and marketing innovation performance of SMEs.

There are significant implications for firm operations, growth and sustainability associated with decisions about sources of funding to use (Denis, 2004; Hall & Lerner, 2010). Apart from the formal financial sector (such as banking sector), prior studies have shown that the informal financial sector plays a major role in financing firms in most emerging economies (Ayyagari, Demirgüç-Kunt, & Maksimovic, 2010; Mullineux & Murinde, 2014) and small firms (Denis, 2004; Wilson, 2015). A heavily regulated formal financing sector cannot cater to growing demand of small firms in transition and emerging economies (Lin & Sun, 2006). Therefore, the informal financing sector plays an important role in these economies in alleviating credit constraints (Buyinza & Bbaale, 2013; Madestam, 2014).

Gerlach-Kristen, O'Connell, and O'Toole (2015) report that SMEs are often constrained by formal credit. In terms of formal financing, banks need to screen firms carefully before providing the bank loans to avoid type I (reject sound lending prospects) and type II (accept

poor lending prospects) errors. This screening and monitoring is costly and it may be simpler to reject SMEs finance applications for more non-fixed asset lending. This situation is more severe for SMEs in transition economies due to the weak institutional environment. Accordingly, growth-oriented SMEs in non-mature capital markets rely on informal finance for their innovative projects (Buyinza & Bbaale, 2013). This supports a background for numerous money lenders to lead the financial market support for growth-oriented, innovative SMEs' by providing for soft borrowing. Through low cost credit for innovative SMEs (Armendáriz & Morduch, 2010), less or no collateral (Wu, Si, & Wu, 2016), informal finance lenders provide credit for innovative SMEs. The rationale for the popularity of these schemes among SMEs is mainly to seek alternatives and soft credit with more accessibility.

Aligned with signalling theory, Almazan, Banerji, and Motta (2008) and Payne, Moore, Bell, and Zachary (2013) report that cheap talk, or low cost signals can also be used by senders to reduce information asymmetries between borrowers and lenders. In this case, informal money lenders have a unique opportunity for close proximity, which promotes SMEs lending by trading on the soft information. This soft information, due to informal money lenders' grass-roots presence, established reputations and extensive knowledge and relationship with the SMEs in an area, enables them to utilise social collateral and personal relationships as a valid means of control. This increases the accessibility and availability of informal finance for innovative SMEs. We expect that:

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

3. Data

Data are assembled from the World Bank Enterprise Surveys⁶ (BEEPS) in Eastern Europe and Central Asia. These BEEPs are jointly produced by the World Bank and the European Bank for Reconstruction and Development and comprise representative random samples of firms across 30 Eastern European and Central Asian economies⁷ of which 14 countries are from the former Soviet Union⁸. We have selected 29 transitional economies for our study. The surveys employ stratified random sampling techniques with identical questionnaires across all countries. BEEPS include both qualitative and quantitative information at the firm level, covering a broad range of issues such as the performance of firms, firm financing, innovation activities and business environment.

Our study utilises 5646 SMEs. The majority of firms is from Russia (1676). Product innovation is the most common form of innovation reported (57.56%). A look at the various forms of innovation shows variability between countries.

Table 1 lists the full study sample base for each country indicating product, process, and marketing and organisational innovation percentage. Additionally, the percentage of non-credit constrained firms, firms with a bank loan, firms with trade credit, and firms with informal financing are reported.

⁶ The World Bank's Enterprise Surveys offer an expansive array of economic data on 130,000 firms in 135 countries. The World Bank 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. The surveys cover a broad range of business environment topics including access to finance, corruption, infrastructure, crime, competition, and performance measures.

⁷ Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Ukraine, Uzbekistan, Albania, Bih, Bulgaria, Croatia, Czech, Hungary, Kosovo, Macedonia, Mongolia, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia and Turkey.

⁸ Former Soviet Union countries are Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Ukraine and Uzbekistan.

Table 1

Total study sample

Country	Innovative (Innov) firms	Product Innov %	Process Innov %	Market Innov %	Organisational Innov%	Non-credit constraints firms %	Firms with bank loan %	Firms with non- bank loan %	Firms with trade credit %	Firms with informal credit* %
Albania	53	71.70	32.08	47.17	33.96	88.68	0.00	20.75	3.77	96.23
Armenia	59	66.28	24.42	50.00	29.07	62.79	100.00	54.65	17.44	97.67
Azerbaijan	27	29.63	40.74	33.33	44.44	59.26	100.00	66.67	7.41	100.00
Belarus	185	47.23	56.60	72.77	64.26	65.96	0.00	16.17	8.09	97.02
Bosnia- Herzegovina	170	68.39	46.63	48.19	50.26	70.98	100.00	35.75	12.95	95.34
Bulgaria	131	47.10	32.90	46.45	57.42	64.52	100.00	0.00	0.00	0.00
Czech	136	76.33	52.07	37.28	37.28	84.62	100.00	22.49	7.10	86.98
Estonia	86	60.78	53.92	47.06	48.04	89.22	100.00	31.37	9.80	95.10
Georgia	46	62.07	60.34	53.45	41.38	74.14	0.00	18.97	5.17	93.10
Hungary	114	57.39	53.91	52.17	35.65	66.96	100.00	40.00	11.30	88.70
Italy	201	64.00	48.89	54.67	53.33	63.56	25.78	10.22	3.11	73.33
Kazakhstan	162	60.42	42.19	46.35	48.44	60.94	100.00	48.44	13.54	94.79
Kosovo	144	72.97	56.08	75.00	71.62	57.43	100.00	25.68	4.05	93.92
Kyrgyzstan	133	68.21	47.68	72.19	66.23	58.94	100.00	45.03	11.26	93.38
Latvia	99	59.29	35.40	34.51	34.51	86.73	100.00	25.66	6.19	87.61
Lithuania	94	61.68	50.47	41.12	50.47	72.90	100.00	16.82	11.21	70.05
Macedonia	177	57.73	40.21	67.53	72.68	68.56	100.00	37.63	7.73	95.88
Moldova	127	70.39	71.71	66.45	65.13	76.32	100.00	46.71	13.82	98.68
Mongolia	189	49.47	64.21	71.58	68.95	47.37	100.00	38.95	12.11	97.37
Montenegro	34	45.24	33.33	45.24	33.33	76.19	0.00	21.43	2.38	100.00
Poland	233	62.85	41.67	55.21	43.40	80.90	0.00	29.17	18.75	93.40
Romania	321	58.06	52.69	66.67	56.18	57.80	5.91	20.16	6.72	95.43
Russia	1686	54.44	51.58	54.80	52.72	77.27	100.00	19.30	7.11	95.49
Serbia	164	66.15	39.49	54.87	40.51	64.10	100.00	48.21	14.36	95.38
Slovakia	80	58.89	41.11	42.22	40.00	76.67	100.00	0.00	0.00	0
Slovenia	123	64.19	20.27	46.62	38.51	73.65	100.00	0.68	0.68	2.03
Tajikistan	118	42.75	32.61	70.29	50.00	59.42	0.00	21.01	5.07	97.83

Turkey	293	40.05	37.68	49.05	45.26	78.91	0.00	22.04	10.90	96.21
Ukraine	252	62.31	38.94	40.19	29.60	52.02	0.00	12.46	5.61	98.13
Uzbekistan	9	76.00	28.00	28.00	28.00	88.00	0.00	24.00	16.00	92.00
Total	5646	57.56	46.98	54.79	50.51	70.68	39.30	24.12	8.38	88.50

Table 2 shows the relationship between financing type (formal and informal) and innovation type. The figures in Table 2 point to a high level of informal finance. Informal financing has a substantial impact on SMEs' innovation where 50 percent of SMEs with informal debt engage with product innovation compared with 25 percent of SMEs with formal financing.

Table 2
Innovation and credit access for firms

	Product Innovation %	Process Innovation %	Marketing Innovation %	Organisational Innovation %	R&D %
Firms with informal finance	50.44	41.76	88.52	43.96	20.66
Firms with bank loan	25.23	18.40	21.80	20.42	9.45

3.1 Variables

Our main dependent variable for this study is *Innovation*. We derive the is *Innovation* variables from the following survey question:

During the last three years, has this establishment introduced (i) new or significantly improved products or service, (ii) methods of manufacturing products, (iii) offering service/organisational structures, and (iv) management practices/marketing methods?

Product_Inno dummy variable, taking the value one if the firm introduced new or significantly improved products or service product, during the last three years and zero otherwise.

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

Market_Inno dummy variable, taking the value one if the firm introduced new or significantly improved management practices/ marketing methods during the last three years and zero otherwise.

Org_Inno dummy variable, taking the value one if the firm introduced new or significantly improved methods of offering service/organisational structures during the last three years and zero otherwise.

Following Love and Martínez Pería (2014), we calculate the formal credit *Constraints* variable, taking value 1 if the firm does not have (i) overdraft facility and (ii) a line of credit or loan from a financial institution, if otherwise, 0. This objective measure avoids the strain arising from business owners underreporting their debt levels (Karlan & Zinman, 2008). The standard empirical strategy to identify financially constricted firms is to analyse investment-cash flow sensitivity measures (Hoshi, Kashyap, & Scharfstein, 1991). However, if the method does not control potential endogeneity of cash flow or ignore the possibility of external finance,

investment cash flow is not an accurate measure (Efthyvoulou & Vahter, 2016). Although, self-reported measures are common in the literature (Hansen & Rand, 2014; Wellalage & Locke, 2016) these self-reported measures capturing credit constraints are subject to potential measurement errors (Kaplan & Zingales, 2000).

Other covariates incorporating basic information about firms form an important part of the study. Variables capturing information covering firm characteristics, owner/ manager characteristics, and institutional characteristics are potentially important for the analysis. These variables are common in studies relating to innovation and credit constraints. We have used the experience of prior research in related areas to assist in guiding our choice of variables. Table 3 presents definitions and metrics for variables included in the models.

With respect to covariate variables, older firms and larger firms have more resources and capabilities for innovation compared to their small counterparts. Therefore, we expect a significant impact from firm age in firm level innovation (Huergo & Jaumandreu, 2004; Pla-Barber & Alegre, 2007). Using Eastern European and Central Asian countries Balsmeier and Czarnitzki (2014) report positive relationships between 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. Export status as a proxy for export participation has been linked to firm innovation (Pla-Barber & Alegre, 2007) and is included.. We also control industry affect by using three industry dummies. Firm ownership may significantly impact firm level innovation (Matzler, Veider, Hautz, & Stadler, 2015), therefore, we include foreign ownership, government ownership and female ownership variables (Díaz-García, González-Moreno, & Jose Sáez-Martínez, 2013; Sastre, 2016; Teruel & Segarra-Blasco, 2017). Also institutional factors such as regulations and corruption may

impact on firm level innovation (Ayyagari et al., 2011; Ayyagari, Demirgüç-Kunt, & Maksimovic, 2014) and are accordingly tested.

Table 3
Definition and measurement of variables

Variable	Definition	Measurement
Dependent variable		
<i>Constraints</i>	Constraints taking value 1 if the firm does not have (i) overdraft facility and (ii) a line of credit or loan from a financial institution, if otherwise, 0.	<i>1=yes;</i> <i>0=otherwise</i>
Independent 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;</i> <i>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;</i> <i>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;</i> <i>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;</i> <i>0=otherwise</i>
<i>Manufacturing</i>	Firm from manufacturing industry	<i>1=yes;</i> <i>0=otherwise</i>
<i>Small</i>	Firm has 5 to 19 employees.	<i>1=yes;</i> <i>0=otherwise</i>
<i>Medium</i>	Firm has between 20 and 99 employees.	<i>1=yes;</i> <i>0=otherwise</i>
<i>Foreign</i>	Percentage of private foreign individuals, companies or organizations	Continuous variable, take range from 0% to 100%.
<i>Government</i>	Percentage of government ownership	Continuous variable, take range from 0% to 100%.
<i>Female</i>	Firm has at least one female owner	<i>1=yes;</i> <i>0=otherwise</i>
<i>lnage</i>	Log number of years since firm has been established	<i>Year(s)</i>

<i>lnTop_Exp</i>	Log number of years' experience of the firm's manager.	<i>Year(s)</i>
<i>Exporter</i>	Firm engaged with direct export	<i>1=yes;</i> <i>0=otherwise</i>
<i>Regulations</i>	Percentage of senior management's time was spent on dealing with requirements imposed by government regulations.	Continuous variable, take range from 0% to 100%.
<i>Corruption</i>	This variable determines the existence of a bribe	<i>1=yes;</i> <i>0=otherwise</i>

This study has 5646 SMEs' data points from 29 transition economies. Descriptive statistics for the data are presented in Table 4. Forty five percent of SMEs report they are credit constrained. Table 4 indicates that 89 percent of innovative firms have access to informal credit. 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.

Innovation variable suggests approximately 42 percent of sample SMEs are engaged with product, process, organisation or marketing innovation activities. A majority of innovative firms (approximately 57%) engage in product innovation. Marketing innovation is present in 55 percent, and organisational innovation 49 percent of innovating businesses of the total sample, 46 percent are process innovative firms.

Manufacturing is the largest, representing 42 percent of firms, followed by core (main) and retail sector firms representing 37 percent and 20 percent respectively. Small firms predominate as almost 53 percent of the sample, and 43 percent of medium size firms contributed. The ownership characteristics reveal 5.2 percent of firms are fully foreign owned and less than 1 percent government owned. Innovation firms owned or jointly

owned constitute 36 percent of the sample. The average age of sample firms is 14.5 years, and managers of the sample firms have approximately 17 years of experience. Twenty-five percent of sample SMEs are exporters. A quarter of the businesses are export oriented.

The variable *Corruption* reveals approximately 32 percent of SMEs in the sample make informal payments to get things done. The *Regulations* variable points to senior managers spending approximately 17 percent of their time dealing with government rules and regulations and some businesses indicated 100 percent of time goes into dealing with regulation. High values for *Corruption* and *Regulation* point toward an institutional environment not supportive to the firms.

Table 4
Descriptive statistics

Variable	Obs	Mean	Std.Dev	Min	Max
<i>Constraints</i>	5646	.4536	.4979	0	1
<i>Informal</i>	5646	.8852	.3187	0	1
<i>Innovation</i>	5646	.4157	.4928	0	1
<i>Product_Inno</i>	5646	.5710	.4949	0	1
<i>Process_Inno</i>	5646	.4616	.4985	0	1
<i>Org_Inno</i>	5646	.4909	.5000	0	1
<i>Market_Inno</i>	5646	.5457	.4979	0	1
<i>Manufacturing</i>	5646	.4155	.4928	0	1
<i>Retail</i>	5646	.2027	.4780	0	1
<i>Core</i>	5646	.3707	.4830	0	1
<i>Small</i>	5646	.5266	.4993	0	1
<i>Medium</i>	5646	.4326	.4954	0	1
<i>Foreign</i>	5589	.0521	.2043	0	1
<i>Government</i>	5586	.0052	.0747	0	.99
<i>Female</i>	5646	.3590	.4797	0	1
<i>age</i>	5608	14.53	9.83	0*	102
<i>lnage</i>	5607	2.487	.6333	0	4.624
<i>Top_Exp</i>	5526	17.07	9.89	1	70
<i>ln_top_exp</i>	5526	2.641	.6903	0	4.248
<i>Exporter</i>	5619	.2541	.4354	0	1
<i>Regulations</i>	5115	17.19	20.94	0	100
<i>ln_Regulations</i>	4269	2.516	1.084	0	4.605
<i>Corruption</i>	5646	.3163	.4650	0	1

*Firm with less than 1 year included in age 0 group.

4. Model Specifications

4.1 Endogeneity of the innovation and credit constraints relationship

The one of the main source of endogeneity of the innovation and financial constraints occurs when a predictor variable correlates with the error term (Antonakis, Bendahan, Jacquart, & Lalive, 2010; Wooldridge, 2002)⁹. The classic meaning of endogeneity refers to the simultaneity problem where the flow of causality is not purely from the predictor variables to the dependent variable. In other words, if we think that changes in the predictor variable may cause changes in a dependent variable or that the predictor variable and a dependent variable are being jointly determined, then there is simultaneity and we would not expect the error term to be uncorrelated with the predictor variables. The decision to engage in innovation activities and the way to finance for this innovation are simultaneously determined (Savignac, 2008).

Selection models, fixed effects models, and instrumental variables are heavily used in literature as techniques to deal with endogeneity, however, those techniques have their own limitations. Although, the field experiment used to correctly estimate causal effects, field experiments 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 recently, the propensity score matching (PSM) technique increase researchers' ability to draw causal inferences using observational data.

4.2 Method

The direct comparison of firms who face credit constraints and others that do not leads to an identification problem. Credit constraints may be correlated with both observable and unobservable factors of firms. If the study fails to correct for this bias, the estimates will give

⁹ Apart from reverse causality or simultaneity, omitted variable biases, measurement errors, and unobservable heterogeneity are the main type of endogeneity problem which occurs in the innovation and credit constraints relationship. In robustness section, using recursive probit model we control both simultaneity and unobservable heterogeneity.

naïve and overestimated results of the impact. Following Rosenbaum and Rubin (1983) and Rosenbaum and Rubin (1985), we perform PSM to pair firms that credit constraints with other firms that are like them, except for credit constraints. It is then assumed that the matched firms would have no systematic differences in response to the treatment (credit constraints in here), so they provide valid counterfactual evidence.

We estimate the probability of being credit constraints as a function of observed characteristics, rank credit constraints firms and non- credit constraints firms by their propensity scores, pair individual credit constraints firms and non- credit constraints firms with similar propensity scores and calculate the average difference in innovation across them.

In this study, we are comparing the innovation of firms exposed to no treatment $T=0$ (non- credit constraints) and innovation of firms exposed treatment $T=1$ (credit constraints). Since only one of these outcomes is observed for each firm, we estimate the average treatment on the treated (ATT), that is the difference in innovation between those treated and those with the same probability of being treated (Cox-Edwards & Rodríguez-Oreggia, 2009; Ichino, Mealli, & Nannicini, 2008).

We use four matching methods: stratification matching; nearest neighbour matching; kernel matching; and radius matching, following (Becker & Ichino, 2002). The standard error for the ATT is calculated, using a bootstrapping procedure, from the standard deviation of the ATT involving 100 bootstrap replications. The ATT is obtained by averaging these differences across the m matches:

$$ATT = \frac{1}{m} \sum_{j=1}^m [y_j^{j \in B=1} - y_j^{j \in B=0}]$$

Following Li (2013), we used four major steps to estimate the propensity score causal effect:

(1) Estimate the propensity score using observational covariates: In the PSM method, choosing covariates is important (Heckman, Ichimura, & Todd, 1997). Chosen covariates X_i must be pre-treatment and affect both outcome and treatment (Lee, 2005, p.44). Covariate selection is guided by trade-offs between variables' effects on bias and efficiency (Garrido et al., 2014). Including the variables, which are related to the outcome but not the treatment, should reduce bias (Austin, 2011). However, covariates should not show causality biases. A common step is used in a logit or probit regression to create a propensity score, with treatment as the outcome variable and the potential confounders as explanatory variables.

(2) Check balance of propensity scores stratum after stratifying the propensity scores into different strata: *Balancing property assumption*: A first critical feature of PSM is the 'balancing property'. This assessing balance is the baseline covariates observed between treated and control groups. This allows the use of the propensity scores as a univariate summary of all observed covariates (Cox-Edwards & Rodríguez-Oreggia, 2009).

(3) Calculate the treatment effect (ATT) by selecting appropriate propensity score methods:

(4) Conduct a sensitivity test to justify that the estimated ATT is robust: *Overlap and common support assumption*: Matching needs to satisfy the overlap (region of common support) of the distributions of the estimated propensity scores for the treatment and comparison groups. This can be examined graphically. If propensity score distributions highly overlap in both range and density, then the treatment and comparison groups are almost identical concerning the chosen covariate

distributions; that is, treatment and the comparison groups have the same propensity to have been treated based on the observable covariates.

5. Results

5.1 Innovation and credit constraints relationship

(I) Selecting covariates for our model

Following Smith and Todd (2005) and Li (2013), based on relevant theory, institutional settings, and previous research we specify variables in the model. Probit analysis using formal credit constraints as an outcome variable, indicates that the following covariates are appropriate to obtaining the propensity scores; industry (*Manufacturing, Retail and Core*) the proportion of formal funds (*Formal_fund*), firm size (*Small and Medium*), firm ownership (*Female_own, Foreign_own and Governmant_own*), firm age (*age*), top manager experience in same field (*Top_Exp*), firm exporting status (*Exporter*) and business obstacle (*Regulations and Corruptions*).

(II) Stratifying and balancing the propensity scores

The next step is to sub-classify propensity scores into different strata such that these blocks are balanced on propensity scores. The number of balanced propensity score blocks depends on the number of observations in the data set (Rosenbaum & Rubin, 1983). In this study, the optimal number of blocks for innovation is six. This number of blocks ensures that the mean propensity score is not different for the treated and controls in each block. We have selected the PSM with a common support option. Our study reports that the balancing property is stratified. Table 5 shows the inferior bound, the number of treated and the number of controls for each block.

Table 5
Balancing property of the propensity score

Panel A: Product Innovation			
Inferior of block of pscore	Credit constraints		Total
	0	1	
.0558005	358	53	411
.2	327	116	443
.3	314	179	493
.4	241	243	484
.6	50	99	149
.8	5	6	11
Total	1295	696	1991

(III) Propensity score matching (PSM) analysis

Now we apply four matching methods on propensity score models. The average treatment effect of treated (ATT) results is shown in Table 6. Results are presented as nearest neighbour matching, kernel matching, radius matching and stratification matching with common support.

Product innovation and credit constraints relationship

In all matching models, the ATT is significant and positive. Comparing different matching models, the magnitude of the ATT, ranges from 0.11 with the kernel, radius and stratification matching to 0.14 with nearest neighbour matching. In nearest neighbour matching method, some of the matches between credit constraints and non-credit constraints firms may be poor because for some credit constraints firms the nearest neighbour may have a very different propensity score but contributes to the estimation of the ATT (Morris, 2007). Therefore, excluding nearest neighbour matching, the magnitude of the ATT for product innovation is approximately 0.11. This indicates that the estimated positive average effect of credit constraints on product innovation outcome for firms who faced in credit constraints is 11 percent. Consequently, we reject hypothesis 1a, which indicates there is a negative

relationship between formal credit constraints and product innovation performance of SMEs. This result is consistent with Kerr, Nanda, and Rhodes-Kropf (2014), reporting that financing constraints promote firms engaged in R&D and innovation in respect to both the ability to shape the rate and the trajectory of innovation. Further, Hewitt-Dundas (2006) reports that credit constraints appear to act as a stimulus to innovation success, either in terms of product development or business strategy. According to the capital structure theories, after using internal funds for early stage of product development, innovative firms are then forced to turn to costly external funds. Such innovative firms have already exhausted their internal funds and banks respond by rationing loans or lines of credit (Gorodnichenko & Schnitzer, 2013).

The consequence of this conundrum is that firms with access to bank finance have less innovative potential than those not having access to credit. This suggests substantial allocative inefficiency in the formal financing sector. As a potentially plausible explanation the credit goes to firms with the best political connections and not those with the best innovation possibilities. This view aligns with Rousseau and Wachtel (2011) and Demetriades and Rousseau (2016), who explain that access to credit will not be growth enhancing while credit markets continue to suffer from systematic allocative inefficiency.

Process innovation and credit constraints relationship

Although in all matching models, the ATT is positive, it is not significant (see t-values)¹⁰. This indicates that the credit constraints have no significant impact on process innovation of SMEs. Therefore, we reject hypothesis 1b, which indicates there is a negative relationship between formal credit constraints and process innovation performance of SMEs.

¹⁰ “The greater the magnitude of t (it can be either positive or negative), the greater the evidence *against* the null hypothesis that there is no significant difference. The closer T is to 0, the more likely there isn't a significant difference”(see <http://blog.minitab.com/blog/statistics-and-quality-data-analysis/what-are-t-values-and-p-values-in-statistics>).

This finding is consistent with Galia and Legros (2004) who find no significant evidence of a linkage between financing constraints and R&D investments of firms in developed countries. Potentially, credit constraints are unimportant to innovation activities due to the absence of cash-flow sensitivity to innovation (Chen & Chen, 2012).

Marketing Innovation and credit constraints relationship

In all matching models, the ATT is significant and negative. Comparing different matching models, the magnitude of the ATT, ranges from 0.028 with the radius to 0.046 with nearest neighbour matching. Kernel and stratification matching models show the magnitude of the ATT for marketing innovation is 0.043. Overall, this indicates that the estimated negative average effect of credit constraints on marketing innovation outcome for firms who faced in credit constraints is around 3 to 5 percent. Therefore, we accept hypothesis 1d, which indicates there is a negative relationship between formal credit constraints and marketing innovation performance of SMEs. This aligns with a widely accepted view that access to finance is key to driving innovation (Ayyagari et al., 2011; Freel, 2007). 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 innovation (Fombang & Adjasi, 2018).

Organisational Innovation and credit constraints relationship

In all matching models, the ATT is significant and positive (except nearest neighbour). Comparing different matching models, the magnitude of the ATT, ranges from 0.031 with the kernel matching to 0.049 with radius matching. The magnitude of the ATT for organisational innovation is approximately 0.032 for stratification matching. This indicates that the estimated positive average effect of credit constraints on organisational innovation outcome for firms who faced in credit constraints is around 3 to 5 percent. Therefore, we reject hypothesis 1c,

which indicates there is a negative relationship between formal credit constraints and organisational innovation performance of SMEs.

Table 6

The impact on formal credit constraints on innovation: propensity score matching (PSM)

	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	696	458	0.144	0.034	4.288	696	458	0.023	0.032	0.709
Kernel matching	696	1295	0.112	0.026	4.368	696	1295	0.028	0.029	0.974
Radius matching (radius=0.01)	688	1293	0.115	0.024	4.862	688	1293	0.016	0.024	0.666
Stratification matching	696	1295	0.114	0.025	4.483	696	1295	0.026	0.026	1.017
	Organisational Innovation					Marketing Innovation				
	No. treated	No. contr.	ATT ^a	Std.Err	t	No. treated	No. contr.	ATT ^a	Std.Err	t
Nearest neighbour matching	696	458	0.017	0.034	0.487	696	458	-0.046	0.032	-1.469
Kernel matching	696	1295	0.031	0.026	1.204	696	1295	-0.043	0.020	-2.203
Radius matching (radius=0.01)	688	1293	0.049	0.022	2.230	688	1293	-0.028	0.023	-1.201
Stratification matching	696	1295	0.032	0.027	1.166	696	1295	-0.043	0.026	-1.617

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

Firm level covariates are included in all model: industry (Manufacturing; Retail and Core) the proportion of formal funds (Formal_fund), firm size (Small and Medium), firm ownership (Female_own, Foreign_own and Governmant_own), firm age (age), top manager experience in same field (Top_Exp), firm exporting status (Exporter) and business obstacle (Regulations and corruptions).

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

(IV) Sensitivity test

(i) Covariate balance summary

This reports the model-adjusted difference in mean and ratio of variances between the treated and untreated for each covariate. For all reported, results differences in weighted means are negligible, and variance ratios are all near one¹¹. The Raw columns show where we started, and, before weighting, differences were large. Appendix 1 reports covariates balanced summary for significant outcome proxies.

(ii) Overlap in the distribution

We also check overlap and common support assumption using the graph. Figure 1 shows the kernel densities of the propensity score including other control variables. Our matching satisfies the overlap and common support assumptions. The figure illustrates a substantial overlap in the distribution.

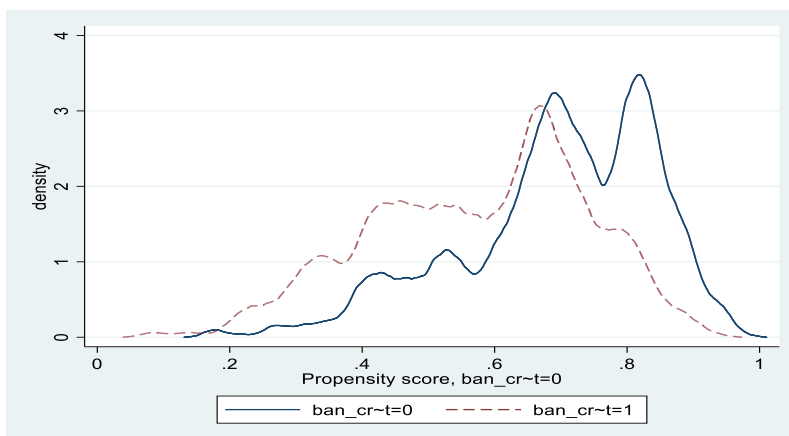


Figure 1: Kernel densities of the Propensity scores for credit constraints firms and non-credit constraints firms

¹¹ Here reported rebalance summary is for only significant outcome variables.

5.2 Innovation, credit constraints and informal finance relationship

Dealing with endogeneity with recursive probit model

Table 7

Different types of innovation, credit constraints and informal credit

Variables	bivariate Probit	bivariate Probit-ME	bivariate Probit	bivariate Probit-ME	bivariate Probit	bivariate Probit-ME	bivariate Probit	bivariate Probit-ME
	<i>Product Innovation</i>		<i>Process Innovation</i>		<i>Organisation Innovation</i>		<i>Marketing Innovation</i>	
<i>Constraints'</i>	.9636* (.5525)	.0192* (.2440)	1.178 (3.884)	-.0114 (1.9048)	1.781*** (.3708)	.0066* (.3693)	-1.721*** (.5070)	-.0751*** (.4309)
<i>Constraints'* Informal</i>	.3438*** (.0669)	.0963*** (.0285)	.0966 (.4285)	.0284** (.8813)	.2024*** (.0779)	.0927*** (.0675)	.3990*** (.0475)	.0837*** (.0243)
<i>Control variables</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Summary Stat</i>								
rho	.2796*** (.0589)		.1135*** (.0244)		.6199*** (.6069)		.4411*** (.2941)	
obs	4864		4864		4152		4152	

Note: Two dependent variables (*Innovation* and *Constraints*) are dummy variables. Column 2 and 3 report bivariate probit and marginal probit regression results, as *Product Innovation* dependent variable. Column 4 and 5 report bivariate probit and marginal probit regression results, as *Process Innovation* dependent variable. Column 6 and 7 report bivariate probit and marginal probit regression results, as *Organisation Innovation* dependent variable. Column 8 and 9 report bivariate probit and marginal probit regression results, as *Marketing Innovation* dependent variable. The interaction variable (*Constraints'* Informal*) use to check the impact of informal credit on credit constraints 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.

Following Crepon (1998) we can define a univariate probit model, where the decision to have innovative activities depends on financial constraints and other determinants of the decision to innovation empathized by the literature. However, p is positive and significant. This means that unexplained factors that affect credit constraints are positively correlated with unexplained factors that affect innovation, which indicates dual endogeneity. To account for this potential dual endogeneity, we estimate a recursive bivariate probit model for *Constraints* and *Innovation*. The model follows the methodology of Maddala (1986), Greene (1996, 2003), and Fisher and Lyons (2006). This model allows us to capture the impacts of *Innovation* on *Constraints*, vice versa. Specifically, Wald test I rejects the hypothesis that $p=0$ and suggests that results from the univariate probit models are biased. Both endogenous variables are binary (*Constraints* and *Innovation*). The recursive bivariate probit model is widely used in literature as a remedy to control endogeneity between binary dependent and independent variables (see Mirris, 2007; Farace & Mazzotta, 2011). Therefore, recursive model bivariate probit results are more appropriate. Although, the effect of constraints on innovation is significant, the effect of innovation on constraints is insignificant, which indicates that the direction of causation is likely to be from constraints to innovation rather than innovation to constraints¹². Therefore, we report recursive model bivariate probit results only for innovation as dependent variable.

Relationships between the four types of firm activity: product, process, organisational and marketing innovation; credit constraints; and informal finance are presented in Table 7. Process innovation reveals no statically significant correlation with credit constraints. Marketing innovation show a statically significant negative relationship with credit constraint. The marginal effect results indicate a 1 percent decrease in credit constraints leads to a 7.5 percent increase in the firm level marketing innovation of SMEs. Credit constraints has

¹² Results not reported here, but available upon requests to authors.

positive impact on product and organisation innovation, as shown in Table 7. SMEs 1 percent increase in credit constraints show a 1.9 percent increase in the product innovation and 0.7 percent increase in the organisation innovation.

Innovation, credit constraints and informal finance

The interactive variable *Constraints' X Informal* reveals when credit constraints SMEs who increased their informal finance usage has impact on their firm level innovation. One percent increase of informal finance will increase product innovation by approximately 12 percent (sum of coefficients .0192 and .0963), process innovation by approximately 2 percent (sum of coefficients -.0114 and .1284), organisation innovation by approximately 10 percent (sum of coefficients .0669 and .0927) and marketing innovation by approximately 1 percent (sum of coefficients -.0751 and .0837).

Overall, this indicates that informal financing can stimulate firm-level innovation in transitional economies. This result is also consistent with prior empirical evidence that suggests a positive relationship between informal finance and firm growth in transitional economies (Degryse et al., 2016 Wu et al., 2017). SMEs' external financing accessibility suffers high information asymmetry. Informal lenders have an advantage over formal financial institutions in collecting soft information about SME borrowers (Lin & Sun, 2005) and provide finance for small firms' innovation. Consequently, we can expect the level of innovation activities may lead to increases in the usage of informal credit by firms. Therefore, this study can conclude that there is a positive relationship between innovation and level of informal finance in the firm. Therefore, we can accept *H₂: The accessibility of informal finance moderates the relationship between formal credit constraints and SMEs' innovation performance.*

6. Robustness

In order to assess the robustness of the results this study conducts regression with several specifications.

(i) *Alternative measures of credit constraints*

Endogeneity, as discussed above, can result from measurement errors. Although Our main *Constraints* proxy is a well-established measurement of formal credit constraints. Other measures of credit constraints, included in several robustness criteria require explanation. Gorodnichenko and Schnitzer (2013) and Mancusi and Vezzulli (2010) suggest self-reported measures to capture credit constants in firms. Consistency testing between our objective measures used above and the subjective alternative provides a robustness test for the analysis and strengthens the findings. Coding of firms' responses to questions concerning the difficulty of accessing external credit proceeds as: 0= No obstacle, 1= Minor obstacle, 2= Moderate obstacle, 3= Major obstacle, and 4= Very serious obstacle. We find that even for alternative constraints measure, our results remain substantially unaltered.

Table 8

The impact on formal credit constraints on innovation: propensity score matching (PSM)-Using alternative proxy of credit constraints

	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	624	463	0.032	0.035	0.905	624	463	-0.038	0.031	-1.252
Kernel matching	624	1380	0.104	0.024	1.442	624	1380	-0.011	0.028	-0.411
Radius matching (radius=0.01)	624	1380	0.103	0.024	1.511	624	1380	-0.014	0.025	-0.551
Stratification matching	624	1380	0.116	0.024	1.083	624	1380	0.026	0.024	0.803
	Organisational Innovation					Marketing Innovation				
	No. treated	No. contr.	ATT ^a	Std.Err	t	No. treated	No. contr.	ATT ^a	Std.Err	t
Nearest neighbour matching	624	463	0.015	0.035	1.436	624	463	0.015	0.033	0.475
Kernel matching	624	1380	0.014	0.025	-1.546	624	1380	-0.012	0.024	2.518
Radius matching (radius=0.01)	624	1380	0.006	0.025	-1.242	624	1380	-0.019	0.024	1.787
Stratification matching	624	1380	0.019	0.025	-1.757	624	1380	-0.011	0.024	2.458

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

Firm level covariates are included in all model: industry (Manufacturing; Retail and Core) the proportion of formal funds (Formal_fund), firm size (Small and Medium), firm ownership (Female_own, Foreign_own and Governmant_own), firm age (age), top manager experience in same field (Top_Exp), firm exporting status (Exporter) and business obstacle (Regulations and corruptions).

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

(ii) *Resampling*

Russian firms represent approximately 30% of total sample. Therefore, we excluded Russian firms and rerun the PSM models. This remove the dominant effect of Russian institutional factors if there exists. However, this results is consistent with the main results, discussed above, confirming credit constraints have a significant impact on firm level innovation and this impact is vary across the innovation types. In particular, similar to main results, credit constraints have no significant impact on firm level innovation and credit constraints has significant positive impact on product and organisational innovation. Further credit constraints show significant negative impact on firm level marketing innovation (Results available upon reuest).

(iii) *Average Treatment Effect (ATE)*

We report the average treatment effect (ATE) in the population (Hirano & Imbens, 2004). In our main results, the ATT would indicate the average effect if everyone in the treated group received the treatment, compared to if no one in the treated group received the treatment. However, 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. Nevertheless, ATT and ATE will not necessarily be equal because the treatment effect varies across participants and varies across participants in the treated and comparison groups¹³. We now report ATE of credit constraints that provides an idea about how credit constraints impact on firm level innovation in the whole population.

In Table 9, the outcome variable is *Product innovation*, and ATE is .1232. This coefficient indicates that the average product innovation of firms in credit constraints is

¹³ The ATT and ATE values are equal in randomized controlled trials.

approximately 12 percent higher than their counterparts, who do not in credit constraints. In contrast, the outcome variable is *Marketing innovation*, and ATE is -.0536. This coefficient indicates that the average marketing innovation of firms in credit constraints is approximately 5 percent lower than their counterparts, who do not in credit constraints. However, process and oraganisational innovation has no significant impact by credit constraints. The overall ATT results align with our main finding which is indicates that credit constraints has positive impact on product innovation and negative impact on marketing innovation. Aslo, credit constraints has no impact on process innovation. Although there is a positive raltionship indicates in credit constraints and organisation innovation in ATT results, it is weak. Therefore, overall ATE results are align with our main findings.

Table 9

Treatment effects estimation

	Product Innovation					Process Innovation				
	Coef.	AI Robust Std.Err.	Z	p> z	[95% Conf.Interval]	Coef.	AI Robust Std.Err.	Z	p> z	[95% Conf.Interval]
ATE Constraints (1 vs 0)	.1232	.0296	4.16	0.000	.0651	.0460	.0297	1.55	0.122	-.0123
Over-identification test for covariate balance H0: Covariates are balanced: chi2(16) = 8.4160 Prob > chi2 = 0.9355						Overidentification test for covariate balance H0: Covariates are balanced: chi2(16) = 15.5794 Prob > chi2 = 0.4827				
	Organisational Innovation					Marketing Innovation				
	Coef.	AI Robust Std.Err.	Z	p> z	[95% Conf.Interval]	Coef.	AI Robust Std.Err.	Z	p> z	[95% Conf.Interval]

ATE Constraints (1 vs 0)	.0338	.0290	1.17	0.244	-.0231	-.0536	.0294	-1.82	0.069	-.1114
Overidentification test for covariate balance H0: Covariates are balanced: chi2(16) = 12.207 Prob > chi2 = 0.7296						Overidentification test for covariate balance H0: Covariates are balanced: chi2(16) = 15.5794 Prob > chi2 = 0.4827				

Firm level covariates are included in all model: industry (Manufacturing; Retail and Core) the proportion of formal funds (Formal_fund), firm size (Small and Medium), firm ownership (Female_own, Foreign_own and Governmant_own), firm age (age), top manager experience in same field (Top_Exp), firm exporting status (Exporter) and business obstacle (Regulations and corruptions).

6. Discussion and Policy Implications

This study extends the existing literature by exploring the relationship between credit constraints and four types of firm level innovation of SMEs from Central Asia and Eastern Europe. Care was taken to ensure causality is checked and possible endogeneity is carefully treated. Innovation may be endogenous to credit constraints in many ways. Apart from measurement errors, unobservable and omitted variable bias, simultaneous causality can exist in the innovation-credit access relationship. We proceeded with a PSM method and bivariate probit models, which controls for endogeneity bias. An appreciation of how innovation, credit constraints, and informal finance effect SMEs is essential when formulating efficacious public policy.

Our first hypothesis of a negative relationship between credit constraint and innovation is confirmed for marketing innovation and our results suggest that SMEs with high credit constraints are less likely to engage with marketing innovation. However, our study suggests that SMEs with high credit constraints are more likely to engaged with product and organisational innovation and, credit constraints has no significant impact on firm level process innovation.

Also, results indicate that the probability of using informal credit is significantly high among SMEs in Central Asia and Eastern Europe. Our second hypothesis of an accessibility of informal finance negatively moderates the relationship between formal credit constraints and SMEs' innovation performance is also confirmed. This is evident in our sample of SMEs suggesting that without much choice, innovative small firms need to depend on informal finance.

Several issues relating to public policy follow from our findings. In low income, emerging, transitional and mature economies, smaller businesses make important contributions to employment and GDP. (OECD, 2004) In many countries they are the staple employment, the potential source of growth and seen as the powerhouse of the economy. To encourage innovation which enhances productivity, reduces costs, or broadens consumer choice are positive sources of increased wellbeing. Harnessing innovation through public policy can lead to net welfare gains when appropriately implemented.

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. Additional search costs can reduce the opaqueness surrounding a small business but cut into profits, especially where loans applications are researched and costs

incurred, and no loan is made. A rational reaction is to impose a series of constraints, leading to rejection of small businesses without information. Scaling interest rates to reflect increasing risk, which remains difficult to estimate, is difficult to maintain and monitor. A more simple dichotomous choice of approve or reject is efficacious, and credit scoring makes the process simple (Locke & Boulanaour, 2009). Error type 1 of approving a loan that might go bad is minimised. Error type 2 of rejecting a loan that will be successful increases.

The public policy issue, against a background of spiralling bad debts for banks in developing economies, is how to free up funds for smaller firms (Agyekum, Locke, Hewa Wellalage, 2016). The formal sector institutions will endeavour to transfer Error 1 risks by suggesting government require small businesses to provide greater levels of disclosure which cuts into the profits of smaller firms; underwrite the loans; or to take out loan insurance when borrowing. Premiums for loan insurance will make this a non-choice. Government can require banks to lend more to smaller businesses. In evidence to date, the World Bank (2017) indicates this results in steadily increasing non-performing loan portfolios, predominantly held by state sector banks.

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. Crowd funding is a contemporary example, and business angels and venture capitalists fall along the spectrum of informal lenders. Small businesses are often suggested as using three forms of investors beyond the owner, family, friends and fools, which captures the high uncertainty associated with many such businesses. Moneylenders make their living through being close to the clients and in many instances, especially in village and urban neighbourhoods, are associated with people over generations. 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.

Support and encouragement for the informal financial sector tends to be anathema for public policy analysts and advisors. Nevertheless, microfinance has made significant progress in achieving positive outcomes for business owners and local communities. The evidence suggests that where these institutions are more regulated there is more mission drift away from lending to the poorest of the poor, and more concentration on financial performance and less on outcomes. How to make policy for enhancing informal sector financing without introducing heavy regulation is a challenge.

The objective, based on the findings in this study, is to enlarge the pool of money available to informal lenders. This needs to be a process so that the additional lending of the informal sector continues to be prudent. As a group of lenders, they pool any state supported finance and lower risk. A public-private partnership model requiring government to make small but regular investments with informal lenders, through low interest loans, in exchange for the small business clients using a bank account to transfer loan instalments to the money lender's account transfer has advantages. There is learning about banking for the small business, there is additional information for the government, there is a small reduction in cost for the moneylenders, who must be protected from interference as a result of making their dealings more transparent, and a win-win scenario arises.

In summary, the 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. What we can say based on this our research is there is a way forward.

References

- Acemoglu, D., Aghion, P., & Zilibotti, F. (2006). Distance to frontier, selection, and economic growth. *Journal of the European economic association*, 4(1), 37-74. doi:10.1162/jeea.2006.4.1.37
- Allen, F., Qian, J., & Qian, M. (2005). Law, finance, and economic growth in China. *Journal of financial Economics*, 77(1), 57-116. doi:10.1016/j.jfineco.2004.06.010
- Almazan, A., Banerji, S., & Motta, A. D. (2008). Attracting attention: Cheap managerial talk and costly market monitoring. *The journal of finance*, 63(3), 1399-1436. doi:10.1111/j.1540-6261.2008.01361.x
- Archibugi, D., & Sirilli, G. (2001). *The direct measurement of technological innovation in business*. in "Innovation and enterprise creation: Statistics and indicators. Paper presented at the Proceedings of the conference held at Sophia Antipolis.
- Armendáriz, B., & Morduch, J. (2010). *The economics of microfinance*: MIT press.
- Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In *The rate and direction of inventive activity: Economic and social factors* (pp. 609-626): Princeton University Press.
- Austin, P. C. (2011). An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate behavioral research*, 46(3), 399-424. doi:<https://doi.org/10.1080/00273171.2011.568786>
- Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2010). Formal versus informal finance: Evidence from China. *The review of financial studies*, 23(8), 3048-3097. doi:10.1093/rfs/hhq030
- Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2011). Firm innovation in emerging markets: the role of finance, governance, and competition. *Journal of Financial and Quantitative Analysis*, 46(6), 1545-1580.
- Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2014). Bribe payments and innovation in developing countries: Are innovating firms disproportionately affected? *Journal of Financial and Quantitative Analysis*, 49(1), 51-75.
- Balsmeier, B., & Czarnitzki, D. (2014). How important is industry-specific managerial experience for innovative firm performance?
- Baumol, W. J. (2002). Entrepreneurship, innovation and growth: The David-Goliath symbiosis. *The Journal of Entrepreneurial Finance*, 7(2), 1.
- Beck, T., & Demirguc-Kunt, A. (2006). Small and medium-size enterprises: Access to finance as a growth constraint. *Journal of Banking & Finance*, 30(11), 2931-2943. doi:10.1016/j.jbankfin.2006.05.009
- Beck, T., Demirgüç-Kunt, A., & Maksimovic, V. (2008). Financing patterns around the world: Are small firms different? *Journal of financial Economics*, 89(3), 467-487.
- Becker, S. O., & Ichino, A. (2002). Estimation of average treatment effects based on propensity scores. *The stata journal*, 2(4), 358-377.
- Buyinza, F., & Bbaale, E. (2013). Access to credit and the effect of credit constraints on the performance of manufacturing firms in the East African region: Micro analysis. *International Journal of Economics and Finance*, 5(10), 85. doi:10.5539/ijef.v5n10p85
- Chen, H. J., & Chen, S. J. (2012). Investment-cash flow sensitivity cannot be a good measure of financial constraints: Evidence from the time series. *Journal of financial Economics*, 103(2), 393-410. doi:<https://doi.org/10.1016/j.jfineco.2011.08.009>

- Cox-Edwards, A., & Rodríguez-Oreggia, E. (2009). Remittances and labor force participation in Mexico: an analysis using propensity score matching. *World development*, 37(5), 1004-1014. doi:<https://doi.org/10.1016/j.worlddev.2008.09.010>
- Demetriades, P. O., & Rousseau, P. L. (2016). The changing face of financial development. *Economics Letters*, 141, 87-90. doi:<https://doi.org/10.1016/j.econlet.2016.02.009>
- Denis, D. J. (2004). Entrepreneurial finance: an overview of the issues and evidence. *Journal of corporate finance*, 10(2), 301-326. doi:10.1016/S0929-1199(03)00059-2
- Díaz-García, C., González-Moreno, A., & Jose Sáez-Martínez, F. (2013). Gender diversity within R&D teams: Its impact on radicalness of innovation. *Innovation*, 15(2), 149-160. doi:10.5172/impp.2013.15.2.149
- Dosi, G., Pavitt, K., & Soete, L. (1990). The economics of technical change and international trade. *LEM Book Series*.
- Efthyvoulou, G., & Vahter, P. (2016). Financial constraints, innovation performance and sectoral disaggregation. *The Manchester School*, 84(2), 125-158. doi:10.1111/manc.12089
- Fombang, M. S., & Adjasi, C. K. (2018). Access to finance and firm innovation. *Journal of Financial Economic Policy*, 10(1), 73-94.
- Freel, M. S. (2007). Are small innovators credit rationed? *Small Business Economics*, 28(1), 23-35. doi:DOI 10.1007/s11187-005-6058-6
- Galia, F., & Legros, D. (2004). Complementarities between obstacles to innovation: evidence from France. *Research policy*, 33(8), 1185-1199.
- Garrido, M. M., Kelley, A. S., Paris, J., Roza, K., Meier, D. E., Morrison, R. S., & Aldridge, M. D. (2014). Methods for constructing and assessing propensity scores. *Health services research*, 49(5), 1701-1720. doi:<https://doi.org/10.1111/1475-6773.12182>
- Gerlach-Kristen, P., O'Connell, B., & O'Toole, C. (2015). Do credit constraints affect SME investment and employment? *The Economic and Social Review*, 46(1, Spring), 51-86.
- Gorodnichenko, Y., & Schnitzer, M. (2013). Financial constraints and innovation: Why poor countries don't catch up. *Journal of the European economic association*, 11(5), 1115-1152. doi:10.1111/jeea.12033
- Habiyaremye, A., & Raymond, W. (2013). Transnational corruption and innovation in transition economies.
- Hajivassiliou, V., & Savignac, F. (2008). Financing constraints and a firm's decision and ability to innovate: establishing direct and reverse effects. Retrieved from <https://ssrn.com/abstract=1680212> or <http://dx.doi.org/10.2139/ssrn.1680212>
- Hall, B. H., & Lerner, J. (2010). The financing of R&D and innovation. *Handbook of the Economics of Innovation*, 1, 609-639.
- Hansen, H., & Rand, J. (2014). The myth of female credit discrimination in African manufacturing. *Journal of development studies*, 50(1), 81-96. doi:10.1080/00220388.2013.849337
- Heckman, J. J., Ichimura, H., & Todd, P. E. (1997). Matching as an econometric evaluation estimator: Evidence from evaluating a job training programme. *The review of economic studies*, 64(4), 605-654. doi:<https://doi.org/10.2307/2971733>
- Heil, O., & Robertson, T. S. (1991). Toward a theory of competitive market signaling: A research agenda. *Strategic Management Journal*, 12(6), 403-418. doi:10.1002/smj.4250120602
- Hewitt-Dundas, N. (2006). Resource and capability constraints to innovation in small and large plants. *Small Business Economics*, 26(3), 257-277.
- Hirano, K., & Imbens, G. W. (2004). The propensity score with continuous treatments. *Applied Bayesian modeling and causal inference from incomplete-data perspectives*, 226164, 73-84.

- Hoshi, T., Kashyap, A., & Scharfstein, D. (1991). Corporate structure, liquidity, and investment: Evidence from Japanese industrial groups. *The quarterly journal of economics*, 106(1), 33-60. doi:10.2307/2937905
- Hottenrott, H., & Rexhäuser, S. (2015). Policy-induced environmental technology and inventive efforts: Is there a crowding out? *Industry and Innovation*, 22(5), 375-401. doi:10.1080/13662716.2015.1064255
- Huergo, E., & Jaumandreu, J. (2004). How does probability of innovation change with firm age? *Small Business Economics*, 22(3-4), 193-207. doi:<https://doi.org/10.1023/B:SBEJ.0000022220.07366.b5>
- Hult, G. T. M., & Ketchen, D. J. (2001). Does market orientation matter?: A test of the relationship between positional advantage and performance. *Strategic Management Journal*, 22(9), 899-906. doi:10.1002/smj.197
- Ichino, A., Mealli, F., & Nannicini, T. (2008). From temporary help jobs to permanent employment: What can we learn from matching estimators and their sensitivity? *Journal of applied econometrics*, 23(3), 305-327. doi:<https://doi.org/10.1002/jae.998>
- Kaplan, S. N., & Zingales, L. (2000). Investment-cash flow sensitivities are not valid measures of financing constraints. *The quarterly journal of economics*, 115(2), 707-712. doi:10.1162/003355300554782
- Karlan, D., & Zinman, J. (2008). Lying about borrowing. *Journal of the European economic association*, 6(2-3), 510-521. doi:10.1162/JEEA.2008.6.2-3.510
- Kerr, W. R., Nanda, R., & Rhodes-Kropf, M. (2014). Entrepreneurship as experimentation. *The Journal of Economic Perspectives*, 28(3), 25-48. doi:10.1257/jep.28.3.25
- Kim, H. D., Park, K., & Roy Song, K. (2017). Do long-term institutional investors foster corporate innovation? *Accounting & Finance*. doi:10.1111/acfi.12284
- Li, M. (2013). Using the propensity score method to estimate causal effects: A review and practical guide. *Organizational Research Methods*, 16(2), 188-226. doi:<https://doi.org/10.1177/1094428112447816>
- Lin, J. Y., & Sun, X. (2006). Information, Informal Finance, and SME Financing. *Frontiers of Economics in China*, 1(1), 69-82. doi:10.1007/s11459-005-0010-1
- Lööf, H., & Nabavi, P. (2016). Innovation and credit constraints: evidence from Swedish exporting firms. *Economics of Innovation and New Technology*, 25(3), 269-282. doi:10.1080/10438599.2015.1076196
- Love, I., & Martínez Pería, M. S. (2014). How bank competition affects firms' access to finance. *The World Bank Economic Review*, 29(3), 413-448. doi:10.1093/wber/lhu003
- Madestam, A. (2014). Informal finance: A theory of moneylenders. *Journal of development economics*, 107, 157-174. doi:10.1016/j.jdeveco.2013.11.001
- Mancusi, M. L., & Vezzulli, A. (2010). *R&D, innovation and liquidity constraints*. Paper presented at the CONCORD 2010 Conference, Sevilla.
- Matzler, K., Veider, V., Hautz, J., & Stadler, C. (2015). The impact of family ownership, management, and governance on innovation. *Journal of Product Innovation Management*, 32(3), 319-333. doi:<https://doi.org/10.1111/jpim.12202>
- Mulkay, B., Hall, B. H., & Mairesse, J. (2001). Firm level investment and R&D in France and the United States: A comparison. *Investing today for the world of tomorrow*, 229-279.
- Mullineux, A. W., & Murinde, V. (2014). Financial sector policies for enterprise development in Africa. *Review of Development Finance*, 4(2), 66-72. doi:10.1016/j.rdf.2014.05.001
- Myers, S. C. (1984). The capital structure puzzle. *The journal of finance*, 39(3), 574-592. doi:10.1111/j.1540-6261.1984.tb03646.x

- Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial Economics*, 13(2), 187-221. doi:10.1016/0304-405X(84)90023-0
- OECD. (2004). Promoting entrepreneurship and innovative SMEs in a global economy. *Second OECD Conference of Ministers responsible for Small and Medium-sized Enterprises (SMEs)*, 44. Retrieved from <https://www.oecd.org/cfe/smes/31919590.pdf>
- Payne, G. T., Moore, C. B., Bell, R. G., & Zachary, M. A. (2013). Signaling organizational virtue: an examination of virtue rhetoric, country-level corruption, and performance of foreign IPOs from emerging and developed economies. *Strategic Entrepreneurship Journal*, 7(3), 230-251. doi:10.1002/sej.1156
- Pla-Barber, J., & Alegre, J. (2007). Analysing the link between export intensity, innovation and firm size in a science-based industry. *International Business Review*, 16(3), 275-293. doi:<https://doi.org/10.1016/j.ibusrev.2007.02.005>
- Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41-55.
- Rosenbaum, P. R., & Rubin, D. B. (1985). Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *The American Statistician*, 39(1), 33-38.
- Rousseau, P. L., & Wachtel, P. (2011). What is happening to the impact of financial deepening on economic growth? *Economic inquiry*, 49(1), 276-288. doi:<https://doi.org/10.1111/j.1465-7295.2009.00197.x>
- Rubin, D. B. (2001). Using propensity scores to help design observational studies: application to the tobacco litigation. *Health Services and Outcomes Research Methodology*, 2(3-4), 169-188. doi:<https://doi.org/10.1023/A:1020363010465>
- Sastre, J. F. (2016). Gender diversity and knowledge innovation barriers. *International Journal of Entrepreneurship and Small Business*, 27(2-3), 193-212. doi:10.1504/IJESB.2016.073980
- Savignac, F. (2008). Impact of financial constraints on innovation: What can be learned from a direct measure? *Econ. Innov. New Techn.*, 17(6), 553-569. doi:10.1080/10438590701538432
- Schatzel, K., & Calantone, R. (2006). Creating market anticipation: An exploratory examination of the effect of preannouncement behavior on a new product's launch. *Journal of the Academy of Marketing Science*, 34(3), 357-366. doi:10.1177/0092070304270737
- Schneider, C., & Veugelers, R. (2010). On young highly innovative companies: why they matter and how (not) to policy support them. *Industrial and Corporate change*, 19(4), 969-1007. doi:10.1093/icc/dtp052
- Smith, J. A., & Todd, P. E. (2005). Does matching overcome LaLonde's critique of nonexperimental estimators? *Journal of econometrics*, 125(1-2), 305-353. doi:<https://doi.org/10.1016/j.jeconom.2004.04.011>
- Stiglitz, J. E. (2000). Capital market liberalization, economic growth, and instability. *World development*, 28(6), 1075-1086. doi:10.1016/S0305-750X(00)00006-1
- Teruel, M., & Segarra-Blasco, A. (2017). Gender diversity, R&D teams and patents: An application to Spanish firms. Retrieved from <http://www.xreap.cat/RePEc/xrp/pdf/XREAP2017-09.pdf>
- Wellalage, N., & Locke, S. (2016). Informality and credit constraints: Evidence from Sub-Saharan African MSEs. *Applied Economics*, 48(29), 2756-2770. doi:10.1080/00036846.2015.1128081
- Wilson, K. E. (2015). Policy Lessons from Financing Innovative Firms. *Browser Download This Paper*.

Wu, J., Si, S., & Wu, X. (2016). Entrepreneurial finance and innovation: Informal debt as an empirical case. *Strategic Entrepreneurship Journal*, 10(3), 257-273. doi:10.1002/sej.1214

Appendix-1

Covariate balance summary

		Raw	Matched	

Number of obs =		2,010	4,020	
Treated obs =		696	2,010	
Control obs =		1,314	2,010	

	Standardized differences		Variance ratio	
	Raw	Matched	Raw	Matched

manufact	-.0769785	-.0040438	.9686253	.9985368
core	-.2247649	-.0222421	.9080323	.991978
small	.1712216	.0049942	.9640869	.9990971
medium	-.3838652	-.0283515	.7371476	.9810296
foreign_own	.2531515	.0007799	2.210392	.9696582
government_ow~d	-.0811367	-.006308	.1591791	.6626184
female_own	.0914258	-.0554421	1.076437	.9523779
lnage	-.0486413	.0439415	1.292529	1.266642
lnmgr_exp	.1378351	.0243675	1.017721	1.002975
exporter	.2790752	-.0409731	1.437407	.9455058
pay_bribe	-.0443333	.0054572	.9630675	1.00494
senior_mgr_time	-.275333	.0400421	.5236324	.8644472
