DO CREDIT CONSTRAINED FIRMS IN AFRICA INNOVATE LESS? A STUDY BASED ON NINE AFRICAN NATIONS

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Do Credit Constrained Firms in Africa Innovate Less?

A Study Based on Nine African Nations

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Abstract

This paper draws on the results of World Bank Enterprise surveys to investigate the relation between financials constraints and innovation performance for a sample of firms in 9 African nations: Ethiopia, Zimbabwe, Rwanda, the Central African Republic, Uganda, Zambia, Tanzania, Ghana and the Democratic Republic of Congo. In common with much of the recent literature focusing on these issues, the analysis makes use of direct measures of innovation and of financial constraints. The econometric analysis takes into account the potential endogeneity of financing constraints to the firm's decision to innovate. The results show that financing constraints have a negative impact on the probability of successful innovation and that this negative impact tends to be greater both for small-sized firms compared to large firms and for young firms compared to old firm. The results have important policy implications and strongly suggest that government subsidies and financial support programs for micro and small-sized firms could make a positive contribution to increasing the innovation performance of African nations.

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1. Introduction

This paper focuses on the relation between financial constraints and innovation performance for a sample of establishments in nine African nations: Ethiopia, Zimbabwe, Rwanda, the Central African Republic (CAR), Uganda Zambia, Tanzania, Ghana and the Democratic Republic of Congo (DRC). The paper provides evidence to show that financial constraints have a negative impact on the innovation performance of firms and that the negative impact is stronger both in the case of small establishments compared to large establishments, and in the case of young establishments compared to older ones.

The paper contributes to a recent literature exploring the impact of financial constraints on innovation using direct measures of financial constraints and of innovation. This contrasts with a traditional literature focusing on the relation between investment and R&D expenditures and cash flow that argued that higher investment-cash flow sensitivities provide a useful measure of financing constraints (Fazzari et al. 1988). This earlier literature focused on advanced industrialized nations and it gave particular attention to small firms in high-tech or R&D intensive industries (Hall and Lerner, 2009 for a survey). Mulkay et al. (2001) compared a panel of US and French firms and showed that investment-cash flow sensitivities are higher in the US, and Bond et al. (1999) compared firms in the UK and Germany, finding that UK firms were more sensitive to financing constraints. The broad conclusions of this literature, however, were that the investments of firms that had exhausted all of their relatively low cost internal funds would be more sensitive to fluctuations in their cash-flow than firms with higher liquidity.

A more recent literature addresses these issues using direct measures of innovation and financing constraints. Savignac (2007), for example, uses data from the French Financing of Technological Innovation (FIT) survey carried in 2000 and focusing on the financial resources used for funding innovative projects. The survey provides direct measures of innovation

inspired by the Oslo Manual definitions and direct measures of financial constraint based on questions asking respondent firms whether a lack of financing sources or too high interest rates have been obstacles preventing them from undertaking innovation projects. Gorodnichenko and Snitzer's (2011) analysis similarly uses direct measures of innovation and financial constraints derived from the World Bank's Business Environment and Enterprise Performance Surveys (BEEPS), which cover Eastern Europe and Commonwealth Independent States (CIS). This approach based on direct measures not only avoids potential problems with using investment-cash flow sensitivities as a proxy for financing constraints,[2] but also overcomes the well-known weaknesses associated with using R&D expenditures as proxy for innovation. Not only is R&D only one amongst several important inputs to innovation, but as research based on the Community Innovation Surveys or surveys adopting the Oslo Manual definitions of innovation have shown, many firms innovate without having undertaken any formal R&D (Arundel et al. 2008; Leitner and Stehrer, 2013; Rammer et al. 2009).

To my knowledge there have been no efforts to adopt this direct measurement approach to investigating the impact of financing constraints on innovation outcomes of firms in African nations. Recent World Bank Enterprise Surveys carried out in selected African nations provide the basis for an analysis of the impact of financing constraints on the innovation performance of establishments using direct measures of innovation based on the Oslo Manual definitions. The limitation of relying on R&D as a proxy for innovation are likely to be particular severe in the case of African nations given that non-R&D innovators are especially characteristic of small and medium-sized establishments that make up the large majority of the population of establishments in Africa. The World Enterprise Surveys also collect rich information on the financing decisions of establishments, including the various sources of financing for working capital and investment on fixed assets, applications for loans or lines of credit from banking and non-bank financial institutions, whether the applications approval or rejection and in the event that a firm did not apply for a loan or line of credit the reasons for this. This information can be used to develop direct measures of financing constraints.

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[2] See notably Kaplan and Zingales (1997) who present evidence showing a non-monotonic relation between investment-cash flow sensitivities and the extent of financing constraints.

In what follows I develop an econometric model exploring the relation between financial constraints and the firm's success in innovating. I compare he importance of the impact of financial constraints for different size categories of establishments and I compare young establishments (less than 4 yrs. since their creation) with older establishments. As a number of authors have observed, the cross sectional nature of the data used to estimate the impact of financing constraints creates a potential problem of endogeneity resulting in biased estimates of the impact of financial constraints on innovation performance (Savignac, 2006; Gordodnichenko and Snitzer, 2011). The simplest way to understand this is to observe that for reasons of asymmetric information associated with the intangible nature of the human and knowledge assets used in the early stages of an innovation project involving search and possibly prototype development, firms wishing to innovate generally rely on internal financing. To the extent that internal funds are exhausted during the early stages of innovation activities, firms wishing to innovate will be forced to turn to relatively costly external financing in the form of bank loans or equity financing for the latter stages including the production and marketing of the new products or services. Firms trying to innovate, then, are more likely to face credit constraints in the form of having their applications to banks for a loan or a line of credit rejected than firms that did not even try to innovate, since these non-innovators will be less likely to have exhausted their internal funds (Gorodnichenko and Snitzer, 2011, p. 5-6). This endogeneity means that econometric estimates of the impact of financial constraints on innovation outcomes will tend to be biased upwards and they may even show a positive relation between innovation and financial constraints where the direction of the impact is negative.

One approach to addressing the endogeneity problem is through the use of instrumental variables. However finding variables that meet the criteria for good instruments often poses a problem since many of the variables that have a direct effect on the endogenous variable will also have an effect on the dependent variable. To circumvent the difficulty in identifying valid instruments, I adopt the approach used by Savignac (2006) and apply a bivariate probit model with correlated disturbances and an endogenous binary variable. The bivariate probit model is a recursive simultaneous equation model where the binary dependent variable in the first equation appears as an endogenous variable on the right-hand side of the second structural equation (Green, 2012, pp. 738-54 for a presentation). As Wilde (2000) has shown,

under the standard assumption that the correlated disturbance terms between the two equations are bivariate normally distributed, the endogenous nature of one of the variables on the right-hand side of the structural equation can be ignored in formulating the log-likelihood. The only restriction on the parameters that needs to be imposed in order for complete identification is that the two equations in the simultaneous model contain a varying exogenous regressor.[3]

Before presenting the base line model in section 3, I present in section 2 descriptive statistics on the population of establishments in the nine nations including data on innovation outcomes and on the percentage of firms that are credit constrained by size category and by nation. Section 4 presents the basic results from the bivariate probit regressions and it presents a sub-sample analysis focusing on different size categories of firms and on comparing young and old firms. Section 5 draws conclusions and identifies certain limitations of the analysis.

2. Data on innovation and financial constraints

The analysis is carried out on establishment level data for nine African nations: Ethiopia, Zimbwabe, Rwanda, the Central African Republic (CAR), Uganda Zambia, Tanzania, Ghana and the Democratic Republic of Congo (DRC). Information on innovation performance, financial decisions and other establishment characteristics for these nine nations is derived from the World Bank Enterprise Surveys carried out in 2011 in the cases of Ethiopia, Zimbwabe, Rwanda, and CAR and in 2013 in the case of Uganda, Zambia, Tanzania and DRC.[4] The surveys use a stratified random sample with stratification according to industry, establishment, size, and region. The sample frame is composed of registered firms in the

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[3] As Savignac (p. 17) observes, there is some confusion on this point due to the claim by Manddala (1983, p. 222) that further exclusion restrictions on the exogenous variables comparable to the linear case are required for identification in the bivariate probit model. Wilde (2000) shows that this is only true in the special case treated by Manddala of the simple intercept model where the exogenous variable in each equation is a constant. Wilde provides an example where a varying dichotomous variable enters the right hand side of both equations.

[4] At the time of drafting this article these are the only African nations for which World Bank Enterprise surveys have been conducted that include both information on financing decisions and on innovation. By the end of 2014 enterprise surveys including innovation data will also be available for Malawi, Namibia, Nigeria, Sierra Leone and South Sudan.

whole non-agricultural economy excluding public and utilities sectors.[5] The analysis is based on the results for 4391 establishments distributed across the nine nations as shown in Table 1.[6]

Table 1

Breakdown of sample population by nation

Country	Year	Observations	Percent of Sample
Ethiopia	2011	605	13.78
Zimbwabe	2011	598	13.62
Rwanda	2011	229	5.22
CAR	2011	146	3.32
Uganda	2013	573	13.05
Zambia	2013	674	15.35
Tanzania	2013	355	8.08
Ghana	2013	700	15.94
DRC	2013	511	11.64

Source: Enterprise Surveys Database.

Table 2 below lists the shares of the population of establishments in each nation that have carried out innovations over the last three years according to three measures: introducing a product or service that is new-to-the market (NewMkt), a product or service that is new-to-the firm (NewFrm), and introducing new or significantly improved methods of manufacturing products or offering services (NewMthd). The share of establishments introducing products or services that are new-to-the market varies from a high of 57.28 percent in Uganda to a low of 21.55 percent in Ethiopia. Uganda is also the nation with the highest share of

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[5] Weights are applied throughout the analysis so that individual observations must be weighted by the inverse of their probability of selection. The survey was carried out in two stages with an initial screener questionnaire administered by phone to be followed up with face-to-face interviews with the manager/owner/director of each establishment. Observation are weighted to correct for the presence of ineligible units with establishments being excluded from the population in the case of dead or out of service phone lines, establishments that never answered the phone, and establishments with incorrect addresses for which it was impossible to find a new address.

[6] Listwise deletion of missing observations on the total sample of 4967 observations resulted in 4391 observations as the population for the econometric analyses.

establishment introducing products or services that are new-to-the firm (68.36) while the lowest share is recorded in Ethiopia (35.81). The gap between the shares of new-to-the market and new-to-the firm is particularly high in Ghana (52.16 and 26.42 respectively) For new manufacturing processes or methods of service delivery, the highest share is in Rwanda with 73.98 percent of the establishments introducing new methods and the lowest occurs in DRC with 29.91 percent having introduced new methods.

Table 2
Share of innovative establishments
(weighted data)

Country	NewMrkt	NewFrm	NewMthd
Ethiopia	21.55	35.81	32.41
Zimbabwe	44.06	56.66	55.84
Rwanda	45.17	61.82	73.98
CAR	41.58	48.89	51.65
Uganda	57.28	68.36	65.57
Zambia	35.29	54.02	42.53
Tanzania	37.81	54.43	51.08
Ghana	26.45	52.31	53.15
DRC	26.10	37.96	29.91

Source: Enterprise Surveys Database.

The shares of innovative establishments may seems surprisingly high in lieu of the relatively low levels of technological development of most firms in these nations compared to enterprises located in more technologically advanced and higher income nations. However, it needs to be appreciated that much, if not most, of the innovative activities captured by the world bank surveys is likely to take the form of what authors as Lee (2001) and Kim (1997) have referred to as 'creative imitation', involving processes of diffusion of technologies and products initially developed by firms in more advanced industrialized nations with some modifications being made to adapt them to the characteristics of local markets. This is likely to be the case even for the category of new-to-the market innovations, since for the majority of establishments the markets catered to are national or local. Only slightly over 5 percent of the establishments have exports that account for more than 50

percent of their sales, and less than half of these exporters report having introduced products or services that are new-to-the market.[7]

Table 3 shows the share of innovative establishments for the entire population according to size category. The results show that a smaller share of small establishments with less than 20 employees innovate according to the three measures than medium-sized or larger establishments. The share of medium-sized establishments that innovate is roughly the same as the share of larger establishments in the case of products or services that are new-to-the market. For new to-to-firm innovations and new manufacturing methods the share of medium-sized establishments innovating is less than the share of larger establishments.

Table 3
Share of innovative establishments across size categories
(weighted data)

	NewMkt	NewFrm	NewMthd
Small < 20	37.33	51.35	49.55
Medium (20-99)	45.68	58.41	55.55
Large (>= 100)	48.95	66.49	61.09
All establishments	40.32	54.91	51.90

Source: Enterprise Survey Database.

In order to identify establishments that are credit constrained, we make use of the approach recently developed by Kuntchev et al. (2012, pp. 9-10) which draws on the rich information collected in the World Bank Enterprise surveys on the financing decisions of the establishments during the year prior to survey. Credit constrained establishments are defined as establishments which did not use external sources[8] of finance for working capital or investments during the year prior to the survey and who either applied for a loan or a line of credit and had their application rejected, or did not apply for a loan or a line of credit because of any of the following terms and conditions: interest rates were not favourable,

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[7] Of the 1090 establishments that responded the question about their main market, only 4 percent identified international markets as being their main market and slightly over 50 percent identified markets in the same municipality that the establishment is located as being the main market.

[8] For working capital, external sources of finance include: finance borrowed from banks or non-bank credit institutions, trade credit , and informal sources including money lenders, friends, relatives etc. For investments external sources of finance include in addition to those cited for working capital new equity share issues.

collateral requirements were too high, the size of the loan and maturity were insufficient, did not think the application would be approved, the application procedures were complex.[9] Table 4 shows the share of credit constrained establishments for the nine nations. The share varies from a high of 50.2 percent in Zimbabwe to a low of 18.32 percent in CAR.

Table 4
Share of establishments that are credit constrained
(weighted data)

Country	Share credit constrained
Ethiopia	50.49
Zimbwabe	52.20
Rwanda	21.13
CAR	18.32
Uganda	30.52
Zambia	32.39
Tanzania	46.00
Ghana	32.28
DRC	45.20
Total	38.27

Source: Enterprise Surveys Database

Table 5 shows the share of credit constrained establishments according to establishment size category. The results show that a larger fraction of both small and medium-sized establishments are credit constrained than larger establishments

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Table 5
Credit constrained across establishment sizes
(weighted data)

	Percent credit constrained
Small < 20	39.79
Medium (20-99)	37.42
Large (>= 100)	27.53
All establishments	38.27

Source: Enterprise Surveys Database

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[9] This corresponds to the category of 'fully credit constrained firms' in the approach developed by Kuntchev et. al. (2012, p. 20). The authors also identify a category of 'partially credit constrained' firms. This corresponds to cases where the firm did have access to external financing but did not have access to bank financing.

3. Baseline Model

The bivariate probit model with an endogenous binary variable takes the following form where W^* and y^* are unobserved latent variables. The latent variable y^* can be interpreted as the expected returns from innovating and W^* is the unobservable severity of financial constraints. The assumption is that the error terms of the two equations are bivariate normally distributed and correlated with the covariance equal to ρ.

$W^* = x'_1\beta_{1+}\varepsilon_1 \quad W = 1$ if $W^* > 0$, 0 otherwise, $\qquad\qquad$ (1)

$y^* = x'_2\beta_2 + \gamma W + \varepsilon_2 \quad y = 1$ if $y^* > 0$, 0 otherwise,

$\varepsilon_1, \varepsilon_2 \sim N(0,1)$

$Cov(\varepsilon_1, \varepsilon_2) = \rho$

Equation 2 presents the baseline bivariate probit model estimated to determine the impact of credit constraints on innovation performance. *FC* is a binary variable equal to 1 if the establishment is credit constrained according the definition presented in section 2 above, and *INNOV* is a binary variable equal to one if the establishment has innovated according to one of the three innovation measures. In the first equation explaining financial constraints, *LogEmp* refers to size of the firm as measured be the natural logarithm of the number of full-time employees, and *Foreign* measures whether or not the firm's ownership is partially or 100% foreign.[10] It is assumed that larger establishments with a greater sales volume will be less likely to be credit constrained and that firms with foreign ownership will have better access to sources of external credit. The regression controls for whether the firm is in the manufacturing or services sectors (*Sector*).

Prob (FC = 1) = f (LogEmp, Foreign, Sector)

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (2)

Prob (INNOV = 1) = f (FC, RD, train, export, logEmp, logEmp^2, Multi-plant, Sector)

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[10] While Wilde (2000) has shown that the two equations are fully identified if there is one varying regressor in each equation it has become common practice in the literature to include an exogenous regressor in the equation predicting the endogenous binary variable that does not appear in the structural equation. This exclusion restriction is met by including *foreign* in the first equation. See Baslevent and El-hamid (2009).

In the second structural equation explaining innovation outcomes, the covariates include *RD*, a binary variable equal to 1 if the establishment undertakes R&D expenditures, *Train,* a binary variable equal to 1 if the establishment offers formal training to its permanent employees, *Export*, a variable equal to 1 if the establishment exports, *LogEmp*, the natural logarithm of the number of employees and *Multi-plant*, a binary variable equal to 1 if the establishment is part of a larger multi-establishment enterprise. Table 6 presents descriptive statistics.

Table 6
Descriptive Statistics
(weighted data)

Variable	Mean	St.Dev.
Product or service new-to-the establishment	.52*	.50
Product or service new-to-the market	.36*	.48
New methods or processes	.50*	.50
R&D	.24*	.43
Train	.34*	.47
Export	.12*	.33
LogEmp	2.82	1.14
$LogEmp^2$	9.26	8.39
Multi-plant	.17*	.38
Foreign	.11*	.32
Sector (= 1 if manufacturing)	.27*	.45
Size < 20 employees	.68*	.47
Size 20-99 employees	.24*	.43
Size >= 100 employees	.18*	.27

* Means correspond to the share of establishments in the sample positively characterized by the variable.

The variable *Export* is designed to capture horizontal linkages and it hypothesized that exporters will be more innovative through their contacts with more knowledgeable foreign customers or due to the increased pressure of international competition. *LogEmp* measures the size of the establishment in terms of number of employees. The hypothesis is that larger establishments are more likely to innovate as they have more resources than smaller

establishments. Returns to scale are hypothesized to be decreasing due to problems of managerial inefficiency and organizational inertia in larger establishments and this is captured by including the square of the natural logarithm of employment (*LogEmp2*). *Multi-plant* controls for whether the establishment is part of a larger multi-plant enterprise. To the extent that innovation activities are concentrated in specific units of multi-establishment enterprises, the expected sign on this variable would be negative. Table 7 presents the correlations between the covariates.

Table 7
Correlations between covariates in the Innovation equation
(weighted data)

	FC	R&D	Train	Export	LogEmp	LogEmp2	Multi
FC	1						
R&D	-.09	1					
Train	-.10	.35	1				
Export	-.10	.11	.09	1			
LogEmp	-.08	.18	.24	.17	1		
LogEmp^2	-.08	.17	.23	.16	.97	1	
Multi-plant	.08	.04	.04	.03	.28	.27	1

4. Main Results

Table 8 presents the results for the probit model not taking into account the endogeneity of financial constraints and for the baseline bivariate probit model taking into account endogeneity. For each of the bivariate probit models the values of rho are near .90 showing that the disturbances of two univariate probit models are highly correlated. The results are consistent with the hypothesis that financial constraints are endogenous to the decision to innovate and that firms that do engage in innovative product or process development projects are more likely to face financial constraints than firms that don't. In each of structural equations predicting innovation outcomes, the coefficient on the financial constraints variable is negative and highly statically significance. In the simple probit models not taking onto account the engogeneity, the value on the financial constraint variable is

relatively weakly negative and less statistically significant in the case of models predicting innovation in the form of new to-the-firm products or new methods, and it is positive and not statistically significant in the case of new-to-the market innovations. Expressed in terms of average marginal effects (see Table 9), the results show after taking into account the endogeneity that being credit constrained reduces the probability of successful innovation in the form of a new-to-the market product or service by about 42 percent. Being credit constrained reduces the probability of successful innovation in the form of a new-to the-firm product or service or new methods by about 43 percent.

Table 8
Results for the Baseline Model
(weighted data)

	Probit model	Bivariate probit model	Probit model	Bivariate probit model	Probit model	Bivariate probit model
Innovation equation	NewMkt		NewFrm		NewMthd	
FC	.05	-1.40***	-.10**	-1.48***	-.09**	-1.51***
R&D	.76***	.45***	.74***	.47***	.74***	.52***
train	.36***	.39***	.41***	.40***	.48***	.45***
export	-.06	.04	-.03	.03	-.02	-.02
logEmp	.12*	.07	.14**	.11	.20***	.18
LogEmp2	-.01	-.02	-.01	-.02*	-.02**	-.03
Multiplant	-.12**	-.21	-.21***	-.32**	-.24***	-.35*
Sector	.06	.00	.11***	.09	.24***	.26***
Constant	_.91***	.09	-.52**	.31	-.82***	.11
Credit Constraint equation						
logEmp		-.12***		-.11***		-.12***
foreign		-.08		-.08		-.06
sector		.10		.07		.09
Constant		.21		-.00		.01
Rho		.93		.90		.90
(Wald test of rho = 0) Prob > chi2		.0000		.0000		.0000
N	*4391*	*4391*	*4391*	*4391*	*4391*	*4391*

***, **, * denote significance at the 0.01, 0.05, 0.10 levels. Robust standard errors correct for intra-group correlation.

Both the probit and bivariate probit models show that there is a positive and statistically significant impact of R&D expenditures and providing formal training for the firm's full-time employees on the probability of innovating according to the three measures. Contrary to expectations, the results show that being an exporter does not have a statistically significant impact on the probability of innovating. However, the measure does not distinguish between the location of the export markets and it is possible that a more refined measure that could capture exports coordinated through global value chains controlled by multinationals from more technologically advanced nations would show a positive effect. The variable measuring whether or not the establishment is part of a multi-unit enterprise is negative in all cases and statistically significant except in the bivariate probit model predicting the probability of new-to-the market innovations. As observed above, the negative effect could be explained by fact that innovative activities are specialized in particular units of larger multi-unit enterprises.

Table 9

Marginal Effects for Biprobit Innovation Equation
(weighted data)

	NewMkt			NewFrm			NewProc		
	direct	indirect	total	direct	indirect	total	direct	indirect	total
FC	-.42***		-.42***	-.43***		-.43***	-.43***		-.43***
R&D	.14***		.14***	.14***		.14***	.15***		.15***
train	.12***		.12***	.12***		.12***	.13***		.13***
export	.01		.01	.01		.01	-.01		-01
logEmp	.02	.02	.04**	.03	.02	.05**	.05	.02	.07**
LogEmp2	-.00		-.00	-.01*		-.01*	-.01		-.01
Multiplant	-.06		-.06	-.09**		-.09**	-.10*		-.10*
Sector	.00	.00	.00	.03	-.01	.02	-.07	-.01	-.06*

The results for the impact of *LogEmp* on innovation activity differ between the probit and bivariate probit models, with the probit models showing that the positive impact is statistically significant while the bivariate models show a non-statistically significant positive impact. This discrepancy can be accounted for by the fact the coefficient estimates for the

structural equation in the bivariate probit model do not take into account the indirect effects of employment on the probability of innovation that are transmitted through the endogenous variable measuring financial constraints. Once these indirect effects are included the results are more consistent as show in Table 9 , where the total marginal effects are decomposed into direct and indirect effects in the case of the variables appearing in both equations of the bivariate probit model. For each of the three forms of innovation, the total marginal effects of *LogEmp* are statistically significant. There is little evidence to support the presence of decreasing returns to scale in the effect of establishment size on innovation. The squared employment term is negative in the case of the model predicting new-to-the firm innovations but it is of borderline statistical significance.

4.1 Sub-sample analysis

The descriptive statistics presented in Table 5 above show that a larger share of the sample of micro and small are credit constrained than the larger firms in the nine African nations. In this section we focus on the related question of possible differences in the size of the effect of being credit constrain according to establishment size. The section also examines the size of the effect for young (< 4yrs) as compared to older (>= 4 yrs) firms. The results presented in Table 10 clearly show in the case of introducing a new good or service that is new-to-the market and in the case of introducing a new method, that the impact of being credit constrained on innovation for small establishments with less than 20 employees is greater than the impact for large establishments with 100 or more employees. There is little difference in the case of new-to-firm innovation for which the medium sized- category shows the largest effect of being credit constrained. The results show both in the case for new-to-the market and new-to-the firm product innovations a larger negative impact of being credit constrained for young establishments compared with older establishments. In the case of introducing new methods, the size of the impact for older firms is slightly larger than for young firms. The results provide clear evidence that impact of financial constraints on innovation is disproportionately large for small and for young in the case of firms introducing new-to-the market innovations. The results are mixed for the case of new-to-the firm innovations and the introduction of new manufacturing methods.

It is a stylized fact that micro and small-sized firms rely less on debt financing than larger firms and that they rely more on informal sources of external finance (Beck et al. 2008). This might be explained by the relative opaqueness of small firms and the difficulties of monitoring these firms which increases problems of asymmetric information raising the wedge between the cost of internal and external funds for small firms. Smaller firms will only turn to relatively costly external finance in situations where they have completely exhausted their internal funds and where the only alternative to applying for a bank loan or line of credit would be abandoning the innovation project. Larger firms facing a smaller wedge may turn to external sources of credit while retaining a precautionary reserve of internal funds.

Table 10
Sub-sample analysis of the impact of financial constraint on innovation
(weighted data)

Dependent variable		NewMkt	NewFrm	NewProc
		Estimate	Estimate	Estimate
Establishment Size	< 20	-1.44***	-1.35***	-1.55***
	20-99	-1.32***	-1.42***	-1.54***
	>= 100	-.32	-1.32***	-.63**
Dependent variable	< 4 yrs.	-1.48***	-1.59***	-1.42***
	>= 4 yrs.	-1.13***	-1.39***	-1.48***

The table presents the bivariate probit estimates for FC in the innovation equation. ***, **, * denote significance at the 0.01, 0.05, 0.10 levels. Robust standard errors correct for intra-group correlation

This difference in the wedge between the costs of internal and external finance could account for the larger negative impact of being financially constrained in the case of small firms, since larger firms when facing a refusal on their loan application would be in a position to turn to their reserve of internal funds. A similar argument could apply to new or young firms which due to their shorter credit history would face a larger wedge between the costs of internal and external funds.

5. Conclusions

The analysis has shown that credit constrained establishments have a lower probability of innovating than establishments that are not credit constrained. The analysis has been based on a unique data set covering registered firms in nine African nations and it uses a novel direct measure of being credit constrained made possible by the rich information on the financial decisions of establishments in the World Bank Enterprise Surveys. The analysis has also shown that the negative impact of being credit constrained on innovation tends to be greater for small establishments than it is for larger establishments. This difference in the importance of the impact of financing constraints may help explain the gap in innovation performance between smaller and larger firms in the sample of nations analyzed here. (see Table 3). This result has important policy implication, since the majority of establishments in African nations are small in size (68 percent of the population in this analysis). This strongly suggests that government subsidies and financial support programs for micro and small and firms could make a positive contribution to increasing the innovation performance of African nations.

An important limitation of the analysis is that it only covers registered firms and does not analyze the relation of financial constraints to the innovation performance of informal economy establishments. For Sub-Saharan Africa, the informal economy has been estimated to account for as much as two thirds of non-farm employment (Charmes, 2012). Since informal sector firms are more likely to rely on informal sources of credit than registered firms, and are more likely to face obstacles in gaining access to bank finance, it is highly probable that credit constraints affect a substantially larger proportion of informal economy establishments than firms in the formal economy. Investigating the sensitivity of innovation to financial constraints in the informal economy is an important area for future research that will require new survey data covering the innovation activities of informal economy firms.

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