Payment Instruments, Finance and Development

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Abstract

This paper studies the effects of a payment technology innovation (mobile money) on entrepreneurship and economic development in a quantitative dynamic general equilibrium model. In the model mobile money dominates fiat money as a medium of exchange, since it avoids the risk of theft, but comes with electronic transaction costs. We show that entrepreneurs with higher productivity and access to trade credit are more likely to adopt mobile money as a payment instrument vis-a-vis suppliers. Calibrating the stationary equilibrium of the model to match firm-level data from Kenya, we show significant quantitative implications of mobile money for entrepreneurial growth and macroeconomic development.

Keywords: Payment Technologies, Theft, Trade Credit, Allocations.
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[§]Before the completion of this paper, our dear friend and co-author Ravindra Ramrattan lost his life at the tragic Westgate Mall terrorist attacks in Nairobi, Kenya.

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1 Introduction

"Mobile-Money helps people to save and borrow and empowers them in a big way." - *Bill Gates* in *2015 Gates Annual Letter*.

Can the development of an efficient payment technology stimulate business growth and thereby contribute to a country's economic development? In particular, can more efficient payment tools help small businesses grow and allow credit access in developing countries, where financing constraints loom large? We address these questions by focusing on a key financial innovation, which has drawn attention of many researchers and policy makers over the recent years: mobile money. Mobile money is an SMS-based money transfer and monetary storage tool, initially developed in Kenya, but now being used in other developing countries across the globe. Mobile money provides users a safe opportunity to carry and share liquidity with cellular phones, critical in socially volatile and risky environments. According to the Global Findex data (Demirguc-Kunt et. al, 2015), in 2014, 58 percent of the adult population in Kenya, 37 percent in Somalia, and 35 percent in Uganda had a mobile money account. While not as wide-spread, mobile money accounts are also being used by enterprises; 35 percent of firms interviewed in the 2014 FinAcces Business survey in Nairobi reported that they accept mobile money as a common method of payment from their customers, while 32 percent of the firms use mobile money when paying for their input purchases.

While an expanding literature has worked on understanding the effect of mobile money adoption on household welfare, this paper assesses the interactions between the adoption of mobile money as a payment instrument, entrepreneurial growth and finance.[1] For this purpose, we develop a dynamic general equilibrium model with heterogeneous firms to evaluate the effects of a technologically advanced payment technology - featuring the properties of mobile money accounts - on firm-level performance and access to supplier credit in an economy characterized by credit imperfections, information asymmetries and most importantly the risk of theft. Our analysis shows that the availability of mobile money reduces the incidence of theft and thus output losses, but also alleviates the transaction frictions between entrepreneurs and suppliers and increases the valuation of trade credit, with positive repercussions for entrepreneurial growth. Calibrating the model to firm-level survey data from Kenya, we uncover significant quantitative effects of the adoption of mobile money on aggregate economic outcomes. Our findings are novel as they reveal the critical interactions between payment instruments, access to finance and business growth.

Figures 1 and 2 motivate our research by revealing two important cross-sectional patterns regarding the utilization of *M-Pesa*, the main mobile money technology brand in the context of Kenya. Using FinAccess Business survey, a data-set which covers over 1,000 SMEs from Kenya, Figure 1

[1] For a review of the recent literature on digital payments, see World Bank, Better than Cash Alliance and Bill & Melinda Gates Foundation (2014).

illustrates that the share of firms using mobile money when purchasing inputs from their suppliers is significantly higher for businesses with above median productivity. Moreover, Figure 2 shows that businesses that receive inputs from their suppliers in exchange for a (delayed) credit repayment are more likely to use M-Pesa as well. Both partial correlations hold when controlling for many other firm characteristics, as we document in Section 2, a result whose firm-level and aggregate implications we will explore theoretically as well as quantitatively in this paper.

- Figures 1 and 2 about here -

Credit enforcement frictions and the risk of theft loom large in many developing economies, including Kenya. Ample research has shown that financing obstacles hold back firm and ultimately aggregate growth - as documented in Beck et al. (2005) and Ayyagari et al. (2008). Information and enforcement frictions are at the core of financing constraints in developing countries, as argued for instance by Paulson et al. (2006). At the same time, the lack of security is another major growth constraint in developing world.[2] Especially the insecurity due to the risk of theft is striking in Kenya. Data from the World Bank's Kenya Enterprise Survey (2013) suggests that every year Kenyan manufacturing firms lose about 1.9% percent of product value due to theft - which equals twice the world average - from shipping to remote domestic markets. Similarly, 29% of Kenyan firms experience losses due to theft and vandalism, compared to the world average of 19%. Also according to the World Bank Enterprise Survey, 82% of firms pay for security services in order to avoid theft in Kenya, compared to the world average of 55%. As we will delineate in Section 2, the FinAccess Business survey of Kenya reveals that firms which see theft as an obstacle to business growth are more likely adopters of the M-Pesa technology. By providing a cheaper and safer money transfer tool, the use of mobile money technology expanded rapidly and became a frequently and widely utilized electronic money instrument for private purposes in the country.[3]

In order to explain the positive association between productivity and mobile money use and the positive association between mobile money use and access to trade credit observed in our survey data, we develop a dynamic general equilibrium model of entrepreneurial finance. In our model, entrepreneurs are heterogeneous in their ability to access trade credit, randomly draw idiosyncratic productivity shocks, and, importantly, get randomly hit by monetary theft. Trade credit expands production opportunities but it is subject to limited commitment and hence a strategic-default constraint. In the benchmark model, theft is a friction that is of primary importance, because it erodes an entrepreneur's fiat money balances and thus inhibits entrepreneur's ability to settle transactions with suppliers. Additionally, theft also damages the entrepreneur's commitment to credit repayment and potentially causes a discontinuation of access to trade credit, because theft is privately observed.

[2]Ayyagari et al. (2008) show that among all the different obstacles highlighted by firm-level surveys, only obstacles related to finance, crime, and policy instability directly affect firm growth.

[3]See Jack and Suri (2011).

In line with empirical evidence and the existing literature, we model mobile money as a payment instrument that is a resolution to theft.[4]

The analytical solution of the model produces a key equilibrium property that matches the empirical regularity of Figure 1: enterprises with higher productivity are more likely to adopt M-Pesa when transacting vis-a-vis suppliers. The intuition for this "primary impact channel" is related to the opportunity cost of a foregone trade with a supplier. For productive entrepreneurs the loss of cash due theft is more costly because of missing an opportunity to invest in a high-yield project; therefore, productive types are more willing to sign up for M-Pesa.

Our theoretical set-up also allows us to capture the empirical regularity of Figure 2 that access to trade credit is associated with a higher demand to use M-Pesa when transacting with suppliers, a "secondary impact channel". Specifically, using our model we isolate three equilibrium (sub)-channels through which mobile money use raises a trade credit borrower's production capacity relative to non-borrowers. First, for a borrower the cost of theft is higher at the input-purchase stage than for non-borrowers, as it is not only the endowment loss that affects the entrepreneur but also the inability to utilize this endowment as down-payment (*collateral*) when borrowing. Therefore, for a given level of entrepreneurial productivity access to trade credit increases the likelihood of mobile money use when purchasing inputs. Second, in the case of theft at the trade-credit-repayment stage, theft is not only associated with the loss of the current value of cash but also with the loss of *future credit market access*. The use of mobile money therefore increases the future credit market valuation for an entrepreneur, which in turn raises the amount of trade credit that the entrepreneur can obtain, and thus reinforces the demand for mobile money. Third, given the risk of theft, the contracted interest rate and therefore *repayment burden* is higher for users of cash compared to mobile money users, lowering the quantity of inputs that an entrepreneur can purchase on credit.

We calibrate the stationary equilibrium of the model to match a set of moments that we observe in Kenyan FinAccess Business survey data from 2014. The parameterized model matches the Kenyan business data well along the dimensions that we target as well as important additional statistics that we do not target directly. Using the parameterized model, we conduct counterfactual quantitative exercises, where we hypothetically shut down entrepreneurs' access to mobile money when purchasing inputs from suppliers. Our key quantitative result reveals that eliminating the use of mobile money in an environment with a theft probability of 2% translates into a macroeconomic output loss of 1.2%. About 75% of this effect is due to the primary impact channel (through productivity-payments complementarity), while the remaining 25% of the effect comes from the secondary impact channel (through finance-payments complementarity). Isolating the sub-components of the secondary impact channel reveals that the collateral (down-payment) channel has negligible growth

[4]To give one example, Sanches and Williamson (2010) formalize the role of theft in ensuring commitment in a search theoretic monetary environment.

effects, whereas future credit market access and repayment burden channels explain 33% and 66% of the secondary impact channel (through alleviating financing constraints), respectively. Importantly, we also show that increasing the extent of trade credit access can substantially increase the effects of M-Pesa through the finance-payments complementarity and generate a substantial financial amplifier to raise the macroeconomic effects of M-Pesa. We would like to also highlight that the measured effects of M-Pesa on entrepreneurial finance and aggregate economy could be a lot more significant if formal sources of finance can be accessible to entrepreneurs, because limited commitment problems are expected to be more significant for formal credit contracts compared to supplier provided informal credit, as argued by Burkart and Ellingsen (2004).

Comparing the estimated outcome effects of M-Pesa with actual growth numbers for the Kenyan economy shows that the introduction of the M-Pesa technology in 2007 can explain 10% of the per-capita income growth between 2007 and 2013 thus pointing to quantitatively significant macroeconomic effects of mobile money technology through entrepreneurial finance.

We conduct an extensive list of robustness checks and consider theoretical as well as quantitative extensions to our benchmark framework, which reveal that our qualitative and quantitative findings are robust to the nature of theft, endogenizing trade credit access, allowing for business capital accumulation and relaxing the assumption that theft is private information.

Our paper has a set of important policy implications. First, we show that more secure payment systems that improve on risky cash holdings and allow for more efficient transfers can have economically meaningful implications for firm performance and macroeconomic development. Specifically, we show that efficient payment systems can have positive effects beyond lowering transaction costs by allowing firms to extend access to external finance and thus grow faster. Second, our results speak to the debate on financial inclusion. While for a long time there has been a focus on credit services for micro- and small entrepreneurs, over the past years the conversation has increasingly broadened to other financial services. Our paper points out the importance of providing efficient payment services as a means to help SMEs by keeping liquidity holdings safe, increasing credit market performance and thereby raising entrepreneurial production. While we use data from Kenya to empirically motivate our study and calibrate the theoretical model, the market frictions we focus on - namely; information asymmetries, financial constraints and theft - are prevalent throughout the developing world. Third, most of the firms in our firm survey are formal enterprises. On the one hand, the underlying mechanism and thus results of household entrepreneurs using M-Pesa to pay their suppliers should not differ from that of formal enterprises and the aggregate effect of M-Pesa might be even larger, should the M-Pesa technology be available for such entrepreneurs. On the other hand, there is increasing evidence that informal or household enterprises are substantially less productive than formal enterprises and that this productivity difference is inherent rather than driven by policy barriers (e.g., La Porta and Shleifer, 2014); we would therefore expect less of an effect from the use of M-Pesa to pay suppliers by household enterprises than formal enterprises. Finally, however, there might be a dynamic dimension in the sense that the expansion of formal enterprises might result in fewer household enterprises and a switch of some of the latter into formal employment.

Related Literature. Our paper relates and contributes to three strands of literature. First, we contribute to the macro-finance literature, which investigates the impact of limited financial enforceability on macroeconomic outcomes. Following the seminal studies by Kehoe and Levine (1993) and Kehoe et al. (2002) we incorporate a limited commitment constraint into a dynamic general equilibrium model, where defaulters get excluded from accessing credit in the future. Different from these papers, in our framework theft raises the likelihood of default and constrains entrepreneurial trade credit opportunities.[5] Our theoretical contribution shows that an efficient payment technology (such as mobile money) - that lowers the probability of theft - can alleviate trade credit constraints arising from limited enforceability and thereby stimulate entrepreneurial performance. We also quantify the aggregate implications of mobile money use - through its impact on enforceability - on financial markets and macroeconomic performance.[6]

Importantly, we contribute to the above mentioned macro-finance literature by developing a novel theoretical foundation (and then also measuring its quantitative implications) concerning the distortionary effects of the interaction between theft and access to trade credit. Specifically, when theft is privately experienced - a feature relevant for the context of a developing country because of limited enforcement capacity and efficiency of the police force - the strong complementarity between theft and limited commitment generates a quantitatively important amplifier mechanism to constrain economic development.[7] As one of our key results we show that M-Pesa is a resolution to this adverse "financial amplifier".

Second, we relate to the rapidly expanding literature gauging the impact of mobile money on financial transaction patterns and welfare, much of which has focused on the Kenyan mobile money technology M-Pesa. In this literature, Jack and Suri (2011) document that three out of four Kenyan

[5]An important recent paper on firms' finance and default is Herranz et al. (2015), with a dynamic model of small firms who can default on contracts in equilibrium (when it is optimal to do so); the authors decompose dynamic default into three parts: one static term (standard) and two dynamic components. Since it goes beyond the scope of this paper, in our model we do not investigate the consequences of non-trivial default and concentrate on the effects of theft shocks on the inability to repay.

[6]Closely related to our work, in this literature, Quadrini (2000) and Cagetti and De Nardi (2006) explore the effects of limited contract enforcement on entrepreneurial wealth accumulation, aggregate saving dynamics and development. Antunes et al. (2008) and Buera and Shin (2013) study the quantitative implications of limited contract enforcement for occupation choice and the efficiency of aggregate capital allocation across a distribution of entrepreneurs.

[7]Studies concerning trust in police support this argument. Global Barometer Survey results, which was conducted in 55 countries from Africa, Asia, Latin America and the Middle East between 2003 and 2007, shows that relative to the whole sample (51%) a smaller share of Kenyans (38%) have trust in police force. GfK Trust in Professions Study (GfK Verein, 2016) reports that, in 2014, fraction of respondents generally or completely trusting in policeman is lowest (25%) in Kenya among 25 countries from Europe, Africa, Asia and Pacific participated.

M-Pesa users indicate that they use M-Pesa to save money. Mbiti and Weil (2011) find that the increased use of M-Pesa lowers the use of informal savings mechanisms (for instance ROSCAS), and raises the propensity to save via formal bank accounts.[8] Finally, while Jack and Suri (2014) study the effect of reduced transaction costs on risk sharing, showing that income shocks lower consumption by 7 percent for non-M-Pesa users whereas consumption of M-Pesa-users is unaffected, Jack and Suri (2016) quantify the overall effect of M-Pesa as a 2% reduction in poverty in Kenya. While this literature has almost exclusively focused on the household use of mobile money, our paper is the first to focus on business use of mobile money and to offer empirical and theoretical evidence on the strategic complementarity between mobile money and trade credit.

The third line of research we contribute to is the literature on the role of trade credit in economic development in developing countries.[9] Suppliers have an advantage over other lenders in financing credit-constrained firms, which makes trade credit prevalent in financially less developed countries where the majority of firms has limited - if any - access to bank credit. Unlike credit from financial institutions, trade credit does not rely on formal collateral but on trust and reputation. Fafchamps (1997) shows in the context of Zimbabwe, where networks and statistical discrimination affect the screening of trade credit applicants, black entrepreneurs are disadvantaged by the difficulty to distinguish themselves from the mass of financially insecure short-lived African-owned businesses. Using firm-level data from five African countries Fisman and Raturi (2004) show that monopoly power is negatively associated with trade credit provision. Using a cross-country analysis, Fisman and Love (2003) show that industries with higher dependence on trade credit financing grow faster in countries with weaker financial institutions. Ge and Qiu (2007) compare the use of trade credit between state owned and non-state-owned companies in China and show that the non-state owned firms use relatively more trade credit when financing their operations. Cull et al. (2009) employ a large panel dataset of Chinese firms and find that poorly performing state-owned firms were more likely to redistribute credit to firms with limited access to formal financial markets during China's economic transition. We contribute to this literature by showing that the use of mobile money as a payment device can serve as a commitment mechanism vis-a-vis creditors and thus enhance growth of financially constrained enterprises.

[8] Kikulwe et al. (2013) analyze the impact of M-Pesa using panel data from small farmers in Kenya. They show that M-Pesa users purchase more inputs, sell a larger proportion of their output in markets, and as a result have higher farm-profits.

[9] Cunat (2007), and Cunat and Garcia-Appendini (2012) provide extensive reviews on trade credit literature.

2 M-Pesa and Tade Credit: Evidence from Kenya

After its launch in 2007, *M-Pesa* rapidly became a popular monetary instrument among Kenyan households.[10] For instance, Jack and Suri (2014) document that as of 2011 70 percent of all households in Kenya had already adopted at least one M-Pesa account. In Kenya, there was a substantial demand for money transfer services before the introduction of M-Pesa[11], but M-Pesa changed the landscape of payment instruments dramatically. On the one hand, access to online monetary transfer had been limited, and other forms of electronic money transfer instruments, such as Western Union, were too costly to transfer money for the general population.[12] On the other hand, cheap money transfer methods such as bringing cash personally or sending cash via bus drivers or friends had been common but were subject to risk of appropriation and theft.

This section provides a short overview for how M-Pesa technology works to store and transfer liquidity safely, introduces the enterprise survey that underpins our work, and shows empirical evidence that motivates our theoretical and quantitative analysis.

2.1 M-Pesa

In Kenya, M-Pesa is the most commonly utilized mobile money service allowing users to send money to any cell phone owner via SMS messages. Cash (fiat money) can be transferred into M-Pesa deposits and vice versa via specialized shops, called *M-Pesa Kiosks*, which are wide-spread all across the country. After being introduced in 2007 by Safaricom, mobile money usage has grown rapidly. From March 2007 to December 2014 the number of M-PESA Kiosks grew 148% annually and reached about 124,000 (about 20 percent of them in Nairobi (FSP interactive maps, 2013)), and the number of customers grew 307% annually and reached about 25 million. In 2013, about 732.5 million transactions were conducted in total, and the total value of money transferred was 22 billion U.S dollars.[13] Since 2007 Kenyan households have utilized M-Pesa for not only transferring or receiving money but also for saving: 85% of Kenyan households store some money in their personal M-Pesa account according to the survey evidence provided by Jack and Suri (2011).

Exchanging cash for M-Pesa deposits is free. The individual only has to visit the mobile money agent and tell the phone number that she wants to deposit money into. However, using M-Pesa comes with *withdrawal fees* - applied when converting M-Pesa into cash - as well as *variable costs* of electronic money transfer increasing in the amount sent. On average, for each unit Kenyan

[10]M stands for mobile and pesa means money in Swahili.

[11]High internal labor migration from rural to urban areas has resulted in high demand for sending money from urban areas to families, relatives and friends living in rural areas (Aker and Mbiti (2010); Jack and Suri (2011)).

[12]See Aker and Mbiti (2010); Jack and Suri (2011); Jack and Suri (2014).

[13]The data used for calculating the number of Nairobi M-Pesa agents is from November 2013. We calculated U.S dollar equivalent of M-Pesa transfers by using 2013 average of the official exchange rate between US $ and Kenyan Shilling.

Shilling (KSh) transferred to a recipient, Safaricom charges the sender with 0.0172 KSh. We will incorporate both withdrawal and variable cost margins of M-Pesa use into the dynamic general equilibrium model that we will develop below.

In addition to facilitating person to person (P2P) transfers, M-Pesa users can pay water, gas and electricity bills as well as save money by earning a certain amount of interest if they upgrade to a special M-Pesa service. There are also some mobile money services through which businesses can send salaries to mobile phones of their workers and repay loans. P2P service is also utilized for transactions, such as purchasing supplies and selling goods to customers, which we shall turn to next.

2.2 Data

In this study we use the Kenya FinAccess Business Survey 2014 - designed by the Financial Sector Deepening Trust Kenya (FSD-K) together with Tilburg University -, which includes a set of novel business-level mobile money usage questions. The survey data were collected in 2014 by FSD-K from a representative cross-section of 1,047 mainly small and medium-size enterprises in Nairobi. The respondents of the questionnaire are owners or executive managers. In Online Appendix of the paper we provide the full details of the questions from the survey that are relevant for our empirical and quantitative analyses as well as a detailed table on descriptive statistics (Table OA1).

There is significant sectoral variation in the sample, with 29 percent and 34 percent of the businesses operating in manufacturing and service sectors, respectively, while 37 percent of enterprises operate in trade.

The key question which we exploit to learn whether a business uses mobile money for business to business transactions asks "whether cash, check or mobile money are common methods of payments when buying inputs from suppliers". Descriptive statistics show that, after cash and checks, mobile money is the third most common method of payment to suppliers when purchasing inputs: 91 percent and 50 percent of the businesses pay for their supplies via cash and check respectively, while mobile money is a common method for 32 percent of the firms. Most firms in our sample have access to bank accounts: 75 percent of firms use business bank accounts for their business operations and 15 percent of them utilize their personal bank accounts for business purposes. In the sample, 24 percent of the firms report that they purchase inputs from their suppliers on trade credit.

In terms of the size measures, the median firm earns around 5,600 U.S dollars per month, averaged over the last 12 months, and employs on average 6 workers.[14] The sample mostly includes formal

[14]In order to have a representative cross-section of firms, our sample (1,047 firms) includes 3 large firms, which employ more than 100 workers. Therefore our profit and employment figures are slightly skewed. However, when we estimate the probit model - that we present in Section 2.3 - with only SMEs (by excluding the large firms), our coefficient estimates do not alter. These alternative estimation results are available upon request.

businesses; 75% of the firms are registered with the Business Registrar at the Attorney General's office. The firms in the sample mostly (75%) have male owners (or managers), and 40% of the owner/managers have at least a university degree.

2.3 Empirical Evidence

Using formal regression analysis we explore which businesses are more likely to use M-Pesa when buying supplies. Specifically, we regress our M-Pesa use indicator, *purchasing supplies via mobile money,* on business characteristics. We estimate the model using a probit regression; we control for sector fixed effects but do not report the coefficient estimates to economize on space.

- Table 1 about here -

Table 1 presents for each characteristic the marginal effect estimates at mean levels and robust standard error estimates in columns (1) and (2), respectively. First, the estimates show that there is a positive correlation between *productivity* and the likelihood of using M-Pesa to pay suppliers, where productivity is measured by profits per employee. The coefficient estimate for productivity shows that, ceteris paribus, one percentage increase in profits per employee is associated with a 2 percentage point increase in the share of firms using M-Pesa to purchase inputs. Second, after controlling for productivity and other business/owner characteristics we find a strong empirical association between *buying inputs on trade credit* and mobile money use. The estimate shows that, ceteris paribus, the share of firms using M-Pesa to purchase inputs is 17 percentage points higher among the firms purchasing supplies on credit. These two empirical results will constitute the basis for the theoretical and the quantitative frameworks that we will explore. The empirical results also show that there is a positive relationship between using mobile money to pay for input purchases and having younger managers, being unregistered and having an accountant.[15]

It is important to note that these estimates do not imply any causality; rather, the result may imply that, for instance, having a trade credit relationship leads to mobile money usage when settling transactions with suppliers and/or using mobile money facilitates trade credit relations between

[15] In table OA2 of Online Appendix, we test the robustness of our key result concerning trade credit access and the use of M-Pesa as a method of payment by first estimating a parsimonious model and then adding control variables gradually. The results show that the estimates on purchasing supplies via credit are highly stable across different regression specifications. We also measure the stability of marginal effects by calculating the ratio between the value in the regression including controls (numerator) - column (5) - and the difference between this effect and the one derived from a regression without covariates (denominator) - column (1). As Bellows and Miguel (2009) suggest, this ratio shows how strong the covariance between the unobserved factors explaining purchasing supplies on credit and using mobile money to pay for supplies needs to be - relative to the covariance between observable factors and entrepreneur's credit use - to explain away the entire effect we find. The ratio is -2, which suggests that to explain the full effect of trade credit-relationship with suppliers on M-Pesa use, the covariance between unobserved factors and existence of trade credit relationships needs to be more than twice as high as the covariance of the included control variables with trade credit. This suggests that it is unlikely that our results are due to omitted variable bias.

businesses. Both directions of causation have important and interesting research and policy implications. In sections 3 and 4, we will therefore focus on providing theoretical explanations for both ways of causation and the quantitative implications of positive associations of M-Pesa use with productivity and trade-credit access.

Before we move on with our theoretical analysis, we would like to mention that we also provide additional empirical results in Online Appendix (Table OA3) from a formal regression analysis - using FinAccess Business - to show that businesses which report "crime and theft" as an obstacle to business growth utilize M-Pesa more often in their transactions vis-a-vis suppliers. This result validates the theft avoidance motivation associated with M-Pesa - confirming also the empirical results by Economides and Jeziorski (2016), who show for the context of Tanzania that the willingness to pay to avoid walking with cash (and using mobile money) an extra kilometer for an extra day is 1.25% of an average transaction. These results demonstrate the property of M-Pesa type payment instruments in alleviating theft-related frictions, which constitutes a key feature of our theoretical structure.

3 Model

We model an economic environment with infinitely lived agents. Time is discrete and indexed with t. There are two types of agents in the economy (*Entrepreneurs* and *Suppliers*) and two types of goods (*Production Input* and *Consumption Good*). Entrepreneurs are heterogeneous agents, who convert supplier provided inputs into the consumption good. The stock of entrepreneurs in the economy is constant and has a finite measure of $\mathscr{E}$.

For expositional convenience we divide each period in two subperiods, which we call *Day* and *Night*. In the *Day* sub-period entrepreneurs meet suppliers in a market place for purchases of production inputs. Conditional on the contractual agreement between a supplier and an entrepreneur, the supplier settles to provide inputs to the entrepreneur in return for an immediate payment in the *Day* market and for a potential late payment to be made in the *Night* market. We interpret the delayed payment option in the *Night* subperiod as the provision of *trade credit*.

There is a large number of suppliers available in the *Day* market, and each entrepreneur can contact many suppliers, but she can sign a contract with at most one of them. This implies that the supplier-profits will be driven to zero in equilibrium. Neither the consumption good nor the supplier provided inputs can be stored in-between any t and $t+1$; and therefore, there is no capital accumulation in the model. We relax this assumption in Section 7.4 and show that while the lack of capital accumulation makes the model more tractable, quantitative results implied by this assumption do not contradict with the firm-level empirical regularities that we observe in the Kenyan (FinAccess) business data. Furthermore, in Section 7.4 we also show that excluding capital dynamics at the firm level could actually dampen the quantitative effects that we are measuring.

3.1 Preferences, Endowments and Production

Suppliers' production technology is linear in labor. Specifically, when a supplier converts $h_{s,t}$ units of his own labor to generate $h_{s,t}$ units of input for an entrepreneur, he suffers $-h_{s,t}$ units of utility loss. We assume that in every period each supplier has a limited amount of labor capacity to produce inputs (denoted with $\bar{h}$).[16] Suppliers have linear preferences to consume the consumption good. By denoting $c_{s,t}$ as the consumption of a supplier s in period t, the preferences of s are described by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[c_{s,t} - h_{s,t}\right], \tag{1}$$

where $\beta(\leq 1)$ is the intertemporal discount factor.

Entrepreneurs are identical in terms of endowments and preferences: each entrepreneur receives e units of consumption good at the beginning of every *Day* sub-period that she can choose to consume.[17] The entrepreneur can also take fractions of this endowment to the *Day* market to make purchases from an input supplier. We assume $e < \bar{h}$, such that there is room for trade-credit to improve entrepreneurs' production capacities. Similar to the suppliers, entrepreneurs have linear preferences with respect to the consumption good: denoting $c_{i,t}$ as consumption of an entrepreneur i in period t, the preferences of an entrepreneur i are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t c_{i,t}. \tag{2}$$

Entrepreneurs convert supplier provided inputs into consumption by operating a production technology. Entrepreneurial output is a function of the quantity of inputs employed in the production process and an exogenously determined idiosyncratic productivity term. The entrepreneur i who purchases and invests $h_{i,t}$ units of inputs in the *Day* sub-period obtains

$$y_{i,t}(h_{i,t}) = A_{i,t} f(h_{i,t}) \tag{3}$$

units of consumption good in the *Night* sub-period. In this production specification $A_{i,t}$ is the entrepreneur i's idiosyncratic productivity draw in period t. Entrepreneurial productivity draws are iid across time and entrepreneurs, assigned from a well-behaved cumulative distribution function

[16] This assumption is utilized in the analytical solution to the model below and does not play a key role in the quantitative analysis.

[17] As we will delineate in Section 7.4, the lack of cross-sectional heterogeneity in entrepreneurial endowment (capital) is not a concern for our quantitative results and does not alter our key qualitative findings.

$G(A)$ and publicly observable as well as verifiable.[18]

3.2 Frictions, Trade Credit, Fiat Money and M-Pesa

There are two class of frictions in the model: *financial imperfections* and *theft*. Financial imperfections are twofold. Fractions of inputs can be purchased on supplier provided trade credit; however, *accessibility* and *enforceability* of credit is limited, restricting the use of trade credit at extensive and at intensive margins respectively. To the end of limited enforceability, strategic default of a borrower on trade credit can be prevented only with the threat of exclusion of a defaulter from accessing trade credit for the next T periods following the incidence of default. With respect to limited accessibility, only a sub-set of entrepreneurs have the capacity to borrow trade credit and they can do so only if they provide the supplier with an up-front payment.

Monetary theft can reduce an entrepreneur's capacity to pay for input purchases from a supplier in the *Day* as well as her ability to repay trade credit in the *Night*. We assume that theft is private information and unverifiable. The mobile-money technology, M-Pesa, insures entrepreneurs against theft of monetary holdings at the expense of electronic transaction costs.

We formalize the details concerning trade credit constraints, theft, fiat money and M-Pesa as follows.

Trade Credit. An entrepreneur can purchase inputs via immediate consumption good transfer in the *Day* market or partially on trade credit, where in this latter case the credit repayment is to be made after the completion of the entrepreneurial production in the *Night* market - as presented in the timing of events in Figure 3.

- Figure 3 about here -

In order to represent the trade credit relationships that we observe in our Kenyan business survey data we assume the following properties. First, at the extensive margin trade credit is available only for a sub-set π of entrepreneurs. Specifically, the fraction $\pi < 1$ of all entrepreneurs are part of a network and they can obtain trade credit on their input purchases in the *Day* market. Limited participation to access trade credit can be motivated with reputation about the history of past transactions being storable only for a fraction of the entrepreneurial population.[19,20] The remaining $1-\pi$ fraction of the entrepreneurs are not part of the trade credit network - lack the reputation to repay credit -

[18] The output from entrepreneurial production in period t cannot be carried over to period $t+1$ because as delineated above the consumption good is non-storable.

[19] The available information can be in the form of a network, from which borrowers get excluded for T periods in the case of trade credit default.

[20] Theoretical papers that investigate the optimal design of payment methods, such as Kocherlakota (1998) and Kocherlakota and Wallace (1998), refer to this type of an arrangement as a record keeping institute.

and hence can only spot-trade in the *Day*. Hereafter, we will refer to the entrepreneurs who can borrow trade credit as "borrower types" and the entrepreneurs who cannot borrow as "creditless types" (or spot-traders). We work with two versions of the model. In the benchmark set-up, we assume that the trade-credit-access type of an entrepreneur is exogenously given and fixed over time. In an alternative version of the model that we present in Section 7, we will endogenize access to the trade credit network as an entrepreneurial decision.

Second, a financially-connected entrepreneur can borrow trade credit only if she makes an upfront payment to the supplier in the *Day* that exceeds ω units of consumption good. Formally, denoting the up-front consumption good down-payment of an entrepreneur i in period t with $x_{i,t}$ and the credit-repayment promised by the same entrepreneur with $b_{i,t}$:

$$b_{i,t} > 0 \;\; if \;\; x_{i,t} \geq \omega, \;\; with \;\; \omega < e. \tag{4}$$

This exogenously determined "down-payment" (or in other words, *collateral*) requirement (ω) allows us to capture the empirical regularity observed in our business survey data that trade-credit finances only a fraction of an entrepreneur's operations.

Third, if a trade credit borrower does not repay her credit obligation $b_{i,t}$ in a *Night* sub-period t, she will be excluded from accessing trade credit between periods $t+1$ and $t+T$ and as a result suffer an endogenously determined consumption loss.[21] Therefore, the repayment on trade credit promised by an entrepreneur cannot exceed the next T periods' credit market valuation ($V_{i,t}$) for that particular entrepreneur such that

$$b_{i,t} \leq V_{i,t}, \tag{5}$$

generating an intensive margin financial constraint.

As an important remark, we would like to note that the constraint (4) will not be binding in the equilibrium of our quantitative specification. The reason for that is given the parameterized model, entrepreneurs will select into becoming either borrowers (for whom (5) might bind depending on the productivity draw) or savers (for whom (5) does not bind), where no entrepreneur would borrow trade credit and at the same time save fractions of her beginning-of-the-period endowment for the *Night* sub-period consumption.

Fiat Money and M-Pesa. Consumption goods can be transferred from entrepreneurs to input sup-

[21] In our quantitative analysis we utilize T to match the aggregate trade credit to output ratio observed in the data. In the current set-up, we implicitly assume that non-compliance with penalizing a defaulter leads to a strong enough punishment of the supplier within the supplier network, such that suppliers do not deviate from executing the T-period exclusion penalty. While we assume competitive supplier markets, there are two arguments underpinning the assumption of exclusion after default. First, a large part of trade credit is given within ethnic networks (Fisman 2003), where information about defaulters is easily shared and defaulters have a hard time regaining trust of the community. In addition, there is a well-functioning credit bureau industry in Kenya that collects data not only from banks but also other sources. This will certainly increase the cost of defaulting including for trade credit borrowers.

pliers in two ways: fiat money (hereafter cash) transfer or mobile money (hereafter M-Pesa) transfer. The key distinctions between cash and M-Pesa are related to the transaction frictions that each payment instrument is capable of avoiding. Specifically, cash transfers between an entrepreneur and a supplier, whether it is the *Day* sub-period upfront input purchase payment or the *Night* sub-period trade credit repayment, is subject to *theft*. As delineated in the timing of events in Figure 3, before entering (*Day* and *Night*) markets to contact suppliers, with probability $1-\theta$ an entrepreneur loses the entire cash holdings that she carried to the market. The quantity of cash that gets stolen cannot be spent to make input purchases and leaves the economy; therefore, theft is a source of inefficiency. Theft shocks are *iid* among entrepreneurs and across time and are private information.

Theft constrains the ability to make a payment to the supplier and as a result of a *Day*-time theft the entrepreneur cannot operate her production technology in that particular period. To the end of a *Night*-time theft, the asymmetric information concerning the incidence of theft implies that in an environment with the option to default strategically, faking a theft shock can be prevented only if non-repayment due to theft is followed by the exclusion of a defaulter from accessing trade credit in the future.[22]

M-Pesa users are not subject to the risk of theft, but the use of M-Pesa comes with electronic transaction costs. We assume that M-Pesa is a hack-proof technology.[23] However, adopting the M-Pesa technology requires a fixed periodic cost of f_e for the entrepreneur, motivated with M-Pesa-to-cash exchange fees charged by the operator, effort costs to visit an M-Pesa kiosk when converting M-Pesa into cash and technology adoption efforts. As observed in practice, there are also variable costs of M-Pesa transfer: the transfer of consumption goods from an entrepreneur to a supplier using the M-Pesa technology requires the compensation of the technology provider with λ units of consumption good for each unit transferred. M-Pesa fees are paid ex-post, specifically after the realization of the *Night* sub-period cash-flow of the entrepreneur - as illustrated in the timing of events (Figure 3).

We provide entrepreneurs with a discrete choice of utilizing cash or M-Pesa when transacting vis-a-vis suppliers. Although payment method decision by assumption is a discrete choice, we do allow - for borrowers - to switch from one payment method to another between *Day* and *Night* transactions. Throughout the paper we will also assume the following in order to generate room for M-Pesa technology to enter the market.

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[22]In section 7, we provide robustness checks for our qualitative as well as quantitative findings by relaxing the key assumptions concerning the nature of theft.

[23]Theft of money deposited in M-Pesa is much more difficult than cash theft as the M-Pesa account and all transfers through M-Pesa are protected with user specific pins and the customers can easily reset their pins if phones are stolen. Also fraud incidences concerning M-Pesa are very limited, too. In a speech on 17 August 2013 the CEO of Safaricom announced that fraud occurrence for customers is only 0.002% of the total money in circulation through M-Pesa, where the average credit-card fraud rate in Kenya is about 0.05%.

Assumption 1. $1 - \theta > \lambda$.

Assumption 1 will be guaranteed by the real world counterparts of θ and λ that we will match in our benchmark model calibration.[24]

3.3 Contracts and Equilibrium

Contracts. Since theft before the *Day*-subperiod transactions reduces an entrepreneur's money balance in the market to zero, a victim of theft in the *Day* sub-period is forced to leave the market before making any contact with suppliers. The cost of a *Day*-time theft is thus a discontinuation of production for that particular period - for both borrowers and non-borrowers.

If the entrepreneur does not experience a theft shock before entering the *Day* market and if she does not have access to trade credit, she covers the total cost of all inputs purchased upfront without any delayed payment. In other words, $b_{i,t} = 0$ for the creditless spot-trader. The relationship of this type of an entrepreneur with a supplier specifies only the amount of inputs to be provided, $h_{i,t}$, and the upfront consumption good transfer to the supplier, $x_{i,t}$, where

$$e \geq x_{i,t} \geq h_{i,t}. \tag{6}$$

The first inequality on the right hand side of (6) guarantees that the quantity of cash carried over to make purchases in the *Day* market cannot be greater than the beginning of the period endowment of an entrepreneur, which specifies the *Day* sub-period budget constraint. The second inequality at (6) needs to hold such that the input supplier would provide the entrepreneur with $h_{i,t}$ units of production inputs. The *Night* sub-period budget constraint for a creditless entrepreneur is then expressed as

$$c_{i,t} + x_{i,t} - e \leq f(h_{i,t}). \tag{7}$$

If the entrepreneur has access to trade credit finance, the contract entails a trade credit clause, interest payment on credit as well as the payment method of the credit: in return for $h_{i,t}$ units of input, the payment to the supplier equals $x_{i,t}$ (paid in the *Day*) plus the trade credit repayment, $b_{i,t}$, to be made in the *Night* sub-period. Formally, if $x_{i,t} \geq \omega$ and the entrepreneur belongs to the trade credit network,

$$x_{i,t} + b_{i,t} g_{i,t}(\theta) \geq h_{i,t}, \tag{8}$$

where $g_{i,t}(\theta)$ is the inverse of a risk premium (interest payment) that is associated with the entrepreneur's exposure to the risk of theft. For an M-Pesa user, $g_{i,t}(\theta) = 1$ and for a cash user

[24] Safaricom charges a $\lambda = 0.0172$ on average per-unit M-Pesa transferred, whereas the incidence of theft $(1 - \theta)$ in Nairobi is at least 2% of the periodic transaction values as we will discuss in Section 5.

$g_{i,t}(\theta) = \theta$. Correction for perceived theft probability is needed in order to induce the supplier to extend credit, since cash users have a relatively lower likelihood of credit repayment. As we delineated before, deviations from terms of a trade credit contract (non-repayment as well as deviating from the method of payment that parties agreed upon) result in the trade-credit exclusion of the entrepreneur for T periods. The entrepreneur's *Day* and *Night* sub-period budget constraint are formulated as

$$x_{i,t} \leq e, \tag{9}$$

$$c_{i,t} + x_{i,t} - e + b_{i,t} + \chi^D_{i,t}\lambda x_{i,t} + \chi^N_{i,t}\lambda b_{i,t} + \chi_{i,t} f_e \leq f(h_{i,t}), \tag{10}$$

where $\chi^D_{i,t}$ ($\chi^N_{i,t}$) is an indicator function which takes the value 1 if and only if the entrepreneur utilizes M-Pesa at *Day* (*Night*) market transactions and $\chi_{i,t} \equiv \max\{\chi^D_{i,t}, \chi^N_{i,t}\}$.

Based on this contracting environment, we define the dynamic general equilibrium as follows.

Definition The dynamic competitive equilibrium is characterized by an infinite stream of inputs provided to each entrepreneur i, $\{h_{i,t}\}^{\infty}_{t=0}$, transfers made to suppliers by every entrepreneur i to a particular supplier, that are upfront $\{x_{i,t}\}^{\infty}_{t=0}$ and on credit $\{b_{i,t}\}^{\infty}_{t=0}$, and payment instrument choices that satisfy the following three conditions:

i. At each entrepreneur-supplier relationship, indexed by the entrepreneur's identity i and the time-period t, a zero-profit condition holds for the supplier that clears the market at the entrepreneur level

$$x_{i,t} + b_{i,t} g(\theta) = h_{i,t}, \tag{11}$$

where $b_{i,t} > 0$ if and only if the entrepreneur is part of the trade credit network, did not default on her trade credit repayment within the last T periods, and $x_{i,t} \geq \omega$.

ii. Deviators of trade credit repayment terms are excluded from accessing trade credit for T periods.

iii. Entrepreneurs choose profit maximizing input quantities, transfers to suppliers and choice of payment methods that are subject to (3), (4), (5), (6), (7), (9), (10) and (11) in order to maximize (2).

4 Analytical Solution

We assume the following general functional-form for the entrepreneurial production technology and provide a set of theoretical results that help us to evaluate the key qualitative properties of the model.

Assumption 2. $y_{i,t}(h_{i,t}) = A_{i,t}h_{i,t}^{\alpha}$, with $0 < \alpha \leq 1$.

Assumption 2 is equivalent to stating that $f'(.) > 0$ and $f''(.) \leq 0$. Denoting $\underline{A}$ as the lowest possible productivity draw, let us also assume $\underline{A} > \frac{1}{\theta}$, such that for all entrepreneurs it is worthwhile to bring cash to the *Day* market in order to purchase inputs in the *Day* market and undertake entrepreneurial production - even if the M-Pesa technology is not available. We make this assumption on the distribution of productivity draws only for analytical purposes (without loss of generality), which we relax when calibrating the model.

4.1 Equilibrium M-Pesa Use, Productivity and Access to Trade Credit

For a creditless entrepreneur there are two possible discrete payment choices: paying for *Day* transactions with M-Pesa or with cash. Our first result establishes a key property of the model that equilibrium M-Pesa use in the *Day* and productivity are positively correlated for a creditless entrepreneur.

Proposition 4.1 *For all* $\alpha \in (0,1]$, *the higher an entrepreneur's productivity the higher is the likelihood of her using M-Pesa when purchasing inputs from a supplier.*

Proof See the Appendix.

This result confirms the empirical regularity that we established in Section 2 regarding the positive association between the likelihood of M-Pesa usage and business productivity. It also shows that even entrepreneurs without access to credit could find M-Pesa use optimal depending on the level of investment productivity. The intuition for this key result follows from the fact that productivity and the "desire to avoid theft" are complementary to each other, because the opportunity cost of endowment is larger for high-productivity entrepreneurs. In the remainder of our analysis we will refer to this "productivity-channel" to demand M-Pesa also as the "primary impact channel" of M-Pesa.

We turn next to evaluating the relationship between access to trade credit and the likelihood of utilizing the M-Pesa technology when settling payments with suppliers and state the following important result.

Proposition 4.2 *Ceteris paribus, entrepreneurs who purchase goods on trade credit are more likely to use M-Pesa to settle payments at both Day and Night transactions compared to the entrepreneurs without access to trade credit. This qualitative property holds for all* $\alpha \in (0,1]$ *and it emerges due to*

(i) the role of M-Pesa in preventing a collateral-loss at the up-front input purchase stage, and

(ii) by the positive impact of M-Pesa on future trade credit valuations and alleviating repayment burden.

The presence of fixed M-Pesa cost (f_e) does not affect the qualitative properties (i) and (ii), while a larger f_e induces a trade credit borrower to use M-Pesa relatively more compared to a creditless entrepreneur.

Proof See the Appendix.

The result at Proposition 4.2 reveals that access to credit works as a financial amplifier to stimulate the demand for M-Pesa, and in turn M-Pesa use alleviates entrepreneur's financing constraints when settling transactions vis-a-vis suppliers. For the rest of the analysis we will refer to the "financial amplifier effect" that works through the complementarity between trade-credit and M-Pesa also as the "complementary- (or "secondary") impact channel" of M-Pesa.

In the Appendix we provide a detailed derivation of Proposition 4.2. Here we sketch the intuition for each equilibrium mechanism which gives rise to this important result. Consider a creditless entrepreneur with productivity-draw A^*, who is indifferent between using cash and M-Pesa.[25] If granted with access to trade credit, the entrepreneur-A^* will have the opportunity to utilize M-Pesa at the input purchase stage (in the *Day*-subperiod) and also at the credit repayment stage (in the *Night*-subperiod) - at periodic (f_e) and variable (λ) costs. We prove the results presented at Proposition 4.2 by showing that the A^*-entrepreneur would develop a preference to use M-Pesa in both *Day* and *Night* transactions once granted with access to trade credit.

The preference of A^* for M-Pesa in the *Day* is first related to the accessibility of trade credit being conditional on an **upfront collateral payment** (down-payment) to be provided to the supplier. This sub-channel is also linked to the primary "productivity" channel of M-Pesa demand. Hence, the A^*-entrepreneur demands M-Pesa in the *Day* transaction because doing so generates a net benefit for her through accessing trade credit in that same period.

Furthermore, in a credit-based relationship, when subject to monetary theft in the *Night* the entrepreneur suffers not only the foregone opportunity to produce, but also loses due to the inability to borrow in the future. The amount that the entrepreneur can borrow in equilibrium in turn is a function of the M-Pesa use, because at the trade credit repayment stage theft is not only associated with the loss of current value of cash but also with the highly important loss of future credit market access. The lack of M-Pesa therefore contracts the **future credit market valuation** for an entrepreneur, which in turn reduces the quantity of inputs that the entrepreneur can borrow in the current period given the expectations of input suppliers. This dynamic complementarity also raises the value of M-Pesa for entrepreneurs who have access to trade credit.

[25] While proving Proposition 4.1, we also prove the existence and the uniqueness of such a cut-off productivity level.

The **repayment burden** channel also raises the demand for M-Pesa. First of all we would like to emphasize that $x_{i,t} + b_{i,t} > h_{i,t}$ is a possible equilibrium feature, such that suppliers could charge interest rates on trade credit.[26] To this end, the contracted payment to the input supplier with fiat money is higher because of the likelihood of theft, i.e. for a cash-user in general equilibrium $g(\theta) = \theta$ instead of $g(\theta) = 1$. For the cash-user this second channel constrains the quantity of inputs that she can borrow in the *Day* market (as long as the enforcement constraint is binding) and raises the relative valuation of M-Pesa.

Finally, the intuition for fixed M-Pesa cost f_e raising the demand of a trade-credit borrower to use M-Pesa (relative to a non-borrower) is related to the local increasing returns to scale feature that fixed costs generate: with fixed costs, the creditless entrepreneurs are less likely to engage in M-Pesa transfers when making purchases from input suppliers because their transaction volumes are smaller than the entrepreneurs who can borrow. Hence, fixed technology costs, such as cash withdrawal fees (and non-pecuniary efforts associated with such M-Pesa-to-cash exchange) amplify the complementarity that we identified between access to trade credit and the use of M-Pesa as a payment instrument.

One important point to emphasize is that the key qualitative property of the model described in proposition 4.2 holds as long as the entrepreneur who promises to make the credit repayment with M-Pesa does in fact have the incentives to pay with M-Pesa and not with cash when the credit repayment time comes. Such contractual deviations from terms of payment instruments can be ruled out in equilibria by imposing the exclusion of borrowers from accessing the credit market if repayments are made with cash instead of M-Pesa - although the contractual repayment promise was based on an M-Pesa transfer.[27]

As a final remark, we would like to mention that in the benchmark theoretical analysis we did not allow for an additional - formal - source of finance for entrepreneurial firms. In the Appendix of the paper we relax this assumption and show that the presence of a formal financing network that could channel funds from unproductive firms to productive ones will not alter our qualitative findings.

[26] Klapper, Laeven and Rajan (2012) use a unique international supplier dataset, which provides detailed information on trade credit contract terms across the globe, and show that trade credit is an expensive method of input financing: Based on the authors' analysis, the average effective interest rate charged on trade credit is high at 54% - across the globe. This means that - throughout the world - businesses pay on average more than 50% interest rate for repaying the cost of items at a future due-date. The authors document that interest expenses on trade credit do not apply only if businesses repay trade credit before the due date (which is called credit repayment on discount and which are only offered by trade credit suppliers as a possibility at 13% of the contracts in the dataset analyzed by Klapper et al. (2012). But, the data shows that as long as the repayment is made on a due-date, a non-negligible interest rate is charged on the business for having purchased on trade credit. Given that these statistics of Klapper et al. (2012) come from a cross-country database (including both advanced and developing economies), cost of trade credit is expected to be even higher in the context of a developing country, such as Kenya. Having said this in our quantitative framework we will not capture the high interest rates documented by Klapper et al. (2012), because the only risk factor that the suppliers need to take into account in our model is the risk of theft.

[27] We note that the creditor will have the incentives to impose this punishment because default following a payment deviation increases the cost of extending trade credit for a supplier.

4.2 Stationary Equilibrium

The only aggregate variable of the model that can exhibit time-variation is the population fraction of trade credit borrowers. It is easy to note that if the total number of default-penalty periods (T) is infinitely large, there is no stationary equilibrium, where positive measures of the population are actively borrowing trade credit. For quantitative purposes - in order to match the properties of the Kenyan business survey data - the analysis requires the existence of a stationary equilibrium with active trade credit borrowers. Therefore, before we turn to investigating the quantitative properties of the model, we assume that T is finite, and establish the following result concerning the existence of a stationary equilibrium with a constant fraction of trade credit borrowers over-time.

Proposition 4.3 *For T finite, the economy exhibits a unique stationary equilibrium characterized by an invariant distribution of trade credit borrowers.*

Proof See the Appendix.

5 Benchmark Calibration

Having derived the analytical properties of our model and proved the stationarity of the equilibrium, we now return to the Kenyan firm-level survey to calibrate the model and to test the quantitative validity of the theoretical mechanisms that we presented in Section 4. In this section we parameterize the model in order to calibrate the stationary equilibrium to match the key firm-level moments observed in the 2014 FinAccess Business Survey data. In section 6 we will use this quantitative framework to gauge the implications of the M-Pesa technology on trade credit allocations, entrepreneurial performance and macroeconomic development.

We first specify the concavity parameter of the production function, α, and assign the commonly applied value of 0.33 to this parameter - as also utilized in other quantitative finance-development frameworks, such as Antunes et al. (2008). The decreasing returns to scale property generates occasionally binding enforcement constraints in equilibrium. Specifically, given the productivity distribution and the beginning-of-the-period endowment, entrepreneurs of low productivity will choose not to exhaust their borrowing limits (dictated by (5)) in equilibrium, while high-productivity types would do.[28] This allows us to match the entrepreneurial-productivity draws of the model with the data so that we can analyze the impact of the M-Pesa technology on the efficiency of allocations.

[28]Since the decreasing returns to scale production technology specification produces a non-degenerate equilibrium distribution of production inputs across entrepreneurs, we no longer need to assume an input-provider capacity constraint ($\bar{h}$) - an assumption we needed when proving the qualitative properties of the model under the constant returns to scale production technology ($\alpha = 1$).

We assume that the idiosyncratic productivity shocks, $A_{i,t}$, are drawn from a log-normal distribution and we choose the density function's descriptive statistics in such a way to match the cross-sectional entrepreneurial productivity dispersion observed in the FinAccess Business survey data. Figure 4 depicts the distribution of the productivity levels that we observe in our survey data as well as the productivity draws of the calibrated model.

- Figure 4 about here -

Additional target moments that we set using the 2014 FinAccess-Business Survey are presented in Table 2.[29] As calibration *targets*, we choose sample moments (means) that are important for assessing the overall adoption of M-Pesa (exploiting the productivity-channel of the model) and trade credit-M-Pesa complementarity (exploiting the amplifier channel) in the economy. Namely, in the stationary equilibrium, using four of our model parameters we aim to match the following four variables observed in FinAccess Business data: average entrepreneurial input-output ratio, average trade credit-output ratio for those entrepreneurs who utilize trade credit in their transactions, fraction of entrepreneurs in the economy who have a trade credit relationship with their suppliers, and finally the fraction of entrepreneurs in the economy who utilize the M-Pesa technology when purchasing inputs from suppliers.

There are two additional sample moments that we are interested in our analysis, which we do *not target* in order to test the quantitative relevance of our qualitative channels: The first one is the fraction of M-Pesa users among those entrepreneurs who borrow trade credit (or alternatively the complementary group of those who do not borrow). The financial-amplifier channel of the model suggests that M-Pesa should be more intensely used among trade credit borrowers (and less intensely among non-borrowers). By not directly targeting this variable with one of our parameters, we test the quantitative relevance of this key qualitative mechanism.

Furthermore, as a second test-moment we investigate the ratio between the the average scale of inputs employed by M-Pesa users and that of by non-users. Based on our theoretical foundation, M-Pesa user entrepreneurs are expected to be on average larger in their input scale compared to non-users for the following reasons: M-Pesa users on average (i) are more productive and are more

[29]The detailed calculation of each target variable is done as follows. The input-output ratio is the share of a firm's monthly expenses on material inputs/supplies (raw material, restocking, etc) in monthly sales, averaged over the last 12 months and across the firms in the sample. Inputs purchased through trade credit is the monthly supplies provided on credit (for raw material, restocking, etc.). The trade credit-output ratio target is the share of inputs purchased on trade credit in monthly sales - averaged across firms. The fraction of entrepreneurs with a trade credit relationship is the share of businesses that received goods or services from suppliers on trade credit. The fraction of businesses in the economy which utilize the M-Pesa technology is the share of businesses which declare that mobile money had been a common method of payment vis-a-vis suppliers over the last 12 months. The fraction of M-Pesa users among those entrepreneurs who borrow trade credit is the fraction of trade credit borrowers who state that mobile money was a common method to pay suppliers over the last 12 months.

likely to access trade credit, (ii) are not exposed to theft in the *Day* market, and (iii) have trade credit constraints, which are relatively more relaxed compared to non-users.

- Table 2 about here -

When matching the demand to use M-Pesa observed in the FinAccess survey using our model's stationary equilibrium, we apply the following definition in order to be able to have a valid comparison between borrower and non-borrower type entrepreneurs: since by construction a trade credit borrower has the chance to interact with a supplier twice (in *Day* and *Night* markets) and a non-borrower only once, we define an entrepreneur with access to trade credit as an "M-Pesa user" only if she utilizes M-Pesa in both *Day* and *Night* transactions. A non-borrower is called an "M-Pesa user" if she utilizes M-Pesa when transacting in the *Day*.

In addition to the M-Pesa user costs (λ and f_e), the remainder of the parameter space of the model also includes local monopoly rents of the entrepreneur which we already set at $\alpha = 0.33$, the probability of being subject to theft ($1-\theta$), the down-payment requirement (ω), the total number of penalty periods following a default (T) and the discount factor (β). Finally, we also have the parameter that determines the fraction of entrepreneurs who can utilize trade credit in their transactions vis-a-vis suppliers, namely π. The model parametrization is presented in Table 3. When parametrizing the stationary equilibrium of the model, some parameters are calibrated to match the moments observed in the survey data, whereas others are assigned with values based on the existing empirical evidence.

- Table 3 about here -

The details of the model parameters, for which we assign values using existing evidence - and common practices in the literature - are as follows. We set β as 0.90 - a standard value utilized in the growth literature. We use a value of 0.98 for θ, which implies that the likelihood of theft is 2%. The value of "theft probability" is chosen somewhat conservatively, because the World Bank's 2013 Kenya Enterprise Survey data documents that every year Kenyan manufacturing firms lose about 5 percent of product value due to theft. Moreover, alternative data sources point out theft being a larger issue for the Kenyan economy. For instance, according to 2011-2013 round of Afrobarometer survey about 16% of Kenyan respondents (and 37% of households in Nairobi) report that at least once something has been stolen from their house over the past 12 months and about 47% of Kenyan respondents state that they feel unsafe when walking in their neighborhood.

The key policy parameters of our model are the M-Pesa user fees. The variable transaction cost associated with M-Pesa use, λ, is set as 1.72% for each unit transferred to the supplier. By assigning this value to λ we match the average unit transfer prices charged by Safaricom in 2014 (the year our survey data was collected).[30]

We do not specify an explicit value for ω in the calibration - except for assuming that any entrepreneur who does not have the capacity to make any down-payment, does not get to borrow.

Next we assign values for f_e, e, T and π to match the 4 calibration targets that we list in Table 2. Given the distribution of idiosyncratic productivity shocks and history of defaults, we set π as 0.31 to match the 24% of the entrepreneurs in the FinAccess Business sample who use trade credit in their operations. We discipline the choice of f_e in order to match the aggregate M-Pesa user percentage of the sample. The aggregate M-pesa use likelihood (the fraction of M-Pesa users in the sample) is 32% for the entire business sample of the FinAccess Survey. To this end, we would like to note that we do not have much flexibility in choosing f_e, because f_e is a periodic transaction cost figure and it should be somewhat comparable to the M-Pesa-to-cash conversion fees charged by Safaricom and effort costs to convert M-Pesa into cash: in this respect, the calibrated value of f_e turns out to be 0.034, which equals about 2.2% of the average expected output in the parameterized economy. The calibrated figure closely resembles the cash-withdrawal fees by Safaricom, which roughly equals 2.9% of the average transaction volume in the economy. This external validity further ensures the soundness of our quantitative structure.

The value of entrepreneurial endowment is set as $e = 0.258$ and the total number of default-penalty periods is chosen as $T = 2$ in order to match the average input-output ratio in the economy (0.30) and the average trade credit-output ratio among trade credit users (0.10).

- Table 4 about here -

As presented in Table 4, by exploiting the parameter π we match the fraction of trade credit users (24%) in the economy perfectly. We deviate slightly from the targeted fraction of M-Pesa users in the sample (the average M-Pesa use likelihood): 32% of all entrepreneurs in the FinAccess Business sample utilize M-Pesa when making input purchases from their suppliers. Our calibration exercise, where we parameterize f_e (the fixed cost of M-Pesa usage) in a realistic fashion to match this moment of interest, generates an aggregate fraction of M-Pesa user firms (the M-Pesa use likelihood of an "average" firm) equaling to 27%. This close match is sustained through the primary impact channel.

By exploiting the remaining two parameters e and T jointly, we do a reasonably good job in matching the trade-credit to output ratio among trade-credit borrowers of 0.10 observed in FinAccess Data, where the calibrated model produces a credit-output ratio of 0.08 among trade-credit

[30]The costs for using M-Pesa is a step function that increases by transaction amount. On average, sending money to another M-Pesa user costs 1% to 3% of the transaction (this amount is higher for non-registered users) and users may pay between 1.8% and 10% of the amount withdrawn from M-Pesa agents. These costs are calculated by using M-Pesa transaction fees retrieved from http://www.safaricom.co.ke/personal/m-pesa/tariffs for August 2014. Please see Online Appendix Table OA4 for the full list of M-Pesa transaction fees.

producers. The calibrated values of the same two parameters (e and T) generate an average input-output ratio of 0.22, where the same ratio in FinAccess Data equals 0.30. The reason why we are somewhat deviating from matching the input-output ratio more closely is related to the parameter T, which is the default-penalty periods, being able to take only discrete values.

One of the key theoretical results from the model indicates that access to trade credit raises the demand to use M-Pesa when making purchases from suppliers. To test the quantitative relevance of our model the fraction of M-Pesa users among trade credit borrowers was left as one of the free (non-targeted) variables of the quantitative framework so that we can understand the quantitative discipline in matching it. The fraction of M-Pesa users among trade credit borrowers in FinAccess Business sample is about 41%. As we report in Table 4, the parameterized model generates a fraction of M-Pesa users among trade credit borrowers that equals 45%. We would like to note that the good fit of our model to data to this end also implies that we could have utilized "the fraction of M-Pesa users with trade credit access" as a target variable and left "the fraction of overall M-Pesa users" as a free variable, in which case we would have still obtained the well-disciplined "aggregate M-Pesa use likelihood" that we are matching within the current framework.

The above good match implies that we match the aggregate M-Pesa use among non-borrowers reasonably well, too: as we present in Table 4, in our calibrated model 22% of all non-borrowers (from the productive end of the distribution) use M-Pesa when purchasing inputs from suppliers. The share of M-Pesa user non-borrowers in FinAccess Business sample is 30%.

Finally, in Table 4 we also present the capacity of our model to match the ratio between the average input-use of M-Pesa users and that of non-users, which based on our theoretical foundation should be greater than 1. In Kenya's FinAccess survey this ratio equals to 1.27.[31] The corresponding ratio in our quantitative framework is 1.24. Hence, we almost perfectly match this key non-targeted moment.

The close match between the model and the data to the end of the two free (non-targeted) moments supports the quantitative validity of our qualitative mechanisms and also indicates that the parameterized model can be utilized to conduct counterfactual policy exercises to understand the interactions between M-Pesa, entrepreneurial performance, trade credit and economic development, which we shall turn next.

6 Counterfactual Analysis

In order to understand the role of M-Pesa for entrepreneurial performance and economic development in Kenya next we turn to running a series of counterfactual policy experiments. In the first

[31] The average input use among M-Pesa user SMEs in the FinAccess sample is 44,532 Kenyan Shillings, whereas the average input use among non-users is 35,044.

counterfactual, we utilize the calibrated benchmark model to gauge how the economic performance of the Kenyan economy would look like if entrepreneurs did not have access to the M-Pesa technology when making purchases from their input suppliers. In order to answer this question, we evaluate the parameterized model's stationary equilibrium with no access to M-Pesa as a payment instrument for the entrepreneurs.[32] The quantitative results from this hypothetical exercise are presented in Table 5.

- Table 5 about here -

Eliminating the use of M-Pesa from business-supplier relationships causes a contraction in the fraction of entrepreneurs who utilize trade credit in their operations: the population ratio of trade credit borrowers goes down from 24% to 23%. As we delineated in our theoretical analysis, the reason for this contraction is that the cost of borrowing rises for the marginal borrower of trade credit when the M-Pesa technology is eliminated. Most importantly, as a result of the equilibrium adjustments caused by the elimination of the M-Pesa technology, the macroeconomic output of the economy (the aggregate output generated by firms' production) contracts by 1.2%. Since in our model there is no population growth, this figure also corresponds to a 1.2% contraction in per-capita (average) income. Similarly, the counterfactual policy experiment also reveals that the aggregate profits generated by the entrepreneurs go down by 0.5%. The relative large reduction in output compared to the share of firms with trade credit is explained by the complementarity between firm productivity and M-Pesa use. The most productive firms are affected the most from shutting-down the M-Pesa technology and even if such firms do not have access to trade credit, they potentially lose the opportunity to interact with suppliers in the absence of M-Pesa and miss out the chance to produce using a highly efficient production technology.

In order to further delineate on the economic significance of the quantitative channel we have uncovered, we calculate its contribution to macroeconomic development of Kenya since the introduction of M-Pesa in 2007. The existence of mobile money shops (M-Pesa Kiosks) is crucial for allowing smooth transactions between users of mobile money. The nationwide statistics from Safaricom shows that the total quantity of M-Pesa Kiosks in the country which convert M-Pesa units into cash and vice versa levelled off as of the end of 2013. According to World Bank data Kenyan per-capita income grew by 12% between 2007 and 2013.[33] This means that the mechanism of our

[32] In other words we raise the periodic cost of M-Pesa technology so high that entrepreneurs do not end up utilizing it when making purchases from their suppliers.

[33] The macroeconomic output in our quantitative analysis is the output aggregation over construction, whole-sale, retail trade, hotels, restaurants, manufacturing, real estate, education, transport, communication, and other service sectors which produced 54% of Kenyan economic output between 2007-2013 according to UNSTAT(2014). In our analysis we assume that our sample is representative for the Kenyan economy. Data for income per capita is from World Bank database. The database shows that Kenya GDP per capita (constant 2010 US$) is about 956 US$ in 2007 and 1073 US$ in 2013.

model can explain 10% of the realized per-capita real income growth over 2007-2013, suggesting quite a significant macro-development impact of the M-Pesa technology through its interactions with entrepreneurial performance and trade credit relations.

Finance and M-Pesa. Next we concentrate on the contribution of the finance-payment nexus in explaining the macroeconomic effects of the M-Pesa technology. Our theoretical analysis had illustrated that in financially developed societies - with easy access to trade credit - the contribution of mobile money on economic outcomes would be larger. In order to evaluate the quantitative relevance of this theoretical result, we conduct two sets of counterfactual policy experiments and report aggregate effects of M-Pesa in alternative economic environments with varying degrees of financial development. Specifically, in counterfactual experiments that are presented in Table 6, we vary the two parameters that determine the financial development level of the economy (π as an extensive margin measure of financial development and T as an intensive margin measure), keep the remaining parameter values at their benchmark calibration levels and report the aggregate outcome effects of the M-Pesa technology.

- Table 6 about here -

Table 6 reveals a strong quantitative complementarity between access to M-Pesa and financial development. Specifically, closing down access to trade credit completely (by setting either $\pi = 0$ or $T = 0$), lowers M-Pesa's contribution to the macroeconomic output from 1.2% of the respective-benchmark aggregate output to 0.9%.

If the level of Kenya's financial development were to increase by about three-fold, through either increasing the number of default penalty periods from $T = 2$ to $T = 6$ and thus relaxing enforcement constraints at the intensive margin or by raising the accessibility to trade credit from $\pi = 31\%$ to $\pi = 100\%$ at the extensive margin, the macroeconomic consequences of M-Pesa would expand by quantitatively important proportions: raising the number of default penalty periods to $T = 6$ (or the coverage of trade credit to $\pi = 100\%$) increases the macroeconomic value of M-Pesa to 2.1% of the benchmark macroeconomic output, which is 233% of the primary (productivity) impact channel (or to 1.7% for the case of $\pi = 100\%$). This result indicates the potential of the financial-amplifier channel of M-Pesa to substantially impact macro-outcomes. Finally, in Table 6 we also show that a financial development experience, through which both π and T rise three-fold, stimulates the effects of the M-Pesa technology on macroeconomic output to 4.3% of the aggregate output while the aggregate entrepreneurial profits go up by 2.0% compared to its initial aggregate level.

These counterfactual financial development exercises uncover that the expansion of trade credit opportunities would increase the demand for M-Pesa, which in turn would substantially increase the realized gains from M-Pesa through finance-payment nexus complementarity. We see this finding in addition to our other theoretical and quantitative contributions - also as an important contribution to the large macro literature on financial amplifier mechanisms, such as Kiyotaki and Moore (1997) and more recently Guerrieri and Lorenzoni (2017) and Guerrieri and Iacoviello (2017).

The role of other structural parameters. We would like to note that non-financial structural parameters of the model influence the aggregate consequences of M-Pesa as well. One such important structural parameter is the discount factor β. As we present in Table 7A decreasing the discount factor from its benchmark value to 0.80 only slightly lowers the aggregate output contribution of M-Pesa to 1.1%. This reduction in the effects of M-Pesa results from the contraction in the credit market valuation captured by the rise in discounting future. Lowering β further down to 0.64 as proposed by Mbiti and Weil (2013) lowers the aggregate output effect of M-Pesa to 0.9%. We would like to note that this last output effect is a conservative lower bound, because the discount rate proposed by Mbiti and Weil (0.64) is the rate at which a household is indifferent between keeping the cash in M-Pesa for one more year or withdrawing it immediately given the M-Pesa withdrawal fees. As the authors also point out, the high discount rate that they propose may not capture a high discounting of the future utility, but it may rather suggest that holding cash in M-Pesa over a long time-period is costly for households.

Most importantly, the higher the probability of theft (low θ), the larger would be the quantitative impact of M-Pesa on economic development. Our choice of $1-\theta = 0.02$ can be considered a quite conservative benchmark for the context of Nairobi. In Table 7B, we conduct another set of counterfactual experiments, in which we eliminate access to the M-Pesa technology in an economy, where all the parameters are fixed at the level of Benchmark-Kenya - except for θ. The counterfactual analysis of Table 7B shows that increasing the probability of theft from its benchmark value of 2% to 3.5% raises the effect of the M-Pesa technology on aggregate output from 1.2% of the benchmark output to 3.6% and the M-Pesa's contribution for entrepreneurial profits from 0.5% to 2.0%. Raising the probability of theft further to 5% would increase M-Pesa's aggregate output and entrepreneurial profit contributions to 5.7% and 3.7% respectively.

Finally, in our theoretical as well as quantitative analyses we allow for fixed costs associated with M-Pesa use (rationalized by cash-withdrawal fees and effort cost of visiting M-Pesa Kiosks). However, in reality using cash comes with fixed costs as well, such as the time and the effort it takes to deliver a cash-payment. Incorporating such cash-use fixed costs would also increase the value added of the M-Pesa technology for the aggregate well-being of the society.

We would like to note that in some of the counterfactual case-studies discussed in this section the aggregate output effects of M-Pesa exceed that of the aggregate expected loss due theft. The intuition for such large quantitative results is related to the amplification of aggregate costs generated by theft through financial linkages - especially the future credit market valuation expansion caused by access to M-Pesa, which prove the quantitative importance of the financial-amplifier impact of M-Pesa use on aggregate outcomes.

- Tables 7A and 7B about here -

Heterogeneity. Table 8A depicts the behavior of model variables across entrepreneur-classifications: the top panel compares "borrowers" against "non-borrowers" and the bottom panel compares "high-productivity entrepreneurs" against "low-productivity entrepreneurs", where the productivity levels are classified relative to the entrepreneur with median-productivity - as below median-A and above median-A. The calibrated model replicates the behavior of borrowers and non-borrowers observed in the data reasonably well - to the extent of capturing the rising input-output ratio (although not attaining the significant quantitative input-output ratio difference between the two groups) and the rising M-Pesa usage with access to borrowing. As highlighted in the benchmark model calibration, we match the average credit-output ratio among borrowers quite well. An important remark we would like to emphasize is that we match the M-Pesa adoption behavior of non-borrowers - as a group - quite well: for these type of entrepreneurs credit access is not available. Therefore, the key theoretical channel that derives the behavior of non-borrowers is the "productivity and M-Pesa" interaction (the primary impact channel), which allows us to sustain this close match between the data and the model in terms of capturing the demand for M-Pesa among non-borrowers.

The calibrated model does also a good job in matching the intensive margin targets (input-output ratio and credit-output ratio) across the two productivity groups. In our survey data, the input-output ratio declines with the level of entrepreneurial productivity, and the model captures this empirical regularity quite well and very closely matches the input-output ratio for both low-productivity and high-productivity entrepreneurs. The model is also capable of matching the negative association between productivity and credit-output ratio by replicating the quantitative credit-output ratio differences across two productivity groups. In terms of the fraction of M-Pesa users, we are not matching the low-productivity group's M-Pesa user percentage because of the discrete payment choice and also the absence of additional features in the model that would generate a demand to use M-Pesa among entrepreneurs of low productivity.

The capacity of our framework to match the moments stemming from these sub-sample (heterogenous) groups of entrepreneurs is an indication for the empirical relevance of the quantitative structure.

- Table 8 about here -

We also investigate the real outcome effects of the M-Pesa technology for both classifications of entrepreneurs. Table 8B's top panel reports the heterogenous effects of M-Pesa on real economic performance for borrowers and non-borrowers. In the calibrated model, the fraction of M-Pesa users among borrowers is about two times of the fraction of M-Pesa users among non-borrowers. A borrower suffers larger output and profit losses when M-Pesa is eliminated from the set of feasible payment instruments. Therefore, the outcome effects of M-Pesa are significantly different across the two groups. Specifically, for borrowers the output effect of the M-Pesa technology is 1.1 percentage points higher than the output effects of M-Pesa for non-borrowers. The output effects of M-Pesa for borrowers is about 1.6 times of the average output-effect of the M-Pesa technology. The same counterfactual exercise also shows that profits contract by about 0.7% for borrowers when M-Pesa is shut down, while profits contract by 0.4% for non-borrowers.

Table 8B's bottom panel reports the heterogenous effects of M-Pesa on real economic performance across productivity-groups. In the calibrated model, more than half of the entrepreneurs do not utilize M-Pesa as a payment method. Therefore, when M-Pesa is eliminated from an entrepreneur's set of feasible payment instruments, entrepreneurs in the bottom half of the productivity distribution do not suffer output or profit losses. There are significant outcome effects for entrepreneurs with high-productivity: the heterogeneity analysis reveals that firms in the top half of the productivity distribution suffer output losses as high as 1.7% of their benchmark output, if M-Pesa becomes inaccessible as a payment instrument. The same counterfactual exercise also reveals that profits contract by about 0.7% for this group. These results illustrate that the quantitative effects of M-Pesa on economic outcomes for high-productivity entrepreneurs is about 1.4-times of the average development-effects of the M-Pesa technology.

Decomposition of M-Pesa Impact Channels. In order to decompose the effects of primary and secondary impact channels of M-Pesa on macroeconomic outcomes, we utilize the benchmark calibration parameters (of Table 3) and assume within this parameterized framework that M-Pesa is available for only *Day*-market input purchase transactions and not for $Night$-market credit repayment transactions. This means that in the economy trade credit is available but M-Pesa cannot be utilized to relax the repayment burden and the limited commitment constraint associated with trade credit.

In this alternative framework when we shut down the availability of M-Pesa (to pay for *Day*-market transactions) the macroeconomic output contracts by 0.92%. Since the macroeconomic output loss from shutting down M-Pesa in the benchmark - with M-Pesa availability in both *Day* and $Night$ - was equivalent of 1.2% of the aggregate output and the macroeconomic output loss from shutting down M-Pesa in the absence of trade credit contracts was 0.9%, we can reach the following conclusions. (i) The collateral sub-channel of the (secondary) financial amplifier mechanism is relatively negligible: in a model with trade credit but no use of M-Pesa in the *Night* M-Pesa's effect on macroeconomic output is 0.92%, while the macro-output effect of M-Pesa is 0.9% if there is no trade credit availability for entrepreneurs at all. Since switching from the former counterfactual to the latter counterfactual also the trade credit market access is shut-down for all entrepreneurs (and as a result benchmark specification alters), which lowers the benchmark output, the aggregate impact of M-Pesa through collateral (down-payment) sub-channel is strictly less than 0.02% of the aggregate output. (ii) Therefore, the primary productivity channel explains about 75% of the

M-Pesa's effect on aggregate outcomes, by reducing the exposure of entrepreneurs to theft before meeting with suppliers for input purchases in the *Day* market. The remaining 25% of the effect is the secondary financial amplifier channel, within which pre-dominantly the repayment burden and future credit market valuations determine the cumulative quantitative effect. In light of the finance & development counterfactuals that we explored before, we emphasize that the contribution of the financial amplifier channel would enlarge (and even substantially exceed the effects of primary impact channel) if the availability of trade credit would increase at extensive and intensive margins.

In order to decompose the sub-channels of financial amplifier effect, we suppose that credit repayment can be made via M-Pesa in the *Night*, but limited commitment constraint does not get relaxed through the expansion in future trade credit valuation. In this alternative framework the aggregate output loss of M-Pesa turns out to be 1.1% of the benchmark macroeconomic output. The implication of this is that the full financial amplifier effect can be decomposed as follows: 33% of the financial amplifier effect is due to future credit market valuation, whereas 66% of it is due to lowering the repayment burden impact, both of which jointly determine the effect of M-Pesa on the trade credit borrowing constraint of the entrepreneur.

7 Sensitivity Analysis and Extensions

In this section, we provide sensitivity analysis for our quantitative findings with respect to the key model assumptions that we have made in the benchmark model.

7.1 Endogenous Access to Trade Credit

So far we have treated access to trade credit as exogenous. The implicit assumption was that this type of an idiosyncratic cost of credit equals zero for a π-fraction of the entrepreneurs, whereas it is prohibitively high for the remaining $1-\pi$ fraction. In this section, we relax this assumption and assume a well-behaved distribution of (idiosyncratic) trade-credit costs among entrepreneurs.

We extend our model by incorporating an additional layer of entrepreneurial discrete choice. In this modified version, by taking a periodic cost of accessing trade credit as given, entrepreneurs decide on whether to utilize trade credit upon realization of productivity draws. Specifically, in each period an entrepreneur needs to incur a capital loss worth κ_i units of consumption in order to access the trade credit network. The periodic-κ costs are deducted from an entrepreneur's net-worth at the end of each period during which she utilized trade credit in her transactions. If the entrepreneur does not commit to incurring this periodic cost she does not get to borrow trade credit when purchasing inputs from suppliers. The credit-access costs can be associated with spending time to build up social capital and credibility vis-a-vis suppliers as well as market-search for suitable suppliers, whose further microfoundations are investigated in the literature on credit-search, such as Barlevy (2003), Somers and Weil (2004), and Petrosky-Nadeau (2015).[34] We assume that the distribution of κ across entrepreneurs is uniform - with a support of $[0, \bar{\kappa}]$ - and fixed over-time.

In Tables 9 and 10, we re-parameterize this alternative model and present the fit with the data, where we calibrate $\bar{\kappa}$ (instead of π) to match the fraction of trade credit borrowers (24%) in the sample while we utilize the remaining parameters to match the moments as in the benchmark calibration.

- Tables 9 and 10 about here -

Utilizing the re-parameterized model with endogenous trade credit access, we conduct the counterfactual of eliminating the M-Pesa technology from entrepreneurs' set of feasible payment instruments and present the economic outcomes of this hypothetical exercise in Table 11. The quantitative results show that allowing for a well-behaved heterogeneity of trade-credit costs (instead of a two-point distribution as in the benchmark) lowers the economic impact of M-Pesa only slightly, contracting the aggregate output effects of M-Pesa from 1.2% of the benchmark output to 1.1% and entrepreneurial profit effects of M-Pesa from 0.5% of the aggregate entrepreneurial profits to 0.4%.

- Table 11 about here -

These quantitative results reveal that incorporating an additional dimension of entrepreneurial heterogeneity that raises credit-costs idiosyncratically across entrepreneurs would not alter the quantitative power of the theoretical channels that we analyzed.[35]

7.2 Aggregate Costs of Theft

In reality the cash that gets stolen from entrepreneurs might still be utilized to undertake some transactions in the economy. In order to analyze the effects of "redistributive theft", let us suppose that the stolen consumption good (in the form of cash) does not leave the economy but it can still be utilized for consumption purposes, by *thieves* themselves. We continue to assume that entrepreneurs

[34] The credit network access cost κ also helps us to provide an alternative motivation for sanctioning the T-period trade credit exclusion penalty. In this alternative formulation, we are basically assuming that it takes time and effort to build a credit relationship. For a defaulter the assumption becomes then such time and effort (κ) to be spent is prohibitively so high (for T periods) so that she would not choose to borrow trade credit for T periods following the incidence of default. We note that this feature makes T-period exclusion penalty implementable also with a perfectly competitive supplier sector, because the penalty in this case can be interpreted as losing an existing quality of a credit relationship for an entrepreneur, to regain which she herself needs to spend resources.

[35] We would like to highlight that in both calibrated models, we assumed that the distribution of access to trade credit (with π or with κ heterogeneity) is orthogonal to the distribution of idiosyncratic productivity draws. This is a conservative parametrization choice: since M-Pesa has a strong quantitative kick through credit transactions, allowing for a correlation between access to credit and productivity would only increase the measured economic effects of the M-Pesa technology further.

face an exogenously given likelihood of being hit by theft. Once cash is stolen, the opportunity to consume that consumption good gets allocated to a thief. The life-time utility derived from consuming stolen cash is given by

$$E_0 \sum_{t=0}^{\infty} \beta^t (\delta c_{\tau,t}), \tag{12}$$

where $0 \leq 1-\delta \leq 1$ is the cost of consuming stolen items (e.g. due to social and legal sanctions). Since δ is less than or equal to 1, a planner would not distribute any funds to thieves at a socially efficient allocation. Under this alternative specification the consumption of stolen items will enter the macroeconomic welfare though, which the individual entrepreneurs won't take into account when choosing payment methods. Therefore, the calibration of the model parameters under this alternative framework - naturally - remains identical to what we have obtained in section 5, because the welfare generated through the consumption of stolen cash does not alter the firm-level decisions and the aggregate statistics that we match using the firm-level data. In order to investigate counterfactuals we need to parameterize only δ: to this end, in our quantitative experiments we gradually raise the level of δ from its benchmark value (*zero*) to study the macroeconomic welfare loss generated from shutting down access to the M-Pesa technology at entrepreneur-supplier transactions.

In Table OA5 of Online Appendix we show that gradual increases in the level of δ reduce the aggregate welfare loss that is generated from a counterfactual, which shuts down M-Pesa as a payment method. However, increasing the marginal utility from the consumption of stolen items to the level of regular consumption (i.e., raising δ to 1) only lowers the aggregate output effect of the M-Pesa technology from 1.2% of the benchmark macro-output to 1.0%. The intuition for the quantitative results from the model being robust to this extension is that the M-Pesa technology is more widely applied by high-productivity entrepreneurs. This productivity-payment technology complementarity is one of the underlying mechanisms in our set-up that generates the quantitative impact of M-Pesa. Therefore, M-Pesa's real economic effects turn out to remain high even when stolen cash can be fully utilized for consumption purposes.

7.3 Publicly Verifiable Theft

In this section we relax the assumption that theft is private information and assume that the incidence of theft can be declared through public institutions - for free. When theft becomes public information, trade credit contracts can be conditioned on the incidence of theft. In this case, the perfectly competitive input supplier sector would imply that theft no longer leads to the exclusion of a defaulter from accessing the credit market. Cash use is still associated with a higher repayment burden though due to the likelihood of the non-repayment state caused by theft. Publicly verifiable theft would lower the aggregate implications of M-Pesa - without altering the qualitative result that access to trade credit raises the likelihood of M-Pesa use vis-a-vis suppliers and the use of M-Pesa stimulates the demand for trade credit. In Tables OA6 and OA7 of Online Appendix we re-parameterize the model with publicly verifiable theft and compare the moments of this alternative model against data.

In Table OA8 we present the counterfactual implications of M-Pesa in this alternative environment. The counterfactual of shutting down M-Pesa deteriorates entrepreneurial performance and causes a macroeconomic output loss of 1.0% as opposed to the 1.2% macro-output effects we have uncovered in section 6. This means that the private nature of theft and its implications for limited commitment increases the overall gains from M-Pesa by 20%.

7.4 Firm Capital Accumulation

The dynamic general equilibrium model that we calibrated using Kenyan FinAccess Business data did not incorporate firm-level capital accumulation dynamics. There is an empirically valid argument for excluding firms' capital accumulation from the analysis, that is related to the low (and almost insignificant) correlations that we observe in our survey-data between capital and trade credit use and between capital and M-Pesa use. Specifically, for the sample of firms that we have in our data-set, we document that the correlation coefficient estimate between inputs purchased on credit per employee and capital stock per employee is 0.07, implying that input purchases on credit explains only 0.5% of the total variation in capital stock. This estimate is statistically insignificant after controlling for business characteristics that we discussed in Table 1. The findings are similar for the relationship between capital stock per employee and the use of M-Pesa at input supplier transactions. The correlation estimate between these two variables is 0.02, which is statistically significant only at 10 percent level. As these numbers indicate the co-movements between capital and trade credit and between capital and M-Pesa use are empirically negligible, we chose not to incorporate capital stock heterogeneity and capital-investment dynamics in our calibrated framework.

Nevertheless we are still interested to theoretically understand if business capital accumulation is allowed, how would this interact with our qualitative mechanism that generates the complementarity between the demand for trade credit and the use of M-Pesa. For this purpose, we assume a constant returns to scale production technology ($\alpha = 1$) and incorporate a basic capital-dynamics structure into our model. Specifically, let us suppose that the production technology of the entrepreneur takes the following form

$$y_{i,t}(h_{i,t}) = \begin{cases} A_{i,t}(1+k)h_{i,t} + \psi & \text{if } i_{i,t-1} \geq \zeta, \\ A_{i,t}h_{i,t} + \psi & \text{if } i_{i,t-1} < \zeta, \end{cases}$$

with $\psi > \zeta$. In this formulation $i_{i,t-1}$ is entrepreneur i's investment in business capital and ψ is a flat return from production which ensures that as long as the entrepreneur produces in the current period, she can invest in business capital for the next period. Business capital invested in $t-1$ becomes operational in period t. Capital investment is financed from the proceedings of the entrepreneurial output in period $t-1$. We consider a stylized capital accumulation procedure: as long as $i_{i,t}$ is greater or equal to ζ, the business will have access to a stock of physical capital in period t worth of k. For any level of investment that is less than ζ, the firm does not get to accumulate any capital stock. Business capital is complementary to supplier provided inputs. We assume that capital investment is irreversible and capital utilized in production depreciates completely. Given this structure, we can derive the following result.

Proposition 7.1 *Allowing for firm-level business capital accumulation raises the overall demand for M-Pesa and reinforces the positive interaction between M-Pesa use and demand for trade credit.*

Proof See the Appendix.

The intuition for this result is related to the inter-temporal dynamics that M-Pesa strengthens. In the absence of M-Pesa, it might not be possible to invest and carry capital to the next period, if the entrepreneur gets hit by a theft shock. M-Pesa increases the chances of investment, raises the future value of credit market participation, and in turn reinforces the interaction between M-Pesa use and demand for trade credit when business capital formation dynamics are allowed.

7.5 Competition

In our benchmark framework enterprises are local monopolies which buy inputs from a perfectly competitive supplier sector and make profits out of these transactions - without an explicitly modelled demand structure for the entrepreneurial output. In a model with a deeper competitive structure, entrepreneurial profits arising from a more efficient payment technology would get redistributed to the consumers as consumer surplus - without necessarily altering the economic contribution of M-Pesa in the aggregate.[36]

Since in this paper analyzing redistributive consequences of M-Pesa (between entrepreneurs and consumers) was not our focus, we tuned down the competitive pressure effects in the benchmark

[36]The quantitative implications of introducing competitive forces into our framework could be analyzed utilizing data on sale prices - as long as such data were available in detail in the firm-level survey. Furthermore, if instead of a cross-sectional survey one could access to a panel data of businesses with records on firm entry and exit, extending the model and the quantitative framework to incorporate a dynamic competitive structure - with entry and exit dynamics of entrepreneurs - will be useful to assess the aggregate development effects of M-Pesa. In such a model there would be additional M-Pesa-driven efficiency gains from correcting misallocation of resources at the extensive margin, which we do not capture in our current framework. This implies that the aggregate outcome effects that we measure in the current framework constitute a lower (conservative) benchmark.

framework. Furthermore, in FinAccess survey the average unit product prices are asked only for the primary products sold by the SMEs in the sample and moreover this question is answered by only 472 out of 1047 businesses. Therefore, the data limitation does not allow to quantify the theoretical consequences of our framework for the redistribution of the gains from M-Pesa between entrepreneurs and consumers. Having said this in Table OA9 of Online Appendix we document that - highly consistent with the theoretical implications of our model - M-Pesa user firms charge “on average” lower prices and this negative effect of M-Pesa use (vis-a-vis suppliers) on sale prices is significant for micro and small enterprises, which are likely to be under substantial competitive pressure. Specifically, in Table OA9 we test whether (given a particular product type as captured by product fixed effects) users of M-Pesa (vis-a-vis suppliers) charge on average lower prices when transacting with customers. We regress (the logarithm of) prices on whether business pays suppliers via M-Pesa and additional firm-level control variables. We find that paying to suppliers via M-pesa is negatively associated with sale prices and this negative relationship is significant when we concentrate on businesses which have less than 10 employees. These results indicate the qualitative (as well as a potential quantitative) relevance of M-Pesa use also on consumer welfare.

8 Conclusion

Building a dynamic general equilibrium model, with key market frictions found in many developing countries - notably enforcement constraints, information asymmetries and theft - and calibrating it to a recent firm-level survey data from Kenya, we show that higher productivity and access to trade credit generates demand to use mobile money as a payment method with suppliers and the use of mobile money in turn raises the value of a credit relationship and hence the willingness to repay. Our model shows significant quantitative effects of these theoretical channels for both firm- and aggregate outcome variables that are robust to a variety of quantitative and theoretical extensions. While our analysis has focused on output effects, our findings have also implications for formal sector employment. There has been an expanding literature documenting that financial development not only affects output but also employment, especially in developing countries (e.g., Pagano and Pica (2011)). In addition, dynamic effects towards more productive and competitive enterprises and towards formal sector production can also result in higher employment effects.

The complementarity between a more efficient payment technology and access to external finance for small businesses that we uncover both theoretically and quantitatively appears to be quite unique in the literature and has important policy implications. Our theoretical channel argues that looking beyond directly improving access to credit by small businesses, broader approaches to improving access to financial services, including payment services, are necessary and can be substantially important for alleviating financial constraints and stimulating business performance.

Our model can be extended in a number of dimensions to include additional benefits of M-Pesa, which can interact with the key mechanisms that we highlighted in this paper. One such important extension would be the storability of inputs that are not utilized in the production in a particular period of time - due to some ex-post shocks to productivity. In such ex-ante unforeseeable times of low productivity, entrepreneurs might find it optimal to extend repayment of credit to consecutive periods while also storing inputs to be utilized in later periods.[37] If such inter-period trade credit contracts can be made available, the benefits of M-Pesa that we capture in our analysis as well as the demand for M-Pesa use when transacting on a credit-based relationship would expand, by alleviating inter-temporal contract frictions. In our current framework we abstract from such inter-temporal trade credit arrangements, which implies that the benefits of M-Pesa that we incorporate in our model could be redefined to include also benefits of having trade credit that is storable over time. There might be also additional gains from a larger share of formal rather than informal enterprises, in line with more efficient financial systems fostering formality of firms (Straub (2005); Beck, Lin and Ma (2014)). We leave these and many other policy relevant extensions to future research.

[37]In Table OA10 of Online Appendix we illustrate that the ratio between stocks of inputs and the expenditures on inputs purchased is higher for users of M-Pesa - a regularity which holds for both borrowers and non-borrowers of trade credit. This implies that inventory management is more efficient for M-Pesa users.

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Table 1: Probit estimates for paying to suppliers via mobile money

	(1) marg. eff.	(2) s. e.
Productivity	0.02**	(0.01)
Purchasing supplies on credit	0.17***	(0.04)
Personal bank account	0.13	(0.08)
Business bank account	0.08	(0.06)
Registered	-0.14***	(0.04)
Accountant	0.10***	(0.04)
Secondary education	-0.15	(0.13)
College education	0.07	(0.17)
University education	0.09	(0.17)
Graduate education	0.13	(0.18)
Male	0.07*	(0.04)
Age	-0.02*	(0.01)
Age^2	0.00	(0.00)
Observations	1,044	

Notes: This table shows the estimation results for the correlation between mobile money use to pay to suppliers and business characteristics. We estimate $Y_i = \beta_0 + X_i^{'}\beta_1 + \varepsilon_i$ for all specifications where i denotes the firm and X_i is the business characteristics, and Y_i equals 1 if the respondent uses mobile money to pay for supplies (0 otherwise). We estimate the model by using Probit regression and report marginal effects at mean levels and robust standard errors in parentheses. To control for sector level fixed effects, we add sector dummies to the estimations. * p<0.1. ** p<0.05. *** p<0.01

Table 2: Calibration Targets

Variable	Kenyan Economy (Mean Values)
Input-Output ratio	0.30
Supplier Trade Credit-Output Ratio for Trade Credit Users	0.10
Fraction of Trade Credit Relation with Suppliers	0.24
Fraction of M-Pesa Users	0.32

Notes: Input-output ratio target is the share of monthly expenses on material inputs/supplies (raw material, restocking, etc.) (B.6b in Appendix OA3) in monthly sales (averaged) over the last 12 months (B.1 in Appendix OA3) - averaged across firms. Inputs purchased through trade credit is the multiplication of the percentage of monthly supplies provided on credit (C.95 in Appendix OA3) with the monthly expenses on material inputs/supplies (raw material, restocking, etc.) (B.6b in Appendix OA3). The trade credit-output ratio target is the average share of inputs purchased through trade credit in monthly sales over the last 12 months (B.1 in Appendix OA3) - averaged across firms that use trade credit to purchase inputs. Fraction of entrepreneurs in the economy who have a trade credit relationship with their suppliers is the fraction of businesses who stated their business receive goods or services from its suppliers on credit (C.94 in Appendix OA3). The fraction of businesses in the economy who utilize the M-Pesa technology when purchasing inputs from suppliers is the average share of businesses that stated that mobile money was a common methods of their payment to suppliers over the last 12 months (answered C.86 as mobile money in Appendix OA3).

Table 3: Model Parameterization for the Kenyan Economy

Parameter	Value	Motivation
α	0.33	Standard capital share value in the Literature
β	0.90	The standard value used in the Growth literature
θ	0.98	As evidenced by World Bank Kenya Enterprise Survey (2014)
λ	0.0172	M-Pesa Transaction Costs retrieved from Safaricom on Aug. 2014
e	0.258	To match average input-output ratio (in FinAccess)
f_e	0.034	To Match fraction of M-Pesa user SMEs (in FinAccess)
π	0.31	To match the fraction of SMEs in a Trade Credit Relation (in FinAccess)
T	2	To match the average trade credit-output for borrowers (in FinAccess)

Table 4: Benchmark Model vs. Kenyan Economy

	Model (Mean Value)	Kenyan Economy (Mean Value)
Input-output ratio	0.22	0.30
Supplier credit-output ratio	0.08	0.10
Fraction of Trade Credit Users	0.24	0.24
Fraction of M-Pesa Users	0.27	0.32
Fraction of M-Pesa Users with Trade Credit	0.45	0.41
Fraction of M-Pesa Users without Trade Credit	0.22	0.30
Average Input M-Pesa Users/Average Input Non-users	1.24	1.27

Notes: The fraction of M-Pesa users among those entrepreneurs who borrow trade credit is the fraction of businesses that stated mobile money was a common method of their payment to suppliers over the last 12 months (answered C.86 as mobile money in Appendix OA3) among the businesses who stated their business receive goods or services from suppliers on trade credit. The model moments are computed in the stationary equilibrium. The input-output ratio is the average of the supplier-provided input-output ratios across all entrepreneurs. The credit-output ratio is the supplier-provided credit-output ratio averaged across all firms that use trade credit. Fraction of trade credit users is the fraction of all active trade credit users (i.e. those entrepreneurs who could borrow but do not because of a low productivity shock in the stationary equilibrium are not included). The computation of the fraction of M-Pesa users takes into account that mechanically trade credit borrowers get to interact with suppliers twice, and hence defines a trade credit borrower as an "M-Pesa user" only if she uses M-Pesa in both *Day* and *Night* transactions.

Table 5: Counterfactual of Cutting Access to M-Pesa Technology

Macroeconomic Output Loss	1.2%
Aggregate Entrepreneurial Profit Loss	0.5%
Input-output ratio	0.22
Supplier credit-output ratio	0.08
Fraction of Trade Credit Users	0.23
Fraction of M-Pesa Users	0
Fraction of M-Pesa Users with Trade Credit	0

Notes: The counterfactual is conducted by hypothetically raising the periodic M-Pesa fee (f_e) so high that every entrepreneur, who otherwise would have utilized M-Pesa in her transactions, endogenously switches to cash.

Table 6: Macro Effects of M-Pesa and Financial Development

	$\pi = 0$	$\pi = 0.31$ (Benchmark)	$\pi = 1$
Macroeconomic Output Loss	0.9%	1.2%	1.7%
Aggregate Entrepreneurial Profit Loss	0.4%	0.5%	0.7%
	$T = 0$	$T = 2$ (Benchmark)	$T = 6$
Macroeconomic Output Loss	0.9%	1.2%	2.1%
Aggregate Entrepreneurial Profit Loss	0.4%	0.5%	0.9%
			$T = 6$ and $\pi = 1$
Macroeconomic Output Loss			4.3%
Aggregate Entrepreneurial Profit Loss			2.0%

Notes: In each alternative quantitative specification, except for a particular financial development indicator (π and/or T), all parameter values are kept at their benchmark level. Based on this alternative quantitative world, we then conduct the M-Pesa counterfactual of cutting access to M-Pesa as a payment method (by setting f_e high enough) and computing the output and entrepreneurial profit losses in the aggregate.

Table 7A: Macro Effects of M-Pesa and Discount Factor

	$\beta = 0.90$ (Benchmark)	$\beta = 0.80$	$\beta = 0.64$
Macroeconomic Output Loss	1.2%	1.1%	0.9%
Aggregate Entrepreneurial Profit Loss	0.5%	0.4%	0.3%

Notes: In each alternative quantitative specification, except for β, all parameter values are kept at their benchmark level. Based on this alternative quantitative world, we then conduct the M-Pesa counterfactual of cutting access to M-Pesa as a payment method (by setting f_e high enough) and computing the output and entrepreneurial profit losses in the aggregate.

Table 7B: Macro Effects of M-Pesa and Theft

	$\theta = 0.98$ (Benchmark)	$\theta = 0.965$	$\theta = 0.95$
Macroeconomic Output Loss	1.2%	3.6%	5.7%
Aggregate Entrepreneurial Profit Loss	0.5%	2.0%	3.7%

Notes: In each alternative quantitative specification, except for θ, all parameter values are kept at their benchmark level. Based on this alternative quantitative world, we then conduct the M-Pesa counterfactual of cutting access to M-Pesa as a payment method (by setting f_e high enough) and computing the output and entrepreneurial profit losses in the aggregate.

Table 8A: Benchmark Model across Entrepreneur Types

	Non-Borrower		Borrower	
	Model	Data	Model	Data
Input-output ratio	0.21	0.26	0.23	0.43
Credit-output ratio	0.0	0.0	0.08	0.10
Fraction of M-Pesa Users	0.22	0.30	0.45	0.41
	Below Median-A		Above Median-A	
	Model	Data	Model	Data
Input-output ratio	0.29	0.31	0.15	0.12
Credit-output ratio	0.09	0.11	0.07	0.06
Fraction of M-Pesa Users	0.0	0.34	0.56	0.42

Notes: Table reports the mean values (from data and from the model), that are computed by averaging out the variables of interest across entrepreneurs in a particular group of entrepreneurs.

Table 8B: M-Pesa Effects across Entrepreneur Types

	Non-Borrower	Borrower
Output Loss	0.8%	1.9%
Entrepreneurial Profit Loss	0.4%	0.7%
	Below Median-A	Above Median-A
Output Loss	0.0%	1.7%
Entrepreneurial Profit Loss	0.0%	0.7%

Notes: Borrowers (non-borrowers) are entrepreneurs who (do not) use trade credit at a period when the M-Pesa technology is available. Above (below) median productivity entrepreneurs are entrepreneurs that have higher (lower) productivity draws than the entrepreneur at the 50th percentile productivity draw in a period. In each alternative quantitative specification all parameter-values are kept at their benchmark level. We conduct the M-Pesa counterfactual of cutting access to M-Pesa as a payment method (by setting f_e high enough) and computing the output and entrepreneurial profit losses in the aggregate. To estimate the output and profit loss per group (borrowers, non-borrowers, above and below productivity group) we aggregate per period output and profits for each group when the M-Pesa technology is available and also when it is not available and compute the difference.

Table 9: Model (Re)-Parameterization - Costly Access To Trade Credit

Parameter	Value	Motivation
α	0.33	Standard capital share value in the Literature
β	0.90	The standard value used in the Growth literature
θ	0.98	As evidenced by World Bank Kenya Enterprise Survey (2013)
λ	0.0172	M-Pesa Transaction Costs retrieved from Safaricom on Aug. 2014
e	0.235	To match average input-output ratio (in FinAccess)
f_e	0.037	To Match fraction of M-Pesa user SMEs (in FinAccess)
$\bar{\kappa}$	0.047	To match the fraction of SMEs in a Trade Credit Relation (in FinAccess)
T	2	To match the average trade credit-output for borrowers (in FinAccess)

Table 10: Costly Credit Model vs. Kenyan Economy

	Model (Mean Value)	Kenyan Economy (Mean Value)
Input-output ratio	0.21	0.30
Supplier credit-output ratio	0.09	0.10
Fraction of Trade Credit Users	0.26	0.24
Fraction of M-Pesa Users	0.25	0.32
Fraction of M-Pesa Users with Trade Credit	0.46	0.41
Fraction of M-Pesa Users without Trade Credit	0.17	0.30
Average Input M-Pesa Users/Average Input Non-users	1.29	1.27

Table 11: Counterfactual of Cutting Access to M-Pesa - Costly Credit

Macroeconomic Output Loss	1.1%
Aggregate Entrepreneurial Profit Loss	0.4%
Input-output ratio	0.21
Supplier credit-output ratio	0.09
Fraction of Trade Credit Users	0.27
Fraction of M-Pesa Users	0
Fraction of M-Pesa Users with Trade Credit	0

Notes: The counterfactual is conducted by hypothetically raising the periodic M-Pesa fee (f_e) so high that every entrepreneur, who otherwise would have utilized M-Pesa in her transactions, endogenously switches to cash.

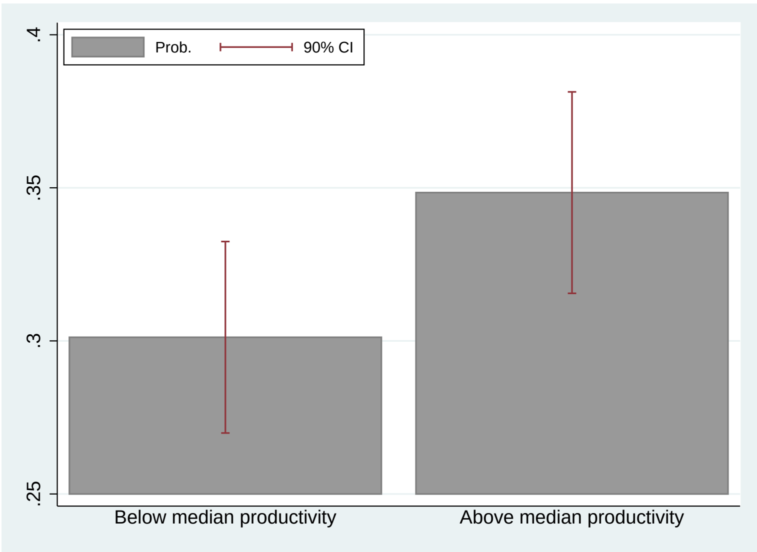

Figure 1: Share of businesses using mobile money to pay to their suppliers by productivity levels
Notes: The Figure shows the predicted share of businesses considering mobile money as a common method of payment to pay to suppliers by productivity level and the 90% statistical confidence levels for those shares after controlling for other business characteristics. Predicted shares are estimated through the model presented in Table 1 after replacing productivity variable in the model with a dummy variable that equals 1 if the profits per employee is above the median level (0 otherwise).

Figure 2: Share of businesses using mobile money to pay to their suppliers by credit relationship with suppliers

Notes: The Figure shows the predicted share of businesses considering mobile money as a common method of payment to pay to suppliers by credit relationship with input suppliers and the 90% statistical confidence levels for those shares after controlling for other business characteristics. Predicted shares are estimated through the model presented in Table 1.

DAY

- Idiosyncratic productivity shocks, $A_{i,t}$, are realized.
- Entrepreneurs receive beginning of the period endowment e.
- Entrepreneurs decide on fractions of e to bring to the *Day* market.
- *Day* market opens.
- Pre-investment theft shocks realized (θ and $1-\theta$): victims cannot purchase inputs.
- Suppliers meet entrepreneurs who did not suffer theft.
- Multiple contacts allowed, but can sign an input contract with only one supplier.
- Input contracts determined: if credit is included, also specifies payment instrument.
- Provision of inputs.
- *Day* market closes.

NIGHT

- Cash-flows from production collected.
- Entrepreneurs decide on the quantity of money to bring to the *Night* market.
- *Night* market opens.
- Post-production theft shocks are realized (θ and $1-\theta$).
- Credit repayment (b) only if not subject to theft in the *Night*.
- *Night* market closes.
- M-Pesa costs are paid (periodic f_e and variable λ).
- Agents consume.

Figure 3: Timing of Events

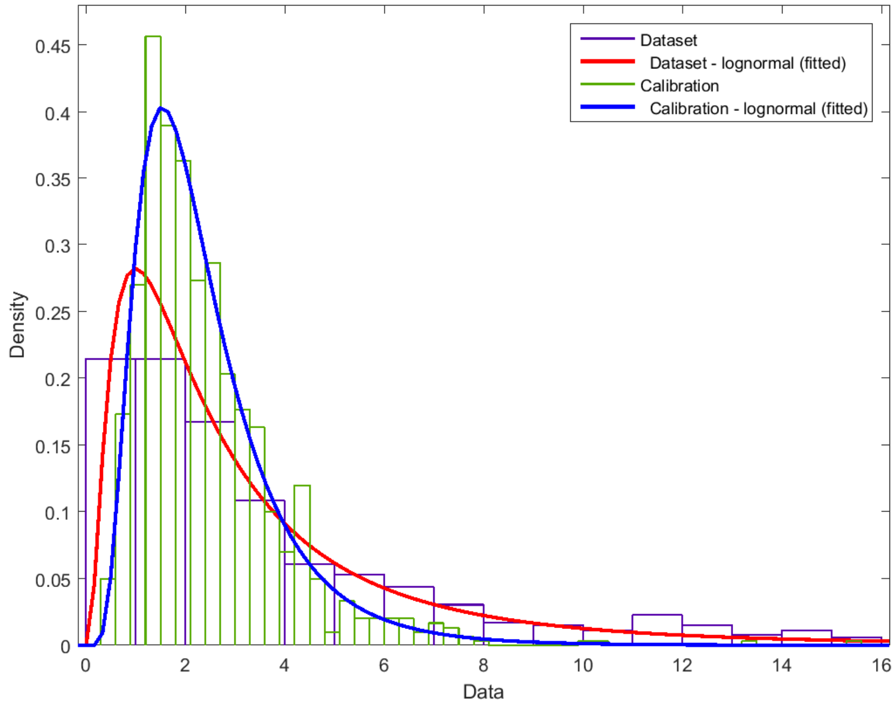

Figure 4: Comparison of productivity distributions - data and the calibrated model

Notes: The Figure compares the productivity distributions from the data against the calibrated model. Productivity distribution from the calibrated model is generated randomly for 1000 entrepreneurs. Y axis shows the density (frequency) and X axis shows the productivity level. Green bars indicate the frequency of corresponding productivity-level in the calibrated model. Purple bars indicate the frequency of corresponding productivity-level in the data. The red line is the fitted values to productivity distribution from the data by using a log-normal distribution. The blue line is the fitted values to productivity distribution from the calibrated model by using log-normal distribution. For the calibrated model the mean of productivity is assumed to be 2.38 and the standard deviation of productivity is assumed to be 1.5. Productivity in the data (A) is calculated by using $A = Salesperemployment/(inputsperemployment)^{\alpha}$, α equals 0.33. We trim extreme values of productivity from data, which are smaller than 7th and bigger than 93th percentiles. For the productivity distribution in the data, the mean productivity is 2.38 and the standard deviation of the productivity is 3.34.

Appendix

Proofs of Propositions 4.1 and 4.2

When proving propositions 4.1 and 4.2, we characterize the solutions for two general class of production function specifications: (a) $\alpha = 1$ (constant returns to scale production) and (b) $0 < \alpha < 1$ (decreasing returns to scale production).

Proof of Proposition 4.1

Case-a ($\alpha = 1$): It is easy to observe that (7) binds in equilibrium. We then note that for an entrepreneur without access to trade credit, the optimum quantity of liquidity brought to the market (in cash) is solved by

$$\max_{x_{i,t}} \; \theta A_{i,t} x_{i,t} + e - x_{i,t}$$

subject to (6) and binding (7). This easily yields $x^*_{i,t} = e$ as the optimum quantity of liquidity brought to the market in cash for all i, since $A_i > \frac{1}{\theta}$ was assumed for every i. Hence both inequalities at (6) hold with equality. If the entrepreneur were to use M-Pesa in her *Day* transaction - instead of cash, the modified optimization problem would also yield $x^*_{i,t} = e$. This is a result guaranteed by Assumption 1. Therefore, entrepreneurs of any productivity level (both trading with cash and M-Pesa) bring the entirety of their beginning of the period endowment e to the market.

For the rest of the proof, for ease of notation, we suppress time-subscripts and express the current value of consumption for a creditless entrepreneur (ℓ) who uses M-Pesa technology (p) as

$$\tilde{U}_p(A_\ell) = A_\ell e - \lambda e - f_e + U, \tag{A1}$$

where U is the (future) continuation value of the creditless entrepreneur. If she used cash to settle transactions, the consumption value of the same entrepreneur would have been

$$\tilde{U}_f(A_\ell) = \theta A_\ell e + U. \tag{A2}$$

Equations (A1) and (A2) imply that a creditless entrepreneur would be indifferent between using M-Pesa and fiat money, i.e. $\tilde{U}_p(A_\ell) = \tilde{U}_f(A_\ell)$, if and only if $A_\ell = A^*$, where the critical productivity level A^* solves

$$(1-\theta)A^* = \frac{f_e}{e} + \lambda. \tag{A3}$$

The left hand-side of (A3) is the unit return to M-Pesa usage, whereas the right hand-side of (A3) is the unit cost of M-Pesa use. Equation (A3) shows that there is a unique creditless A^*-entrepreneur, who is indifferent between using M-Pesa and not using it. For any $A > A^*$, benefits of M-Pesa exceed M-Pesa costs - establishing the result presented in the proposition for $\alpha = 1$.

Case-b ($0 < \alpha < 1$): The result in case-a fully remains with decreasing returns to scale (DRS) production technology. To observe this, with a DRS production we can express the value functions evaluated at the optimal quantity of liquidity brought to the market as:

$$\begin{aligned}\tilde{U}_p(x_p^*;A_\ell) &= A_\ell(x_p^*)^\alpha - \lambda x_p^* - f_e + U,\\ \tilde{U}_f(x_f^*;A_\ell) &= \theta A_\ell(x_f^*)^\alpha + U,\end{aligned}$$

where given the constraint-set x_p^* denotes the optimum liquidity brought for an M-Pesa based exchange and x_f^* denotes the optimum liquidity for a cash-based exchange. Assumption 1 guarantees that $x_p^* \geq x_f^*$. We note that $x_p^* = x_f^*$ if and only if $x_f^* = e$, in which case $x_p^* = x_f^* = e$ constitute the constrained input demand for A^*, which could be relaxed with the provision of trade credit.

Suppose that A^* is constrained, such that $x_p^* = x_f^* = e$. Solving for the critical A^* from

$$\tilde{U}_p(x_p^*;A^*) = \tilde{U}_f(x_f^*;A^*)$$

yields $(1-\theta)A^* = \frac{f_e}{e^\alpha} + \lambda e^{1-\alpha}$ and we again obtain the property that for any $A > A^*$ benefits of M-Pesa exceed M-Pesa costs. If on the other hand A^* is unconstrained, such that $e > x_p^* > x_f^*$, then DRS functional form gives

$$x_p^* = \left(\frac{\alpha A^*}{1+\lambda}\right)^{\frac{1}{1-\alpha}};\ x_f^* = (\alpha\theta A^*)^{\frac{1}{1-\alpha}},$$

and the indifference condition ($\tilde{U}_p(x_p^*;A^*) = \tilde{U}_f(x_f^*;A^*)$) becomes

$$(1-\alpha)(A^*)^{\frac{1}{1-\alpha}}\left(\frac{\alpha}{1+\lambda}\right)^{\frac{\alpha}{1-\alpha}} - f_e = (1-\alpha)(A^*)^{\frac{1}{1-\alpha}}(\alpha\theta)^{\frac{\alpha}{1-\alpha}}. \quad \text{(A4)}$$

We can again note that plugging in any $A > A^*$ on the LHS and the RHS of (A4) causes the LHS to exceed the RHS because of Assumption 1. Therefore, for any $A > A^*$ benefits of M-Pesa exceed M-Pesa costs also if A^* is unconstrained. □

Proof of Proposition 4.2

Case-a ($\alpha = 1$): We can observe that (10) binds in equilibrium. We then note that for an entrepreneur with access to trade credit, who uses cash in both of her *Day* and *Night* transactions, the optimum quantity of liquidity brought to the market (in cash) is solved by

$$\max_{x_{i,t}} \theta[A_{i,t}(x_{i,t} + \theta b_{i,t}) - b_{i,t}] + (e - x_{i,t})$$

subject to (4), (5), (9), (11); and, also binding (10). This optimization program yields $x_{i,t}^* = e$ as the optimum quantity of liquidity brought to the market for all i, since $A_i > \frac{1}{\theta}$ for every i and hence (9) binds as well. If the entrepreneur were to use M-Pesa in her *Day* or *Night* transactions - instead of cash, the modified optimization problem by Assumption 1 would also yield $x^*_{i,t} = e$.

Having determined the optimal liquidity carried to the market, we express the market clearing conditions at the entrepreneur-level as

$$h_{\ell,t} = e, \tag{A5}$$

$$h_{c,t} = e + b_{c,t} g_{c,t}(\theta), \tag{A6}$$

where (A5) is the zero-profit condition at all creditless supplier-entrepreneur spot trades and (A6) is the zero-profit condition at all trade-credit-based supplier-entrepreneur trades.

The linearity of the model implies that there are two types of borrowers: (i) borrowers for whom $b_{i,t} = \bar{h} - e$ with $b_{i,t} < V_{i,t}$ and hence the enforceability constraint does not bind but the input supplier's capacity constraint binds and (ii) financially constrained borrowers with $b_{i,t} = V_{i,t}$ and $b_{i,t} < \bar{h}$. Without loss of generality we concentrate on the case of financial constraints only. Then, since by the time credit relationships are established the future credit market values are the same for all entrepreneurs - who use a particular payment technology - we can denote the credit market valuation for the next T-periods of all M-Pesa using trade credit borrowers with V and index an M-Pesa user borrower with the sub-script p. Let us index a trade credit borrower who carries fiat money to settle transactions with f. Since the entrepreneur-f gets exposed to the risk of theft and gets excluded from future credit participation with probability $1-\theta$, her future credit market valuation for the next T-periods equals θV. Furthermore, the M-Pesa user's credit repayment is $1/\theta$ times lower than that of the cash user, because the likelihood of a no-repayment outcome with fiat money is $g(\theta) = \theta$ whereas $g(\theta) = 1$ for the M-Pesa user. Therefore, given supplier's zero profit condition, we can express the quantity of inputs extended to M-Pesa and fiat money users in the *Day* subperiod as follows

$$h_{p,t} = e + V, \tag{A7}$$

$$h_{f,t} = e + g(\theta)\theta V = e + \theta^2 V, \tag{A8}$$

where (A7) is the input supplied to an M-Pesa user trade credit borrower, whereas (A8) is the input supplied to a fiat money user.

Denoting the consumption value of an entrepreneur in a trade credit relationship with $\tilde{V}$ and reserving the subscript-p for M-Pesa use and the subscript-f for fiat money, there are four different consumption value functions for a trade credit borrower A^*, where A^* is implicitly defined as in (A3). These value functions can be indexed by the payment choices in the *Day* (the 1st sub-script) and in the *Night* (the 2nd sub-script): $\tilde{V}_{pp}(A^*)$, $\tilde{V}_{pf}(A^*)$, $\tilde{V}_{fp}(A^*)$, and $\tilde{V}_{ff}(A^*)$. We want to understand whether the A^*-entrepreneur would pick $\tilde{V}_{pp}(A^*)$ and strictly prefer to utilize M-Pesa in both *Day* and *Night* transactions, although she was indifferent towards using M-Pesa in the absence of a trade credit contract.

We start with the *Day*-subperiod and first show that $\tilde{V}_{pf}(A^*) > \tilde{V}_{ff}(A^*)$. Let us denote the quantity of credit that can be extended to the entrepreneur with θb, where we are not necessarily assuming a binding enforceability constraint. Since in both pf and ff payment regimes the credit repayment is to be made in cash, the interest rate on θb units of credit equals $\frac{1}{\theta}$, because in the *Night* (due to the absence of M-Pesa usage) the likelihood of a non-repayment is $1-\theta$. Hence we can express the value functions as

$$\begin{aligned}\tilde{V}_{pf}(A^*) &= A^*e+(A^*\theta-1)\,b-\lambda e-f_e+V_{pf},\\ \tilde{V}_{ff}(A^*) &= \theta\,[A^*e+(A^*\theta-1)\,b]+V_{ff},\end{aligned}$$

where V_{pf} and V_{ff} denote the continuation values - with V_{pf} and V_{ff} are equalized as $V_{pf}=V_{ff}=U+\theta V$. Then, the entrepreneur with productivity-A^* prefers M-Pesa in her *Day*-subperiod transaction, i.e. $\tilde{V}_{pf}(A^*)>\tilde{V}_{ff}(A^*)$, if

$$A^*e+(A^*\theta-1)\,b-\lambda e-f_e>\theta\,[A^*e+(A^*\theta-1)\,b]\,. \tag{A9}$$

Since $(1-\theta)A^*=\frac{f_e}{e}+\lambda$ from (A3) and that $A^*>\frac{1}{\theta}$, the strict inequality at (A9) holds for all parameter restrictions of the model. The intuition is as follows: the strict preference for M-Pesa in the *Day* is related to the accessibility of trade credit being conditional on an **upfront collateral** (down-payment) to be provided to the supplier. Hence, A^* demands M-Pesa in the *Day*-subperiod transaction because doing so generates a net benefit worth of $(1-\theta)\,(A^*\theta-1)\,b$.

Having established the result on A^*'s preference to use M-Pesa in the *Day* transaction - conditional on expecting to use cash in the *Night*, what we would like to investigate next is whether the entrepreneur-A^* would strictly prefer M-Pesa as a payment instrument when repaying credit in the *Night* as well. Assuming a binding enforcement constraint (5) and using it together with (A7), the current consumption value of A^* with M-Pesa - at both *Day* and *Night* subperiod transactions - can be expressed as follows

$$\tilde{V}_{pp}(A^*)=\{A^*e+(A^*-1)V\}-\{\lambda(e+V)-f_e\}+\underbrace{V+U}_{=V_{pp}}, \tag{A10}$$

where the first component on the right hand side is the return to entrepreneurial production with M-Pesa, the second component is the cost of M-Pesa use, the third component is the value of next T-periods' credit market participation with M-Pesa, and the fourth component is the future value of creditless spot-trades.

Similarly, using (A8), the current value function of an enforcement constrained borrower with cash when settling upfront payment and credit repayment transactions is expressed as

$$\tilde{V}_{ff}(A^*)=\{\theta[A^*e+(A^*-1)\underbrace{g(\theta)}_{=\theta}\theta V]\}+\underbrace{\theta V+U}_{=V_{ff}}, \tag{A11}$$

where the first component on the right hand side of (A11) is the return to entrepreneurial production with fiat money, the second component is the value of next T-periods' credit market participation with fiat money, and the third component is the future value of creditless spot-trading.

Then, for a borrower of trade credit, the difference in current consumption value functions between M-Pesa and fiat money use becomes the following

$$\tilde{V}_{pp}(A^*)-\tilde{V}_{ff}(A^*)=(1-\theta)A^*e+(1-g(\theta)\theta^2)(A^*-1)V-\lambda(e+V)-f_e+(1-\theta)V. \tag{A12}$$

Using (A3) in (A12) yields

$$\tilde{V}_{pp}(A^*) - \tilde{V}_{ff}(A^*) = (1 - g(\theta)\theta^2)(A^* - 1)V - \lambda V + (1-\theta)V. \tag{A13}$$

M-Pesa raises (i) the future trade credit valuation of the entrepreneur and (ii) lowers the likelihood of a non-repayment and as a result the cost of borrowing in expense of electronic transaction costs, since with cash $g(\theta) = \theta < 1$ whereas with M-Pesa $g(\theta) = 1$. Both channels work in the same direction to stimulate the capacity to borrow trade credit and to scale up the entrepreneurial production. In order to isolate the impact of (i) from (ii) on willingness of the A^*-entrepreneur to use M-Pesa at a credit-based relationship, we first shut down the channel (ii). This means we hypothetically assume that $g(\theta) = 1$ as in a partial equilibrium set-up. This clearly lowers the relative valuation of M-Pesa compared to fiat money, because with $g(\theta) = \theta$ we would have had $(1 - g(\theta)\theta^2) = (1-\theta^3)$ on the right hand side of (A13) which is greater than $(1-\theta^2)$. For $g(\theta) = 1$, by re-arranging the right hand side of (A13), the sufficient condition for a trade credit borrower A^* to strictly prefer M-Pesa over fiat money becomes

$$(1-\theta^2)(A^* - 1) + (1-\theta) > \lambda. \tag{A14}$$

From (A3) we know that $\lambda < (1-\theta)A^*$ for $f_e > 0$. For now, let us suppose that $f_e = 0$, and then the condition (A14) can be replaced with

$$(1-\theta^2)(A^* - 1) + (1-\theta) > (1-\theta)A^*.$$

After rearranging terms this inequality reduces to

$$\theta > 0, \tag{A15}$$

implying that $V_{pp}(A^*) > V_{ff}(A^*)$. This qualitative property has the following implication: access to trade credit generates an endogenous preference to use M-Pesa for the entrepreneur indexed with A^* at both *Day* and *Night* transactions instead of using cash at all transactions - noting that the A^*-entrepreneur was indifferent between using M-Pesa and fiat money without access to trade credit. And, this preference emerges for the most general parameter condition of the economy, that is $\theta > 0$. The intuition behind this important result is that the lack of M-Pesa contracts the **future credit market valuation** for a borrower, which in turn reduces the quantity of inputs that the entrepreneur can borrow in the current period given the expectations of input suppliers.

Going back to the **repayment burden** channel, the contracted payment to the input supplier with fiat money is higher because of the likelihood of theft, i.e. for a cash-user in general equilibrium $g(\theta) = \theta$ instead of $g(\theta) = 1$. For the cash-user this second channel constrains the quantity of inputs that she can borrow in the *Day* market and raises the relative valuation of M-Pesa. Formally, the consequence of the repayment burden channel can be observed by replacing the $(1-\theta^2)$ term on the right hand side of the inequality (A13) with $(1-\theta^3)$.

In order to complete the analysis we need to show that (i) the A^*-entrepreneur would have a strict preference to use M-Pesa at both *Day* and *Night* transactions even if her enforceability constraint is not binding, (ii) $\tilde{V}_{pp}(A^*) > \tilde{V}_{pf}(A^*)$, and (iii) $\tilde{V}_{pp}(A^*) > \tilde{V}_{fp}(A^*)$

First, we show that (i) and (ii) hold: the entrepreneur with productivity-A^* strictly prefers M-Pesa over fiat money in *Day* market transactions - for an arbitrary quantity of borrowed funds b - and hence she is willing to pay the fixed-cost f_e. By taking her payment-choice behavior in the *Day* as given, let us now suppose that $b < V$ such that the enforceability constraint is not binding for the entrepreneur with productivity level A^*. In this case, the decision of A^* to pay with M-Pesa in the *Night* market would have no effect on the quantity of inputs she can purchase in the *Day* market - through the effects of a relaxed enforceability constraint, because this constraint is not binding in the first place. Therefore, the entrepreneur A^* would use M-Pesa at a *Night* repayment transaction only if

$$\lambda b < (1-\theta)V + \left(\frac{1}{\theta} - 1\right) b.$$

The left hand side of this inequality is the cost of transacting with M-Pesa. The first term on the right hand side is the benefit of using M-Pesa for future credit market access, while the second term is the interest repayment gain from transacting with M-Pesa. Clearly, the larger V, the higher is the preference to utilize M-Pesa when repaying trade credit. Therefore, a sufficient (but not necessary) condition for A^* to prefer M-Pesa over fiat money is

$$\lambda < (1-\theta)\left(1 + \frac{1}{\theta}\right), \tag{A16}$$

which is guaranteed by Assumption 1. This also implies that $\tilde{V}_{pp}(A^*) > \tilde{V}_{pf}(A^*)$.

Finally, we establish that the condition (iii) is also satisfied: Given the parameter restriction summarized at (A16), one can also observe that $\tilde{V}_{pp}(A^*) > \tilde{V}_{fp}(A^*)$ - confirming that for the case of A^*-entrepreneur the payment choice where she pays with cash in the *Day* and with M-Pesa in the *Night* can be ignored. Thus we establish the results summarized at items (i) and (ii) in the proposition.

Fixed M-Pesa costs. We assumed $f_e = 0$ so far. Letting $f_e > 0$ leads to a contraction in the right hand-side of (A14), since with $f_e > 0$, $\lambda < (1-\theta)A^*$ holds. This means that the M-Pesa usage of a trade credit borrower becomes more likely compared to a creditless-type if f_e rises.

Case-b ($0 < \alpha < 1$): Building upon the result for case-b the next question we would like to address is whether A^* would develop a preference towards using M-Pesa in both *Day* and *Night* transactions if she had access to trade credit with a decreasing returns to scale production technology. There are two sub-cases to consider in the absence of trade credit access: (i) unconstrained A^* (who won't demand trade credit even if it is accessible), and (ii) constrained A^*. For the case-(i), access to credit will trivially have no effect on the indifference between cash and M-Pesa, because that particular A^* will continue to self-finance and not demand trade credit even when granted with access to trade credit. Hence, the rest of the proof concentrates on the case of constrained-A^*. Importantly, we also note that in our calibrated model that we present in Section 5 the creditless entrepreneur who is indifferent between cash and M-Pesa is indeed financially constrained.

Since A^* is financially constrained (in the case of no trade credit access), she would choose to make an up-front payment worth of e units and borrow in order to increase her production opportunities when granted with access to trade credit. Therefore, denoting the optimum quantity of credit repayment to be made to a supplier for cash and for M-Pesa based transactions with b_f^* and b_p^*, respectively; we can express the following value functions for a borrower-entrepreneur - each indexed by specific payment methods:

$$\begin{aligned}
\tilde{V}_{pp}(b_p^*;A^*) &= A^*(e+b_p^*)^\alpha - \lambda e - f_e - b_p^* - \lambda b_p^* + U + V \\
\tilde{V}_{pf}(b_f^*;A^*) &= A^*(e+\theta b_f^*)^\alpha - \lambda e - f_e - b_f^* + U + \theta V \\
\tilde{V}_{fp}(b_p^*;A^*) &= \theta[A^*(e+b_p^*)^\alpha - f_e - b_p^* - \lambda b_p^*] + U + V \\
\tilde{V}_{ff}(b_f^*;A^*) &= \theta[A^*(e+\theta b_f^*)^\alpha - b_f^*] + U + \theta V
\end{aligned}$$

At first in all value functions, replace $(1-\theta)A^*e^\alpha = \lambda e + f_e$ derived at (i). Then comparing $\tilde{V}_{pp}(b_p^*;A^*)$ against $\tilde{V}_{fp}(b_p^*;A^*)$, we can state that $\tilde{V}_{pp}(b_p^*;A^*) > \tilde{V}_{fp}(b_p^*;A^*)$ if and only if

$$(1-\theta)[A^*(e+b_p^*)^\alpha - (1+\lambda)b_p^*] > (1-\theta)A^*e^\alpha - \theta f_e, \tag{A17}$$

which holds for all parameter configurations of the model: set $f_e = 0$ at the RHS of (A17) in order to observe that LHS exceeds RHS, because b_p^* is the optimally chosen quantity of borrowed inputs (constrained or unconstrained) whose marginal cost equals $(1+\lambda)$ - yielding a profit figure on the LHS that is larger than the fully-constrained profit figure on the RHS.

By the same logic, next we show that $\tilde{V}_{pf}(b_p^*;A^*) > \tilde{V}_{ff}(b_p^*;A^*)$, since

$$(1-\theta)[A^*(e+\theta b_f^*)^\alpha - b_f^*] > (1-\theta)A^*e^\alpha, \tag{A18}$$

where θb_f^* is the optimally chosen quantity of borrowed inputs whose marginal cost equals $\frac{1}{\theta}$ - yielding a profit figure on the LHS of (A18) that is larger than the fully-constrained profit figure on the RHS.

The last remaining part to complete the proof is to show that $\tilde{V}_{pp}(b_p^*;A^*) > \tilde{V}_{pf}(b_f^*;A^*)$. The proof for this has to take two cases into consideration: (1) unconstrained borrowing, and (2) constrained borrowing. (1) If the entrepreneur is unconstrained then $\tilde{V}_{pp}(b_p^*;A^*) > \tilde{V}_{pf}(b_f^*;A^*)$ if and only if

$$(1-\alpha)A^*\left(\frac{\alpha A^*}{1+\lambda}\right)^{\frac{\alpha}{1-\alpha}} + (1-\theta)V > (1-\alpha)A^*(\alpha\theta A^*)^{\frac{\alpha}{1-\alpha}}. \tag{A19}$$

The inequality (A19) is satisfied by Assumption 1 and $\theta < 1$. (2i), the entrepreneur can be constrained by $b_p^* = V$ and $b_f^* = \theta V$. In this case, $\tilde{V}_{pp}(b_p^*;A^*) > \tilde{V}_{pf}(b_f^*;A^*)$ if and only if

$$A(e+V)^\alpha - A(e+\theta^2 V)^\alpha > \lambda V.$$

Since the entrepreneur is constrained at $b_p^* = V$ with marginal cost of borrowing $1+\lambda$, we can state that if she had the chance to increase her borrowing from $\hat{b}_p = \theta^2 V$ to $b_p^* = V$ at a total cost of $(1+\lambda)(1-\theta^2)V$, she would do so. This means

$$A(e+V)^{\alpha} - A(e+\theta^2 V)^{\alpha} > (1+\lambda)(1-\theta^2)V > \lambda V, \tag{A21}$$

where the second inequality at (A21) is satisfied by Assumption 1 and $\theta < 1$. (2ii), the entrepreneur can also be constrained in the following way: $b_p^* < V$ and $b_f^* = \theta V$, where the entrepreneur faces a binding enforceability constraint only if she uses cash in her transactions. Also, for this case $\tilde{V}_{pp}(b_p^*;A^*) > \tilde{V}_{pf}(b_f^*;A^*)$, because

$$(1-\alpha)A^*\left(\frac{\alpha A^*}{1+\lambda}\right)^{\frac{\alpha}{1-\alpha}} + (1-\theta)V \underbrace{>}_{\text{by }(A19)} (1-\alpha)A^*(\alpha\theta A^*)^{\frac{\alpha}{1-\alpha}} > A(e+\theta^2 V)^{\alpha} - \theta V, \tag{A22}$$

where the second inequality at (A22) follows from the fact that profits should rise for a cash-user as she moves from constrained profit maximization to the uncostrained profit maximization. Finally, (2iii), the possibility of $b_p^* = V$ and $b_f^* < \theta V$ also yields $\tilde{V}_{pp}(b_p^*;A^*) > \tilde{V}_{pf}(b_f^*;A^*)$, since

$$A^*(e+V)^{\alpha} - V(\lambda+\theta) > A^*(e+\theta b_f^*)^{\alpha} - b_f^* \tag{A23}$$

is guaranteed by the larger marginal cost of production on the RHS compared to the LHS - given by $\lambda + \theta < 1$ (guaranteed by Assumption 1).

Finally, so far we set $f_e = 0$. Since this a fixed cost term that does not interact with the concavity of the production technology, we again note - as in the case of $\alpha = 0$ - that the M-Pesa usage of a trade credit borrower becomes more likely compared to a creditless-type if f_e rises. This completes the proof for the proposition also for the case of $0 < \alpha < 1$ □

Proof of Proposition 4.3

Let $\mathscr{C}_t$ denote the measure of entrepreneurs with a clean credit history at the beginning of period t, who are eligible to borrow. Suppose the unconditional probability of becoming a borrower is q, which is time-invariant given our distributional assumptions. The probability of being subject to theft is $1-\theta$. Then the outflow of entrepreneurs from the credit market who will not be able to borrow in period $t+1$ is $q(1-\theta)\mathscr{C}_t$. The inflow of entrepreneurs into the credit market in period $t+1$, who had defaulted in period $t-T$ is $q(1-\theta)\mathscr{C}_{t-T}$. From here, we can note that as long as

$$\mathscr{C}_t = \mathscr{C}_{t-T}$$

in some t, the economy will be in a stationary equilibrium in all time periods τ with $\tau \geq t$. Next, we need to establish that for t large enough $\mathscr{C}_t = \mathscr{C}_{t-T}$ holds. Starting with period-1, with a T-period default penalty (for $T \geq 2$) we can note that $\mathscr{C}_1 > \mathscr{C}_2 > ... > \mathscr{C}_T > \mathscr{C}_{T+1}$. While the outflow of entrepreneurs from the credit market who will not be eligible to borrow in period $T+2$ equals $q(1-\theta)\mathscr{C}_{T+1}$, the inflow of agents in period

$T+2$ is $q(1-\theta)\mathscr{C}_1$. Since $\mathscr{C}_1 > \mathscr{C}_{T+1}$, we note that $\mathscr{C}_{T+2} > \mathscr{C}_{T+1}$. Formally, defining $z \equiv q(1-\theta)$

$$
\begin{aligned}
\mathscr{C}_2 &= (1-z)\mathscr{C}_1, \\
\mathscr{C}_{T+1} &= (1-z)^T\mathscr{C}_1, \\
\mathscr{C}_{T+2} &= (1-z)^T\mathscr{C}_1 + (1-z)\mathscr{C}_1 - z(1-z)^T\mathscr{C}_1,
\end{aligned}
$$

using which we can also note that $\mathscr{C}_{T+2} > \mathscr{C}_2$; and $\mathscr{C}_{T+2} > \mathscr{C}_{T+3} > \mathscr{C}_{T+4} > \mathscr{C}_{T+1}$. This implies that $|\mathscr{C}_{T+2} - \mathscr{C}_{T+4}| < |\mathscr{C}_1 - \mathscr{C}_T|$. Iterating the process forward yields

$$|\mathscr{C}_t - \mathscr{C}_{t+T}| < |\mathscr{C}_{t-(T+1)} - \mathscr{C}_{t-1}|$$

for all t. Hence, $\lim_{t\to\infty}\mathscr{C}_t = \bar{\mathscr{C}} > 0$. □

Proof of Proposition 7.3

We first establish the part of the proposition on the positive impact of capital accumulation on demand to use M-Pesa. For this, let's first consider the case of a creditless entrepreneur, A_ℓ, who did not accumulate capital from the previous period. If she uses M-Pesa for her input-purchase transaction, the current consumption value can be expressed as

$$\tilde{U}_p(A_\ell) = A_\ell e - \lambda e - f_e + U_h, \tag{A24}$$

while if the entrepreneur were to to use M-Pesa, the consumption valuation would be expressed as

$$\tilde{U}_f(A_\ell) = \theta A_\ell e + \theta U_h + (1-\theta)U_l. \tag{A25}$$

Different from the benchmark theoretical analysis of Section 4, in these expressions there are two different continuation values for spot-trading - U_h and U_l with $U_h > U_l$, because if the entrepreneur cannot accumulate capital in the current period her productivity (and hence consumption) in the next period would be lower. Solving (A24) and (A25) together gives the critical A^* as

$$(1-\theta)A^* = \frac{f_e}{e} + \lambda - (1-\theta)(U_h - U_l). \tag{A26}$$

If the critical A^*-entrepreneur had accumulated capital to utilize in current period's production, it would have solved

$$(1-\theta)A^* = \frac{1}{1+k}\left[\frac{f_e}{e} + \lambda - (1-\theta)(U_h - U_l)\right]. \tag{A27}$$

Comparing (A26) and (A27) against (A3) reveals that A^* contracts, implying that a larger fraction of creditless entrepreneurs utilize M-Pesa in their input purchases, in a model that allows for capital dynamics.

Moving on to the case of a "borrower-type" A^* (with as well as without in-built capital in the current period), we can easily conclude that her demand to use M-Pesa would be strictly larger than the demand to use M-Pesa for a critical-A^* solved in a model absent capital dynamics. Similar to the case of a spot-trader, the result follows from the fact that with capital dynamics there are two different future values of credit market participation - V_h and V_l with $V_h > V_l$, because if the entrepreneur cannot accumulate capital in the current period her productivity (and hence consumption) in the next period would be lower. The presence of this mechanism strengthens the interaction between demand to use M-Pesa and demand for trade credit. □

An Alternative Form of External Finance

In developing countries, trade-credit finance is crucial for SMEs to run their operations, as also observed in our Kenyan survey data. However, other forms of finance can co-exist with trade credit. In this section we permit an alternative form of external finance for entrepreneurs and incorporate this extension to allow for general equilibrium feedbacks and investigate the interactions between trade credit and the alternative form of external finance in response to the mobile money technology development. This extension mimics the availability of a formal banking structure. We will show that the presence of such alternative finance forms could complement the development implications of M-Pesa - through trade credit channel that we studied so far - even if borrowing through the alternative financial instruments is not subject to the theft friction.[38]

In this extended version of the model, there is an inter-entrepreneurial credit market that opens for transactions after entrepreneurs meet suppliers (upon the realization of *Day*-theft shocks) and closes right after the entrepreneurial output gets realized. In the entrepreneurial credit market, by taking competitive prices as given, entrepreneurs can use fractions of their unutilized initial endowment to finance other entrepreneurs' input purchases in return for credit repayment. The following assumptions characterize the entrepreneurial credit market.

1. The entrepreneurial credit market transactions are not subject to theft.
2. Credit repayment takes place in the same period.
3. The lending rate and the borrowing rate, that prevail in the general equilibrium are equal to each other and denoted as r_t.
4. An entrepreneur's borrowing capacity in the entrepreneurial credit market is constrained by

$$m_{i,t} \leq \phi \pi_{i,t}, \tag{A28}$$

   where $m_{i,t}$ is the entrepreneur's borrowing in the inter-entrepreneurial credit market and $\pi_{i,t}$ is her within-period profits. The parameter ϕ measures the degree of borrowing limit.

5. Access to entrepreneurial credit is also subject to a limited participation constraint and only those who are eligible to borrow trade credit can borrow credit from other entrepreneurs. This assumption is supported in our survey data , because the correlation between borrowing trade credit and using other forms of loans is 0.12 (with a p-value of 0.00).

[38]This assumption dampens the quantitative implications of M-Pesa.

We keep the rest of economic environment as in our benchmark model, and allow for a decreasing returns to scale production technology for the entrepreneur so that we can discuss the implications M-Pesa on efficient allocations. Given this extension we are interested in understanding the effects of M-Pesa on economic outcomes and how the presence of the alternative form of finance interacts with our key mechanism. First we observe that in equilibrium $r_t \geq 1$ must hold; otherwise, no entrepreneur would be willing to extend credit to another one. This allows us to obtain the following result.

Lemma A.1. *In the absence of M-Pesa technology:*

1. *If $r_t > \frac{1}{\theta}$, trade credit and entrepreneurial credit co-exist in equilibrium. In this case both financially constrained and unconstrained borrow trade credit; and only financially constrained borrowers demand entrepreneurial credit.*

2. *If $1 < r_t < \frac{1}{\theta}$, trade credit and entrepreneurial credit co-exist in equilibrium. In this case both financially constrained and unconstrained borrow entrepreneurial credit; and only financially constrained borrowers demand trade credit.*

Proof Case i. Following the entry into the input market, the maximization problem of an unconstrained type, who invests larger than her own endowment e, is given by

$$\max_{b,m} \; A_i(e+g(\theta)b+m)^{\alpha} - b - mr,$$

where $g(\theta) = \theta$ for all entrepreneurs since M-Pesa is not available. Since $r > 1/\theta$ and trade credit (b) and entrepreneurial credit (m) are perfect substitutes of each other, the optimal structure of finance satisfies $\{b^* > 0,\ m^* = 0\}$ for an unconstrained entrepreneur. The maximization problem of a constrained type is given by

$$\begin{aligned} \max_{b,m} \quad & A_i(e+g(\theta)b+m)^{\alpha} - b - mr, \\ s.t. \quad & b \leq \theta V, \\ & m \leq \phi \pi_i. \end{aligned}$$

Denoting ζ_b and ζ_m as the Lagrange multipliers associated with trade credit and entrepreneurial credit constraints respectively, $r > 1/\theta$ implies $\{b^* > 0,\ m^* > 0\}$ with $\{\zeta_b > 0,\ \zeta_m = 0\}$ or $\{\zeta_b > 0,\ \zeta_m > 0\}$.

Case ii. For an unconstrained type we have $\{b^* = 0,\ m^* > 0\}$, whereas for a constrained entrepreneur $\{b^* > 0,\ m^* > 0\}$ with $\{\zeta_b = 0,\ \zeta_m > 0\}$ or $\{\zeta_b > 0,\ \zeta_m > 0\}$. □

The intuition for Lemma A.1 is straightforward. When entrepreneurial credit is expensive relative to trade credit, entrepreneurs that are unconstrained (mediocre productivity types who would invest more than e in their production technology) fully substitute away from entrepreneurial credit and solely rely on trade credit provided by suppliers. Constrained entrepreneurs (high-productivity types), who cannot increase their borrowing through trade credit, would receive their marginal unit of credit from the entrepreneurial credit market. When entrepreneurial credit is cheaper than trade credit, unconstrained types' entire borrowing comes through the entrepreneurial credit market. Constrained borrowers are again active in both markets in this alternative case, but this time the marginal unit of credit is demanded from input suppliers. This theoretical result establishes that entrepreneurial credit and trade credit co-exist, because the constrained (high-productivity) types request both sources of finance to run their operations. Building upon this result we also derive the following.

Proposition A.2. *The M-Pesa technology improves the allocation efficiency in the entrepreneurial credit market and thereby stimulates the aggregate economic activity.*

This result follows from the complementarity between M-Pesa and trade credit that we established in previous sections. For the case of $r_t > \frac{1}{\theta}$, M-Pesa relaxes trade-credit constraints among financially constrained entrepreneurs which raises the quantity of trade credit utilized in production for all constrained entrepreneurs and as a result profits go up. Given this expansion of trade credit, as long as entrepreneurial credit constraints (A28) were also binding for some of the high productivity types, entrepreneurial credit gets reallocated - among financially constrained - from relatively low productive entrepreneurs towards entrepreneurs with highest productivity, resulting in aggregate productivity gains. This reallocation occurs because entrepreneurial credit constraints get relaxed relatively more for entrepreneurs with highest productivity, raising the aggregate demand for entrepreneurial credit (and as a result r_t) and causing the reallocation of credit towards highest productivity types. The same mechanism is in action also when $1 < r_t < \frac{1}{\theta}$. But, different from the previous one in this second case entrepreneurial credit gets reallocated towards highest-types also from unconstrained entrepreneurs - resulting in even larger aggregate productivity gains. Therefore, we conclude by stating that the presence of alternative forms of finance do not undermine and - to the contrary - potentially reinforce the macroeconomic effects of the M-Pesa technology through general equilibrium credit-allocation adjustments.

Online Appendix (Not Intended For Publication)

Survey Questions from FinAccess Business 2014 and Additional Tables

Listed according to the section in the FinAccess Business 2014 survey.

B.1 On average, what were the monthly sales of the business over the last 12 months? Interviewer: this question refers to the total sales, not the profits, of the business. The question on profits is asked later on in the questionnaire. Make sure that the question is properly understood by the respondent. (KSh/Don't know/Refuse to answer)

B.3 What is the main product (or service) item you sell in your business? (name of product or service/Not applicable/Don't know/Refuse to answer)

B.4 Can you give us an estimate of the sales price of this product you have charged during the last month. Note: If the survey is conducted, e.g. in September 2013, this question refers to the average price from August 2013. (KSh per unit)

B.6b Can you estimate your average monthly expenses on material inputs/supplies (raw material, restocking, etc.): (do not include investments) (KSh value/ Don't know/ Refuse to answer)

B.7 What was the total monthly income the business earned on average over the last 12 months after paying all expenses including wages of employees, taxes, rents, interest expenditures etc., but not including any income you paid yourself? That is, what were the average monthly profits of your business during last 12 month? (KSh/ Don't know/Refuse to answer)

B.9 Now I am going to ask you questions about the properties currently used in your business. Please tell me the approximate value of your assets in each of the following categories. Think of the value as how much it would cost you to replace the assets with ones in similar condition. 1. Buildings (e.g. business premises, office space, warehouses, etc) 2. Land (only if used by the business) 3. Machinery (including electronics, computers, etc) 4. Vehicles (company car or personal car used regularly for business operations) 5.Inventory/stock of supplies/raw material currently owned by the firm 6. Furniture and furnishings (Value,if owned, KSh/Don't know/Refuse to answer)

B.11a Number of permanent employees (employees who have worked in the firm on a daily basis for at least 3 consecutive months) (Total/ Don't know/ Refuse to answer)

B.11b Number of casual employees (Total/ Don't know/ Refuse to answer)

B.14 Of all of these issues indicated on the card, what do you think are the main obstacles to expanding your business? Choose up to three options; Use show card. (Electricity/Transportation/Tax rates/ tax administration/Business licensing and permits/Customs and trade regulations/Labour regulations/Inadequately educated workforce/Access to finance (e.g. collateral)/Cost of finance (e.g. interest rates)/Political environment/Macroeconomic environment (inflation, exchange rate, interest rate)/Corruption/ Crime, theft, disorder/Access to land for expansion / relocation/Other (describe)

C.1 Does your business have an account with a bank? (Yes, personal account used for the business/Yes, the business has its own account/No/Don't know/Refuse to answer)

C.86 What were the common methods of payment to your suppliers over the last 12 months? Spontaneous mention. MULTIPLE mentions possible (1. Cash 2. Cheque 3. Swift Transfer 4. Direct Debit 5.Money transfer through the internet (e.g. Paypal) 6. Mobile Money (M-Pesa, Airtel etc.) 7. Western Union 8.Credit-debit cards 9. In kind 10. Other (Specify))

C.87 Does your business use mobile money (M-Pesa, Airtel money, etc.) in order to receive payments from customers? (Yes/No/Don't know/ Refuse to Answer)

C.94 Does the business receive goods or services from its suppliers on credit? (Yes/No)

C.95 If yes, what percentage of supplies is provided on credit on a monthly basis on average? (%/Don't know/Refuse to answer)

F.2 Does this business have an accountant? (Yes/No/Don't know/Refuse to answer)

G.2 Business owner age: (years/ Don't know/ Refuse to answer)

G.3 Business owner gender? 1. Male 2. Female 3. Don't know 4. Refuse to answer

G.4 Business owner education? 1.None 2.Some primary 3.Primary completed 4.Some secondary 5.Secondary completed 6.College (after secondary) 7. Some university 8.University completed 9.Master degree 10. PhD 11. Dont know 12. Refuse to answer

Table OA1: Descriptive statistics

Panel A: Sectoral breakdown	Definition	Number	Share			
Manufacturing	equals 1 if the business is manufacturing sector, 0 otherwise	302	29%			
Service	equals 1 if the business is in service sector, 0 otherwise	360	34%			
Trade	equals 1 if the business is in trade sector, 0 otherwise	385	37%			
Panel B: Financial charac.		Mean	S.D.	Min.	Median	Max.
Purchasing supplies via cash	equals 1 if the cash is a common method of payment to pay to suppliers, 0 otherwise	0.91	0.28	0	1	1
Purchasing supplies via check	equals 1 if the check is a common method of payment to pay to suppliers, 0 otherwise	0.50	0.50	0	1	1
Selling goods and services via mobile money	equals 1 if the mobile money is common method of payment from your customers,, 0 otherwise					
Purchasing supplies via mobile money	equals 1 if the mobile money is common method of payment to your suppliers, 0 otherwise	0.32	0.47	0	0	1
Purchasing supplies on credit	equals 1 if the enterprise receive goods or services on credit, 0 otherwise	0.24	0.42	0	0	1
Personal bank account	equals 1 if the business owner uses personel bank accout for the business, 0 otherwise	0.15	0.35	0	0	1
Business bank account	equals 1 if the enterprise has a business bank account, 0 otherwise	0.76	0.43	0	1	1
Panel A: Size and productivity		Mean	S.D.	Min.	Med.	Max.
Profit	Monthly profits during the last 12 months, in U.S dollars	51712	636859	0	5581	1.98E+07
Employment	Total number of permanent and temporary employment plus the owner	24	106	1	6	2101
Productivity	Profits divided by employment, in U.S dollars	3101	11696	0	775	259690
Panel D: Other charac.		Mean	S.D.	Min.	Med.	Max.
Registered	equals 1 if the enterprise is registred, 0 otherwise	0.66	0.47	0	1	1
Accountant	equals 1 if the enterprise have an accountant, 0 otherwise	0.56	0.50	0	1	1
Primary education	equals 1 if the business owner/manager have at most primary level level education, 0 otherwise	0.01	0.11	0	0	1
Secondary education	equals 1 if the business owner/manager have secondary level education, 0 otherwise	0.11	0.31	0	0	1
College education	equals 1 if the business owner/manager have college level education, 0 otherwise	0.16	0.37	0	0	1
University education	equals 1 if the business owner/manager have university level education, 0 otherwise	0.29	0.46	0	0	1
Graduate education	equals 1 if the business owner/manager have master or PhD. level education, 0 otherwise	0.11	0.31	0	0	1
Male	equals 1 if the business owner/manager is male, 0 otherwise	0.75	0.43	0	1	1
Age	Age of the business owner/manager	42	9	20	40	90

Notes: The table shows the variable definitions and descriptive statistics for the selected variables. Mean, S.D., Min., Med. and Max. show sample average, standard deviation, minimum, median, and maximum of the corresponding variables.

Table OA2: Stability test for the Probit Regression

	(1)	(2)	(3)	(4)	(5)
Purchasing supplies on credit	0.12***	0.16***	0.14***	0.16***	0.17***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Productivity		0.03***	0.02***	0.02**	0.02**
		(0.01)	(0.01)	(0.01)	(0.01)
Personal bank account			0.15*	0.13	0.13
			(0.08)	(0.08)	(0.08)
Business bank account			0.11*	0.08	0.08
			(0.06)	(0.06)	(0.06)
Registered			-0.12***	-0.14***	-0.14***
			(0.04)	(0.04)	(0.04)
Accountant			0.14***	0.10***	0.10***
			(0.04)	(0.04)	(0.04)
Secondary education				-0.15	-0.15
				(0.13)	(0.13)
College education				0.06	0.07
				(0.17)	(0.17)
University education				0.09	0.09
				(0.17)	(0.17)
Graduate education				0.12	0.13
				(0.18)	(0.18)
Male				0.06	0.07*
				(0.04)	(0.04)
Age				-0.02*	-0.02*
				(0.01)	(0.01)
Age^2				0.00	0.00
				(0.00)	(0.00)
Observations	1,047	1,044	1,044	1,044	1,044
Pseudo R^2	0.02	0.04	0.08	0.12	0.12
Sector FE	No	No	No	No	Yes

Notes: This table shows the estimation result for the correlation between mobile money use to pay to suppliers and business characteristics. We estimate $Y_i = \beta_0 + X_i' \beta_1 + \varepsilon_i$ for all specifications where i denotes the firm and X_i is the business characteristics. Y_i is the mobile money use to pay suppliers. We estimate Probit models, report marginal effects and robust standard errors in parentheses. To control for unobserved regional and sector level fixed effects, we add sector and region dummies to all estimations. * p<0.1. ** p<0.05. *** p<0.01

Table OA3: Paying suppliers via M-Pesa and theft

Crime and theft is an obstacle to expand business	0.12***	(0.04)
Purchasing supplies on credit	0.19***	(0.04)
Productivity	0.02**	(0.01)
Personal bank account	0.13	(0.08)
Business bank account	0.08	(0.06)
Registered	-0.15***	(0.04)
Accountant	0.10**	(0.04)
Secondary education	-0.16	(0.12)
College education	0.07	(0.17)
University education	0.09	(0.17)
Graduate education	0.13	(0.19)
Male	0.06*	(0.04)
Age	-0.02	(0.01)
Age^2	0.00	(0.00)
Observations	1,044	

Notes: This table shows the estimation results for the relationship of paying suppliers via mobile money with whether crime, theft and disorder is an obstacle to expand the business. Obstacle indicator equals 1 if the crime, theft, and disorder is reported as an obstacle by the business (0 otherwise). We estimate $Y_i = \beta_0 + X_i^{'}\beta_1 + \varepsilon_i$ for all specifications where i denotes the firm and X_i is the vector of business characteristics including theft indicator, and Y_i equals 1 if the respondent uses mobile money to pay for supplies (0 otherwise). We estimate the model by using Probit regression, and report marginal effects at mean levels and robust standard errors in parentheses. To control for sector level fixed effects, we add sector dummies to the estimations. * p<0.1. ** p<0.05. *** p<0.01

Table OA4: M-Pesa money transfer transaction fees

Transaction Range (Ksh.)		Transaction Charge (Ksh.)	Transaction Range/Transaction Charge		
Min.	Max.		Min.	Max.	Average
(1)	(2)	(3)	(4)	(5)	(6)
10	49	1	10.00%	2.04%	6.02%
50	100	3	6.00%	3.00%	4.50%
101	500	11	10.89%	2.20%	6.55%
501	1000	15	2.99%	1.50%	2.25%
1001	1500	25	2.50%	1.67%	2.08%
1501	2500	40	2.66%	1.60%	2.13%
2501	3500	55	2.20%	1.57%	1.89%
3501	5000	60	1.71%	1.20%	1.46%
5001	7500	75	1.50%	1.00%	1.25%
7501	10000	85	1.13%	0.85%	0.99%
10001	15000	95	0.95%	0.63%	0.79%
15001	20000	100	0.67%	0.50%	0.58%
20001	25000	110	0.55%	0.44%	0.49%
25001	30000	110	0.44%	0.37%	0.40%
30001	35000	110	0.37%	0.31%	0.34%
35001	40000	110	0.31%	0.28%	0.29%
40001	45000	110	0.27%	0.24%	0.26%
45001	50000	110	0.24%	0.22%	0.23%
50001	70000	110	0.22%	0.16%	0.19%
Overall average for unit costs:			2.40%	1.04%	1.72%

Notes: This table documents the transaction fees when money is transferred through M-Pesa. Column 3 shows the fee that an M-Pesa user is charged when she or he transfers an amount within the transaction ranges indicated by Columns 1 and 2. To calculate unit costs we divide each transaction fee in Column 3 to the corresponding minimum and maximum transaction ranges in Columns 1 and 2. The minimum unit cost is given by Column 4, and the maximum unit cost is given by Column 5. Column 6 shows the average of minimum and maximum unit costs. At the bottom of the table we also report overall average for minimum, maximum, and average unit costs.

Table OA5: M-Pesa Counterfactual with Theft Re-entry

	$\delta = 0$ (Benchmark)	$\delta = 0.25$	$\delta = 0.50$	$\delta = 0.75$	$\delta = 1$
Aggregate Welfare Loss	1.2%	1.1%	1.0%	1.0%	1.0%
Input-output ratio	0.22	0.22	0.22	0.22	0.22
Supplier credit-output ratio	0.08	0.08	0.08	0.08	0.08
Fraction of Trade Credit Users	0.23	0.23	0.23	0.23	0.23
Fraction of M-Pesa Users	0	0	0	0	0
Fraction of M-Pesa Users with Trade Credit	0	0	0	0	0

Notes: Aggregate welfare in this table includes also the aggregate utility derived from consuming stolen cash - given the exogenously specified marginal utility of consumption (δ). The counterfactual is conducted by hypothetically raising the periodic M-Pesa fee (f_e) so high that every entrepreneur, who otherwise would have utilized M-Pesa in her transactions, endogenously switches to cash.

Table OA6: Model (Re)-Parameterization - Publicly Verifiable Theft

Parameter	Value	Motivation
α	0.33	Standard capital share value in the Literature
β	0.90	The standard value used in the Growth literature
θ	0.98	As evidenced by World Bank Kenya Enterprise Survey (2013)
λ	0.0172	M-Pesa Transaction Costs retrieved from Safaricom on Aug. 2014
e	0.258	To match average input-output ratio (in FinAccess)
f_e	0.034	To Match fraction of M-Pesa user SMEs (in FinAccess)
π	0.30	To match the fraction of SMEs in a Trade Credit Relation (in FinAccess)
T	2	To match the average trade credit-output for borrowers (in FinAccess)

Notes: The model is re-parameterized in such a way that, compared to the benchmark calibration, default due to theft no longer leads to the exclusion of the defaulter from accessing trade credit in the next T-periods.

Table OA7: Publicly Verifiable Theft Model vs. Kenyan Economy

	Model (Mean Value)	Kenyan Economy (Mean Value)
Input-output ratio	0.22	0.30
Supplier credit-output ratio	0.08	0.10
Fraction of Trade Credit Users	0.23	0.24
Fraction of M-Pesa Users	0.26	0.32
Fraction of M-Pesa Users with Trade Credit	0.39	0.41
Fraction of M-Pesa Users without Trade Credit	0.22	0.30
Average Input M-Pesa Users/Average Input Non-users	1.21	1.27

Table OA8: Counterfactual of Cutting Access to M-Pesa - Publicly Verifiable Theft

Macroeconomic Output Loss	1.0%
Aggregate Entrepreneurial Profit Loss	0.3%
Input-output ratio	0.22
Supplier credit-output ratio	0.08
Fraction of Trade Credit Users	0.24
Fraction of M-Pesa Users	0
Fraction of M-Pesa Users with Trade Credit	0

Notes: The counterfactual is conducted by hypothetically raising the periodic M-Pesa fee (f_e) so high that every entrepreneur, who otherwise would have utilized M-Pesa in her transactions, endogenously switches to cash.

Table OA9: The relationship between paying suppliers via M-Pesa and prices

	(1) All Firms	(2) Firms with 10 or less employees
Using M-Pesa to pay suppliers	-0.22	-1.36*
	(0.58)	(0.76)
Purchasing supplies on credit	-0.84	-0.09
	(0.64)	(0.93)
Personal bank account	-1.01	-1.25*
	(0.62)	(0.75)
Business bank account	-0.51	-0.86
	(0.51)	(0.57)
Registered	0.21	0.22
	(0.47)	(0.55)
Accountant	0.53	0.23
	(0.46)	(0.60)
Secondary education	0.24	0.76
	(1.01)	(1.34)
College education	-0.66	0.44
	(1.08)	(1.42)
University education	0.20	1.16
	(1.05)	(1.38)
Graduate education	-1.34	-0.62
	(1.35)	(2.01)
Male	0.30	0.58
	(0.40)	(0.43)
Age	-0.05	-0.17
	(0.11)	(0.26)
Age^2	0.00	0.00
	(0.00)	(0.00)
Constant	13.34***	14.63**
	(2.87)	(5.68)
Observations	472	349
R^2	0.60	0.63
Product Fixed Effects	Yes	Yes

Notes: This table shows the estimation results for the relationship between prices and using mobile money to pay to suppliers. Price (in logarithm) is the dependent variable. We estimate $Price_i = \beta_0 + X_i' \beta_1 + \varepsilon_i$ where i denotes the firm and X_i is the vector of business characteristics including the variable for using mobile money to pay suppliers. We estimate the model by using OLS method and report robust standard errors in parentheses. To control for product fixed effects, we add product dummies to the estimation. The first column reports the result for all firms that price information is available. The second column reports the results for firms with 10 or less employees. * p<0.1. ** p<0.05. *** p<0.01.

Table OA10: Input Stocks/Inputs Expenditures Ratio in FinAccess Kenya

	Non-users	M-Pesa users
Without Trade Credit	3.87	6.50
With Trade Credit	5.07	5.83

Notes: This table shows the average stocks per input expenses for Kenyan economy by trade credit use and M-pesa use to pay suppliers. We estimate these by using Kenya FinAccess Business Survey.