

Payment Instruments, Finance and Development: Evidence from Mobile Money Technology^{*}

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Abstract

This paper studies the effect of a payment technology innovation (mobile money) on contract enforcement and economic development in a dynamic general equilibrium model, calibrated with firm-level survey data. In the model mobile money dominates fiat money as medium of exchange as it avoids the risk of theft, but comes with transaction costs. We show that trade credit borrowers are more likely to adopt mobile money as payment instrument vis-a-vis their suppliers, while using mobile money in turn reduces the cost of borrowing, relaxes enforcement constraints, and eases access to trade credit. More efficient payment methods thus increase the use of trade credit and firm-level output. Calibrating the stationary equilibrium of the model to match a set of moments from a firm-level survey in Kenya, we evaluate the quantitative implications of mobile money on entrepreneurial performance and development.

Keywords: Payment Technologies, Trade Credit, M-Pesa, 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 relax firms’ financing constraints and thereby contribute to a country’s economic development? In particular, can more efficient payment tools help small businesses gain access to credit and grow in developing countries, where financing constraints loom large? We address these questions by focusing on a key financial revolution, 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 in cellular phones, critical in socially volatile and risky environments. According to the Global Findex data, 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 surveyed 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 and enforceability of trade credit contracts for enterprises.¹ We develop a dynamic general equilibrium model of financial development with heterogeneous firms to evaluate the supplier credit and firm-level performance effects of a technologically advanced payment technology - featuring the properties of mobile money accounts - in an economy characterized by credit imperfections, information asymmetries and risk of theft, prominent in most developing economies. We show that the availability of mobile money increases access to trade credit along both intensive and extensive margins, with positive repercussions for firms’ output. Calibrating our model to firm-level survey data, we show significant aggregate effects of the adoption of more efficient payment technologies, such as mobile money. Our findings are novel as they reveal the critical interactions of the payment technology with access to external funding and firm growth.

Figure 1 illustrates the strong empirical relationship between the use of mobile money and access to trade credit, using survey data for over 1,000 firms from Kenya. Specifically, it shows that share of firms using mobile money when purchasing inputs is significantly higher for businesses which receive inputs from their suppliers in exchange of a (delayed) credit repayment. This partial correlation holds when controlling for many other firm characteristics and is consistent with causality going

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

into either direction, as we will explore theoretically as well as quantitatively.

- Figure 1 about here -

We develop a dynamic general equilibrium model of entrepreneurial finance to explain this positive association of mobile money usage and use of trade credit. In our model, entrepreneurs are heterogeneous in their ability to access trade credit, randomly draw idiosyncratic productivity shocks, and get randomly hit by monetary theft shocks. Trade credit is subject to limited commitment and hence a strategic-default constraint. In the benchmark model, theft is private information, erodes an entrepreneur's fiat money balances and thus repayment capacity, and therefore causes a discontinuation of access to trade credit due to non-repayment. We model mobile money as a resolution mechanism to theft, in line with previous literature.² The analytical solution of the model produces equilibrium properties matching the empirical observation that enterprises with access to trade credit, *ceteris paribus*, are more eager to use mobile money compared to the rest of the entrepreneurial population. Trade credit yields higher entrepreneurial production, which complements and raises the likelihood of mobile money use.

Using our model we can isolate three general equilibrium 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 collateral for 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 borrow 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. In an extension to our model we provide entrepreneurs with an option to endogenously select into trade credit relationships, thus capturing both extensive and intensive margin interactions between firms' demand for mobile money and access to trade credit.

We calibrate the stationary equilibrium of the model to match a set of moments that we observe in the Kenyan FinAccess Business survey from 2014. The parameterized model matches the Kenyan business data well along the dimensions that we target as well as an important additional statistics that we do not target directly, which is the fraction of mobile money users among trade credit borrowers. Using the parameterized model, we conduct counterfactual quantitative exercises,

²To give one example, Sanches and Williamson (2010) formalizes the role of theft in inducing commitment in a search theoretic monetary environment.

where we hypothetically shut down entrepreneurs' access to mobile money when purchasing inputs from suppliers. Eliminating the use of mobile money results in a contraction in overall supplier credit in the economy and lower use of inputs. The aggregate output of the economy contracts by 0.33% in the model where access to trade credit is exogenously distributed among businesses. In the alternative framework, where signing up for a trade credit relationship is endogenous, shutting down the mobile money technology additionally lowers the share of entrepreneurs with access to trade credit, resulting in 0.47% lower output.

These results reveal the strength of the quantitative interaction between trade credit and mobile money as a payment method. Comparing the output effects that we estimate with actual growth numbers for the Kenyan economy suggests that the introduction of the mobile money technology M-Pesa in 2007 can explain 14% of the total factor productivity growth between 2006 and 2013 thus pointing to quantitatively significant macroeconomic effects of mobile money technology through the entrepreneurial finance channel. We also provide a list of robustness checks for our qualitative and quantitative results with respect to the nature of theft in the economy and capital accumulation dynamics to generalize our findings.

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 and macroeconomic performance. 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 firms expand their trade credit network and raise production. While we use data from Kenya to empirically motivate our study and calibrate our theoretical model, the market frictions we focus on - information asymmetries, enforcement constraints and theft - are prevalent throughout the developing world.

Our paper relates and contributes to four 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), Kehoe, Levine and Prescott (2002) and Azariadis and Lambertini (2003) 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.³ Our theoretical contribution shows that an efficient payments technology (such as mobile money) that lowers the probability of

³An important recent paper on firms' finance and default is Herranz et al. (2015), in which authors construct a dynamic model of small firms who can default on contracts in equilibrium (when it is optimal to do so), and they 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 inability to repay.

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.⁴

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, which we will describe in more detail below. Morawczynski and Pickens (2009) document that mobile money users started to send smaller and more frequent remittances than users of other payment channels after the introduction of the M-Pesa technology, resulting in an expansion in total remittances sent to the rural areas of Kenya. Directly related to our theoretical model, Vaughn (2007) shows that some individuals store money in M-Pesa under safety considerations, especially when travelling across Kenya. Jack and Suri (2011) document that three out of four Kenyan M-Pesa users indicate that they use M-Pesa to save money. Using ethnographic methods in three communities, Plyler et al. (2010) argue that M-Pesa stimulates small business growth and thereby increases the circulation of money in these communities. 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.⁵ Finally, 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. Building upon a set of theoretical arguments, Jack et al. (2010) suggest that the Kenyan M-Pesa revolution would lead to an expansion in financial connectedness and stimulate economic growth. While this literature has almost exclusively focused on the household use of mobile money, our paper is the first that focuses on business use of mobile money and offers empirical and theoretical evidence on the strategic complementarity between mobile money and trade credit. In this context we also contribute to the finance and growth literature, showing the important role that efficient payment systems can have on macroeconomic outcomes by expanding firms' access to non-bank external finance.

The third line of research we contribute to is the literature on the role of trade credit in economic development in low income countries. 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

⁴Closely 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), Quintin (2008), and Buera et al. (2013) study the quantitative implications of limited contract enforcement for occupation choice and the efficiency of aggregate capital allocation across a distribution of entrepreneurs.

⁵Further, Eijkman et al. (2010) explore the functioning of M-PESA stores, which stand ready to exchange cash and mobile-money. Their findings suggest that such stores need to have intensive management of liquidity to serve customers, which is difficult to handle in rural areas. 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.

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 (2001) shows that trade credit is positively correlated with capacity utilization, while Fisman and Raturi (2004) show that monopoly power is negatively associated with trade credit provision. Using 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 commitment mechanism vis-a-vis creditors and thus enhance growth of financially constrained enterprises, underlining the importance of efficient payment instruments for firm's access to external funding, including trade credit, and their performance.

Finally, a growing literature analyzes the development implications of mobile phone usage in low-income countries. Earlier studies in the literature explore how mobile technologies can solve information asymmetries regarding market prices in the context of development. Jensen (2007) and Aker (2010) investigate the impact of information flows through increased mobile phone service coverage on market price dispersion in South Indian Fisheries Sector and grain markets in Niger, respectively, and document a reduction in price dispersion in those markets and therefore increase in welfare. Similarly, Muti and Yamato (2009) show that increased information about market prices due to mobile phone network expansion in Uganda between 2005 and 2007 enhanced market participation of banana farmers in remote communities. Our findings show that in developing countries mobile phone technologies may also help foster economic and financial connectedness between enterprises.

The rest of our paper is organized as follows. In section 2, using the FinAccess Enterprise Survey data we document a key empirical regularity for the co-variance between M-Pesa use and trade credit access. Section 3 develops a dynamic general equilibrium model of entrepreneurial finance to account for this empirical pattern. In section 4, we provide an analytical solution to our model. Section 5 calibrates the model economy to match a set of moments from the FinAccess Enterprise Survey data. Section 6 presents the quantitative analysis, where we estimate the development implications of the M-Pesa technology for the Kenyan economy. Section 7 provides a sensitivity analysis and section 8 concludes.

2 Mobile Money and Evidence from Kenyan Businesses

After its launch in 2007, M-Pesa⁶ rapidly became popular among Kenyan households. Given that its use poses lower risks than informal payment methods, storing money in mobile form implies lower risk than holding cash, and using M-Pesa when transferring money costs less than bank transfers. Jack and Suri (2014) document that as of 2011 70 percent of adult population in Kenya had already adopted an M-Pesa account.

There was a substantial demand for money transfer services before the introduction of M-Pesa⁷, but M-Pesa changed the landscape of payment services in Kenya 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 (Akers and Mbiti (2011); Jack and Suri (2011); Jack and Suri (2014); Morawczynski and Pickens (2009)). 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. Data from the World Bank's Enterprise Survey suggests that every year Kenyan manufacturing firms lose about 2 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 22%). 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 56%. By providing a cheaper and safer money transfer tool, the use of M-Pesa technology expanded rapidly and became a frequently and widely utilized electronic money instrument for private purposes in the country.⁸

This section provides a short overview for how M-Pesa technology is applied to transfer money, introduces the enterprise survey that underpins our work, and shows empirical evidence that motivates our theoretical model.

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 agents, which are wide-spread all across the country. After being introduced in 2007 by Safaricom, mobile money usage has grown rapidly. Growing at the annual rates of 86% and 52% since 2007, as of December 2014, the number of total M-PESA agent outlets and customers reached 124,000 (around 20 percent of them in Nairobi (FSP interactive maps, 2013)) and 25 million respectively. During 2013, 282.5 million transactions were conducted

⁶M stands for mobile and pesa means money in Swahili.

⁷High 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 (Akers and Mbiti (2011); Jack and Suri (2011)).

⁸See Jack and Suri (2011).

in total, and the total value of money transferred was 1.9 million Kenyan shillings (22 billion U.S dollars).⁹ Since 2007 Kenyan households have utilized M-Pesa for not only transferring or receiving money but also for saving: 85% of the 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 is free. The individual only has to visit the mobile money agent with his or her ID and deposit money into the M-Pesa account. However, using M-Pesa comes with *fixed 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 Shilling (KSh) transferred to a recipient, Safaricom charges the sender with 0.01 KSh. We will incorporate both cost margins into the dynamic general equilibrium model that we develop below.

In addition to facilitating person to person (P2P) transfers, M-Pesa users can pay water, electric, 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 via 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 novel business-level mobile money usage questions. The survey data was collected in 2014 by FSD-K from a representative cross-section of 1,047 mainly small and medium enterprises in Nairobi. The respondents of the questionnaire are owners or executive managers. Table 1 presents detailed variable definitions and descriptive statistics for our sample. In the appendix of the paper we provide the full details of the questions from the survey that are relevant for our empirical and quantitative studies.

- Table 1 about here -

Panel A of Table 1 shows that there is quite some 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.

Panel B presents selected business financial characteristics. 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 method of payments when buying inputs from suppliers”. Descriptive statistics show that, after cash and checks, mobile money is the third most common

⁹Data used for calculating number of Nairobi M-pesa agents are from November 2013. We calculated U.S dollar equivalent of M-pesa transfers by using 2013 average of official exchange rate.

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 banks 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.

Panel C presents business size and productivity related indicators. The median firm earns around 5,600 U.S dollars per month, averaged over the last 12 months and employs on average 6 workers.¹⁰

Finally, Panel D presents other business characteristics. Our sample mostly includes formal 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 a 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 selected business characteristics introduced in Table 1. We estimate the model using a probit regression; we control for sectoral fixed effects in the regression but do not report the coefficient estimates to economize on space.

- Table 2A and 2B about here -

Table 2A 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 positive correlation between productivity, where productivity is measured as profits per employee, and the likelihood of using M-Pesa to pay suppliers. Second, and most importantly, 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. 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.

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

¹⁰In order to have a representative cross-section of firms, our sample (1,047 firms) includes about 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 will present in Section 3 for only SMES, our coefficient estimates do not alter. These alternative estimation results are available upon request.

variables gradually. We present these estimates in Table 2B. 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.

It is important to note that these estimates do not imply any causality; rather, the result may imply that 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 businesses. Both directions of causation have important and interesting research and policy implications. In sections 3 and 4, we will therefore focus on providing a theoretical explanation for both ways of causation, and especially address why having a trade credit relationship with suppliers and paying suppliers via mobile money may complement each other.

To sum up, the empirical regularity we have shown in this section and whose theoretical micro-foundation we would like to investigate is that *after controlling for a measure of firm performance (productivity), buying inputs on trade credit and the use of M-Pesa as a payment method with suppliers are positively related.*

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 \mathcal{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. 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 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 show in the appendix of the paper 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.¹¹

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}).¹² 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

$$E_0 \sum_{t=0}^{\infty} \beta^t [c_{s,t} - h_{s,t}], \quad (1)$$

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.¹³ The entrepreneur can also take fractions of this endowment to the *Day* sub-period 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

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

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 produc-

¹¹Furthermore, as we also discuss in the appendix, excluding capital dynamics at the firm-level is not necessarily a concern for the key theoretical findings from the model either.

¹²This assumption is utilized in the analytical solution to the model below and does not play a key role in the quantitative analysis.

¹³As we delineate in the appendix, 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.

tion 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

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

units of consumption good in the *Night* sub-period, where $f'(\cdot) > 0$ and $f''(\cdot) \leq 0$. 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 $G(A)$ and publicly observable as well as verifiable.¹⁴

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

There are two essential 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 repayment is limited. 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, in 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* sub-period 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* sub-period market - as presented in the timing of events in Figure 2. The following three features allow us to represent the trade credit relationships that we observe in our Kenyan business survey data.

- Figure 2 about here -

First, 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* sub-period market. Limited participation to access trade credit can be motivated with reputation about the history of past transactions being available only for a fraction

¹⁴The 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.

of the entrepreneurial population.¹⁵¹⁶ The remaining $1 - \pi$ fraction of the entrepreneurs are not part of the trade credit network - lack the reputation to repay credit - and hence can only spot-trade in the *Day* market. 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 type of an entrepreneur (π fraction) is exogenously given and fixed over time. In an alternative version of the model, we will endogenize access to the trade credit network as an entrepreneurial decision. In our theoretical analysis and quantitative experiments we will investigate the implications of both model specifications.

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

$$b_{i,t} > 0 \text{ if } x_{i,t} \geq \omega, \text{ with } \omega < e. \quad (4)$$

This exogenously determined “internal finance 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.¹⁷ 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

$$b_{i,t} \leq V_{i,t}. \quad (5)$$

Fiat Money and M-Pesa. Consumption goods can be transferred from entrepreneurs to input suppliers 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 2, 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

¹⁵The 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.

¹⁶Theoretical papers that investigate the optimal design of payment methods, such as Kocherlakota (1997) and Kocherlakota and Wallace (1998), refer to this type of an arrangement as a record keeping institute.

¹⁷In our quantitative analysis we utilize T to match the aggregate trade credit to output ratio observed in the data.

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. 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 with the exclusion of a defaulter from accessing trade credit in the future. 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.

M-Pesa users are not subject to the risk of theft, but the use of M-Pesa comes with transaction costs. We assume that M-Pesa is a hack-proof technology.¹⁸ However, adopting the M-Pesa technology requires a fixed periodic cost of f_e for the entrepreneur, motivated with fixed cash withdrawal fees and effort costs to visit an M-Pesa agent when converting M-Pesa into cash. 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.

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. 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

$$e \geq x_{i,t} \geq h_{i,t} \quad (6)$$

The first inequality on the right hand side of (6) restricts 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 is the *Day* sub-period budget constraint). The second inequality at (6) needs to hold such that the input supplier would have incentives to provide the entrepreneur with $h_{i,t}$ units of production inputs.

¹⁸Theft 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. At a speech in 17 August 2013 CEO of Safaricom announced that fraud occurrence for customers is only 0.002% among the total money in circulation through M-pesa, where the average credit-card fraud rate in Kenya is about 0.05%.

If the entrepreneur is connected to the credit network, 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 to $x_{i,t}$ (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,

$$x_{i,t} + b_{i,t}g_{i,t}(\theta) \geq h_{i,t}, \quad (7)$$

where $g_{i,t}(\theta)$ is the inverse of a risk premium (interest payment) that is associated with the perceived probability of the entrepreneur not being subject to theft before repaying her trade credit obligation. For an M-Pesa user, $g_{i,t}(\theta) = 1$ and for a cash user $g_{i,t}(\theta) = \theta$. 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 exclusion of the entrepreneur for T periods. Based on this contracting environment, we define the dynamic general equilibrium as the following. Finally, the entrepreneur's *Night* sub-period budget constraint is expressed as

$$c_{i,t} + b_{i,t} + \chi_{i,t}^D \lambda x_{i,t} + \chi_{i,t}^N \lambda b_{i,t} + \chi_{i,t} f_e \leq y_{i,t}, \quad (8)$$

where $\chi_{i,t}^D$ ($\chi_{i,t}^N$) is an indicator function which takes the value 1 and 0 otherwise if and only if the entrepreneur utilizes M-Pesa at *Day* (*Night*) market transactions and $\chi_{i,t} \equiv \max\{\chi_{i,t}^D, \chi_{i,t}^N\}$.

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

$$x_{i,t} + b_{i,t}g(\theta) = h_{i,t}, \quad (9)$$

where $b_{i,t} > 0$ if and only 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), (8) and (9) in order to maximize (2).

4 Analytical Solution

We make the following functional form assumption regarding the entrepreneur's production technology in order to provide a set of closed-form theoretical results that help us to evaluate key qualitative properties of the model. Before we proceed with the quantitative framework, we will show that the qualitative results based on Assumption 1 can easily be extended to a framework, where the technology of the entrepreneur takes a general decreasing returns to scale form.

Assumption 1. $y_{i,t}(h_{i,t}) = A_{i,t}h_{i,t}$.

Denoting \underline{A} as the lowest possible productivity draw, let us assume $\underline{A} > \frac{1}{\theta}$, such that for all entrepreneurs it is worthwhile to carry cash in order to purchase inputs in the *Day* market and undertake entrepreneurial production - even if M-Pesa technology is not available.

4.1 Social Planner's Allocation without Financial Imperfections

We consider a social planner that is not subject to financing constraints but takes into account theft. Since the production technologies of entrepreneurs and suppliers are linear and also $A_i > \frac{1}{\theta}$ for all entrepreneurs, social planner would distribute resources based on the first-best allocation rule. This means, the social planner asks each input supplier to provide \bar{h} units of labor (the maximum capacity of labor associated with each supplier) at every entrepreneur-supplier meeting. Then the socially optimal level of aggregate output of the economy in any period t would be expressed as

$$Y_t = \bar{h} \int_{\underline{A}}^{\bar{A}} A_{i,t} di. \quad (10)$$

4.2 Markets with Financial Imperfections

In order to evaluate the behavior of an economy with financial frictions, we first note that given suppliers' zero-profit condition, for a creditless spot-trader

$$\max_{x_{i,t}} \theta A x_{i,t} - (e - x_{i,t})$$

solves $x_{i,t} = e$. Since the value of transacting in the market is higher for a trade credit borrower (than a non-borrower), borrowers would set $x_{i,t} = e$ as well. Therefore, all entrepreneurs in the economy carry the entirety of the beginning-of-the period endowment to the *Day* market.

To understand the dynamic interactions between trade credit finance and M-Pesa use, let us first assume that access to trade credit is exogenously distributed among entrepreneurs, such that the fraction π of all entrepreneurs can borrow trade credit - provided they do not experience a theft

shock when entering the *Day* market. Then, market clearing implies

$$e = h_{\ell,t}, \quad (11)$$

$$e + b_{c,t}g_{i,t}(\theta) = h_{c,t}, \quad (12)$$

where (10) is the zero-profit condition at all creditless supplier-entrepreneur spot trades and (11) is the zero-profit condition at all trade-credit-based supplier-entrepreneur trades.

If inputs employed at production is unconstrained

$$h \equiv \operatorname{argmax} A_i h^\alpha - h$$

determines the quantity of inputs with $h = (\alpha A_i)^{\frac{1}{1-\alpha}}$. The quantity of inputs extended on credit can be constrained as in the following

$$b_{i,t} = \min\{\bar{h} - e, V_{i,t}\}. \quad (13)$$

This means there could be two types of trade-credit constraints: (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 $b_{i,t} = V_{i,t}$.

For our theoretical as well as quantitative analyses we will concentrate only on financial constraints. Furthermore, for most of the theoretical results, we assume $b_{i,t} = V_{i,t}$. However, we will also show that this assumption is made without loss of generality and that allowing unconstrained entrepreneurs does not change the qualitative findings of the paper. Therefore, when calibrating the model in section 5 we will allow for non-binding enforceability constraints as well, which will hold for entrepreneurs hit by low productivity shocks.

With financially constrained entrepreneurs, 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 future credit market valuation 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 excluded from future credit participation with probability $1 - \theta$, her future credit market valuation equals to 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

$$h_{p,t} = e + V, \quad (14)$$

$$h_{f,t} = e + g(\theta)\theta V = e + \theta^2 V, \quad (15)$$

where (14) is the input supplied to an M-Pesa user trade credit borrower, whereas (15) is the input supplied to a fiat money user.

4.2.1 Equilibrium M-Pesa Use and Productivity

The current value of consumption of a creditless entrepreneur (ℓ) who uses M-Pesa technology (p) is expressed as

$$\tilde{U}_{p,t} = A_{\ell,t}e - \lambda e - f_e + U, \quad (16)$$

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

$$\tilde{U}_{f,t} = \theta A_{\ell,t}e + U. \quad (17)$$

Equations (16) and (17) imply that a creditless entrepreneur would be indifferent between using M-Pesa and fiat money if $A_\ell = A^*$, where the critical productivity level A^* solves:

$$(1 - \theta)A^* = \frac{f_e}{e} + \lambda. \quad (18)$$

The left hand-side of (18) is the unit return to M-Pesa usage, whereas the right hand-side of (18) is the unit cost of M-Pesa use, which leads us to obtain our first qualitative result.

Proposition 4.1 *The higher an entrepreneur's productivity the higher is the likelihood of her using M-Pesa when purchasing inputs from a supplier.*

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.

4.2.2 Equilibrium M-Pesa Use and Access to Credit

Next, we turn to evaluating the relationship between access to trade credit and the likelihood of employing the M-Pesa technology when settling payments with suppliers. A creditless entrepreneur who draws the productivity shock A^* becomes indifferent between using cash and M-Pesa. If granted with access to the trade credit network, the same entrepreneur with productivity A^* would 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.

To the end of the *Day*-subperiod transactions, as an initial result we show that A^* -entrepreneur would prefer to use M-Pesa over cash at the upfront payment stage. In order to observe this, without loss of generality, suppose that A^* cannot utilize M-Pesa in the *Night*-subperiod credit repayment stage. Let us denote the quantity of credit that can be extended to the entrepreneur with b , where we are not necessarily assuming a binding enforceability constraint. The interest payment on b would be equal to $\frac{1}{\theta}$, because in the *Night* (due to the absence M-Pesa usage) the likelihood of a non-repayment is $1 - \theta$. Then, A^* prefers M-Pesa in the *Day* if and only if

$$A^*e + \left(A^* - \frac{1}{\theta}\right)b - \lambda e - f_e > \theta \left[A^*e + \left(A^* - \frac{1}{\theta}\right)b\right].$$

Since $A^* > \frac{1}{\theta}$, this strict inequality holds. 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 payment to be made to the supplier. Hence, A^* demands M-Pesa in the *Day*-subperiod transaction because doing so generates a net benefit worth of $(1 - \theta) \left(A^* - \frac{1}{\theta}\right)b$. This result is a confirmation for the empirical regularity we obtained in section 2 - that access to trade credit raises the likelihood of M-Pesa preference of an entrepreneur when transacting with a supplier.

Corollary 4.2 *Access to trade credit raises an entrepreneur's willingness to pay for her Day market transactions with M-Pesa.*

What is as much important is to understand whether the entrepreneur- A^* prefers M-Pesa over cash in the *Night*-subperiod as well, because if so, as we will discuss below this would relax financing constraints of the entrepreneur, reduce her repayment burden and further enhance her production capacity.

Therefore, what we would like to investigate next is whether the same A^* -entrepreneur would strictly prefer to switching to M-Pesa as a payment instrument when purchasing inputs in the *Day* as well as repaying credit in the *Night* if she had access to trade credit. For this let us first assume that the enforcement constraint (5) is binding. Then, using (14), the current consumption value of a borrower with M-Pesa - at both *Day* and *Night* subperiod transactions - can be expressed as follows

$$\tilde{V}_{p,t} = \{A^*e + (A^* - 1)V\} - \{\lambda(e + V) - f_e\} + V + U, \quad (19)$$

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 future credit market participation with M-Pesa, and the fourth component is the future value of creditless spot-trades. Similarly, using (15), the current value function of a borrower with cash when settling

upfront payment and credit repayment transactions is expressed as

$$\tilde{V}_{f,t} = \{\theta[A^*e + (A^* - 1)\underbrace{g(\theta)}_{=\theta}\theta V]\} + \{((1 - \theta) + \theta^2)V\} + U, \quad (20)$$

where the first component on the right hand side of (20) is the return to entrepreneurial production with fiat money, the second component is the value of future credit market participation with fiat money, and the third component is the future value of creditless spot-trading. We would like to note that with probability θ the entrepreneur becomes a debtor in period t and then - given this state - with probability $1 - \theta$ she ends up defaulting on the supplier. This means with probability $\theta(1 - \theta)$ a borrower who uses fiat money gets excluded from credit-based transactions in the future - lowering her credit market valuation by $\theta(1 - \theta)V$ compared to an M-Pesa user. Then, for a borrower of trade credit, the difference in current consumption value functions between M-Pesa and fiat money use becomes the following

$$\tilde{V}_{p,t} - \tilde{V}_{f,t} = (1 - \theta)A^*e + (1 - g(\theta)\theta^2)(A^* - 1)V - \lambda(e + V) - f_e + \theta(1 - \theta)V. \quad (21)$$

Using (18) in (21) yields

$$\tilde{V}_{p,t} - \tilde{V}_{f,t} = (1 - g(\theta)\theta^2)(A^* - 1)V - \lambda V + \theta(1 - \theta)V. \quad (22)$$

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 the scale of 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 (22) which is greater than $(1 - \theta^2)$. For $g(\theta) = 1$, by re-arranging the right hand side of (22), the sufficient condition for a trade credit borrower A^* to strictly prefer M-Pesa over fiat money becomes

$$(1 - \theta^2)(A^* - 1) + \theta(1 - \theta) > \lambda. \quad (23)$$

From (18) we know that $\lambda < (1 - \theta)A^*$ as long as the fixed cost of M-Pesa use f_e is greater than 0. For now, let us suppose that $f_e = 0$, and then the condition (23) can be replaced with

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

which after rearranging terms reduces to

$$\theta A^* > 1. \tag{24}$$

Since the lower bound for the productivity distribution satisfies $\underline{A}\theta > 1$, the strict inequality (24) holds for all A^* . This qualitative property has the following implication: access to trade credit generates an endogenous demand to use M-Pesa for the entrepreneur indexed with A^* at both *Day* and *Night* transactions - noting that the A^* -entrepreneur was indifferent between using M-Pesa and fiat money (and did not have a strict preference to demand M-Pesa), had she did not have access to trade credit. Since we isolated away the channel on M-Pesa demand that works through the cost of interest payment, we formalize the next result.

Proposition 4.3 *Ceteris paribus, entrepreneurs who purchase goods on trade credit are more likely to use M-Pesa to settle payments at all transactions compared to the entrepreneurs without access to trade credit. This result holds because of the impact of M-Pesa on future trade credit valuations and in turn on enforceability constraints.*

The intuition behind this result is related to the increasing value of entrepreneurial production induced by credit, which complements and raises the likelihood of M-Pesa use. At a credit-based relationship, when subject to monetary theft the entrepreneur suffers not only the foregone opportunity to produce, but also loses due to credit market frictions the ability to borrow. 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 raises the value of M-Pesa for entrepreneurs who have access to trade credit.

One important point to emphasize is that the key result in proposition 4.3 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 are ruled out in equilibrium 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 made based on an M-Pesa transfer.¹⁹

Going back to the cost of borrowing channel (ii), the contracted payment to the input supplier with fiat money is higher because of the likelihood of theft, i.e. in general equilibrium $g(\theta) = \theta$

¹⁹We 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.

instead of $g(\theta) = 1$. For a cash user this second channel increases the repayment burden and constrains the quantity of inputs that the entrepreneur can borrow in the first place and raises the relative valuation of M-Pesa. Formally, the consequence of repayment burden channel can be observed by replacing the $(1 - \theta^2)$ term on the right hand side of the inequality (22) with $(1 - \theta^3)$.

Corollary 4.4 *The contraction in the repayment burden with M-Pesa reinforces an entrepreneur's demand to use M-Pesa in a credit-based supplier relationship.*

So far, we presented qualitative results under the assumption that the enforceability constraint is binding for trade credit borrower. In reality this does not have to be the case - as we will allow in our quantitative analysis below. Therefore, before we move on with our analysis we would like to show that the result presented at Proposition 4.2 could hold for general parameterizations of the model even if the enforceability constraint is not binding. As shown above, the entrepreneur with productivity- A^* strictly prefers M-Pesa over fiat money in *Day* market transactions - given an arbitrary an quantity of borrowed funds, b . Suppose that $b < V$ such that the enforceability constraint is not binding (which as also delineated above would prevail if the capacity of an input-supplier \bar{h} is small enough). In this case, the decision of the A^* to pay with M-Pesa in the *Night* market would have no effect on the quantity of inputs he can purchase in the *Day* market - through the effects of a relaxed enforceability constraint, since this constraint is not binding in the first place. Therefore, the entrepreneur A^* would use M-Pesa in a *Night* repayment transaction only if

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

which is not a function of A^* . 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 M-Pesa on future credit market access, while the second term is the interest repayment gain from transacting with M-Pesa. Re-arranging terms yields:

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

Clearly, the higher V , the higher is the preference to utilize M-Pesa when repaying trade credit. Therefore, a sufficient (not necessary) condition for A^* to prefer M-Pesa over fiat money is

$$\theta(\theta + \lambda + 1) < 1.$$

The first term on the left hand side is a fraction, and hence it is strictly less than 1. The second term is the summation of two fractions, both of which have relatively low real-world counterparts. Safaricom charges a $\lambda = 0.01$ on average per-unit M-Pesa transferred, whereas the incidence of theft (θ) in Nairobi is less than 10% of the transaction values as we will discuss in Section 5. Therefore, $\theta(\theta + \lambda + 1) < 1$ would hold in the representation of the parameter space that we

consider. This allows us to conclude that given the parameter configurations that we will consider in our quantitative analysis all entrepreneurs with access to trade credit settle credit repayment transactions in the *Night* market using M-Pesa. This result holds regardless of the shape of the entrepreneurial production technology and entrepreneur’s idiosyncratic productivity draw.

Proposition 4.5 *If λ (M-Pesa transfer costs) and θ (probability of theft) are small enough, regardless of the shape of the entrepreneurial technology and realization of productivity draws, all entrepreneurs with access to trade credit settle transactions in the Night market using M-Pesa.*

4.2.3 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 (23), 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. We summarize this result with the following corollary.

Corollary 4.6 *Ceteris paribus, a higher fixed cost of M-Pesa adoption makes a trade credit borrower more likely to use M-Pesa compared to a creditless entrepreneur.*

The intuition is related to the local increasing returns to scale feature that fixed costs generate: with fixed costs, the credit constrained 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 user 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 use of M-Pesa as a payment instrument.

4.2.4 Comparing Decentralized Equilibrium with Social Planner’s Allocation.

As we delineated above, regardless of an entrepreneur’s productivity, the social planner allocates \bar{h} units of supplier input to each entrepreneur. In the decentralized equilibrium with financial market imperfections, access to inputs is determined by an entrepreneur’s trade credit opportunities and the willingness to utilize M-Pesa, where the latter correlates with idiosyncratic productivity shocks. Therefore, in a decentralized market equilibrium the aggregate output of the economy turns out to be lower than the socially optimal level of macroeconomic output. Contractions in M-Pesa adoption and usage fees would therefore increase the quantity of inputs purchased on trade credit and entrepreneurial performance at the firm-level. The counterfactual policy experiments below will aim to quantify the impact of M-Pesa technology in improving the allocation efficiency in the economy and the aggregate economic performance.

4.2.5 Endogenizing Access to Trade Credit

So far we have assumed an exogenous distribution of access to trade credit across entrepreneurs and thus confirmed a uni-directional impact of purchasing inputs on trade credit on the likelihood of M-Pesa use. This result matches the empirical regularity that we documented in section 2. However, in order to evaluate the potential of reverse causality in this empirical pattern, we now argue that access to credit is endogenously determined among entrepreneurs, where in each period an entrepreneur needs to incur a non-monetary loss worth of $\kappa_{i,t}$ units of consumption in order to access the trade credit network. If the entrepreneur does not incur this periodic cost she does not get to borrow trade credit when purchasing inputs from suppliers. The joining the network costs can be associated with building up social capital and credibility vis-a-vis suppliers.

In order to allow for endogenous access to trade credit, we alter the timing of events in the economy such that at the beginning of each period, before productivity shocks are realized, each entrepreneur draws a non-pecuniary “joining the trade-network” cost, denoted by $\kappa_{i,t}$. We assume that κ network costs are drawn from a cumulative distribution function $H(\kappa)$.

The independence of periodic κ -cost from productivity draws - coupled with the trade credit M-Pesa complementarity highlighted above - yields that a rise in M-Pesa usage costs would lower the demand for signing up for a trade credit relationship among those entrepreneurs who have high levels of κ . We summarize this intuitive result in the following proposition.

Proposition 4.7 *Ceteris paribus, a rise in M-Pesa transaction costs reduces the value of a trade credit contract, willingness to cover the network access cost κ_i and the aggregate number of trade credit borrowers.*

An important part of our quantitative analysis will focus on isolating the transmission of the real effects of M-Pesa usage through the extensive margin of trade credit relationships generated in the economy.

4.3 Stationary Equilibrium

The macro variables of the model which can exhibit time-variation are 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 our business survey data - the analysis requires the existence of a stationary equilibrium with active trade credit borrowers. Therefore, we assume that T is finite, and establish the following result concerning the existence of a stationary equilibrium.

Proposition 4.8 *For T finite, the economy exhibits a unique stationary equilibrium characterized by an invariant distribution of trade credit borrowers.*

Proof See the Appendix.

Next we turn to investigating the quantitative properties of the unique stationary equilibrium generated by the model.

5 Benchmark Calibration

In this section we make functional form assumptions and calibrate the stationary equilibrium of the dynamic general equilibrium model to match the key moments observed in the 2014 FinAccess Business Survey data that are important to describe the private sector - that mostly includes SMEs - in the Kenyan economy. In section 6 we will use this quantitative framework to gauge the implications of M-Pesa user costs for trade credit, entrepreneurial output and macroeconomic development. The target moments that we set using the 2014 FinAccess-Business Survey are presented in Table 3.

- Table 3 about here -

As calibration targets, we choose sample moments (means) that are important for assessing the quantitative relevance of our theoretical channel in determining the level of macroeconomic development. Namely, in the stationary equilibrium, using five of our model parameters we aim to match the means observed in the FinAccess Business 2014 for the following five variables: average entrepreneurial profit share, average entrepreneurial input-output ratio, average trade credit-output ratio for those entrepreneurs who utilize trade credit, 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 is one additional sample moment that we are interested in our analysis: The fraction of M-Pesa use among those entrepreneurs who borrow trade credit. The qualitative mechanism from the model suggests that M-Pesa use should be more intense among trade credit borrowers. By not directly targeting this variable with one of our parameters, we put the quantitative relevance of our qualitative mechanism at test. When matching the demand to use M-Pesa - observed in the FinAccess survey - in our model's stationary equilibrium, we make the following assumption 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*.

We assume that the entrepreneurial technology exhibits the following decreasing returns to scale functional form

$$y_{i,t} = A_{i,t} h_{i,t}^\alpha, \quad \text{with } 0 < \alpha < 1. \quad (25)$$

The decreasing returns to scale property generates occasionally binding enforceability constraints in equilibrium - without the need to vary the input suppliers' capacity to produce (\bar{h}) across entrepreneurs. Specifically, given the productivity distribution and the beginning-of-the-period endowment, entrepreneurs of low productivity will not exhaust their borrowing limits. However, we will specify the upper tail of the productivity distribution in such a way that entrepreneurs of high productivity will have binding enforcement constraints. Regarding the qualitative properties of the model; with a decreasing returns to scale production technology - as we have proven in Proposition 4.5 - all entrepreneurs with access to credit would settle *Night* market transactions using M-Pesa (since that result does not depend on the shape of the production) - as long as θ and λ are small enough. As we will present below real-world counterparts of λ and θ are relatively small quantities, giving rise to the applicability of Proposition 4.5. Given such parameterization of the framework, we show in the Appendix of the paper that the decreasing returns to scale technology assumption does not alter the key qualitative findings presented from Propositions 4.1, 4.3, and 4.7 either.

To the end of the productivity distribution, we assume that the idiosyncratic productivity shocks, $A_{i,t}$, are drawn from a uniform distribution and choose the lower-bound productivity as $1/\theta$, which implies that the marginal product of one unit input is at least as high as its marginal cost among entrepreneurs. In addition, we also parameterize the upfront payment requirement as $\omega = 1$, such that given the productivity distribution, all entrepreneurs see some benefits of accessing the trade credit finance. Specifically, the return to trade credit is high for high-productivity types and low for low-productivity types.

In addition to the M-Pesa user costs (λ and f_e), the remainder of the parameter space of the model includes local monopoly rents of the entrepreneur (α), the probability of being subject to theft (θ), the measure of entrepreneurs in the economy (\mathcal{E}), the total number of penalty periods following a default (T) and the discount parameter (β). Finally, we also have the parameter(s) to match the fraction of entrepreneurs with access to trade credit. As we delineated above we consider two versions of the model: (i) exogenous distribution of trade credit access, in which case we will parameterize π (the population share of trade credit users); and, (ii) endogenous distribution of access to trade credit, in which case we will parameterize the distribution of κ_i , the cost of accessing the trade credit network.

The model parameterization under the assumption of exogenous credit distribution is presented in Table 4. When parameterizing the stationary equilibrium of the model, some parameters are calibrated to match the moments observed in Kenyan FinAccess Business Survey, whereas others are assigned with values based on the existing empirical evidence.

- Table 4 about here -

The details of the model parameterization are as follows. We set β as 0.95 - a standard value utilized in the Real Business Cycle Literature. We use a value of 0.95 for θ , which implies that the

likelihood of theft is 5%. This is a quite conservative benchmark when it comes to the probability of theft in Kenya because according to 2011 Afrobarometer survey a 33% of Kenyan households (and 37% of households in Nairobi) report that at least once something has been stolen from their house and 5% of Kenyan households (and 11% of households in Nairobi) state that they feel unsafe when walking in the neighborhood (Afrobarometer Network, 2011). The unit transaction cost associated with M-Pesa use, λ , is set as 1% of each payment made to the supplier by an entrepreneur. By assigning this value to λ we match the prices charged by Safaricom (the operator of M-Pesa) to their customers.²⁰

Next we assign values for f_e , α , e , T and π (or κ -distribution) to match the 5 calibration targets that we listed in Table 3. We set π as 0.25 to match the fraction of the entrepreneurs in the FinAccess Business sample who use trade credit. We choose f_e to match the sample share of entrepreneurs who use the M-Pesa technology when making purchases from the input suppliers, which equals to 0.32. The value of entrepreneurial endowment e is chosen to match the aggregate input-output ratio of 0.31. The input's share in production, α , is calibrated to match the entrepreneurial profit share of 0.45 - observed in FinAccess Business. The total number of penalty periods T is chosen as 2 to match the credit-output ratio of 0.21 for trade credit users. Finally, we use the measure of entrepreneurs (\mathcal{E}) as a scaling parameter, which we choose such that the benchmark aggregate output equals to 100 - net of theft and M-Pesa transaction costs.

- Table 5 about here -

As presented in Table 5, with exogenous trade-credit access we match the targeted sample moments (means) of entrepreneur's profit share, supplier credit-output ratio, and fraction of trade credit users perfectly. We only deviate slightly from the targeted fraction of M-Pesa users in the economy. 32% of all entrepreneurs in the FinAccess Business sample utilize M-Pesa when making input purchases from their suppliers. Our calibration exercise, where we use the parameter f_e (the fixed cost of M-Pesa adoption) to match the moment of interest, generates a population fraction of M-Pesa user SMEs equaling to 34%. Similarly, we do not match the average input-output ratio perfectly, where the sample mean equals 0.31, while our model produces an input-output ratio of 0.39.

The key theoretical result 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 we leave the fraction of M-Pesa user trade credit borrowers as a free (un-targeted) variable and investigate the performance of our parameterized model in matching it. The fraction of M-Pesa using trade credit borrowers in FinAccess Business sample is about 42%. The parameterized model

²⁰The costs for using M-Pesa is a step function that decreases by transaction amount. On average, sending money to another M-Pesa user costs 0.2% 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> on February, 2015.

generates a fraction of M-Pesa users among trade credit borrowers equaling to 45%. This close match supports the quantitative validity of our qualitative mechanism and also indicates that the parameterized model can be utilized to conduct counterfactual policy exercises to understand the interactions between M-Pesa, trade credit and economic performance.

In Table 6, we parameterize the alternative model, where we allow for endogenous selection into the trade credit network. In this alternative specification, we incorporate a trade credit choice into the timeline that we presented in section 3. Specifically, at the beginning of each period, before productivity shocks are realized, each entrepreneur draws a “joining the trade-network” cost, denoted by $\kappa_{i,t}$. An entrepreneur becomes eligible to borrow from the trade credit network if she covers the periodic κ -cost. We assume that κ is distributed uniformly between the interval $[0, \bar{\kappa}]$. We calibrate $\bar{\kappa}$ to match the fraction of trade credit borrowers (0.25) among the sample of SMEs.

- Tables 6 about here -

Trade credit networking costs are non-monetary. Therefore, this assumption coupled with the timing of events that we presented in section 4 implies that the performance of the calibrated model in replicating the data is exactly the same across the two alternative calibration frameworks. To be precise, the timing of κ draw which leads the draw of A produces the model performance that we present in Table 7 which is identical to what we have obtained in Table 5.

- Tables 7 about here -

6 Counterfactual Analysis

In order to understand the role of M-Pesa technology for entrepreneurial performance and economic development in Kenya, we run counterfactual policy exercises to quantify the importance of the M-Pesa use in alleviating the frictions between entrepreneurs and suppliers in the Kenyan economy. In the first counterfactual, we utilize the model with exogenous trade credit use and gauge how the economic performance of the Kenyan economy would have looked like if entrepreneurs did not have access to M-Pesa when making purchases from their suppliers. In order to answer this question, we use our parameterized model and hypothetically shut down the access to M-Pesa in supplier relationships.²¹ The quantitative results from this hypothetical exercise are presented in Table 8.

- Table 8 about here -

Eliminating the use of M-Pesa from business-supplier relationships causes an expansion in the input-output ratio, mostly because entrepreneurial output contracts following the shutting-down

²¹In other words we raise the cost of M-Pesa technology so high that entrepreneurs do not end up utilizing this technology when making purchases from their suppliers.

of the M-Pesa technology. Similarly, the credit-output ratio contracts when we eliminate the M-Pesa use because of the increasing likelihood of theft in the economy, which makes the financial constraints tighter for borrowers with access to trade credit.²² Finally, and most importantly, as a result of these adjustments, the macroeconomic output of the economy (the aggregate output generated by the SMEs) contracts by 0.33%. While this seems like a small change in the level of macroeconomic development, we would like to note that the impact of M-Pesa use on the macroeconomy is determined by the extent of theft. With a higher probability of theft (low θ) the impact of M-Pesa on entrepreneurial as well as macroeconomic performance would be larger. Therefore, this quantitative result lets us conclude that the use of M-Pesa when making input purchases from suppliers is quantitatively important in alleviating transaction frictions in business-supplier relationships and in turn for macroeconomic development in countries like Kenya with high information asymmetries, enforcement constraints and incidence of theft.

Our theoretical results suggest a strong interaction between access to trade credit and the use of M-Pesa when making input purchases. In this respect, next we turn to the model with “endogenous trade credit allocations” and run a counterfactual exercise in order to isolate the feedbacks through changes in trade credit access on entrepreneurial performance and macroeconomic development. We present the counterfactual quantitative exercise with endogenous trade credit selection in Table 9. When the trade credit relationship is an endogenous choice variable for an entrepreneur, due to the complementarity between M-Pesa and the value of trade credit relationships, shutting down the M-Pesa technology lowers the fraction of trade credit borrowers by 1 percentage point. The decline in trade credit relationships further suppresses the macroeconomic development and causes a total contraction in macro output by 0.47%. This quantitative result allows us to highlight the strong interaction between trade credit and M-Pesa as an important determinant of the economic consequences of the mobile money technology.

- Table 9 about here -

Finally, to assess the economic importance of the mechanism we have proposed, we calculate its contribution to economic growth of Kenya since the introduction of M-Pesa in 2007. The existence of mobile money agents is crucial for allowing smooth transactions between users of mobile money. The nationwide statistics from Safaricom shows that the total quantity of mobile money agents in the country who convert M-Pesa units into cash and vice versa levelled off as of the end of 2013. Kenyan total factor productivity grew 3.3% between 2006 and 2013. The quantitative exercise resulting from the “endogenous trade-credit access specification” implies that M-Pesa generates 0.47% per-capita income growth for the Kenyan economy.²³ This means that the mechanism we have proposed can

²²We would like to note that the fraction of trade credit borrowers do not change in this exercise, since access to trade credit allocation is set exogenously at 25%.

²³The macroeconomic output in our quantitative analysis is the output aggregation over construction, wholesale, retail trade, hotels, restaurants, manufacturing, real estate, education, transport, communication, and other

explain 14% of per-capita real income growth over the same period of time, suggesting quite a large macroeconomic impact of mobile money through its effect on entrepreneurial finance.

7 Sensitivity Analysis

In this section, we provide an analysis for the sensitivity of our qualitative findings and counterfactual experiments with respect to the two key assumptions concerning the incidence of theft. Specifically, so far we have assumed that

- (a) stolen cash does not get to re-enter the economy - inducing theft to be fully inefficient, and
- (b) theft is private information - an assumption which interacts with our limited enforceability constraint.

In sections 7.1 and 7.2 we relax assumptions (a) and (b), respectively, and study the consequences of these exercises for our theoretical and quantitative results.

7.1 Aggregate costs of theft

Suppose that the stolen consumption good (in the form of cash) does not leave the economy but it can be utilized for consumption purposes by *thieves*. Thieves are infinitely-lived agents, who don't have access to a production technology but to know-how to steal. We continue to assume that entrepreneurs 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 (privately as in the benchmark economy), whose life-time preferences are given as follows

$$E_0 \sum_{t=0}^{\infty} \beta^t (\delta c_{\tau,t}), \quad (26)$$

where $0 < 1 - \delta < 1$ is the cost of consuming stolen items (e.g. due to social and legal sanctions) and δ measures the degree of efficient use of stolen items in the economy. Since thieves do not have access to a productive technology and δ is less than 1, the planner would not distribute any funds to thieves at a socially efficient allocation in a first-best world. Under this alternative specification the consumption of thieves will enter the macroeconomic welfare, which the individual entrepreneurs won't take into account when choosing payment methods. Therefore, the quantitative results stemming from the counterfactual policy experiments are expected to be different. Since

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. We calculate the total factor productivity growth in 2006-2013 by using the methodology in Beck et al (2000). Data for income per capita, capital stock per capita, share of labor compensation and capital depreciation rate for Kenya are from Feenstra et al. (2013) and UNSTAT(2014). The details of the calculation are available upon request.

the behavior of individual entrepreneurs in the economy remain as in the benchmark model, the qualitative interactions between the choice of M-Pesa as a payment method and trade credit are identical to what had been derived in section 4.

We turn next to investigating the quantitative effects of M-Pesa. The calibration of the model parameters under this alternative framework - naturally - remain identical to what we have obtained in section 5, because the welfare of thieves does not alter the firm-level decisions and the aggregate statistics that we match using our firm-level data. In order to investigate counterfactuals we need to parameterize δ . And to this end, in our experiments we gradually raise the level of δ from its benchmark value (0) to study the macroeconomic welfare loss generated by shutting down access to the M-Pesa technology at entrepreneur-supplier transactions.

- Table 10a and 10b about here -

Tables 10a and 10b present the quantitative exercises. In 10a (10b) we vary δ and investigate the aggregate consumption loss due to inability to use M-Pesa in a model with exogenous (endogenous) access to credit. With exogenous access to trade credit, as we increase the level of δ - as expected - the aggregate welfare loss goes down that is generated from a counterfactual, which shuts down M-Pesa as a payment method. The intuition for this quantitative result is clear: theft generates a redistribution and M-Pesa use limits this redistribution. The higher the efficient use of the redistributed funds (measured by δ), the lower is the value of M-Pesa as a payment instrument for the macroeconomic well-being.

Moreover, our quantitative experiments in 10a also reveal that when $\delta = 0.75$ the aggregate loss from our contractual turns out be slightly negative, i.e. M-Pesa reduces aggregate welfare. This result is very important from a quantitative point of view. M-Pesa reduces the incidence of theft, but it comes with electronic transaction costs (periodic cost f_e and the variable cost λ). 10a shows that when δ is large enough, the aggregate benefits from redistributing fractions of entrepreneurial funds (by theft) outweighs the benefits of M-Pesa net of electronic transaction costs. Hence, for $\delta = 0.75$ given the empirically observed electronic transaction costs, M-Pesa turns out to be a counterproductive financial development product. For this particular case although M-Pesa improves individual welfare and avoids theft at the firm-level, M-Pesa's aggregate productivity benefits - mitigated by the welfare of thieves, which individual firm owners do not take into account when choosing payment methods - do not compensate the electronic transaction costs. Therefore, in a second-best world, where the incidence of theft cannot be prevented, within the boundaries of our calibrated model a social planner would not allow the development of a mobile payment instrument if the redistributive effects generated by theft is large enough.

Table 10b repeats the same counterfactual for the case of endogenous trade credit formation. When trade-credit network of firms are endogenously determined, as we have analyzed before, the equilibrium implications of M-Pesa use are much more substantial. Therefore, Table 10b shows

that rising δ reduces the positive welfare consequences of M-Pesa with endogenous credit as well, but different from what we obtained in Table 10a, for this case even for δ large enough the net aggregate M-Pesa benefit produced by our calibrated model turns out to be positive.

7.2 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. Since theft is 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 (due to theft) from accessing the credit market - equalizing the value of future credit market access for both M-Pesa and cash users at the level of an endogenously determined V . Cash use still requires a higher repayment burden (interest payment to the supplier to compensate him for the risk of non-repayment) though due to the likelihood of the non-repayment state caused by theft. Therefore, the creditless A^* -entrepreneur (from section 4 who is indifferent between using cash and M-Pesa) would prefer to use M-Pesa over cash in the *Night*-subperiod (in addition to the *Day*-subperiod transaction) if

$$\left(A^* - \frac{1}{\theta}\right)V < (A^* - 1)V - \lambda V,$$

which after re-arranging terms yields the condition

$$\lambda < \frac{1 - \theta}{\theta}. \tag{27}$$

Inequality (27) reveals that the likelihood of an entrepreneur with a productivity draw of A^* committing to use M-Pesa at the credit repayment stage depends on the parameter conditions of the economy. This condition is satisfied at the benchmark values that we assigned to λ ($= 0.01$) and θ ($= 0.05$) in section 5.

- Table 11a and 11b about here -

Publicly verifiable theft lowers the quantitative implications of M-Pesa use on relaxing financing constraints - 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 to sign up for trade credit relationships. We evaluate the quantitative implications of M-Pesa with publicly verifiable theft at tables 11a and 11b - with and without endogenous trade credit formation. The counterfactual of shutting down M-Pesa deteriorates entrepreneurial performance and causes a macroeconomic output loss of 0.23% (0.30%) with exogenous (endogenous) trade credit as oppose to the 0.33% (and 0.47%) of output loss we have uncovered in section 6. These results indicate that an overall 33-36%

of the aggregate effects of M-Pesa on macroeconomic output is channelled through relaxing the enforceability constraints associated with entrepreneurs' trade credit limits.

8 Conclusion

Building a dynamic general equilibrium model, with key market frictions found in many developing countries - notably information asymmetries, enforcement constraints and theft - and calibrating it to recent firm-level survey data from Kenya, we show that 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 apply for trade credit. Our model shows significant quantitative effects on both firm- and aggregate level of more efficient payment methods.

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. Therefore, the analysis of this paper shows that mobile money technology is not only welfare-enhancing for households as the recent literature pointed out, but also growth-enhancing through its impact on firms' access to external funding.

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Table 2A: Probit estimates for paying to suppliers via mobile money and business characteristics

	(1)	(2)
	marg. eff.	s. e.
Productivity	0.02**	(0.01)
Purchasing supplies on credit	0.17***	(0.04)
Personal business account	0.13	(0.08)
Business 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)
<i>Age</i>	-0.02*	(0.01)
<i>Age</i> ²	0.00	(0.00)
Observations	1,044	

Notes: This table shows the estimation results for the correlation between using mobile money to pay to suppliers and business characteristics. We estimate $Y_i = \beta_0 + X_i' \beta_1 + \epsilon_i$ for all specifications where i denotes the firm and X_i is the business characteristics, and Y_i equals to 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 to the estimations. To control for missing observations due to refusing to answer and not knowing, we add dummy variables for each reason. * p<0.1. ** p<0.05. *** p<0.01

Table 2B: Stability test

	(1)	(2)	(3)	(4)	(5)
Purchasing supplies on credit	0.12*** (0.04)	0.16*** (0.04)	0.14*** (0.04)	0.16*** (0.04)	0.17*** (0.04)
Productivity		0.03*** (0.01)	0.02*** (0.01)	0.02** (0.01)	0.02** (0.01)
Personal account			0.15* (0.08)	0.13 (0.08)	0.13 (0.08)
Business account			0.11* (0.06)	0.08 (0.06)	0.08 (0.06)
Registered			-0.12*** (0.04)	-0.14*** (0.04)	-0.14*** (0.04)
Accountant			0.14*** (0.04)	0.10*** (0.04)	0.10*** (0.04)
Secondary education				-0.15 (0.13)	-0.15 (0.13)
College education				0.06 (0.17)	0.07 (0.17)
University education				0.09 (0.17)	0.09 (0.17)
Graduate education				0.12 (0.18)	0.13 (0.18)
Male				0.06 (0.04)	0.07* (0.04)
Age				-0.02* (0.01)	-0.02* (0.01)
Age2				0.00 (0.00)	0.00 (0.00)
Observations	1,047	1,044	1,044	1,044	1,044
Pseudo R2	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 using mobile money to pay to suppliers and business characteristics. We estimate $Y_i = \beta_0 + X_i' \beta_1 + \epsilon_i$ for all specifications where i denotes the firm and X_i is the business characteristics. 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. To control for missing variables, we add dummy variables for "refusing to answer" or "not knowing" answers when it is relevant. * p<0.1. ** p<0.05. *** p<0.01

Table 3: Calibration Targets

Variable	Kenyan Economy (Mean)
Entrepreneur's Profit Share	0.45
Input-Output ratio	0.31
Supplier Trade Credit-Output Ratio for Trade Credit Users	0.21
Fraction of Trade Credit Relation with Suppliers	0.25
Fraction of M-Pesa Users	0.32

Table 4: Model Parameterization for the Kenyan Economy - with Exogenous Credit Allocation

Parameter	Value	Motivation
α	0.55	To match the average share of entrepreneurial profits (in FinAccess Survey)
e	0.29	To match average input-output ratio
β	0.95	The standard value used in the RBC-Growth literature
λ	0.01	M-Pesa Transaction Costs retrieved from Safaricom website on February 2015
f_e	0.065	To Match fraction of M-Pesa user SMEs (in FinAccess)
θ	0.95	As evidenced by Afrabarometer Network (2011)
\mathcal{E}	98.46	To match the macroeconomic output of 100 in benchmark calibration
π	0.25	To match the fraction of SMEs with Trade Credit Relation (in FinAccess)
T	2	To match the average trade credit-output for borrowers (in FinAccess)

Table 5: Benchmark Model vs. Kenyan Economy - with Exogenous Credit Allocation

	Model	Kenyan Economy
Entrepreneur's Profit Share	0.45	0.45
Input-output ratio	0.39	0.31
Supplier credit-output ratio	0.21	0.21
Fraction of Trade Credit Users	0.25	0.25
Fraction of M-Pesa Users	0.34	0.32
Fraction of M-Pesa Users in with Supplier-Credit	0.45	0.42

Table 6: Model Parameterization for the Kenyan Economy - with Endogenous Credit Allocation

Parameter	Value	Motivation
α	0.55	To match the average share of entrepreneurial profits (in FinAccess Survey)
e	0.29	To match average input-output ratio
β	0.95	The standard value used in the RBC literature
λ	0.01	M-Pesa Transaction Costs retrieved from Safaricom website on February 2015
f_e	0.065	To Match fraction of M-Pesa user SMEs (in FinAccess)
θ	0.95	As evidenced by Afrabarometer Network (2011)
\mathcal{E}	98.46	To match the macroeconomic output of 100 in benchmark calibration
$\bar{\kappa}$	1.02	To match the fraction of SMEs with Trade Credit Relation (in FinAccess)
T	2	To match the average trade credit-output for borrowers (in FinAccess)

Table 7: Benchmark Model vs. Kenyan Economy - with Endogenous Credit Allocation

	Model	Kenyan Economy
Entrepreneur's Profit Share	0.45	0.45
Input-output ratio	0.39	0.31
Supplier credit-output ratio	0.21	0.21
Fraction of Trade Credit Users	0.25	0.25
Fraction of M-Pesa Users	0.34	0.32
Fraction of M-Pesa Users in with Supplier-Credit	0.45	0.42

Table 8: Counterfactual of Shutting M-Pesa Down with Exogenous Credit Allocation

Macroeconomic Output Loss	0.33%
Entrepreneur's Profit Share	0.45
Input-output ratio	0.40
Supplier credit-output ratio	0.19
Fraction of Trade Credit Users	0.25
Fraction of M-Pesa Users	0
Fraction of M-Pesa Users in with Supplier-Credit	0

Table 9: Counterfactual of Shutting M-Pesa Down with Endogenous Credit Allocation

Macroeconomic Output Loss	0.47%
Entrepreneur's Profit Share	0.45
Input-output ratio	0.41
Supplier credit-output ratio	0.18
Fraction of Trade Credit Users	0.24
Fraction of M-Pesa Users	0
Fraction of M-Pesa Users in with Supplier-Credit	0

Table 10a: M-Pesa Counterfactual with Exogenous Credit and Theft Re-entry

	$\delta = 0$ (Benchmark)	$\delta = 0.25$	$\delta = 0.50$	$\delta = 0.75$
Aggregate Welfare Loss	0.33%	0.21%	0.09%	-0.04%
Entrepreneur's Profit Share	0.45	0.45	0.45	0.45
Input-output ratio	0.40	0.40	0.40	0.40
Supplier credit-output ratio	0.19	0.19	0.19	0.19
Fraction of Trade Credit Users	0.25	0.25	0.25	0.25
Fraction of M-Pesa Users	0	0	0	0
Fraction of M-Pesa Users in with Supplier-Credit	0	0	0	0

Table 10b: M-Pesa Counterfactual with Endogenous Credit and Theft Re-entry

	$\delta = 0$ (Benchmark)	$\delta = 0.25$	$\delta = 0.50$	$\delta = 0.75$
Aggregate Welfare Loss	0.47%	0.35%	0.23%	0.10%
Entrepreneur's Profit Share	0.45	0.45	0.45	0.45
Input-output ratio	0.41	0.41	0.41	0.41
Supplier credit-output ratio	0.18	0.18	0.18	0.18
Fraction of Trade Credit Users	0.24	0.24	0.24	0.24
Fraction of M-Pesa Users	0	0	0	0
Fraction of M-Pesa Users in with Supplier-Credit	0	0	0	0

Table 11a: M-Pesa Counterfactual with Exogenous Credit and Publicly Verifiable Theft

Aggregate Welfare Loss	0.23%
Entrepreneur's Profit Share	0.45
Input-output ratio	0.40
Supplier credit-output ratio	0.20
Fraction of Trade Credit Users	0.25
Fraction of M-Pesa Users	0
Fraction of M-Pesa Users in with Supplier-Credit	0

Table 11b: M-Pesa Counterfactual with Endogenous Credit and Publicly Verifiable Theft

Aggregate Welfare Loss	0.30%
Entrepreneur's Profit Share	0.45
Input-output ratio	0.40
Supplier credit-output ratio	0.20
Fraction of Trade Credit Users	0.24
Fraction of M-Pesa Users	0
Fraction of M-Pesa Users in with Supplier-Credit	0

Figure 1: Share of businesses using mobile money to pay to their suppliers according to 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 according to whether the businesses have credit relationship with input suppliers and the 95% statistical confidence levels for those shares after controlling for other business characteristics. To reach to predicted shares, we estimate the model for which the estimation results are shown in Table 2.

- DAY**
- Idiosyncratic productivity shocks, $A_{i,t}$, are realized.
 - Entrepreneurs receive beginning of the period endowment e .
 - Credit types (π and $1 - \pi$) are determined.
 - 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 paid (periodic f_e and variable λ).
 - Agents consume.

Figure 2: Timing of Events

Appendix

Proof of Proposition 4.6

Let \mathcal{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 $q(1 - \theta)\mathcal{C}_t$. The inflow of entrepreneurs into the credit market in period $t + 1$, who had defaulted in period $t - T$ is $q(1 - \theta)\mathcal{C}_{t-T}$. From here, we can note that as long as

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

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 $\mathcal{C}_t = \mathcal{C}_{t-T}$ holds. Starting with period-1, with a T -period default penalty (for $T \geq 2$) we can note that $\mathcal{C}_1 > \mathcal{C}_2 > \dots > \mathcal{C}_T > \mathcal{C}_{T+1}$. While the outflow of entrepreneurs from the credit market who will not be eligible to borrow in period $T + 2$ equals to $q(1 - \theta)\mathcal{C}_{T+1}$, the inflow of agents in period $T + 2$ is $q(1 - \theta)\mathcal{C}_1$. Since $\mathcal{C}_1 > \mathcal{C}_{T+1}$, we note that $\mathcal{C}_{T+2} > \mathcal{C}_{T+1}$. Formally, defining $z \equiv q(1 - \theta)$

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

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

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

for all t . Hence, $\lim_{t \rightarrow \infty} \mathcal{C}_t = \bar{\mathcal{C}} > 0$. \square

Generalizing Qualitative Properties for a DRS Technology

We start with Proposition 4.1 which highlights that entrepreneurs of higher productivity - in the absence of access to trade-credit - are relatively eager to utilize M-Pesa in the *Day* market compared to entrepreneurs with low productivity. This result holds also when we assume a decreasing returns to scale (DRS) production technology ($y = A_i h^\alpha$) for an entrepreneur. To observe this, with a DRS

technology using the notation from Section 4, we can note the following:

$$\begin{aligned}\tilde{U}_{p,t} &= A_{\ell,t}e^\alpha - \lambda e - f_e + U, \\ \tilde{U}_{f,t} &= \theta A_{\ell,t}e^\alpha + U,\end{aligned}$$

which solves for the critical A^* as $(1 - \theta)A^* = \frac{f_e}{e^\alpha} + \lambda e^{1-\alpha}$. The critical A^* implies that the higher productivity of a spot-trader, the larger would be her willingness to pay in the *Day* market transactions.

Next we turn to the applicability of Proposition 4.3 under the DRS technology: first given the parameterization of the quantitative model Proposition 4.5 applies, which allows us to argue that all borrowers use M-Pesa in *Night* market transactions. Taking this as given, all we need to show for the validity of Proposition 4.3 is whether the entrepreneur with productivity- A^* would strictly prefer M-Pesa when transacting in the *Day* market. To this end, A^* would have a strict preference towards M-Pesa if

$$\underbrace{A^*(e + b_{i,t})^\alpha - \lambda e - f_e - b_{i,t} - \lambda b_{i,t} + U + V}_{\tilde{V}_{p,t}} > \underbrace{\theta[A^*(e + b_{i,t})^\alpha - b_{i,t} - \lambda b_{i,t}] + U + V}_{\tilde{V}_{f,t}}.$$

Since A^* is defined as $(1 - \theta)A^*e^\alpha = \lambda e + f_e$, we replace the value of A^* in this inequality to get:

$$(1 - \theta)[A^*(e + b_{i,t})^\alpha - b_{i,t} - \lambda b_{i,t}] > (1 - \theta)A^*e^\alpha.$$

The left hand side of this expression is always greater than the right hand side (and hence A^* strictly prefers M-Pesa in *Day* market transactions), because $b_{i,t} > 0$ is determined as a result of entrepreneur's profit maximization problem - regardless of whether the enforcement constraint is binding or not.

Finally, the Proposition 4.7 simply follows since the result at Proposition 4.7 builds upon the applicability of Proposition 4.3.

An Extension: Firm Capital Accumulation

The dynamic general equilibrium model that we calibrated using Kenyan 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 observed 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 dataset, 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. 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.

The remaining question to be addressed is whether allowing for business capital accumulation would wipe out the qualitative mechanism of our model that generates the complementarity between the demand for trade credit and the use of M-Pesa when transacting with suppliers. In this section, by extending the theoretical model from section 3, we theoretically show that allowing for capital accumulation dynamics as a matter of fact could strengthen the interactions between demand to use M-Pesa and trade credit. In order to evaluate this additional theoretical channel, let us suppose that the production technology of the entrepreneur takes the following form:

$$y_{i,t}(h_{i,t}) = \begin{cases} A_{i,t}(1+k)h_{i,t} & \text{if } i_{i,t-1} \geq k, \\ A_{i,t}h_{i,t} & \text{if } i_{i,t-1} < k, \end{cases} \quad (28)$$

where $i_{i,t-1}$ is entrepreneur i 's investment in business capital. 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 straightforward capital accumulation procedure: As long as $i_{i,t}$ is greater or equal to some exogenously fixed-capital stock level k , 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 $i_{i,t}$, the firm does not get to accumulate any capital stock. Business capital is complementary to supplier provided inputs as presented at specification (28). We assume that capital investment is irreversible and capital utilized in production depreciates completely.

Assumption 2. $\frac{1}{\theta} > 1 + k$.

Assumption 2 will carry the important equilibrium implication that the continuation value of accessing trade credit as an M-Pesa user would exceed the continuation value of trade credit as a cash-user for all realizations of idiosyncratic productivity shocks. This assumption helps us to avoid a degenerate distribution of M-Pesa vs. cash use in equilibrium among trade credit borrowers. We keep the remaining structure of the model unchanged from the case of exogenous trade credit specification and furthermore assume that the decision to invest into next period's capital stock is undertaken before consumption (and after the periodic M-Pesa costs are paid) in the timing of events. Given this structure, we can derive the following result.

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

Proof First, let us evaluate the cutoff productivity level at a creditless entrepreneur-supplier relationship. Assuming without loss of generality that the entrepreneur accumulated capital in the previous period and denoting the cut-off entrepreneur who is indifferent between using M-Pesa and cash at a creditless relationship with \hat{A} , we can derive

$$\hat{A}(1 - \theta)(1 + k)e = \lambda e + f_e + U_f - U_p, \quad (29)$$

where U_f is the continuation value of a creditless relationship when the entrepreneur uses cash at current period transactions while U_p is the continuation value of a creditless relationship when the entrepreneur uses M-Pesa. Different from the benchmark model, in this extension we have to differentiate between U_p and U_f because the continuation value depends on having a built-in capital stock for the next period, which in turn hinges on whether the entrepreneur could accumulate enough proceedings at the end of the period or not. Briefly, for \hat{A} low enough business capital cannot be invested, hence $U_p = U_f$. For interim-levels of \hat{A} business capital can be invested only if the entrepreneur does not pay M-Pesa transaction fees; and at the same time, also if the entrepreneur does not experience a theft shock (and can produce). Therefore, when \hat{A} takes mediocre values, we get $U_f > U_p$. A third case arises if \hat{A} is high enough, under which case business capital can be accumulated after paying M-Pesa fees. In this third scenario, we have $U_p > U_f$ because if cash is used in market transactions there is a likelihood that capital investment cannot be made due to the theft shock that would prevent the entrepreneur from producing.

Next, similar to our analysis in section 4, we ask the question whether the cut-off entrepreneur with productivity \hat{A} and built-in business capital k would turn out to strictly prefer using M-Pesa in supplier transactions in the market if she would have had access to a “trade credit contract”. We would like to first note that given assumption 2, the continuation value of accessing trade credit with M-Pesa use (V_p) and with cash (V_f) will always satisfy $V_p \geq V_f$. The reason for that is as follows: In the benchmark specification without capital accumulation, we had $V_p = V$ and $V_f = \theta V$. With business capital investment, for interim values of \hat{A} the business can only invest in capital if the entrepreneur risks taking cash to the market. In this case the complementarity of capital to production can raise V_f above θV but given assumption 2 the highest value that V_f could ever attain is V_p . We can express the current values of using M-Pesa and cash at “credit-based” supplier transactions as the following:

$$V_{p,t} = \left[\hat{A}(1 + k)e + (\hat{A} - 1)(1 + k)V_p \right] - [\lambda(e + V_p) - f_e] + V_p + U_p, \quad (30)$$

$$V_{f,t} = \theta \left[\hat{A}(1 + k)e + (\hat{A} - 1)(1 + k)V_f \right] + \theta V_f + U_f. \quad (31)$$

Utilizing (29) in (30) and (31), for low levels of \hat{A} (such that $V_p = V_f$) we can show that the entrepreneur strictly prefers M-Pesa over cash ($V_{p,t} > V_{f,t}$) because $1 > \theta$. For \hat{A} high enough, such

that the cost of capital investment could be covered after paying periodic M-Pesa fees, we will have $V_p > V_f$. For this case, the valuation of M-Pesa use would also strictly dominate the valuation of cash use because $V_{p,t} > V_{f,t}$ is expressed as

$$\theta \hat{A}(1+k) > 1, \tag{32}$$

and furthermore, comparing the condition for strict M-Pesa usage at (32) (with capital accumulation) against the condition for strict M-Pesa usage without capital accumulation that we derived at (24), we can observe that the likelihood of the \hat{A} -entrepreneur to switch to M-Pesa when she has access to a trade credit contract is relatively higher when capital accumulation is allowed. We can conclude with this qualitative finding because of the presence of the $(1+k)$ multiplier on the left-hand-side of (32). \square

This result indicates that the absence of firm-level capital dynamics is not necessarily critical for our qualitative results. To the contrary, allowing for capital accumulation might even strengthen the interaction between the demand to use M-Pesa and trade credit and the consequences of M-Pesa use for entrepreneurial performance and the macroeconomy.

Survey Questions from FinAccess Business 2014

1. 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.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)
 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)
- 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