Payment Instruments, Enforceability and Development: Evidence from Mobile Money Technology[*][†]

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Abstract

The relationship between efficient payment instruments and enforcement constraints is studied in the context of economic development. Using a novel enterprise survey from Kenya, we document a strong positive association between the use of mobile money as a method to pay suppliers and access to trade credit. We propose a dynamic general equilibrium model with heterogeneous entrepreneurs, limited financial commitment and the risk of theft to account for this empirical pattern. Mobile money dominates fiat money as a medium of exchange in its capacity to avoid theft, but it comes with electronic transaction costs. The interaction between risk of theft and limited enforcement of trade credit contracts generates demand for mobile money as a payment method with suppliers. The use of mobile money in turn reinforces valuation of trade credit contracts and relaxes enforcement constraints. Calibrating the stationary equilibrium of the model to match a set of moments in Kenyan enterprise data, the importance of the endogenous interactions between mobile money and trade credit on entrepreneurial performance and macroeconomic development is investigated.

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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*.

Could the development of an efficient payment technology relax financial constraints and boost business investment and growth? In particular, for the context of the developing world, does digital money help small businesses gain access to credit? We address these questions by focusing on a key financial revolution, which has drawn the attention of many researchers and policy makers over the recent years: The mobile money technology M-Pesa, an SMS-based money transfer and monetary storage tool, initially developed in Kenya, but now being used in other developing countries across the globe.

While an expanding literature worked on understanding the effect of mobile money (and other digital payment services) on household welfare, this paper assesses the interactions between the use of mobile money as a payment method and enforceability of trade credit contracts for entrepreneurial firms. We develop a dynamic general equilibrium model with heterogeneous firms to evaluate the supplier credit and firm-level performance effects of a technologically advanced payment technology - featuring the properties of M-Pesa - in an economy with credit imperfections, information asymmetries and risk of theft.[1] The key qualitative finding from the model uncovers a complementarity between using mobile money to pay suppliers and quantity of inputs purchased on trade credit. Empirical evidence from a recent Small-and-Medium-Size Enterprise (SME) survey data coming out of Kenya (FinAccess Business 2014) supports this novel theoretical property. The dynamic general equilibrium model also reveals that the availability of a mobile money technology as a payment instrument can significantly contribute to business development (through relaxing financial constraints) and stimulate macroeconomic performance. Calibrating our model to a set of moments from the Kenyan SME survey data, we find that the availability of the mobile money technology could raise the macroeconomic output by 0.33-0.47%.

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

After its launch in 2007, M-Pesa[2] rapidly became the payment method of choice across Kenya. 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 for payment purposes costs less than bank transfers. As of 2011, 70 percent of adult population in Kenya had an M-Pesa account (Jack and Suri (2014)). There was already a substantial demand for money transfer before the introduction of M-Pesa[3], 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 they were subject to risk of appropriation and theft. Data from the World Bank's Enterprise Survey suggests that every year Kenyan manufacturing firms loose about 2 percent of product values due to theft - which equals to twice the world average - from shipping to remote domestic markets. Similarly, 29 percent of Kenyan firms experience losses due to theft and vandalism (compared to the world average of 22 percent). According to the World Bank Enterprise Survey, 82 percent of firms pay for security services in order to avoid theft in Kenya, compared to the world average of 56 percent. By providing a cheaper and safer money transfer tool, the use of M-Pesa technology expanded rapidly and became the most frequently and widely utilized electronic money instrument for private purposes in the country (Jack and Suri (2011)).

In addition to enhancing money transfer from one household to another, M-Pesa technology serves as an electronic payment instrument at entrepreneurial firms as well. Having said this one should also note that the penetration of M-Pesa as a commonly accepted method of payment at Kenyan businesses has been far slower compared to the adoption rates of M-Pesa among households. In a recent survey of 1,047 Nairobian SMEs (FinAccess Business Survey 2014), 35 percent of firms report that they accept M-Pesa as a common method of payment from their customers. Similarly,

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

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

on the supply side, about 32 percent of the firms state that they use M-Pesa as a tool when paying to their suppliers. These statistics document that at most one out of three SME in Kenya adopts and uses the M-Pesa technology to run its operations.

In this paper, we study the use of the M-Pesa technology as a method of payment to ease input purchases by SMEs. Specifically, using the Kenyan FinAccess Survey our regression analysis shows that after controlling for a large number of business and owner characteristics to have a trade credit contract with suppliers exhibits a strong positive covariance with enterprises' M-Pesa use when settling payments with suppliers. Figure 1 summarizes this finding and shows that the predicted probability of using mobile money when purchasing inputs is significantly higher for businesses who receive trade credit from their suppliers. This empirical finding is consistent with causality going into either direction, as we will also explore model in our theoretical framework.

- Figure 1 About Here -

To account for this empirical pattern, we propose a dynamic general equilibrium model of entrepreneurial finance. In our model, entrepreneurs are heterogeneous in their ability to access trade credit and randomly draw idiosyncratic productivity shocks and get hit by monetary theft. Theft erodes an entrepreneur's fiat money balances; in addition, for borrowers it causes a discontinuation of access to trade credit due to non-repayment. We model the M-Pesa technology as a resolution mechanism to theft - as highlighted in the previous literature.[4] The analytical solution of the model matches the empirical observation that enterprises with access to trade credit, ceteris paribus, are more willing to adopt and use the M-Pesa technology. Trade credit allows higher entrepreneurial production, which complements and raises the likelihood of M-Pesa use. There are two channels through which M-Pesa use raises a 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; if an entrepreneur's initial endowment is stolen, it is not only the endowment loss that affects the entrepreneur but also the inability to utilize this endowment as collateral in raising the capacity to produce by borrowing. Similarly in the case of theft at the *trade-credit-repayment stage*, theft is not

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

only associated with the loss of the current value of cash but also the loss of future credit market access. The use of M-Pesa therefore reduces the future credit market valuation for an entrepreneur, which in turn relaxes financial constraints to raise the quantity of trade redit that the entrepreneur can borrow. Second, given the risk of theft, the contracted interest rate and therefore repayment burden is lower for M-Pesa users than users of cash, which shrinks the quantity of inputs that an entrepreneur can purchase on credit.

We also extend this theoretical set-up and provide entrepreneurs with an option to endogenously select into trade-credit relationships. This extension allows us to capture that at the extensive margin access to M-Pesa technology stimulates demand for trade-credit and vice versa.

We calibrate the stationary equilibrium of the model to match a set of moments that we observe in the Kenyan FinAccess Business Survey 2014. The parameterized model matches the Kenyan SME data well along the dimensions that we calibrate as well as an important additional statistics that we do not target directly, which is the fraction of M-Pesa users among trade-credit borrowers. Using the parameterized model, we conduct a counterfactual quantitative exercise, where we shut down the access to M-Pesa technology for entrepreneurs when purchasing inputs from suppliers. Eliminating the use of M-Pesa from SME-supplier relationships causes a contraction in overall supplier credit in the economy, therefore lower use of inputs, and ultimately lower output. As a result of these changes, the macroeconomic output of the economy (the aggregate output generated by the SMEs) contracts by 0.33% in the model where access to trade credit is exogenously distributed among SMEs. This result lets us conclude that the use of a technologically advanced monetary instrument when making input purchases from suppliers is quantitatively relevant for alleviating transaction frictions in SME-supplier relationships and in turn for macroeconomic development. In the alternative framework, where joining a network and signing up for a trade credit relationship is endogenous, shutting down the M-Pesa technology additionally lowers at the extensive margin the quantity of entrepreneurs with a trade-credit contract. The decline in trade credit relationships further suppresses macro output by to total of 0.47%. This quantitative result underlines the strong interaction between trade credit and M-Pesa and the importance of extensive margin adjustments in driving macro effects of an efficient payment instrument. Comparing the output effects that we estimate with actual growth numbers for the Kenyan economy suggests that the introduction of M-Pesa can explain 14% of per-capita real income growth and 3.4% of the total factor productivity growth between 2006 and 2013 thus pointing to quite a large macro-development effect of mobile money technology.

The findings of our paper have strong policy implications. First, 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 development. 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 network and production.

Related Literature

Our paper relates to four strands of literature. First, our paper also contributes 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. Our theoretical contribution shows that an efficient payments technology (such as M-Pesa) lowers the probability of theft and alleviates trade credit constraints arising from limited enforceability, and thereby stimulates entrepreneurial performance. We also quantify the aggregate implications of M-Pesa use - through its impact on enforceability - on financial markets and macroeconomic performance. In this respect, we also relate to the strand of research focusing on the quantitative implications of financial frictions on macroeconomic development. Closely related to our work, in this literature, Quadrini (2000) and Cagetti and De Nardi (2006) explore the effects of limited contract enforcement on entrepreneurial wealth accumulation, aggregate saving dynamics and development. Antunes et al. (2008), 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.

We also contribute to the rapidly expanding literature gauging the impact of digital money on finanical transaction patterns and household welfare. Morawcyznski and Pickens (2009) document that in Kenya M-Pesa users sent smaller and more frequent remittances than users of other payment channels- resulting in a sizable increase in remittances to rural areas following the introduction of the M-Pesa technology. 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 lowered the use of informal savings mechanisms (for instance ROSCAS), and raised 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. While this literature has exclusively focused on the household use of M-Pesa, our paper is the first - to our best knowledge - that focuses on business use of M-Pesa and offers an empirical and theoretical analysis of the strategic complementarity of mobile money usage and trade credit use. Building upon a set of theoretical arguments, Jack, Suri and Townsend (2010) suggest that the Kenyan M-Pesa revolution would lead to an expansion in financial connectedness and stimulate economic growth. Our paper formalizes the role of theft and its interaction with M-Pesa technology to explain the impact of M-Pesa on trade-credit connectedness and the resulting development consequences.

[5] Further, 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.

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 has limited if any access to bank credit. Unlike credit from financial institutions, trade credit does not rely on formal collateral but on trust and reputation. Fafchamps (1997) shows in the context of Zimbabwe, where network effects 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) use 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 showing that the use of mobile money as payment device could serve as commitment mechanism vis-a-vis creditors and thus enhances growth of financially constrained enterprises, underlining the importance of efficient payment forms for firm 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. We contribute to this literature by showing that, in addition to enhancing information flows between economic agents, mobile phone technologies may also help foster economic and financial relationships between enterprises in developing countries.

The rest of the paper is organized as follows. In section 2 we provide motivational empirical evidence for the co-variance between M-Pesa and trade credit use. Section 3 develops a dynamic general equilibrium model of entrepreneurial finance. In section 4, we provide an analytical solution to our model and match the empirically observed pattern between M-Pesa use and trade credit. Section 5 calibrates the model economy to match a set of moments that we document using the FinAccess Enterprise Survey data. Section 6 presents a quantitative analysis, where we estimate the aggregate implications of M-Pesa transaction costs for financial markets and macroeconomic development of the Kenyan economy. Section 7 provides a discussion concerning the implications of firms' capital accumulation dynamics for the key mechanism of our model. Section 8 concludes.

2 M-Pesa and Some Motivating Empirical Evidence

This section provides a short overview of the mobile money technology M-Pesa, 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 86% and 52% annually, 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 in total, and the total value of money transferred was 1.9 million Kenyan shillings (22 billion U.S dollars) - equivalent to 40% of Kenyan GDP in 2013.[6] Since 2007 Kenyan households have utilized M-Pesa for not only transferring or receiving money but also for saving: 85 percent of the households store some money in their M-Pesa account household according to survey evidence from Jack and Suri (2011).

Opening an M-Pesa account carries a fixed cost of registration as well as using an electronic technology. We will incorporate this technology adoption cost into the dynamic general equilibrium model that we calibrate. 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. Sending money via SMS involves a variable cost increasing in the amount sent via SMS, and this cost increases if the receiver is not a registered user of M-Pesa. On average, for each unit Kenyan Shilling (KSh) transferred to a recipient, Safaricom charges the sender with 0.01 KSh - a service cost which we will also utilize when calibrating our model. Withdrawing mobile money is also subject to variable costs, which increase in the amount of M-Pesa units transferred.

In addition to facilitating person to person (P2P) transfers, customers can buy goods or pay water, electric, gas and electricity bills to M-Pesa member businesses. There are also some mobile money services via which businesses can send salaries to mobile phones of their workers. P2P service is sometimes also utilized for business related transfers (e.g. purchasing supplies, repaying informal loans) or purchasing goods and services (e.g. paying taxi fees).

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 mobile money usage questions. The survey data were collected in 2014 by FSD-K from a representative cross-section of 1,047 mainly small and medium enterprises in Nairobi. The respondents of the questionnaire are owners or executive managers of the firms that were operational in 2014. Table 1 presents detailed variable definitions and descriptive statistics for our sample.

[6] Data 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.

- Table 1 About Here -

Panel A of Table 1 shows that there is quite some sectoral variation in our sample, with 29% and 34% of the businesses operating in manufacturing and service sectors, respectively, while 37% 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, mobile money, or etc. are common method of payments to suppliers". Statistics show that, after cash and checks, mobile money is the third most common method of payment to pay to suppliers when purchasing inputs: 91% and 50% of the businesses pay for their supplies via cash and check respectively, while mobile money is a common method for 32% of the firms. Most firms in our sample have access to bank accounts: 75 percent of firms use business accounts for their business operations and 15% of them utilize their personal accounts for businesses. 24% of the firms report that they purchase their inputs from their suppliers on credit.

Panel C presents business size and productivity related indicators. The median firm earns around 5600 U.S dollars per month, averaged over the last 12 months and employs 6 workers, ranging from 1 (i.e. self-employed) to 2106 employees.[7]

Finally, Panel D presents other business characteristics. Our sample mostly includes formal businesses; 75% percent 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

[7]Profits have a very skewed distribution, as the sample is very heterogeneous including relatively large (1000 employees) and very small (self employed) firms.

coefficient estimates to economize on space.

- Table 2 About Here -

Table 2 presents the marginal effect of our estimates at mean levels and robust standard error estimates for each characteristic in columns (1) and (2), respectively. The estimates show that more productive businesses and businesses having younger managers are more likely to use mobile money to pay for their business supplies. Unregistered firms and firms having an accountant are more likely to use mobile money to pay for input purchases. Critically, we find a strong link between *trade credit relationships* and *mobile money use*. The estimate shows that, ceteris paribus, businesses that purchase supplies on credit, are 17 percentage points more likely to use M-Pesa when purchasing inputs. We also test the robustness of this result by first estimating a parsimonious model and then adding control variables gradually. We present these estimates in Table A1 in the Appendix. 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 between businesses and/or using mobile money facilitates credit relationships 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 address why having a trade credit relationship with suppliers and paying suppliers via mobile money complement each other.

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 $\mathcal{E}$. There is a large number of suppliers, such that in equilibrium the profits of any supplier will be driven to zero.

For expositional convenience we divide each period into two subperiods, which we call as *Day* and $Night$. In the *Day* subperiod entrepreneurs meet suppliers. 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* and for a potential credit repayment to be made in the $Night$. We interpret the delayed payment to be made in the $Night$ subperiod as the provision of trade credit.

Each entrepreneur can meet many suppliers in the *Day*, but she can sign a contract with at most one supplier. Agents do not discount between the *Day* sub-period and the $Night$ sub-period. 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. As we will delineate in section 7, 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 our survey data. Furthermore, as we will also discuss in section 7 excluding capital dynamics at the firm-level is not necessarily a concern for the key theoretical findings from the model either.

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 endowment (denoted with $\bar{h}$).[8] Suppliers have linear preferences to consume the consumption good. By denoting $c_{s,t}$ as the consumption of a supplier s in period t, the preferences of s are described by

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

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

Entrepreneurs are identical in terms of endowments and preferences: each entrepreneur receives e units of consumption good at the beginning of every *Day* sub-period that she can choose to consume or utilize in her transactions vis-a-vis a supplier. Similar to the suppliers, entrepreneurs have linear preferences with respect to the consumption good as well: denoting $c_{i,t}$ as consumption of an entrepreneur i in period t, the preferences of entrepreneur i are given by

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

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

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

units of consumption good in the $Night$ subperiod, where $f'(.) > 0$ and $f''(.) \leq 0$. In this production specification $A_{i,t}$ is the entrepreneur i's idiosyncratic productivity draw in period t. Productivity draws are *iid* across time and among entrepreneurs and are drawn from a cumulative distribution

[8] Unused labor hours cannot be accumulated over-time.

function $G(A)$. Entrepreneurial productivity draws are publicly observable as well as verifiable. The output from entrepreneurial production in period t cannot be carried over to period $t+1$ because as delineated above the consumption good is non-storable.

3.2 Trade-Credit, Fiat Money and M-Pesa

There are two essential frictions in the model: *financial imperfections* and *theft*. Financial imperfections are twofold. First, inputs can be purchased on supplier provided trade-credit; however, enforcement of credit repayment is limited: 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. The higher T, the larger is the cost of default for an entrepreneur. Furthermore, only a sub-set of entrepreneurs have the capacity to borrow trade-credit. Limited participation in the trade-credit market can be motivated with information about the history of past transactions being available only for a fraction of the entrepreneurial population. The available information can be in the form of a network, from which borrowers can get excluded for T periods in the case of trade-credit default. Being part of the network thus allows access to supplier credit.[9]

Second, monetary theft can reduce an entrepreneur's capacity to make input purchases from a supplier in the *Day* as well as her ability to repay her trade-credit in the $Night$. We assume that theft is private information and unverifiable, which implies that defaults caused by theft would be punished with the exclusion of the theft victim from accessing trade credit for T periods. The mobile-money technology, M-Pesa, will be able insure entrepreneurs against theft of monetary holdings, in expense of electronic transaction costs.

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

Trade Credit. An entrepreneur can purchase inputs via immediate consumption good transfer in the *Day* (using her *Day* sub-period endowment e) 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

[9] Theoretical 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.

$Night$. 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, with the credit maturing in the consecutive $Night$ sub-period. Credit extension though is constrained and subject to *limited enforcement* constraint. Specifically, an entrepreneur can borrow only if she makes an upfront consumption good payment to the supplier worth of her Day sub-period consumption good endowment, e. Moreover, the repayment on trade-credit extended to the entrepreneur i in period t ($b_{i,t}$) cannot exceed the next T periods' credit market valuation ($V_{i,t}$) for the entrepreneur such that

$$b_{i,t} \leq V_{i,t}. \tag{4}$$

If a trade-credit borrower does not repay her credit obligation $b_{i,t}$ in 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.[10] We would like to note that the inequality (4) is a no-strategic-default constraint. This means in equilibrium the entrepreneurs would not strategically default on their trade-credit repayment to make a financial return out of it. However, theft can prevent a debtor from repayment and hence force her to default mechanically, which we shall turn next.

The remaining fraction $1 - \pi$ of the entrepreneurs are not part of the trade-credit network and lack the commitment device to repay. Hereafter, we will refer to the entrepreneurs who can borrow trade credit as "borrower types" and the entrepreneurs who cannot borrow as "creditless types". 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 the second version of the model, we endogenize access to the network as an entrepreneurial decision. In our theoretical analysis and quantitative experiments we will investigate the implications of both model specifications.

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,

[10] In our quantitative analysis we utilize T to match the aggregate trade-credit to output ratio.

whether it is the *Day* sub-period upfront input purchase payment or the $Night$ sub-period trade-credit repayment, is subject to *theft*. With probability $1-\theta$ an entrepreneur looses the entirety of her fiat money holdings before she settles a transaction with the supplier. The aggregate quantity of cash that gets stolen cannot be spent to make input purchases in the economy. Theft shocks are *iid* across entrepreneurs and across time and are private information. This implies in an environment with the option of strategic default, faking a theft shock can be prevented only if non-repayment due to theft is followed with an exclusion of the defaulter from accessing the credit market. M-Pesa users are not subject to the risk of theft, but the use of M-Pesa comes with electronic transaction costs. Adopting the M-Pesa technology requires a fixed periodic-cost of f_e for the entrepreneur. Additionally there are 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.[11]

3.3 Contracts

When an entrepreneur i and a supplier s meet in the *Day* sub-period t, they sign an input-provision contract. Since theft in the *Day* reduces an entrepreneur's initial fiat money balances to zero, a victim of theft in the *Day* sub-period is forced to discontinue her contract with the supplier. If the entrepreneur does not experience a theft shock when she enters the *Day* and if she is not part of the network, she covers the cost of inputs purchased upfront with a trade-credit extension. In other words, $b_{i,t}=0$ for this particular entrepreneur. The contract of this type of an entrepreneur specifies only the amount of inputs to be provided $(h_{i,t})$ and the immediate consumption good transfer to the supplier, denoted with $x_{i,t}$, where

$$e \geq h_{i,t} = x_{i,t}. \tag{5}$$

The right hand side of (5) needs to hold such that the input supplier has incentives to produce the entrepreneurial production inputs.

[11]We do not include payment by check in our model for several reasons, as check payments incur a cost but also are subject to risk of fraud, thus combine the costs of both cash and M-Pesa. In addition, including the option of check payments in our model would complicate the model without providing additional insights.

The compensation of the supplier can be paid via cash and/or M-Pesa, which is part of the contractual agreement. If the payment is to be settled with cash, there are no ex-post transaction costs but the risk of the realization of the theft shock. If the payment is made with M-Pesa, the entrepreneur does not experience the theft shock; however, she will have to pay a fixed M-Pesa cost worth of f_e units of the consumption good and $\lambda x_{i,t}$ units as variable M-Pesa cost. Throughout the paper we will assume that all M-Pesa fees are paid ex-post after the realization of the $Night$ sub-period cash-flow of the entrepreneur, as observed in practice.

If the entrepreneur is of a borrower-type, the contract can entail a trade-credit clause as well. Specifically, in return of $h_{i,t}$ units of input, the payment to the supplier equals to e (paid in the Day) plus the trade-credit repayment, $b_{i,t}$, to be made in the $Night$ sub-period:

$$e + b_{i,t}g_{i,t}(\theta) \geq h_{i,t}, \tag{6}$$

where $g_{i,t}(\theta)$ is 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 produce and extend credit, since cash users have a lower likelihood of credit repayment.

As delineated above a borrower is not completely unconstrained when accessing trade credit. First of all, the receipt of goods on trade-credit is subject to not being a victim of theft in the Day sub-period. This means: if the entrepreneur cannot provide the supplier with e units of the consumption good in the Day, she cannot borrow at all. Furthermore, how much the entrepreneur can borrow depends on her future credit market valuation, $V_{i,t}$, as delineated with the limited commitment constraint (4). Similar to the creditless entrepreneur, a borrower-entrepreneur decides on whether Day and $Night$ sub-period payments should be made via cash transfers or by M-Pesa and the transfer mode of credit-repayment becomes part of the contractual agreement. If M-Pesa is the chosen method of payment both at the upfront payment stage and at the credit repayment stage, the entrepreneur incurs the fixed cost of f_e units as well as the variable electronic transaction cost of λe for the Day sub-period transaction and the variable electronic transaction cost of $\lambda b_{i,t}$

for the $Night$ sub-period transaction.

3.4 Timing of Events

The timing of events in any time period t can be summarized as follows.

Day-subperiod:

1. Entrepreneurs' idiosyncratic productivity shocks, $A_{i,t}$, are realized.

2. Credit types are determined

3. Suppliers meet with entrepreneurs.

4. Input contracts are determined: (i) Credit can become part of the contract if the entrepreneur is part of the network. (ii) Trade credit contract also specifies whether upfront as well as credit repayment will be settled with cash or M-Pesa.

5. Pre-production theft shocks are realized.

6. If the entrepreneur experiences theft, the input contract is discontinued and the supplier does not provide the entrepreneur with production inputs.

7. If the entrepreneur does not experience the theft shock, she extends the initial payment to the supplier and inputs are provided.

Night-subperiod:

1. Entrepreneurs obtain the returns from production measured in terms of consumption-good cash-flow.

2. Post-investment theft shocks are realized.

3. Credit repayment takes place.

4. If a borrower experienced a theft shock and as a result could not honor her debt obligation, she will be excluded from the credit market starting period $t + 1$ for T periods.

5. Periodic M-Pesa costs (including the fixed costs) are paid to the M-Pesa technology provide.

6. Agents consume.

3.5 Interpretation of the Model

The assumption that having been victim of theft is private information is crucial in our model to generate a non-trivial interaction between M-Pesa use and trade credit. Since credit enforcement is limited, an entrepreneur could lie and say that she was subject to theft and default on her promised repayment obligation. We assume that the only instrument to rule out such strategic default is the suspension from the network - and hence credit - for a defaulter, who claims to have been victim of theft. Such enforcement mechanisms that rest on financial exclusion of defaulters have been argued to be effective in a variety contexts where formal institutions are weak (Greif (1993) and Platteau (2006)). Especially, in the context of development economics, the case for inducing repayment through exclusion-sanctions is well-understood (Besley and Coate (1995)). Since membership in the network and access to trade credit are one-to-one related in our model, theft will imply an exclusion from future credit-based transactions.

Our equilibrium analysis will reveal that entrepreneurs who purchase inputs on credit will have higher incentives to pay M-Pesa fees and use the M-Pesa technology when settling payments. Being excluded from the network - and thus losing access to trade credit - works as a loss of reputation in our model. Specifically, a credit-constrained entrepreneur who loses her cash because of theft suffers only from the loss of the current value of her cash. A borrower-type entrepreneur - if subject to theft - loses her "cash" as well as her opportunity to benefit from the trade-credit access. The intuition is that an efficient payments technology to improve the likelihood of repayment for a borrower would relax the limited enforcement constraints and yield a higher quantity of input provision to the entrepreneur in the *Day* subperiod and enhance her business performance. Next we shall turn to proving this underlying economic intuition.

3.6 Optimizing Behavior and Equilibrium

Entrepreneurs maximize life-time value by choosing how much input to invest in entrepreneurial production technology and by choosing the appropriate payment methods. Suppliers maximize utility by providing appropriate labor efforts to produce production inputs.

Definition The dynamic general equilibrium is characterized by an infinite stream of inputs provided by suppliers, $\{h_{i,t}\}_{t=0}^{\infty}$, transfers made to suppliers, $\{x_{i,t}\}_{t=0}^{\infty}$ and $\{b_{i,t}\}_{t=0}^{\infty}$, and payment methods at which entrepreneurs and suppliers maximize lifetime utility and the input market clears.

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.

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

Denoting $\underline{A}$ as the lowest possible productivity draw, we assume $\underline{A} > \frac{1}{\theta}$, such that for all firms it is worthwhile to shop for inputs and to undertake entrepreneurial production even without the use of the M-Pesa technology.

4.1 Social Planner's Allocation

Let us consider a social planner's problem as a benchmark in order to illustrate the first-best allocation of this economy. Following that we provide the decentralized markets outcome and investigate how the M-Pesa technology alleviates credit market imperfections and impacts the aggregate performance of the economy.

The social planner takes the probability of theft into consideration. Since the production technology of the entrepreneur is linear and $A_i > \frac{1}{\theta}$ for all entrepreneurs, the social planner would ask each input supplier to provide $\bar{h}$ units of labor (the maximum capacity of labor associated with each supplier) at every entrepreneur-supplier meeting. This implies that the first-best aggregate output of the economy in any period t would be expressed as:

$$Y_t = \bar{h} \int_{\underline{A}}^{\bar{A}} A_{i,t} di. \tag{7}$$

4.2 Decentralization with Imperfect Credit Enforcement and Exogenous Access to Credit

Let us first assume that access to trade credit is exogenously distributed among entrepreneurs, such that the fraction π of all entrepreneurs can apply for trade-credit whereas the remaining entrepreneurs cannot. As we delineated before, defaulting borrowers are excluded from accessing the credit for the next T periods. In equilibrium, suppliers make zero net profits - a condition which closes the economy with the following

$$x_{\ell,t} = h_{\ell,t}, \tag{8}$$

$$e + b_{c,t} g_{i,t}(\theta) = x_{c,t} = h_{c,t}, \tag{9}$$

where (8) is associated with a creditless supplier-entrepreneur contract and (9) with a credit-based supplier-entrepreneur contract. In equation (8), the ℓ-subscript stands for creditless (liquidity) transaction whereas the c-subscript at equation (9) stands for trade-credit relations - a notation we will keep for the rest of our analysis. We note that on the left-hand-side of (9), we take into account the probability of credit non-repayment due to theft.

For an entrepreneur who cannot make input purchases on credit, the inequality (8) implies:

$$h_{\ell,t} = e. \tag{10}$$

Similarly, if the entrepreneur is part of the network - and hence can purchase on credit - the quantity of inputs extended on credit is determined by

$$b_{i,t} = min\{\bar{h} - e, V_{i,t}\}. \tag{11}$$

This means there are two types of trade-credit borrowers in the economy: borrowers for whom $b_{i,t} = \bar{h} - e$ with $b_{i,t} < V_{i,t}$ and hence the enforceability constraint does not bind and constrained borrowers with $b_{i,t} = V_{i,t}$.

Let us assume that $b_{it} = V_{it}$ for all borrowers of trade-credit - an assumption we will relax when calibrating the model. We would like to note that this financial constraint status is at the intensive margin. At the extensive margin, $1 - \pi$ fraction of all entrepreneurs are completely shut-down from accessing trade-credit. Let us denote the future credit market valuation with V for all M-Pesa using trade-credit borrowers and index an M-Pesa user borrower with p. Since a trade-credit borrower f who does not use the M-Pesa technology (and instead carries cash to settle market transactions that includes credit repayment) gets exposed to the risk of theft and is excluded from future credit with probability $1 - \theta$, her future credit market valuation equals to θV. Furthermore, the M-Pesa user's credit repayment in the non-theft state is $1/\theta$ times higher than that of the cash user because of the likelihood of a no-repayment outcome with fiat money is $g(\theta) = \theta$. Therefore, we can express the quantity of inputs extended to M-Pesa and fiat money users in the *Day* subperiod as

$$h_{p,t} = e + V, \tag{12}$$

$$h_{f,t} = e + g(\theta)\theta V = e + \theta^2 V, \tag{13}$$

where (12) is the input supplied to an M-Pesa user trade-credit borrower, whereas (13) is the input supplied to a fiat money user.

Equilibrium M-Pesa Use.

The current value function (denoted with $\tilde{U}$) of a creditless entrepreneur (ℓ) who uses M-Pesa technology (p) can be expressed as

$$\tilde{U}_{p,t} = A_{\ell,t}e - \lambda e - f_e + U, \tag{14}$$

where U is the (future) continuation value of the creditless entrepreneur. The consumption value if the same entrepreneur without trade-credit were to use fiat money (f) to settle transactions would have been

$$\tilde{U}_{f,t} = \theta A_{\ell,t} e + U. \tag{15}$$

Equations (14) and (15) imply that the entrepreneur would be indifferent between using M-Pesa and fiat money if $A_\ell = A^*$, where A^* solves:

$$(1-\theta)A^* = \frac{f_e}{e} + \lambda. \tag{16}$$

The left hand-side of (16) is the return to M-Pesa usage, whereas the right hand-side of (16) is the 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 (measured in terms of the profits per employee). Next, we turn on evaluating the relationship between access to trade credit and the likelihood employing the M-Pesa technology when settling payments with suppliers. A creditless entrepreneur when draws the productivity A^* becomes indifferent between using fiat money and M-Pesa. What we would like like to investigate is whether the A^*-entrepreneur would strictly prefer M-Pesa use over fiat money when he accesses the trade-credit network. Using (12), the current consumption value of a borrower with using M-Pesa when purchasing the inputs and when repaying the trade-credit can be expressed as follows

$$\tilde{V}_{p,t} = \{A^* e + (A^* - 1)V\} - \{\lambda(e+V) - f_e\} + V + U, \tag{17}$$

where the first component on the RHS 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 transactions. Similarly, using (13) the current value function of a borrower with cash usage when settling input purchase and credit payment transactions is

$$\tilde{V}_{f,t} = \{\theta[A^*e + (A^* - 1)\underbrace{g(\theta)}_{=\theta}\theta V]\} + \big\{((1-\theta) + \theta^2)V\big\} + U, \tag{18}$$

where the first component on the RHS 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 liquidity 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 fiat money user with access to credit 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 with access to credit. Then, for a borrower of trade credit, the difference between M-Pesa and fiat money in current consumption value functions can expressed as follows

$$\tilde{V}_{p,t} - \tilde{V}_{f,t} = (1-\theta)A^*e + (1 - g(\theta)\theta^2)(A^*-1)V - \lambda(e+V) - f_e + \theta(1-\theta)V. \tag{19}$$

Using (16) in (19) yields:

$$\tilde{V}_{p,t} - \tilde{V}_{f,t} = (1 - g(\theta)\theta^2)(A^*-1)V - \lambda V + \theta(1-\theta)V. \tag{20}$$

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. 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 use compared to fiat money when settling transactions, because with $g(\theta) = \theta$ we would have had $(1 - g(\theta)\theta^2) = (1-\theta^3) > (1-\theta^2)$. With $g(\theta) = 1$, by re-arranging the RHS of (20), the sufficient condition for an entrepreneur A^* at a credit-based relationship to strictly prefer M-Pesa over fiat money is expressed as in the following:

$$(1-\theta^2)(A^*-1)+\theta(1-\theta) > \lambda. \tag{21}$$

From (16) 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 $f_e = 0$, then the condition (21) can be replaced with

$$\begin{aligned} (1-\theta^2)(A^*-1)+\theta(1-\theta) &> (1-\theta)A^*, \\ \Rightarrow (1+\theta)(A^*-1)+\theta &> A^*, \\ \Rightarrow \theta A^* - 1 - \theta + \theta &> 0, \\ \Rightarrow \theta A^* &> 1. \end{aligned} \tag{22}$$

We would like to note that $\theta A^* > 1$ holds for all the entrepreneurs in the economy, since we assumed $\underline{A}\theta > 1$. Hence, the strict inequality (22) holds for all parameter conditions. This has the following implication: Access to trade-credit generates a strict demand to use M-Pesa for the entrepreneur indexed with A^*, where A^*-entrepreneur was indifferent between using M-Pesa and fiat money if he were to participate in a creditless relationship. Since we isolated away the channel on M-Pesa demand that works through the cost of borrowing, we formalize the following result.

Proposition 4.2 *Ceteris paribus, entrepreneurs who purchase goods on trade-credit are more likely to use M-Pesa to settle payments compared to the entrepreneurs without access to trade-credit. This result holds because of the impact of M-Pesa on future trade-credit valuation and in turn on the enforceability constraint.*

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 because of a foregone opportunity to produce, but also due to credit market frictions the ability to borrow during that particular period. 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 use 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 rational expectations of the input suppliers. This dynamic complementarity raises the value of M-Pesa use for entrepreneurs who have access to trade-credit contracts.

One important thing to note is that the key result in proposition 4.2 holds as long as the entrepreneur who promises to make the credit repayment with M-Pesa does in fact have the incentives to pay with M-Pesa and not with cash when the credit repayment time comes. We can rule out contractual deviations by assuming that suppliers can punish defaults followed by payment method deviations severely, such as not only cutting access to the credit market but not allowing to pay with M-Pesa for a large enough number of periods. Note that the creditor will have the incentives to impose this punishment because default following a payment deviation incrases the cost of extending trade credit for a supplier.

Going back to the cost of borrowing channel (ii); ex-post interest payments with fiat money are higher because the likelihood of theft. For a cash user this second channel increases the repayment burden and constrains the quantity of inputs that an entrepreneur can borrow in the first place and raises the relative valuation of M-Pesa use. Formally, the consequence of repayment burden channel can be observed by replacing the $(1-\theta^2)$ term on the left hand side of the inequality (21) with $(1-\theta^3)$.

Corollary 4.3 *The contraction in the repayment burden with M-Pesa reinforces an entrepreneur's demand to use M-Pesa at a credit-based supplier relationship.*

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 (22), 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 4.4 *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. Such fixed cost costs of M-Pesa adoption can be associated with cost of registration to open an M-Pesa account, cash withdrawal fees (in case a conversion from M-Pesa to cash is demanded) and finally technology usage costs (learning and applying how to use M-Pesa). In our quantitative analysis, we will calibrate the value of f_e.

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, 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.

4.3 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 access to trade credit on the likelihood of M-Pesa use corresponding to the empirical regularity we documented in section 2. In order to evaluate the potential of reverse causality in the empirical pattern, we now argue that the 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.

At the beginning of each period, before productivity shocks are realized, each entrepreneur draws a non-monetary "joining the trade-network" cost, denoted by $\kappa_{i,t}$. We assume that κ is drawn from a cumulative distribution function $H(\kappa)$ and *iid* among entrepreneurs and across time.

The independence of periodic κ-cost from productivity draws - coupled with the trade-credit M-Pesa complementarity highlighted above - yields that any change 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 4.5 *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.*

Part of our quantitative analysis below will focus on isolating the transmission of the real effects of M-Pesa usage through the number of trade credit relationships generated in the economy.

4.4 Stationary Equilibrium

The macro variables of the model, which can exhibit time-variation, are the population fraction of trade-credit borrowers who use *cash* and the population fraction of trade-credit borrowers who use *M-Pesa* when purchasing inputs from suppliers. 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 fractions of the population use M-Pesa and cash when making input purchases on trade-credit. For quantitative purposes, our analysis requires the existence of a stationary equilibrium, where borrowers choose to utilize cash as well as M-Pesa when making input purchases. Therefore, we assume that T is finite. Moreover, given the parameter restrictions that we will impose, $T = 2$ yields an equilibrium trade-credit/output ratio matching the trade-credit/output ratio that we observe in FinAccess Business Kenya. For, $T = 2$, we obtain the following result.

Proposition 4.6 *When $T = 2$, a unique stationary equilibrium exists in which positive fractions of trade-credit borrowers use cash and M-Pesa at purchasing supplier-inputs.*

Proof 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 $t-2$ is $q(1-\theta)\mathcal{C}_{t-2}$. From here, we can note that as long as

$$\mathcal{C}_t = \mathcal{C}_{t-2}$$

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 $\mathcal{C}_t = \mathcal{C}_{t-2}$ holds. Starting with period-1, with a 2-period default penalty we can note that $\mathcal{C}_1 > \mathcal{C}_2 > \mathcal{C}_3$ for periods $1, 2$ and 3. While the outflow of entrepreneurs from the credit market who will not be eligible to borrow in period 4 equals to $q(1-\theta)\mathcal{C}_3$, the inflow of agents in period 4 is $q(1-\theta)\mathcal{C}_1$. Since $\mathcal{C}_1 > \mathcal{C}_3$, we note that $\mathcal{C}_4 > \mathcal{C}_3$. Formally, defining $z \equiv q(1-\theta)$

$$\begin{aligned}
\mathcal{C}_2 &= (1-z)\mathcal{C}_1, \\
\mathcal{C}_3 &= (1-z)^2\mathcal{C}_1, \\
\mathcal{C}_4 &= (1-z)^2\mathcal{C}_1 + (1-z)\mathcal{C}_1 - z(1-z)^2\mathcal{C}_1,
\end{aligned}$$

using which we can also note that $\mathcal{C}_4 > \mathcal{C}_2$; and $\mathcal{C}_4 > \mathcal{C}_5 > \mathcal{C}_6 > \mathcal{C}_3$. This implies that $|\mathcal{C}_4 - \mathcal{C}_6| < |\mathcal{C}_1 - \mathcal{C}_3|$. Iterating the process forward yields

$$|\mathcal{C}_t - \mathcal{C}_{t+2}| < |\mathcal{C}_{t-3} - \mathcal{C}_{t-1}|$$

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

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 for the Kenyan economy. In section 6 we will use this quantitative framework to gauge the implications of M-Pesa adoption and usage costs for trade credit, entrepreneurial output and macroeconomic development. The target moments that we set using the 2014 FinAccess SME 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 FinAcccess 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 suggests M-Pesa use to 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.

With respect to the functional forms, we assume that the entrepreneurial technology exhibits the following decreasing returns to scale functional form

$$y_{i,t} = A_{i,t} k_{i,t}^{\alpha}, \quad \text{with } 0 < \alpha < 1. \tag{23}$$

We assume that the idiosyncratic productivity shocks, $A_{i,t}$, are drawn from a cumulative distribution function

$$G(A) \quad = \quad A^{1/\gamma_A}, \tag{24}$$

where $\gamma_A > 0$. Note that when γ_A equals one, productivity is uniformly distributed across entrepreneurs. When γ_A is greater than one, productivity distribution is concentrated among entrepreneurs with low levels of productivity. We set γ_A equal to 1 such that the productivity distribution is uniform and choose the lower bound of the productivity distribution as $1/\theta$, such that as in our theoretical model all entrepreneurs stay active even without M-Pesa technology.

In addition to the M-Pesa user costs (λ and f_e), the parameter space of the model includes 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 that governs the fraction of entrepreneurs, who apply for trade-credit. As we delineated above we consider two versions of the model: (i) exogenous distribution of trade credit use, in which case we will parameterize π, the population share of trade-credit users; and, (ii) endogenous distribution of use of trade credit, at which case we will parameterize the distribution of κ_i, the cost of accessing the record keeping institute.

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 for the Kenyan economy in the 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 and especially Nairobi, as, according to 2011 Afrobarometer survey in Kenya 33% of households in Kenya (37% of households in Nairobi) report that at least once something has been stolen from their house and 5% of households in Kenya (11% of household 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 at 1% to match the transaction cost observed in practice when making payments to suppliers.[12]

[12]The 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.

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 the 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, the measure of entrepreneurs ($\mathcal{E}$) is chosen such that the benchmark output equals to 100 - net of theft and M-Pesa transaction costs.

The parameterized model matches the SME survey data quite well along the dimensions that were targeted (the first 5 statistics in Table 5), as well as the important additional statistics that we did not target using the model parameters, which is the fraction of M-Pesa users among trade-credit borrowers.

- Table 5 about here -

As presented in Table 5, we can match the targeted sample moments (means) of entrepreneur's profit share, supplier credit-output ratio, 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 fraction of M-Pesa users 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 actual fraction of

M-Pesa using trade credit borrowers in FinAccess Business sample is about 42%. The parameterized model generates a fraction of M-Pesa users among trade credit borrowers equaling to 45%. This close match supports the quantitative validity of our theoretical 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 $[0, \bar{\kappa}]$ and iid among entrepreneurs and across time. We calibrate $\bar{\kappa}$ to match the fraction of trade-credit relationships (0.25) among the sample of SMEs. Trade credit costs are non-monetary, which coupled with the timing of events that we impose implies that the performance of the benchmark calibration replicating the data remains exactly the same in the alternative specification as we show in Table 7.[13]

- Tables 6 and 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 look 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

[13]To be precise, the timing of κ draw leads the draw of A.

relationships.[14] The quantitative results from this hypothetical exercise are presented in Table 8.

- Table 8 about here -

Eliminating the use of M-Pesa from SME-supplier relationships causes an expansion in the input-output ratio, mostly because entrepreneurial output contracts following the shut-down of access to 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.[15] 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 larger 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 to conclude that the use of M-Pesa when making input purchases from suppliers is quantitatively important in alleviating transaction frictions in SME-supplier relationships and in turn for macroeconomic development in the Kenyan economy.

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

[14] In 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.

[15] We 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%.

strong interaction between trade credit and M-Pesa as an important determinant of the economic consequences of 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. Kenyan total factor productivity and real per capita income grew 3.3% and 14%, respectively, between 2006 and 2013. The quantitative exercise result from the endogenous model implies that M-Pesa generates 0.5% TFP growth for the Kenyan economy through trade credit channel on an annualized basis.[16] This implies that the mechanism we have proposed can explain 14% of TFP growth and 3.4% of per-capita real income growth over the same period, suggesting quite a large macroeconomic impact of mobile money technology.

7 An Extension: Firm Capital Accumulation

The dynamic general equilibrium model that we calibrated using Kenyan SME 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 data-set, we document that the correlation coefficient estimate between inputs purchased on credit per employee and capital stock per employee is 0.07, implying that input purchases on credit explains only 0.5% of the total variation in capital stock. This estimate is statistically insignificant after controlling for business characteristics that we discussed in Table 1. The findings are similar for the relationship

[16]The 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 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.

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 show there are negligibly positive co-movements between capital and trade credit and between capital and M-Pesa use.

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 result, let us suppose that the production technology of the entrepreneur takes the following form:

$$y_{i,t}(h_{i,t}) = \begin{cases} A_{i,t}(1+k)h_{i,t} & \text{if } i_{i,t-1} \geq k, \\ A_{i,t}h_{i,t} & \text{if } i_{i,t-1} < k, \end{cases} \tag{25}$$

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 (25). 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 a 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 7.1 *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

$$\hat{A}(1-\theta)(1+k)e = \lambda e + f_e + U_f - U_p, \tag{26}$$

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 a theft shock that will 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:

$$V_{p,t} = \left[\hat{A}(1+k)e + (\hat{A}-1)(1+k)V_p\right] - [\lambda(e+V_p) - f_e] + V_p + U_p, \quad (27)$$

$$V_{f,t} = \theta\left[\hat{A}(1+k)e + (\hat{A}-1)(1+k)V_f\right] + \theta V_f + U_f. \quad (28)$$

Utilizing (26) in these value functions, 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

$$\theta\hat{A}(1+k) > 1, \quad (29)$$

and furthermore, comparing the condition for strict M-Pesa usage at (29) (with capital accumulation) against the condition for strict M-Pesa usage without capital accumulation that we derived at (22), 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 (29). □

The result at proposition 7.1 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.

8 Conclusion

Using a novel SME survey from Kenya (FinAcess Business 2014) we documented a positive co-variance between the use of Mobile-Money (M-Pesa) as a payment method when purchasing inputs from suppliers and the use of trade credit among SMEs. In order to understand what drives this relationship, we developed and solved a dynamic general equilibrium model with heterogeneous entrepreneurs (SMEs). Our model exhibits imperfect credit markets (with limited commitment) and theft, where theft erodes an entrepreneur's fiat money balances and additionally - due to non-repayment (default) - for borrowers it causes a discontinuation of access to trade credit. In this framework, M-Pesa dominates fiat money as a medium of exchange in its capacity to avoid theft but it comes with electronic payment transaction costs.

The key theoretical result from the model shows that access to trade credit generates demand to use M-Pesa as a payment method with suppliers and the use of M-Pesa in turn raises the value of a credit relationship and hence the willingness to apply for trade credit. We calibrated our model to match a set of moments that we observe in the Kenyan FinAcess Survey and quantify the importance of interactions between M-Pesa and trade credit on entrepreneurial performance and macroeconomic development. Eliminating the use of M-Pesa from SME-supplier relationships reduces the macroeconomic output of the economy (the aggregate output generated by the SMEs) by 0.33%. Endogenizing access to trade credit increases the quantitative effect even further, as the lack of a mobile money technology lowers the fraction of trade credit relationships among SMEs. This would further suppress the macroeconomic development and causes a total contraction in macroeconomic output by 0.47%.

The link between 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. It shows 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 welfare enhancing. At the same time, our analysis shows that mobile money technology is not only welfare-enhancing on the household level as the recent literature pointed out, but also growth-enhancing by improving firm productivity.

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Tables and figures

Table 1: Descriptive statistics

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

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

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

	(1) marg. eff.	(2) s. e.
Productivity	0.02**	(0.01)
Personal business account	0.13	(0.08)
Business Account	0.08	(0.06)
Purchasing supplies on credit	0.17***	(0.04)
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 educatio	0.13	(0.18)
Male	0.07*	(0.04)
Age	-0.02*	(0.01)
Age^2	0.00	(0.00)
Observations	1,044	

Notes: This table shows the estimation results for the correlation between 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 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)
γ_A	1	Uniform productivity distribution
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)
γ_A	1	Uniform productivity distribution
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

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.

Appendix

Table A1: Stability test

	(1)	(2)	(3)	(4)	(5)
Purchasing supplies on credit	0.12***	0.16***	0.14***	0.16***	0.17***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Productivity		0.03***	0.02***	0.02**	0.02**
		(0.01)	(0.01)	(0.01)	(0.01)
Personal account			0.15*	0.13	0.13
			(0.08)	(0.08)	(0.08)
Business account			0.11*	0.08	0.08
			(0.06)	(0.06)	(0.06)
Registered			-0.12***	-0.14***	-0.14***
			(0.04)	(0.04)	(0.04)
Accountant			0.14***	0.10***	0.10***
			(0.04)	(0.04)	(0.04)
Secondary education				-0.15	-0.15
				(0.13)	(0.13)
College education				0.06	0.07
				(0.17)	(0.17)
University education				0.09	0.09
				(0.17)	(0.17)
Graduate education				0.12	0.13
				(0.18)	(0.18)
Male				0.06	0.07*
				(0.04)	(0.04)
Age				-0.02*	-0.02*
				(0.01)	(0.01)
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