Economics of Microcredit-From current crisis to new possibilities

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Abstract Following the United Nations declaration of 2005 as the International Year of Microcredit, international organizations began to promote a tighter regulatory and supervisory framework for the microcredit industry. In this paper, I review the theoretical basis of this development considering recent empirical findings that microcredit programs tend to have initial success yet demonstrate few significant benefits beyond the initial two years. I utilize an agent-based simulation as an ex-ante policy assessment tool to examine this tighter regulatory strategy. My findings for Kenya, with possible application to other developing countries and regions, suggest that a less rigid regulatory framework is more likely to lead to more sustained positive impacts. The study has important implications for how policymaking should be conducted. It suggests that the benefits of policy emulation of best practice, "what works", may be transitory.

Keywords Microcredit; Financial Development; Agent-based Models; Financial Crises; Causes of Financial Crises; Government Policy and Regulation

1 Introduction

The voluminous empirical literature on microfinance (Banerjee et al., 2015; Cull et al., 2009, 2011; Haldar and Stiglitz, 2016; Kotir and Obeng-Odoom, 2009; Armendariz and Morduch, 2010) seems to be heading toward the consensus that while the microcredit industry seems to be succeeding at helping poor borrowers start, or expand, a micro-businesses, very few significant benefits persist beyond the initial two years (Banerjee et al., 2015; J-PAL, 2018; Haldar and Stiglitz, 2016). The results of Banerjee at al.(2015) are particularly significant because the study is the first and longest running investigation of the standard small collateral-free joint liability group loan product (JLG).

This widespread finding regarding the relatively rapid dissipation of microcredit loans' impacts, calls into question not only the manner in which microcredit institutions operate, but the theoretical foundation on which they are based. That theoretical foundation is based strongly on the value of financial intermediation. Financial intermediation theory is based on the notion that by increasing the "ease with which borrowers and savers can be brought together, and once together, the confidence they have in one another" economic growth is facilitated (Rajan and Zingales, 1998, p. 569; see also King and Levine, 1993. See Werner (2016) for a critique of the theory). Consistent with financial intermediation theory, microcredit programs are hypothesized to reduce poverty by increasing the quantity of funds for starting or developing sustainable micro-businesses; to facilitate the channeling of resources to the highest-return investment projects; to enable risk sharing; and to reduce the liquidity constraints faced by entrepreneurs (Robinson, 2001; Dichter and Harper, 2007; Armendariz and Morduch, 2010; Cull et al., 2011; Ayayi and Yusupov, 2012; Banerjee et al., 2015; Haldar and Stiglitz, 2016).

The main goal of the main microcredit loan product (i.e., JLG) was therefore to increase the quantity of credit/investment to the poor in underserved markets in the rural and informal sectors of developing countries. However, while JLG was able to increase the quantity of credit, the quality of credit—from the perspective of the SME sector—was sacrificed (see for example Associated Press,2012).

The reliance on financial intermediation as a theoretical justification for microcredit programs has led governments to perceive their primary role in the microcredit industry as one of providing the legal, regulatory and supervisory framework (Beck et al., 2018; Atieno et al., 2010; Kodongo and Kendi, 2013; Cull et al., 2011). For example, Atieno et al. (2010, p. 390-1) observed that Kenya's 2030 vision (2007) for financial services had no national policy towards microfinance beyond the provision of a regulatory framework.

Tighter regulations are thought to ensure integrity and accountability which increases confidence and legitimacy, to attract investors and depositors (Cull et al., 2009, 2011); to reduce unit transaction costs from the larger scale of operations (Kodongo and Kendi, 2013; AMFI-K, 2014); and, overall, to treat "microfinance as a serious part of the financial sector and as a business concern, not an act of charity" (UNCDF, 2006; Statement of the Advisors Group to the United Nations International Year of Microcredit, 2005).

However, as Lensink (1996, p. 163) observed—based on previous financial sector reform efforts—increasing formal sector regulations in sub-Saharan Africa (SSA) has produced disappointing results. Lensink attributed the disappointing results to "the strong focus of the adjustment programmes on the formal banking sector" while neglecting a large informal sector that was more attractive to savings. Andersen and Tarp (2003), relying on a survey of the finance-growth literature, suggested a cautious approach to financial sector regulatory reform since the alleged direct effect from financial development to economic growth is not adequately supported by econometric work.

Cull et al. (2011) examined 245 microfinance lending institutions and found that due to the cost of complying with regulations "profit-oriented microfinance institutions respond[ed] to supervision by maintaining profit rates but curtailing outreach to women and customers that are costly to reach. Banerjee et al. (2015) noted that the rate of return on microbusinesses is lower than the rate of interest generally charged on microloans [see also Ayayi and Sene (2010)]. Consequently, the demand for microloans has been declining (33 percent in their study) which raises serious questions about the ability of a tighter regulatory and supervisory approach to meet the developmental aspirations of developing SSA countries. Haldar and Stiglitz (2016) questioned the move to emulate and scale up a purely "economic" model when the initial success of the JLG loan product depended primarily on a "social" model (see also Yunus et al., 2010). Dang, Gorton, Holmstr¨om, and Ordon˜ez (2017) have also questioned the importance of allocative efficiency and financial intermediation as the primary function of the banking sector (see also Werner, 2016). They questioned the former because banks do not replicate the price discovery function of capital markets—the higher costs, and benefits, of information production will tend to sort borrowers towards capital markets and away from banks, and vice versa (p. 1028)—and the latter because, they argue, banks exist to produce money.

In this paper, I examine the move toward tighter regulatory supervision of the microcredit industry after 2005/06. For the most part, I focus on the risk averse climate that these regulations have engendered. While recent empirical evidence has shown that the microcredit industry may not be meeting its developmental and welfare goals, it is not clear whether tighter regulations will be a help or a hindrance. In addition, I propose a quantified evidence-based methodology for ex-ante assessment of new financial regulations as required by recent statutory changes. These requirements (for example, Kenya's Statutory Instruments Act of 2013) mandate that regulatory authorities make consultation with persons likely to be affected for every statutory instrument that is likely to have direct, or substantial indirect, effect on business or restrict competition.

I develop an agent-based computer simulation (Farmer et al., 2003; Rama, 2006; Axtell, 2005), as the main empirical expository device for conducting the investigation in a formal and quantified way. The simulation compares alternative policy interventions as follows: (i) baseline or no intervention; (ii) risk averse microcredit loans; (iii) risk tolerant microcredit loans; (iv) government subsidies; and (v) direct cash transfer.

I use data from Kenya in the simulation. Among African countries, Kenya has done reasonably well in its development endeavors and has therefore provided the archetypal African example (Leys, 1974; Bates, 1989; Leonard, 1991).

The rest of the paper is organized as follows. Section 2 provides the setting. Section 3 discusses the theoretical framework. Section 4 presents the empirical methodology (simulation). Section 5 the gives the results of the simulation. Section 6 discusses robustness checks while section 7 concludes with a discussion of the main implications of the study.

2 Setting

At the broadest level, I am seeking to enhance our understanding of the workings of the market

system in developing countries. While scholars have tended to focus on the institutional and regulatory environment (e.g., rules of the game in North (1990), Ostrom (1990) among others), I argue that the process of money creation is the main lever through which governments direct the operation (i.e., allocation and employment of resources) of market economies (see Minsky, 1986). Limitations in the efficacy of monetary policies' tools and instruments, therefore, can explain much of the persistent disappointing economic performance of many developing countries in the period following market liberalization. The microcredit industry, within this context, can be thought of as an emergent socioeconomic phenomenon that developed to address limitations in the formal institutional processes of money creation. Consequently, the tightening of the regulatory supervision of the industry, based solely on financial intermediation theory (i.e., via policy emulation and policy transfer), is not only misguided but self-defeating.

While monetary and regulatory institutions overlap (i.e., institutions that create new money and institutions that redistribute existing money), the overlap conceals essential differences (within the context of market economies). Consequently, the regulatory system does not replace, or replicate, the functions of the monetary system, especially during periods of rapid, or discontinuous, productivity growth.

The argument exploring the main thesis of the paper can be broken down into three consecutive questions. First, does a tighter regulatory supervision of the microcredit industry, by itself, deliver on its developmental objectives? If no (as suggested by recent empirical findings), is the industry better able to deliver on its objectives when a broader set of policies are used in conjunction with it? Finally, can these contradictory approaches be coherently integrated?

Two recent developments motivate this re-examination of the microcredit industry. First, the finding that few significant benefits of microcredit persisted beyond the initial two years (Banerjee et al., 2015; J-PAL, 2018; Haldar and Stiglitz, 2016). Secondly, innovations in transactional technologies (i.e., ubiquitous mobile phone transactions in developing countries) that allow cheap and ubiquitous collection of transactional information.

3 Theoretical Framework

I begin this section by looking at serious flaws and limitations in the currently predominant theoretical frameworks. These serious flaws make it necessary to go beyond standard models in our examination of the regulatory structure being recommended for the microcredit industry. Going beyond standard models is not only necessary for explaining (at the micro- or process level) the "initial success—rapid dissipation" paradox in microcredit programs; it will help to fill a void in financial development theory. My approach is based on the conjecture that the same single process can be used to explain the initial success as well as the rapid dissipation. Despite the critical importance of addressing the problem of financial and economic fluctuations, little research has examined specifically its relationship to microcredit programs.

The argument of the paper is closely related to findings in de Janvry et al. (1991) who attributed the persistence of poverty in the rural sector to market failure. Market failure is used to explain the apparently irrational behavior of individual rural entrepreneurs by "not [being] responsive to price incentives and to opportunities to adopt new technologies". Market failure, as used in the paper, refers to economic situations where "the cost of a transaction through market exchange creates disutility greater than the utility gain that it produces, with the result that the market is not used for the transaction" (ibid). de Janvry et al. argued that rural and informal sector households are more susceptible to market failure because they own or can produce the products or factors which the household uses. Consequently, when the market price of their production output is higher than the production cost, but lower than total costs (when transaction costs are added) it becomes advantageous to the household to neither buy nor sell and thus to be self-sufficient in this product or factor.

While de Janvry et al. attributed market failure to transaction costs, I argue that market failure is caused by too little risk transfer. How risk transfer mitigates market failure can be examined using two methods. The first method—based on theoretical abstraction of aggregated producer decisions before production—can be described algebraically. For example, the classic Schumpeterian risk transfer (1927, 1928, 1954) which requires credit creation (i.e., loans to producers) before the increase in economic output. Therefore, producers/entrepreneurs can take the risk that their own productive activities (i.e., increase in output) may create market failure—by causing market prices to fall (according to the law of supply and demand) below total costs—because this risk has been transferred to the bank. A narrower version of the underlying problem is described in the seminal paper by Romer (1990) using the term "nonconvexities". Nonconvexities is the idea that the firm that makes intentional investments in R&D will fail to "recover those cost by selling the new good for a price that is higher than its constant cost of production" because of spillovers (i.e., R&D is a nonrival input) and free entry into this activity. Romer's solution to the

"nonconvexities" problem is the notion that R&D has a human component that is rivalrous; therefore, this part of the R&D investment does not spillover.

The second method—based on producer's actual behavior after production—can be described using an agent-based computer simulation (ABM). The simulation mimics real world behavior, it rejects the assumption in de Janvry et al. and Romer (i.e., endogenous growth model) that profit-maximizing agents may not lower their prices below their cost of production (or they go out of business). The agent-based computer simulation departs from algebraic formulation in five areas: 1) market prices, also production costs, are transactional (i.e., not an instantaneously adjusting economy-wide product price) reached through the market process of haggling/bargaining (Geertz, 1978); 2) producers will adjust their prices downwards (within limits) to the individual buyer's budget constraint in order to allow market clearing; to maintain customers/market share; and to prevent market failure (i.e., the Kirzian (Kirzner, 1973) notion that entrepreneurs are forward looking agents who see changes in prices as opportunities to be exploited and assume that the fall in prices is a trend that is more likely than not to continue); 3) these producer pricing decisions are determined and limited by available cash flows rather than profits; 4) therefore, bank loans are used primarily as working capital to cushion declines in cash flows (rather than starting or expanding businesses), especially during period of discontinuous economic change; and 5) the process requires the transfer of risk to the bank.

3.1 Predominant theories and their critics

While financial intermediation theory (micro-level) underpins the predominant theory of financial development (see seminal contribution by King and Levine, 1993) and quantity theory of money (macro-level) underpins predominant theory of monetary economics [see Minsky (1986, p. 124), Taylor (1993), Akerlof and Shiller (2009, p. 78), and, Adam, Maturu, Ndung'u, and O'Connell (2010, p. 142) among others], these theoretical frameworks have been criticized as being seriously flawed (see Bernanke and Blinder (1988); Bernanke, Gertler & Gilchrist (1999); Greenwald and Stiglitz (2003); Werner (2016); Lee and Werner (2018), among many others).

The serious flaw, in Bernanke and Blinder (1988), is attributed to the asymmetrical treatment of the bank's balance sheet in most standard models because money or bank liabilities have a special role but bank credit/loans or bank assets (p. 435) are overlooked. The main point in Bernanke and Blinder, for purposes of this study, is the idea that rather than bank liabilities and interest rates, bank credit/loans provide the main instrument of monetary policy. The special function of bank credit, therefore, is as a channel of monetary policy. However, since this paper was published, Bernanke (among others) has often moved away from bank credit toward more orthodox principles and ideas—often based on a perceived lack of legal and constitutional authority at the expense of legal and constitutional responsibilities (see for example, Ball, 2016b). For instance, in Bernanke (2003); Bernanke, Reinhart & Sack (2004), and Bernanke (2020), Bernanke advocates "quantitative easing (i.e., where the Fed purchases asset including Treasuries, Agency bonds and mortgage-backed securities (MBS)) and forward guidance (publicly announced promise or commitment to conduct policy in a specified way)" as the "principal new tools used by the Fed". However, Bernanke seems to conflate the message that monetary policy is willing to go beyond standard tools (based on a pragmatic interpretation of the law) to achieve the publicly announced targets with the message that it will push standard tools (based on a narrow interpretation of the law) to the limit to achieve the publicly announced target. The distinction is clearer if we differentiate Bernanke before 2003 and Bernanke after 2003 (see Krugman, 2012; Ball, 2016) based on his views on the duty of monetary policy in forestalling the credit-market imperfections that provide a financial accelerator to business fluctuations (see Bernanke, Gertler & Gilchrist, 1999). The lack of commitment to correcting the underlying institutional/structural causes of financial crises [while focusing on disproportionately on symptoms; exaggerating the power of the Fed's "principal new tools" to kowtow the economy; and the conflating monetary indicators, such as inflations and GDP data, with economic fundamentals] is dangerous because financial crises have enormous economic and political consequences.

Greenwald and Stiglitz (2003) focus squarely on institutional limitations facing banks. The relevance of their study to this paper is the idea that where segment or sector specific cost exist (e.g., information asymmetry, transaction costs, enforcement costs etc.,), bank will limit the provision of credit thereby causing rationing of credit to these sectors/segments (see also Stiglitz and Weiss, 1981; Blinder, 1987; Saxegaard, 2006; Weeks, 2010). However, strong reliance on quantity theory[1] and financial intermediation theory[2] has lessened the heterodoxy of this

[1] Quote: "we argue that the key to understanding monetary economics is the demand and supply of loanable funds, which in turn is contingent on understanding the importance, and consequences, of imperfections of information and the role of banks" (p. 3). It is not clear whether information imperfections change the aggregate demand and supply of loanable funds, or whether they merely change the terms and distribution.

contribution. More succinctly, because the model of institutional limitations focuses on the problem of "bankruptcy and default" when "loans are not repaid", the contribution limits the possibility that banks transfer risk. Thus, the authors argue, "the key to understanding the behavior of banks is understanding limitations on their ability to absorb these risks, and how their ability and willingness to do so can change with changes in economic circumstances and in government regulations" (ibid). The problem is that the mathematical/mechanical model of institutional structure, being pro-cyclical rather than counter-cyclical, excludes the main avenues of discontinuous socioeconomic change. The banking sector is critical to the market system precisely because it is willing and able to absorb pecuniary risks. Bank behavior is noteworthy precisely when it overcomes these institutional and structural constraints e.g., by lending to borrowers whose likelihood to repay is unknown or unlikely because it believes the project is worthwhile or the customer is deserving.

Werner's (2016) comprehensive review of banking theories relies on empirically gained knowledge to argue that financial intermediation and the fractional reserve theories of banking should be rejected, and credit creation theory be adopted. In Werner's account the main distinction between the fractional reserve theory and the credit creation theory is the notion that individual banks, in addition to the banking system as a whole, can create credits. However, Werner's extensive research on this topic, here and elsewhere, does not extend beyond the quantity theory of money.

3.2 "Credit channel" of the monetary transmission mechanism

The alternative approach to the basic financial intermediation theory and quantity theory of money has been called the "credit channel" of the monetary transmission mechanism (MTM). The credit channel "stresses the importance of intermediaries in the provision of credit and the special nature of bank loans" in monetary policy (Blinder and Stiglitz, 1983; Blinder, 1987; Bernanke et al., 1998; Greenwald et al., 1984; Fuerst, 1992; Kashyap and Stein, 1994; Bernanke and Gertler, 1995; Greenwald and Stiglitz, 2003; Khan, 2011).

However, while bank credit has been examined extensively in the financial development and monetary policy literature, the actual mechanism itself remains a "black box" (Bernanke and Gertler, 1995). Two factors, in my view, can help to explain why this vital process is so poorly described in monetary theory. First, the paucity of micro-level information in empirical work. Secondly, the fact that the institutional framework surrounding the "credit channel" have developed organically rather than through deliberate policy design. Monetary policy tools and instruments have evolved, a) from tacit norms and inherited traditions (Graeber, 2014; King, 2016); b) from financial crises (Minsky, 1986; Bernanke, 2020); and c) from innovations in transactional technologies (Blinder and Stiglitz, 1983; Greenwald and Stiglitz, 2003; Dang et al., 2017), rather than empirical research and theory building. Consequently, the "black box" allows the valorization of financial intermediation and the misunderstanding of the specialness of bank credit to continue.

The "black box" nature of the monetary transmission mechanism presents a challenge for connecting theory to evidence (and vice versa), or theory to practice (and vice versa). Indeed, providing such a connection would be, in and of itself, an important contribution to the literature.

Perhaps the best starting point in the effort to connect theory to evidence is the seminal paper on financial development by King and Levine (1993) titled "Finance and growth: Schumpeter might be right". I contrast key insights made by Schumpeter in several books and papers (1927, 1928, 1934) and the presentation of Schumpeterian ideas in the financial development literature.

The primary distinctions between Schumpeter's key insights and financial development literature (see King and Levine, 1993; Rajan and Zingales, 1998; Levine et al., 2000; Beck et al., 2000; Levine et al., 2000), for purposes of this study, is credit creation and risk transfer. In Schumpeter, the bank anticipates the increase in physical productivity by the entrepreneur and produces/creates bank credit/money in advance of this increase. Thus, only the bank bears the risk, and development, or growth, occurs through the transfer of risk from the entrepreneur to the bank. Schumpeterian economic development theory, therefore, rejects the view that innovation and growth (i.e., increase in physical productivity) can occur from savings alone (1934, pp. 95-100) before/without money/credit

[2] Quote: "banks provide vital certification, monitoring, and enforcement services, ascertaining who is likely to fulfill their promises to repay, ensuring that money lent is spent in the way promised, and collecting money at the due date" (ibid). As discussed above Dang, Gorton, Holmstr¨om, and Ordon˜ez (2017) have rejected this allocative efficiency idea because the higher costs, and benefits, of information production will tend to sort borrowers towards capital markets.

creation. As Schumpeter states it, "banks "systematically" and "significantly" create credits exceeding the sum of savings existing and entrusted to them and the value of commodities existing at the moment" (1927, p. 301). Schumpeter emphasizes that this credit creation is not a "mistake or aberration from sound principles" (ibid). Further, since the form of money used in the economy serves no function other than as a means of payment (ibid, pp. 301-302) the bank is different from other commodity sellers because it is not, within limits, "acting under the pressure of cost" when creating credits (ibid, p. 307).

The consequence of credit creation is the second of Schumpeter's "heresies"; that is, the distinction between financial or revenue productivity and physical or real productivity (1934, p. 95). As a result of credit creation, the "parallelism between the flow of money and the flow of goods [is] destroyed" (1927, p. 302) and "processes in terms of means of payment are not merely reflexes of process in terms of goods" (1934, p. 95)

While Schumpeterian credit creation and financial development theory rely on the same vocabulary and the same empirical variables (i.e., private credit often expressed as a ratio to GDP) and generally yield similar empirical results, the two theoretical perspective produce vastly different policy recommendations. The same findings, interpreted differently, led Levine et al. (2000) and Beck et al. (2000) to focus on stronger "legal rights of creditors" and "efficiency of contract enforcement" as a strategy for expanding the amount of private credit. In contrast, Khan (2011) working with the same variables, recommended that monetary policy in Sub-Saharan African (SSA) countries set intermediate targets on the amount of private credit (in addition to the price of money i.e., key interest rate). Weeks (2010) recommended that monetary policy in SSA countries lower real rates of interest which would boost credit demand by lowering the cost of borrowing. Lower real rates of interest also reduce the rationing of loans and prevent the diversion of public funds into debt servicing. Asongu (2012, 2016) reviewed largely the same data when examining monetary policy's duty to offset adverse short-run shocks to economic activity and found that in some cases the traditional discretionary monetary policy tools and instruments have limited ability to offset output fluctuations, hence monetary policy may not use these instruments for expansionary or contractionary policies (2012, p.867).

4 Empirical Methodology and Data

The success-dissipation problem suggests that the regulatory impact assessment (RIA) of the microcredit industry belongs to the category of policy problems that have come to be known as "wicked" (Rittel and Webber, 1973). The term "wicked" is used to highlight the fact that the problem is complex and structurally uncertain (Nilsson et al., 2008); policy solutions are difficult to identify due to incomplete, contradictory and changing evidence (Nilsson et al., 2008; Kolkman et al., 2016) and the fact that the problem is susceptible to unintended consequences (Newman and Head, 2017). The wicked nature of such policy problems, and the strong desire to base policy solutions on a rigorous and systematic appraisal of empirical facts, has led to the call for more advanced policy assessment tools (Nilsson et al., 2008). Recently, there has been an increasing interest in the use of computer- based simulations as an advanced tool of inquiry into RIA in a formal and quantified way (Nilsson et al., 2008; Van Daalen et al., 2002).

Computer-based simulations have shown promise in ex-ante policy assessments. The power of computer simulations lies in their ability to model interactions of agents from the bottom up (Bourguignon et al., 2008; Bergmann, 1990); to model economic fluctuations (Delli Gatti et al., 2010; Ashraf et al., 2017; Dosi et al., 2010, 2015); and to model emergent phenomena which are counter- intuitive and unanticipated (Epstein and Axtell, 1996; LeBaron, 2001; Axtell, 2005; Miller and Page, 2007; Fagiolo and Roventini, 2012).

The simulation used in this paper is developed on the MASON framework (Keith Sullivan and Gabriel Balan, 2005). MASON, which stands for Multi Agent Simulator Of Neighborhoods, is an agent-based model framework for fast discrete-event multiagent simulation written in the Java programming language and designed for large custom-purpose simulations. MASON is a joint effort between George Mason University's Evolutionary Computation Laboratory and the GMU Center for Social Complexity.

4.1 Modeling Overview and Purpose

The microcredit simulation compares the existing microcredit framework to a more risk tolerant framework. The main hypothesis is that tighter regulations, by themselves, produce a risk averse credit environment and a relatively lower level of resource employment. In this environment, "patient" entrepreneurs are compelled to only accept profitable offers—which is to say, where the

buyer's offer price (limited by the buyer's "budget constraint") is greater than their cost of production plus transaction costs.

In contrast, a risk-tolerant credit environment produces a higher level of resource employment as "impatient" entrepreneurs bargain (Geertz, 1978) and accept "good enough" market-clearing offers— which is to say, where the buyer's offer price (limited by the buyer's "budget constraint") is close enough to the entrepreneur's cost of production plus transaction costs.

The simulation developed is perhaps closest to Ashraf, Gershman, and Howitt (2017). Ashraf et al. examined the role that banks play in supporting exchange activities facilitated by a self-organizing network of entrepreneurial firms. However, in a departure from Ashraf et al., the present simulation seeks to model production and pricing decisions rather than the market entry and exit decisions of firms. This approach is similar to Blinder (1987) and Bernanke and Gertler (1995, p. 38) among others who observed that firms with relatively poor access to credit markets respond to declining cash flow by cutting production and employment rather than exiting the market. When the decline in cash flow is due to a slowdown in sales, firms may respond by lowering prices and adopting lower cost methods of production. Price reduction and new methods compelled by credit contraction is an essential element of Schumpeter's theory of economic development (1927, p. 302).

The simulation is related to Delli Gatti, Gallegati, Greenwald, Russo, and Stiglitz (2010) who used an agent-based simulation to model how a slowdown in a firm's sales combined with credit constraints can cascade to the broader economy. Their model of the financial accelerator channel is based on imperfect information which prevents the bank from discriminating between good and bad borrowers. Thus, the bank will raise interest rates on all borrowers thereby pushing the most credit worthy borrowers from credit markets. Delli Gatti et al. surmise that the credit network economy can exhibit higher growth rates if more credit is extended to finance increasing levels of production— although this will lead to higher leverage and increased systemic risk.

Similarly, Dosi, Fagiolo, Napoletano, Roventini, and Treibich (2015) showed that an agent-based simulation can be used to reproduce a wide array of macro- and micro-empirical regularities. Once the regularities have been reproduced, their model provides a framework to examine the most appropriate combination of fiscal and monetary policies for dealing with persistent fluctuations, deep recessions and banking crises. One important simulation result in Dosi et al. (2015) is that austerity policies appear to be self-defeating. In addition, monetary policies may matter during economic downturns but may be irrelevant during periods of high profits and low liquidity constraints.

4.1.1 Overview of the Experiments

The simulation seeks to model the pricing decisions of SME sector entrepreneurs based on different terms of credit. First, a baseline experiment model is developed by using 2009 census data from Kenya. Because real data is being used, and the need to keep things simple, the baseline experiment does not attempt to robustly reproduce stylized macroeconomic facts from micro behavioral characteristics. However, once a baseline is established, various other experiments may be conducted. These experiments examine how different terms of credit affect entrepreneurial behaviors and economic outcomes.

The experiments are meant to examine the impact of tighter regulatory supervision and banking sector subsidies (Von Pischke, 2007; Dichter and Harper, 2007) on a bank's risk behavior; how a bank's risk behavior is transmitted to entrepreneurial risk behavior, and how entrepreneurial risk behavior impacts economic activity and welfare.

The simulation is based on a Continuous Double Auction (CDA) model which is the most common market exchange institution used in real-world trading of equities and commodities (Das et al., 2001). The general CDA model features a fixed-duration trading period where buy orders (bids) and sell orders (asks) are submitted at any point during the period; if compatible bids and asks (in terms of price and quantity) are present, then trades are executed immediately. The current implementation of CDA compares two main experiments based the farmer model (Farmer et al., 2003; Rama, 2006) as follows: "patient entrepreneurs" (with risk-averse microcredit loans) place "Limit Orders" which specify a sell (bid) price and only execute if the sell price (representing the cost of production plus transaction costs) is higher than the buyer (ask) price (representing the buyer's budget constraint). Impatient entrepreneurs (with risk tolerant loans) place "Market Orders" which specify a sell (bid) price and is generally executed at the market price, even when the sell price (representing the cost of production plus transaction costs) is higher than market price. Therefore, in a "Market Orders" exchange, the entrepreneur incurs a loss. The entrepreneur takes the loss because 1) the risk is transferred to the bank, and 2) the transaction price is the best price he can get.

Table 1 Simulation Experiments.

Variations in Agent Rules (Types of Experiments)		
Experiment	**Brief Description**	**Policy Treatment**[1]
Baseline	LimitOrders: execute only when bid price is higher than ask price	None
Risk-averse	LimitOrders: execute only when bid price is higher than ask price	Provide risk averse loans e.g. JLG loans
Risk-tolerant	MarketOrders: always execute whether bid price is higher than ask price or not	Provide risk tolerant loans programs
Cash Transfer	LimitOrders: execute only when bid price is higher than ask price	Provide direct cash transfer to consumption-side to increase Buyer purchasing power.
Government Subsidy	LimitOrders: execute only when bid to price is higher than ask price	Provide government subsidy lower production costs e.g. on health, transport and education

[1] Details provided in later sections.

The entrepreneur's "cost of production"' and the buyer's "budget constraint" are constructed using the same algorithm to mimic the insight in de Janvry et al. (1991). The process of exchange, or trade, takes place as a two-sided match where the agents are randomly paired.

To increase the robustness of results, three additional experiments are included that vary agent rules and model parameters. The baseline model (or control) contains no policy treatment, and "Limit Orders" is used. The government subsidy experiment uses "Limit Orders" and a policy intervention on the entrepreneur side. The direct cash transfer experiment uses "Limit Orders" and a policy intervention on the consumer (buyer) side. Details of these experiments are presented later in the paper.

4.1.2 Entities, state variables, and scales

This subsection outlines the structure of the model, specifying the types of entities in the model (e.g., types of agents, spatial units, environmental variables) and their low-level state variables that constitute the state of these entities.

Table 2 Environment Variables.

Environment Variables		
Variable Name	**Brief Description**	**Parameters**[1]
Direct Cash Transfer	Treatment in experiment 3	e.g., constant of Ksh. 50 for each consumer product category
Subsidy	Treatment in experiment 5 (Government subsidy)	e.g., 10%, 20% or 30% reduction in cost of for education
Bank credit	Treatment in experiment 2 and 3.	Amount is calculated as short-fall needed to produce one extra unit
	In experiment 2 and 3	Profits, if any, are used to repay loans
Entrepreneur Ask Price	Represents cost of production for each product category	Calculated as the higher of income * CPI Rate or Poverty Wage * CPI Rate
Buyer Price	Buyer Bid Price for each product category	Calculated as the higher of income * CPI Rate or Poverty Wage * CPI Rate

[1] Calculation to determine value of parameter.

Table 3 Low-level state variables.

Low-Level State Variables		
Variable	**Brief Description**	**Source**[1]
District	spatial units are 71 Districts based on 2008 boundaries	2009 Kenya Population & Housing Census Results
Income	Household-level income, also Capital, is calculated using a Pareto distribution from the District-level Poverty Rate	District-level poverty Rate from Census Data
Agent Role	Agent is either an Entrepreneur (Producer) or Buyer (Consumer i.e., Employed)	2008-09 Kenya Demographic and Health Survey (KDHS) by Kenya National Bureau of Statistics which contains District-level for Employment and Type of Employment.
Poverty Rate	District-Level Urban and Rural Poverty Data	2005-6 Kenya Integrated Household Budget Survey (KIHBS) by Kenya National Bureau of Statistics - Ministry of Planning and National development
Products	CPI ratios of 12 product cate-	2005 Consumer Price Index (CPI)

[1] Main Dataset used to compile data.

4.1.3 Process overview and scheduling

The lists the processes that occur in the model and how they are scheduled, how entrepreneur and buyer and agent interact and trade, and in which order, and when the state variables are updated is discussed in section 4.3 below.

4.2 Data

Data from Kenya is used to provide the low-level state variables as shown in table 4. Table 5 shows a sample of the dataset in this file which contains 578 unique rows. As table 5 shows, the main data source is Kenya Population & Housing Census Results (2009) which contains district-level aggregates of activity status (employment status), rural and urban population distributions, population, and other household characteristics. Other data sources include the district- level poverty rate and "Type of Employment" from the Kenya Demographic and Health Survey (KDHS) for years 2008-09 issued by the Kenya National Bureau of Statistics and the 2005 CPI index from CBK. More details of how the data is used in the simulation will be provided at the appropriate section. A summary of the environment, or experiment variables is contained in table 3. The table shows the treatments that are used to vary parameters in the simulation and when they are used.

Table 5 Sample of the dataset.

District	District Code	Urban	Gender	Employed%	SeekingWork%	Economically Inactive%	Employment Unclassified%	Population	Poverty Rate	Number Poor
MOMBASA	301	Urban	Female	0.314	0.096	0.545	0.045	219202	0.376	335150
MOMBASA	301	Urban	Male	0.548	0.099	0.314	0.038	226015	0.376	335150
NAIROBI E	102	Urban	Female	0.44	0.086	0.416	0.058	486416	0.22	632373
NAIROBI E	102	Urban	Male	0.632	0.073	0.247	0.048	505613	0.22	632373
NAIROBI N	103	Urban	Female	0.41	0.124	0.41	0.057	444671	0.22	632373
NAIROBI N	103	Urban	Male	0.597	0.096	0.261	0.046	462536	0.22	632373
NAIROBI W	101	Urban	Female	0.41	0.096	0.431	0.063	287343	0.22	632373
NAIROBI W	101	Urban	Male	0.6	0.079	0.271	0.05	306514	0.22	632373
TURKANA	701	Rural	Male	0.645	0.073	0.11	0.172	86235	0.943	481442
TURKANA	701	Urban	Female	0.258	0.164	0.44	0.138	21200	0.943	481442
TURKANA	701	Urban	Male	0.312	0.174	0.374	0.14	19515	0.943	481442
NAIVASHA	732	Rural	Female	0.422	0.051	0.494	0.032	62325	0.394	376833

4.3 Design concepts

The simulation seeks to provide an advanced ex-ante policy assessment tool using actual data from Kenya. Each simulation step represents a single market interaction between potential buyer and producer/entrepreneur. The decision to be an entrepreneur and produce for the market (or be self-sufficient) or be an employee and buy from the market is modelled as financially equivalent (i.e., using the same algorithm). However, since paid jobs are not always available (i.e., involuntary unemployment), I have used actual district-level employment data to estimate the distribution of entrepreneurs and employed workers.

The simulation seeks to model product-level behavior based on Consumer Price Index (CPI) from CBK. This level of granularity allows the simulation framework to examine specific subsidies and direct cash transfers. In addition, since declines in private credit are often caused by government fiscal deficits, it is useful to build a framework that includes estimates of the tradeoff between the deficit spending and government subsidies within the model. For example, better roads reduce transaction costs (of transportation) while government spending on education and health reduces the burden of these costs on consumers.

4.3.1 Initialization

This subsection describes how the model is started, and the external inputs (i.e., data) used to give initial values to the low-level state variables. Table 3 and 4 have provided the entities and environment variables. The environment variables are crude estimates, however, in future extensions these values may be sourced from empirical data.

The model is initialized as follows,

1. Read district-level data from the prepared csv data file. A sample of this file is shown in table 5.
2. Create micro-level agents (individual buyers/consumers/employed and entrepreneurs) from the district-level dataset.
3. Calculate each buyer's total income and product-level budget constraint. The buyer's total income is calculated using a pareto distribution of the district-level poverty rate from the Population and Housing Census Results 2009 dataset. Income below Kshs. 2,913 for urban areas and Kshs. 1,562 for rural areas is considered poor. The apportioning of total income into product-level "budget constraint" uses CPI categories from CBK data for 2015 shown in table 6. The "budget constraint" or "ask price" for each product category is calculated by multiplying the total income by each CPI weight.

4. Calculate each entrepreneur's total capital and product-level cost of production. Identical to number 3 above, the entrepreneur's total capital is calculated using a pareto distribution of the district-level poverty rate from the Population and Housing Census Results 2009 dataset. The apportioning of total capital into product-level "cost of production" uses CPI categories from CBK data for 2015 shown in table 6. The "cost of production" or "bid price" for each product category is calculated by multiplying the total capital by each CPI weight.

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Table 6 CPI Weights for Kenya in 2015.

Asset Category	CPI
Food & Non-Alcoholic Beverage	36%
Housing Water Electricity, Gas & other Fuels	18%
Transport	8%
Clothing & Footwear	7%
Furnishings Household Goods & Maintenance	6%
Miscellaneous Goods & Services	4%
Restaurant & Hotels	4%
Communication	3%
Education	3%
Health	3%
Recreation & Culture	3%
Alcohol & Tobacco	2%

One of the main output variables used in the paper is the poverty [reduction] measures. The poverty measure used for presenting information on the poor in an operationally convenient manner is the FGT measure developed by Foster, Greer, and Thorbecke (1984). The formula to calculate FGT is shown in equation 1 and 2.

$$P_\alpha = \left(\frac{1}{n}\right) \sum_{i=1}^{q} \left(\frac{z - y_i}{z}\right)^\alpha$$

Equation 1

$$\overline{G} = \sum_{i=1}^{q} \frac{G_i}{q}$$

Equation 2

Where n is the size of population, q is the index identifying the individual whose consumption level lies just on the poverty line, and α is a parameter capturing the analyst's concern for the depth of poverty. If $\alpha = 0$ is chosen, then this index is just a head-count index $H = q/n$. If $\alpha = 1$, then the poverty measure that we get is the product of the head-count index and the average consumption gap among the poor HG which considers incidence of poverty and depth, where α can be viewed as a measure of poverty aversion: A larger a gives greater emphasis to the poorest poor.

5 Simulation Results

This section presents a summary of the simulation observation. Table 7 contains a summary of the results of 4 different executions for 10,000 transactions summarized by experiment. The columns show number of poor (i.e., count of rejected transactions), GDP (aggregate of completed transaction), transaction count, average prices, intervention cost (unpaid loans for risk-tolerant and risk-averse experiment; or government subsidy for GovtSubsidy experiment; or cash transfers for CashTransfer experiment), returns (aggregation of transaction prices less unit cost of production) and net returns (return less intervention cost).

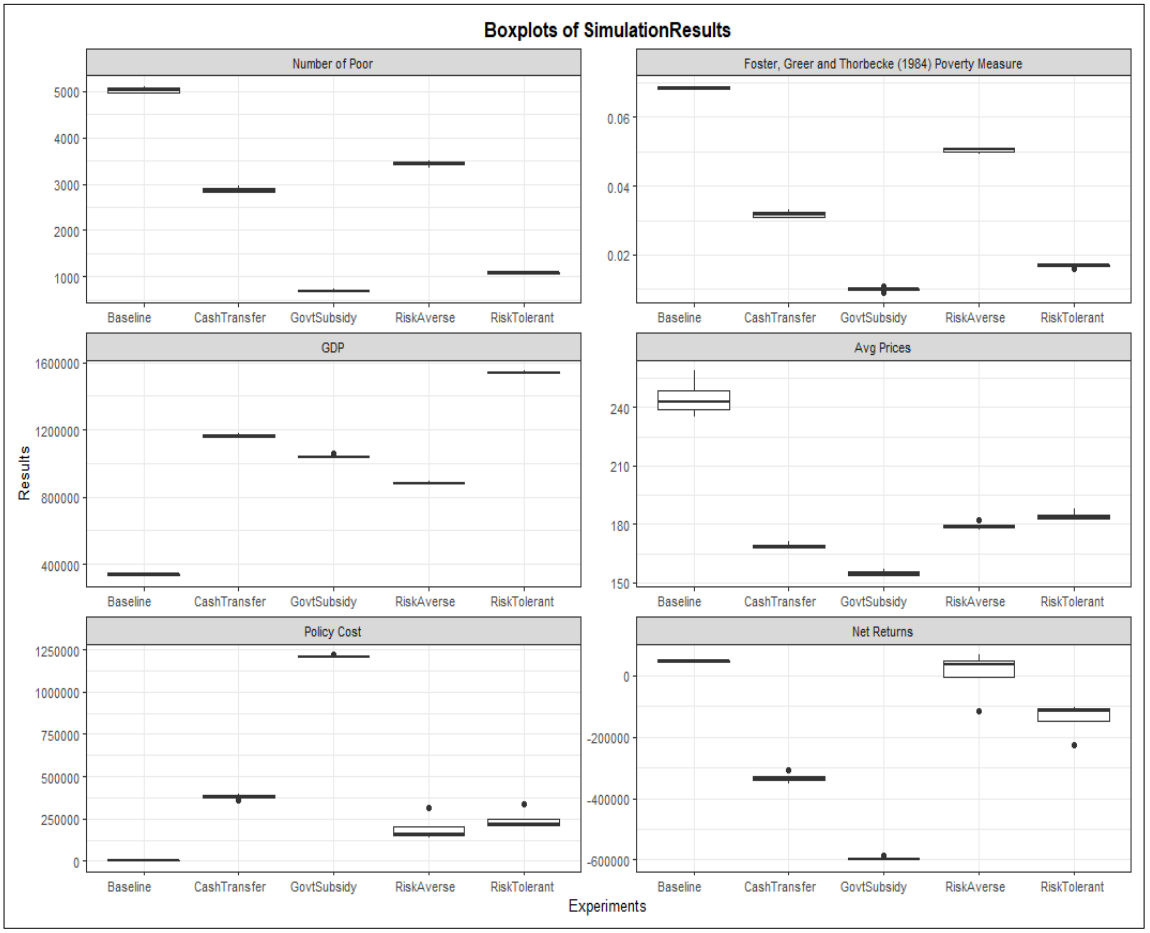

Fig. 2 Box Plot of Simulation Results for Experiments.

In summary, the results support the hypothesis that risk tolerant credit, can alleviate poverty as measured using FTG, increase employment of human and other resources as measured by an aggregation of completed transaction without triggering unintended consequences such as inflation as measured by average prices. Details of these results are discussed below.

The first plot in figure 2 shows a box plot of the summary results for differences in the intensity of poverty as measured using a modified FTG measure with $\alpha = 2$. The results show (the higher the better) that the government subsidy treatment had the most impact on poverty, followed by the risk tolerant loans, cash transfers, risk averse loans and baseline, respectively.

The second plot in Figure 2 shows a box plot of the summary results for simple count of poor. Risk-tolerant experiment where only 10% of transaction attempts were rejected because the buyer did not have enough money, compared with 50%, 35%, 30% and 7% for baseline, risk-averse, cash transfer and government subsidy, respectively.

The total successful transaction is shown in the third plot which contains a box plot of the summary results for the market value of total exchanges (i.e., GDP). The plot provides a clear demonstration that the treatment in risk-tolerant experiment is optimal compared to cash transfer, government subsidy, risk-averse, and baseline, respectively.

Table 7 Results Summary.

Run 1						Interest Free Debt Repayment		
	PovN.[1]	**FTG Val.**	**GDP**[2]	**Cnt**[3]	**AvgP**[4]	**IntCost**[5]	**Rtn**[6]	**NetRtn**[7]
Baseline	5109	0.069	324,309	1,319	245	0	43,448	43,448
Risk-tolerant	1119	0.017	1,537,398	8,773	184	206,979	103,693	-103,286
Risk-averse	3479	0.051	869,922	5,105	179	133,809	202,101	68,292
GovtSubsidy	694	0.010	1,040,451	9,130	155	1,208,423	611,324	-597,099
CashTransfer	2950	0.033	1,168,131	4,775	169	393,879	41,720	-352,159
Run 2						5% Interest on Debt Repayment		
Baseline	4950	0.068	339,453	1,409	240	0	44,924	44,924
Risk-tolerant	1057	0.016	1,535,438	8,824	183	214,228	94,293	-119,935
Risk-averse	3348	0.049	880,137	5,271	177	153,623	193,355	39,732
GovtSubsidy	689	0.010	1,037,664	9,165	153	1,207,143	603,692	-603,451
CashTransfer	2820	0.031	1,175,839	4,819	168	383,019	46,039	-336,980
Run 3						10% interest on Debt Repayment		
Baseline	4986	0.068	338,334	1,437	235	0	47,553	47,553
Risk-tolerant	1061	0.017	1,540,660	8,846	182	216,631	107,295	-109,336
Risk-averse	3438	0.050	892,227	5,151	179	168,951	198,807	29,856
GovtSubsidy	730	0.011	1,035,388	9,145	154	1,209,543	611,487	-598,056
CashTransfer	2826	0.031	1,147,390	4,881	168	359,697	52,872	-306,825
Run 4						No Debt Repayment		
Baseline	5055	0.069	351,559	1,354	259	0	48,896	48,896
Risk-tolerant	1100	0.017	1,553,672	8,777	188	339,583	112,666	-226,917
Risk-averse	3492	0.051	878,285	5,104	182	315,675	200,126	-115,549
GovtSubsidy	657	0.009	1,056,699	9,184	157	1,222,156	635,529	-586,627
CashTransfer	2898	0.032	1,160,076	4,745	171	382,687	47,137	-335,550

[1] Number of poor (i.e., Count of rejected transactions);
[2] Market GDP (aggregate of transaction prices for transaction);
[3] Number of completed exchanges.
[4] Average of all CPI category prices;
[5] Intervention cost ("credit defaults", government subsidy or cash transfers);
[6] Returns (aggregation of transaction prices less unit cost of production) and [7] Net returns (return less intervention cost).

The box plot of average prices shows that treatment in risk-tolerant experiment is much better than baseline, but slightly worse than the other policy alternatives. This result can be explained by the greater number of accepted exchanges; in the other experiments, these market exchanges would have been rejected.

The plot of estimated policy costs in term of monies spent is plotted with an inverted Y axis so that high is better. The baseline experiment has the lowest policy cost at zero while government subsidy has the highest. The plot of net return confirm that the risk-tolerant experiment has the best performance.

6 Robustness Checks

The paper sought to provide an explanation for the empirical finding that while the microcredit industry is succeeding at helping poor borrowers start (or expand) businesses, few significant benefits persisted beyond the initial two years. Consequently, the computer simulation in section 4 was not intended for making precise predictions, but rather to provide the expository device for conducting the investigation in a formal and quantified way.

All the same, reasonable robustness checks were conducted by modifying some of the analytic choices and then reporting their effects on the estimates of interest. These choices included interest rates (0%, 5%, and 10%) and debt repayment.

The set of feasible robustness checks was reduced by using actual data from Kenya, and the insight in de Janvry et al., (1991) that rural and informal sector households are different because they own or can produce the products or factors which the household uses. Therefore, the production cost of domestic production and market prices were assumed to be financially equivalent (i.e., estimated using the same algorithm). Actual district-level employment data was used to estimate the distribution between domestic producers/entrepreneurs and employed workers.

In addition, the set of feasible robustness checks was reduced by focusing on microcredit loan's impact on market-clearing pricing decisions (see Blinder, 1987; Bernanke and Gertler, 1995, p. 38).

7 Implications

While recent empirical research has found that the currently predominant model of the microcredit industry does not meet the developmental and welfare goals that developing countries have for it (Banerjee et al., 2015; J-PAL, 2018; Haldar and Stiglitz, 2016), there is a gap in our understanding of why this is happening. It is not clear whether tighter regulatory supervision will

help or hinder the industry in meeting its main goals.

The finding of this paper suggests that tighter regulatory supervision, by itself, will hinder the microcredit industry. The study attributed the unsatisfactory performance to a flawed theoretical foundation. Reliance on this theoretical foundation has led developmental organizations to dictate a risk-averse strategy for the microcredit industry. The simulation in section 4 to 5 demonstrated that this risk-averse model is inferior to a risk-tolerant model insofar as poverty alleviation and economic growth are concerned, without producing unintended consequences such as inflation.

The findings of the study have important implications for how policymaking should be conducted. At issue is whether policymaking should privilege top-down policy emulation/transfer of "evidence-based best practice" fortified by tight regulatory supervision so that the real world is pushed to behave according to our theoretical models. Or whether policymaking should be based on the inverse: privileging bottom-up organic/evolution of market-based solutions. Put differently, whether the goal of economic theory and practice is directing the facts on the ground along guardrails established by static theoretical models; or helping economic theory and practice to catchup to the facts and trends on the ground.

The study provided support for the latter approach based on the insight that economic change/development is discontinuous and dialectical/cyclical. Therefore, the rigid human-designed, human-managed regulatory approach is effective in the short run; but the success is not enduring. In this perspective, it can be argued, the emergence of the microcredit industry, when it did, was a bottom-up organic development that followed the adoption of the market system by developing countries. The microcredit industry provided a link to monetary policy in line with the key Schumpeterian insight that bank credit is part of money creation and risk transfer.

In addition, the study suggested that the risk-averse model may bring about market failure (i.e., situations where households prefer self-sufficiency to market exchanges). The main consequence of market failure is that the government' ability to direct the operation of market economies is compromised.

While the implementation of the risk-tolerant model for microcredit industry is a topic for future research, the simulations suggested a way forward. The key is taking advantage of advances in transactional technologies (i.e., ubiquitous mobile transactions) to reduce micro-level information asymmetries, and risks to investors. Therefore, our interest in transactional technologies goes beyond the cheaper, quicker, and easier ways to transfer money, and focuses on their potential as sources of micro-level electronic information. Micro-level information (i.e., sales data) allows entrepreneurs in the SME sector to obtain credible information on market structure and the activities of related firms. This information allows these entrepreneurs and investors to form more realistic expectations on revenue and physical productivity. Thus, more skilled entrepreneurs are able to obtain better terms of credit and grow their enterprises by attaining greater market share. This data can also allow the subsidized microcredit programs to focus on the production of goods and services that actually reduce poverty among the poor rather than the over-concentration on the more profitable goods and services for the middle class and rich. This incentive structure can support the government's goal of promoting technological development and economic growth.

Ideally, these entrepreneurial loans will be competitive, short-term, contingent credit contracts that are geared primarily toward working capital and smoothening temporary declines in cashflows e.g., from slowdown in sales. In order to reduce corruption, contracts can be awarded using a machine learning algorithm based on relative performance of micro-enterprises to each other as measured by a constructed microentrepreneurial rating—an approach currently being implemented at a still-small scale by a number of financial technology ("fintech") startups in Sub-Saharan Africa with similarity to Kenya. The microentrepreneurial rating and short-term contingency credit contracts enables the creation of an auction market for entrepreneurial credit. Such a market has the potential to mitigate problems of moral hazard (entrepreneurial funds are less likely to be diverted towards other purposes) and adverse selection, (i.e., higher-rated firms may get better terms of credit).

Such an approach places single entrepreneurial ventures within a more broadly-based "entrepreneurial ecosystem" at the sectoral, or sub-national regional scale rather than at the household or firm scale. This information- focused future research will map the entrepreneurial ecosystem and provide a simple relational inventory (or graph) identifying the different participants in the ecosystem by quantitatively describing their connections, roles and relationships.

In addition, the simulation developed for the study suggests new approaches for building tools for conducting advanced ex-ante policy assessment as required by law. For example, Kenya's Statutory Instruments Act of 2013 makes it a requirement that regulatory authorities make consultation with persons likely to be affected for every statutory instrument that is likely to have direct, or substantial indirect, effect on business or restrict competition. Although the simulation is a provisional first step, it provides a useful analytical framework for the regulatory consultations

envisioned in the legislation.

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Conflict of interest

The authors declare that they have no conflict of interest.

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