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The Link between Access to Bank Loans and Income Distribution in Agent Based Modeling: A Theoretical Framework

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Preface

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The Link between Access to Bank Loans and Income Distribution in Agent Based Modeling: A Theoretical Framework*

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Abstract

The agent-based model of Dosi, Fagiolo, Napoletano, and Roventini (2013) assumed that there exists a well-functioning banking system and industries are composed of both capital and non-capital goods producing sectors. They found that monetary policy has a minimal role in affecting functional income distribution. The model is modified to capture the realities of developing countries where the banking system's supply of services is smaller than what is optimal. The system is heavily influenced by inside agents and industries are dominated by non-capital goods producing firms. The modified model theoretically links firms' access to bank loans and functional income distribution in agent-based modeling. The results based on the modified model indicate that when firms have access to bank loans, functional income distribution improves. Unlike many firm level studies which focus on the firms per se, this study argues that it is possible to utilize firms' economic actions and their access to bank loans to explain how income inequality is generated and how it evolves over time. This paper theoretically finds personal income distribution as an emergent phenomenon. This result is in agreement with Thomas Schelling's 'Micromotives and Macrobehaviour', where he established aggregate behavior as an emergent phenomenon. The major conclusion is that access to bank loans at the firm level improves income distribution in society.

Keywords: Access to bank loans, functional income distribution, personal income distribution, agent-based modeling; evolving systems; economic emergence.

JEL Classification Codes: C60; C600; C63.

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1. Introduction

In the early stages of economic development, the focus of developing economies was on problems of expanding economic activities and increasing outputs. However, in the process of economic expansion, the problem of equity in income distribution became a common economic challenge throughout these economies, attracting the attention of economists and policy makers. Therefore, income inequality is one of the economic challenges facing developing economies targeting a relatively faster rate of economic growth, inclusiveness of growth and poverty reduction.

In economics, the concept of income distribution is understood as personal income distribution and functional income distribution. Field (2007) classifies personal income distribution as being related to income inequality, poverty analysis, income mobility and economic well-being. Functional income distribution which is the focus of this dissertation is attributed to post-Keynesian thinking and is about distribution of income between wages and capital income. Dosi, Fagiolo, Napoletano, and Roventini (2013) noted that functional income distribution is closely associated with personal income distribution suggesting the use of the same concept of income distribution.

For Ethiopia, the last decade witnessed an average economic growth rate of 8.5 per cent. However, this growth process in addition to a general positive impact on poverty reduction was accompanied by increasing income inequality. For example, according to the World Bank, the per capita gross national income was US$ 200 and US$ 370 for 1993 and 2009 respectively while for low income countries the corresponding figures for the respective years were US$ 538 and US$ 1,257. For sub-Saharan Africa, the corresponding per capita figures were US$ 261 and US$ 569.The poverty head count index declined from 45.5 per cent in 1995, to 42.2 per cent in 1999, 38.9 per cent in 2004 and 29.6 per cent in 2011. However, Dercon, Hoddinott, and Tassew (2011) show a reversal in recent years, in that the poverty head count index was U-shaped. It was 55 per cent for 1995, 36 per cent for 1999, 35 per cent for 2004 and 52 per cent for 2009 for Ethiopia.

Focusing on the share of industrial income, Ethiopian firm level data on the medium and large scale manufacturing firms indicates that during 1996and 2009,the share of wages ranged from a minimum of 3 per cent to a maximum of 4 per cent of the total manufacturing value added with a standard deviation of 0.002. The trend indicates a declining pattern. While there is growing concern about expanding the manufacturing sector in Ethiopia, one may argue that the low and declining share of wages is socially incompatible with increasing industrialization, because this distributional conflict may refute the initial motive for industrialization itself. There is also additional concern about expanding urbanization with a parallel increase in industrial wages of workers. If the income share of this increasing industrial population deteriorates, then it is natural to expect more inequalities and social conflicts which are detrimental to social progress.

The2013official report of the Ministry of Finance and Economic Development of Ethiopia (MoFED) indicated that for 2011, the Gini coefficients for rural and urban populations were 0.27 and 0.37 respectively, while the national average for the same year was 0.30. However, the difference between reported and actual income inequality has been a debated issue among researchers and social planners. Of late, the Government of Ethiopia has recognized the gravity of the income inequality problem and indicated a

need for an inclusive growth policy to improve income distribution in the rapid growth and transformation process.

Inequality in opportunities among citizens for accessing the country's resources is a major challenge facing Ethiopian society. Access to bank loans either at household or firm levels is one area where such inequality in opportunity is revealed. The gravity of such inequality is more pronounced in the modern industrial population. The underlying causes for this could be attributed to the immature status of the banking system and the regulatory requirements of the banking industry.

Looking at banking services, currently the Ethiopian banking system consists of 19 commercial banks out of which three are public banks -- the Commercial Bank of Ethiopia (CBE), the Development Bank of Ethiopia (DBE) and the Construction and Business Bank of Ethiopia (CBBE). The remaining 16 are privately owned commercial banks. In addition, there are31 microfinance institutions and over 8,200 saving and credit cooperatives (SACCOs) operating in both rural and urban areas. The ownership structure of microfinance institutions is mixed. The large microfinance institutions are partially owned by regional states, some by non-governmental organizations (NGOs) and others by private owners.

The government-owned commercial bank, the Commercial bank of Ethiopia (CBE), is the dominant commercial bank. CBE accounted for 70 per cent of the total assets of banks as of May 2013 (IMF, 2013). The remaining 30 per cent was accounted for by the other commercial banks.

On the allocation of funds to the manufacturing sector, CBE's official statistics show that during 2009/10–2013/14, out of the total dispersement of loans by CBE, on average, 40.37 per cent of the loans were to the manufacturing sector while the remaining funds were allocated mainly to government projects. During the same period, the remaining private banks allocated only 7.85 per cent of their loan dispersement to the manufacturing sector, while on average only 28.18 per cent of the country's loan dispersement went to the manufacturing sector. Private commercial banks are inclined to finance services, other than import and export businesses.

Government owned banks allocate credit on the basis of government directives while the private banks allocate credit under the heavily regulated public credit policy but relatively freely by their own mechanisms. From the existing regulatory and institutional conditions, and also from the data, it is evident that the dominance of the government in the banking system is going to continue while private banks will remain heavily controlled. Under this set-up, we may argue that as long as public policy continues to marginalize private banks, these banks will continue to advance short-term loans which are less risky instead of financing long-term investment projects which are carried out by the manufacturing sector. Thus, public policy dominance and interventions explain to a large extent the skewed distribution of funds between public and private and manufacturing, agriculture and service sectors.

The high rate of growth and increased income inequalities combined with a desire to make growth inclusive raises a need for identifying firm level drivers of functional income distribution. This includes explaining the possible channels through which these drivers influence income distribution at the national level. Of the major constraints most commonly reported by firms, this study focuses on the problem of access to bank loans.

Limitation in access to investment capital and working capital are seen as factor that permanently makes functional income distribution unequal. Knowledge about such a relationship can be useful for promoting a better organization of the financial market as well as both economic growth and equality in income distribution.

Linking bank loans to functional income distribution is an issue that requires investigation because the distributional conflict between the shares of wage payments and capital incomes has a potential impact on the financial position of firms. A high wage share could undermine firms' profitability, survival and ability to operate at full capacity or to further expand investments. Thus, firms have to look for external sources of finance, for example, bank loans to overcome their internal financial constraints. However, not all the financially constrained firms will be successful in securing bank loans. Those firms which are successful in securing bank loans will be in a position to operate at full capacity and also expand their operations. This will enable them to pay higher wage rates. On the contrary, the unsuccessful ones will operate below their full capacity and consequently they will be forced to minimize costs by reducing salary expenditures. In the first case, functional distribution income will improve while in the second case, it can even worsen. Both outcomes will have implications for the evolution of labor share, skills and as a result, on the evolution of personal income distribution at the national level.

Thus, this study is motivated by the fact that researches in macroeconomics are largely concentrated around the investigation of the determinants of economic growth, while less emphasis is placed on distributional aspects or inclusiveness of growth. However, the issue of income distribution is equally important, in addition to its positive/negative effects on productivity and growth. It is well-known that social conflicts arise due to income inequalities that may incite economic instability which could potentially harm the growth process itself. As noted in Stoker (1993), it is difficult to conceive of an important question of economic policy that does not have a distributional component. Therefore, interest in distributional issues is not only for its own sake but also for better understanding the effects of income distribution on broader macroeconomic performance.

Piketty (2014) has documented the evolution of income inequality in different parts of the world. According to the author, in traditional societies the primary basis of social inequality and most common cause of the conflict of interest between those who receive land rents and those who pay them has always been at the heart of a distributional conflict. Piketty continued to argue that in the modern production system the evolution of income inequality is deeply rooted in shares of output allocated to wages and profits. The labor conflict between workers at the Marikana platinum mine near Johannesburg and the mine's owners in 2012 is presented by Piketty to demonstrate this non-optimal return allocation phenomenon.

Another proponent of better distribution, Stiglitz (2012) elaborates on how income inequality has brought the world economic system to instability in different parts of the world and in different periods. He takes the cases of the 2011 Arab spring in Tunisia and Egypt to demonstrate how income inequality can cause instability and create economic crises.

The core synopsis here is that a high share of wages may serve as incentive to improve the productivity of labor, while high share of profits which is a major source of inequality serves as an incentive for saving and investments and a basis for capacity expansion and growth. Whether increased capacity and growth induce fairness and inclusiveness,

thereby reducing risks of social conflict, or further create a more unequal society has been a contentious issue.

Once the implications of income inequality on the broader macroeconomic performance are understood, there is a demand from academics as well as policymakers for understanding mechanisms responsible for generating income inequality and its evolution. Functional income distribution is closely associated with the modern production systems of urban populations. This will have implications for personal income distribution. In situations where urban income inequality is more pronounced than rural income inequality, examining drivers for functional income distribution becomes natural. This argument is based on the fact that mechanisms responsible for creating income inequality are less stagnant in rural areas than they are in urban areas. Therefore, it could be argued that mechanisms driving functional income distribution are also responsible for variations in personal income distribution.

The role of finances in enhancing economic growth is well known. This is emphasized in, for example, Gurley and Shaw (1955), Mackinnon (1973), and Rajan and Zingales (2003). On the other hand, the question of the role of access to finance by economic agents (firms and households) in the distribution of the generated wealth remains largely unexplored (Céline and Thomas, 2011). Demirgüç-Kunt and Levine (2009) note how economists have overlooked the impact of finance on income inequality.[1]

Despite the importance of the relationship between finances and income distribution, few studies find that the structure and performance of a country's financial sector greatly affects income distribution (Jovanovic, 1990; Levine, 2005; Beck, Demirgüç-Kunt, and Levine, 2007; Claessens and Perotti, 2007; Gimet and Lagoarde-Sego, 2011; Dosi et al., 2013). However, literature is limited for a number of reasons. First, the channels and directions that affect income distribution are not well established, and second where some channels exist, research results are found to be mixed (Claessens and Perotti, 2007).

This study aims at contributing to existing literature on the relationship between access to bank loans and income distribution. From the methodological point of view, the study explores the use of agent-based computational economics (ACE) to link firms' access to bank loans and functional income distribution. By simulating the evolution of functional income distribution, it tries to find out if improved access to bank loans at the firm level is one mechanism through which a society can become more equal and achieve a higher level of welfare and well-being.

According to Leigh Tesfatsion (2000), who is also one of the pioneers, ACE is roughly defined by its practitioners as the computational study of economies modeled as evolving systems of autonomous interacting agents. ACE is the computational study of economic processes modeled as dynamic systems of interacting agents. A principal concern of ACE researchers is to understand the apparently spontaneous formation of global regularities in economic processes, such as the unplanned coordination of trading activities in decentralized market economies that economists associate with Adam Smith's invisible hand.

The challenge here is to explain how these global regularities arise bottom-up, through the repeated local interactions of autonomous agents channeled through socioeconomic

[1]For example, they showed that the three volumes of the *Handbook of Income Distribution* did not mention the possible connection between income inequality and access to finances.

institutions rather than from the top-down imposition of fictitious coordination mechanisms such as market clearing constraints or an assumption of single representative agents.

Agent-based modeling is a bottom-up approach to macroeconomics where the aggregate phenomenon cannot often be inferred from the behavior of the representative agent in market equilibrium. In such a situation the equilibrium is continuously brought about by the implicit coordination of the Walrasian auctioneer. On the contrary, in agent-based approaches, an aggregate phenomenon emerges spontaneously from the interactions of individuals struggling to coordinate their actions in the markets.

What is missing in conventional economic analysis is a treatment of 'economic emergence' whereby economic structures arise that cannot be explained simply by examining their components. Thus, the 'whole can be greater than the sum of its parts'. In neo-classical economic theory, the whole is already considered to be a fully optimized configuration of its components, subject to whatever constraints are imposed. So there is no distinction between wholes and parts and, thus, no treatment of emergence (Foster and Metcalfe, 2012). Thus the use of agent-based computational economics helps overcome the limitations of the previous theories and methods without using strong assumptions. Furthermore, the method is more suitable for an analysis of the distributional policy scenario.

By the 1990s, there had been a major development in macroeconomics in the form of a shift in economic methodology from representative agent based micro-foundation and general equilibrium to an evolutionary, complex and adaptive systems approach(see Beinhocker, 2006, for a survey). Beinhocker sees the economy as a complex evolving system, that is, as ecology of heterogeneous economic agents whose interactions continuously change the structure of the system itself (Dosie et al., 2011).

Among the leading critiques of the mainstream economic methodology are Kirman (1992) and Hartely (1997) who have openly challenged the representative agent approach of building micro-founded macroeconomic models. They argue that the representative agent based micro-foundation did not actually serve the purposes for which it was intended:

(i) escaping the Lucas critique, and (ii) building micro-founded macroeconomic models. Particularly when it comes to the issues of finance and income distribution, the representative agent based micro-foundation for macroeconomics is not theoretically sound for two reasons: (i) financial intermediation requires the simultaneous existence of financially surplus and deficit units in an economy, and (ii) inequality implies the simultaneous existence of poor and rich in an economy which are inherent and inevitable features of the economic system. In both cases, how the representative agent can be used to pass micro-behavior to macro-behavior is not theoretically clear.

Agent-based models can capture such heterogeneities and income inequalities as an emergent phenomenon which is the outcome of interactions among these heterogeneous agents. This is unlike the simple summation of the outcome of each agent's actions in existing models. This makes the agent-based alternative superior under such circumstances as compared to the standard approach in mainstream economics.

The contribution of this research can be measured on the basis of the following points. First, it will contribute to the limited literature base that links firms' access to bank loans with functional income distribution as a driver of personal income distribution.

Second, functional income distribution is becoming the center of social conflict and disagreements and as such attracting the attention of economists and policymakers.[2]Unlike most of the studies which focus on a factor analysis of personal income distribution, this study gives an evolution of inequality from the perspective of functional income distribution and can thus provide useful information for policymakers.

Third, on the methodological side, unlike the standard representative agent based micro to macro passage in the mainstream economic analysis, the micro to macro passage in ACE is an emergent phenomenon (Gatti et al., 20011), that is, macro-behavior endogenously emerges from agents' interactions. The decision making process is a result of satisfying (see Marc 2006; Arnold and Boekholt, 2002; Jaffe et al., 2002; and Nelson and Winter, 1982) rather than optimizing behavior, bounded and adaptive rather than perfect foresight, out of equilibrium interactions rather than an equilibrium analysis. The use of an ACE environment for developing countries will contribute to the current methodological controversies in economic science.[3] This paper argues that extending the existing ACE model for developing countries where well-functioning financial markets do not exist is a contribution by itself.

In sum, by explaining the possible mechanisms responsible for the evolution of functional income distribution, it is hoped that the findings here will have significant policy implications. The paper also provides an alternative way of looking into economic problems where the standard analytical tools alone are inadequate particularly in this era when economic policymakers have felt that they are less successful or have been simply left abandoned by the use of standard economic models.[4]

The rest of the paper is organized as follows. Section 2 explores ACE literature. Section 3 discusses the appropriateness of ACE for studying the relationship between bank loans and income distribution.Section4 presents the original model while Section 5 extends the original model to fit a developing country's realities. Section 6 presents the results while Section 7 concludes.

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[2]On 16 August 2012, the South African police intervened in a labor conflict between workers at the Marikana platinum mine near Johannesburg and the mine's owners, stockholders of Lonmin, Inc., based in London. Police fired on the strikers with live ammunition. Thirty-four miners were killed. As often in such strikes, the conflict is primarily concerned with wages. In this case, the miners had asked for a doubling of their monthly wage from 500 to 1,000 euros. After the tragic loss of life, the company finally proposed a monthly raise of 75 euros. This episode reminds us, if we needed reminding, of the question of what share of output should go to wages and what share to profits—in other words, how should the income from production be divided between labor and capital?. This has always been at the heart of distributional conflict (Piketty, 2014). It should be noted that in general growth is divided between investors, workers and the state. In this we have ignored taxes.

[3]Nobel Laureate Robert Lucas maintains that the design and acquisition of new tools of analysis foster the advancement of scientific research. Not only do these tools permit rigorous development of previously identified lines of thought, but they also enhance the very emergence of original paths of research (Bruunand Luna, 2000).

[4]In November 2010, the European Central Bank's (ECB) then Governor Jean-Claude Trichet opened the ECBs flagship annual Central Banking Conference with a challenge to the scientific community to develop radically new approaches to understanding the economy (for detail, see Colander et al. (2997).

2. ACE: The foundation, evolution and current status

2.1 Fundamental causes for the foundation of ACE

Before proceeding to the use of ACE, some critiques forwarded by economists against standard models in economics are discussed here. For some time there has been a strong suggestion of opposition to modern macroeconomic models. The critiques include Howitt (2006), Shimer (2009) and Pesaran and Smith (2011). The critiques among others ask, how can models that assume away any agent coordination problems shed much light on macro-phenomena that are intrinsically involved with such problems? They argue that what makes macroeconomics a separate field of study are the complex properties of aggregate behavior that emerge from an interaction among agents. Since in a complex system aggregate behavior cannot be deduced from an analysis of individuals alone, representative agent models fail to address the most basic questions of macroeconomics. Thus, an analysis of individuals' lack of representation of aggregate behavior of agents is the main source of disagreement among the proponents and opponents of ACE models.

For example, on the question of how a macro-economy should be modeled, Howitt (2006) says that any meaningful model of the macro-economy must analyze not only the characteristics of the individuals but also the structure of their interactions. Such a view is usual in other disciplines, ranging from biology to physics and sociology. Howitt recognizes that the aggregate behavior of systems of particles, molecules, neurons and social insects cannot be deduced from the characteristics of a 'representative' of the population. The same is true for various components of economic systems; the fallacy of composition exists, and must be dealt with using appropriate approaches.

In advancing the argument, Shimer (2009) recalls how models are built in the mainstream framework and says that the models are built on two foundations. First, households maximize expected utility subject to a budget constraint. Second, firms maximize expected profits. He continues to argue that these two pieces being elements of a macroeconomic model does not imply agreement on how economic agents behave in the real world.

The tradition favored by the standard framework is to keep a macro-model simple, keep the number of its parameters small and well-motivated by micro-facts, and put up with the reality that no model can, or should, fit most aspects of the data. In this tradition, the number of parameters is kept small by using very special functional forms, such as power utility functions and Cobb-Douglas production functions. These models and their treatment of micro-facts clashes with the mainstream macro-econometric practice, which rather than keeping the number of parameters small, has increasingly adopted semi-parametric or non-parametric approaches. Aggregation across heterogeneous micro-decision rules invariably leads to macro-relations with very different dynamic properties. In these relations no simple extrapolation from micro- to macro-behavior seems possible (Pesaran and Smith, 2011).

Theoretically consistent micro-foundations based on either a representative agent or a continuum of agents that can be aggregated, have been seen as a necessary condition for acceptable macro-econometric modeling. While micro-foundations, if available, may be useful, regarding them as the defining quality of an acceptable macro-model fails to recognize the difference between microeconomics and macroeconomics. A central

criterion for evaluating macroeconomic models must be their relevance for government decisions about fiscal, monetary and financial stability policies. There may be some who insist that the government should have little or no role in macro-management apart from price stability. However, given the extent of government expenditure, taxation and regulation, particularly in the financial sphere, it is essential that the models should inform macroeconomic policy. A deviation from such a rule will induce that otherwise policy will be persuaded by relatively uninformed commentators, usually with vested interests.

The restrictive representative agent rules out any meaningful lending and borrowing among agents. As a consequence, it greatly reduces the role played by financial markets, collateral requirements, default and bankruptcy. The price of including heterogeneous agents is typically a much more complicated dynamic system with fewer qualitative results. Some researchers have taken heterogeneity to be accounted for by agent-based modeling.

However, the conceptual apparatus used in a macroeconomic analysis is still dominated by the Walrasian general equilibrium. Colander (2006) reacts to this and says that the mainstream macroeconomic theory remains firmly rooted in general equilibrium micro-foundations. It is based on the isolated optimal choice behaviors of utility maximizing households subject to budget constraints, profit-maximizing firms and technological constraints. In the presence of constraints, model closures and equilibrium conditions are imposed to solve market clearing quantities. However, real-world factors such as subsistence needs, incomplete markets and imperfect competition and strategic behavioral interactions induce significant complications in practice. Therefore, open-ended learning that tremendously complicates analytical formulations is typically not incorporated in the analysis (LeBaron and Tesfatsion, 2008).

Because the analytic macro-models discussed earlier are so technically difficult, it is not clear which model, if any, will provide a meaningful advance. However, because of the increase in computing power over the past decade, there is another approach that cuts the Gordian analytic knot and uses agent-based computational economic (ACE) models to analyze macro-economy issues.

2.2. The birth and evolution of ACE under the Santa Fe perspective

The development of ACE is closely linked with the work conducted at the Santa Fe Institute, a private, not-for-profit, independent research and education center founded in 1984 in Santa Fe, New Mexico. Since its foundation, the purpose of the institute has been fostering multi-disciplinary collaboration in pursuit of understanding the common themes that arise in natural, artificial and social systems. This unified view is the dominant theme of what has been called the new science of complexity.

The main outcomes of the research project conducted at the Santa Fe Institute were three books, all bearing the title *The economy as an evolving complex system* (Anderson, Arrow and Pines, 1988; Arthur, Durlauf and Lane, 1997; Blume and Durlauf, 2006).[5]The

[5]In September 1987, 20 people came together at the Santa Fe Institute to talk about 'the economy as an evolving, complex system'. Ten were theoretical economists, invited by Kenneth J. Arrow, and ten were physicists, biologists and computer scientists, invited by Philip W. Anderson. The meeting was motivated

main characteristics of the Santa Fe approach can be summarized as identifying models having cognitive foundations, structural foundations, no global controller and exhibiting continual adaptation, perpetual novelty and out-of-equilibrium dynamics.

The theoretical foundation of ACE is rooted in the work of Thomas Schelling, one of the Nobel Laureates in economic science in 2005.In his 1978 book *Micromotives and Macrobehavior*, Schelling expressed the following: 'People are responding to an environment that consists of other people responding to their environment, which consists of people responding to an environment of people's responses' (Schelling, 1978: 14). This suggests that sometimes the dynamics are sequential.

Despite the fact that ACE models are most often computer models, and that the methodology could not develop in the absence of cheap and easy-to-handle personal computers, it is beneficial to remember that one of the most well-known ACE models, the pioneering work on spatial segregation by Thomas Schelling, did not make use of computers (Schelling, 1971).[6]

Now, the advent of the fast computational and programming techniques and critiques of traditional macroeconomic models coupled with the global financial crisis that started in 2007 has facilitated ACE to emerge as a new paradigm in macroeconomics.[7]ACE is considered as a bottom-up approach in macroeconomics (Tesfatsion, 2006; Gatti et al., 2011; and Dosi et al., 2013).

Starting in the mid-1980s, various researchers have sought to develop agent-based computational economics tools to capture in useful terms the complexity of real-world economic phenomena. The question of whether the application of such tools facilitates a more appropriate empirical approach to macroeconomic modeling is intensely discussed in Epstein and Axtell (1996) and Tesfatsion and Judd (2006) respectively in the first and second volume of the *Handbook of Computational Economics*.

The development of a theory and application of agent-based computational models has brought an alternative way of looking into issues which involves the modeling of interacting complex social systems. Particularly, the second volume of the *Handbook of Computational Economics* focused on ACE emphasizing on a computationally intensive method for developing and exploring new kinds of economic models.

In their joint publication, LeBaron and Tesfatsion(2008) note that macro-economists seek to understand the structure and performance of economies at national or regional levels and the manner in which government policymakers attempt to influence this structure and performance over time. Such an understanding would seem to require a

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by the hope that new ideas bubbling in natural sciences, loosely tied together under the rubric of 'the sciences of complexity', might stimulate new ways of thinking about economic problems.

[6]As Schelling recalls, he had the original idea while seated on a plane, and investigated it with paper and pencil. When he arrived home, he explained to his son the rules of the game and got him to move zincs and coppers from the child's own collection on a checkerboard, looking for the results. He says; 'The dynamics were sufficiently intriguing to keep my 12-year-old engaged' (Schelling, 1978, 2006).

[7] The ACE approach has become a paradigm in economics because it has already fulfilled two common features that scientific paradigms share in common. First, their achievements have enough novelty to attract a permanent group of scientists away from competing models of scientific activities. Second, their open-endedness must allow for addressing many different kinds of problems (Kuhn, 1996).

systematic exploration of the intricate feedback loops connecting micro-behaviors, interaction patterns and macro-regularities as observed in real-world economies. This is in line with or supports the notion of ACE having become a paradigm in economics.

Once the initial conditions in the model have been specified by the modeler, all subsequent world events are driven by the agent's interactions. These interactions, that is, attempts by agents to express actions within their worlds are determined dynamically in 'run-time' by the agent's internal structures, informational states, beliefs, motivations and data-processing methods. A crucial point is that modelers do not need to constrain agent interactions a-priori by the imposition of equilibrium conditions, homogeneity assumptions or other external coordination devices that have no real-world references. Ideally, the agents in ACE models should be as free to act within their computational worlds as their empirical counterparts are within the real world.

Gatti et al. (2011) expanded the points by LeBaron and Tesfatsion as follows. In contrast to the actions of the Walrasian auctioneer in representative agent models of mainstream macroeconomics, outcomes in ACE are explained as emerging from continuous adaptive dispersed interactions of a multitude of autonomous, heterogeneous and bounded rational agents living in a truly uncertain environment.

ACE models implemented on modern computational platforms can include millions of heterogeneous interacting agents (Axtell, 2001).Farmer and Foley (2009) declared that the economy requires agent-based modeling and therefore, the question is not whether this can be done, but whether it should be done, and for what purpose.

2.3. The advantages of ACE over the existing mainstream economic methodology

Since a divide has been opened up between mainstream economic methodologies and ACE modeling, there have been continuous efforts by ACE modelers to convince the economics profession what the ACE modeling techniques have brought as advantages over the exiting mainstream methodologies:

First, ACE modeling forces one to be precise: Unlike theories and models expressed in equations, a computer program has to be completely and exactly specified if it is to run. It is often relatively easy to model theories about processes, for programs are all about making things within the computer change.

Second, an experiment can be setup and repeated many times, using a range of parameters or allowing some factors to vary randomly. Of course, carrying out experiments with a computational model of some social phenomenon will yield interesting results only if the model behaves in the someway as the human system or, in other words, if the model is a good one.

Third, ACE models can also be used to test for observational equivalence (Tesfatsion, 2003), that is, for the possibility that multiple distinct micro-structures are capable of supporting a given observed macro-regularity.

Fourth, the use of ACE models could also facilitate the development and experimental testing of integrated theories that build on theory and data from many different fields of social science. In particular, ACE frameworks could encourage economists to address growth, distribution and welfare issues in a more comprehensive manner embracing a

variety of economic, social, political and psychological factors, thus restoring the broad vision of early political economists (Tesfatsion, 2003).

Finally, the advantage of the ACE approach for macroeconomics is that it removes the tractability limitations that limit analytic macroeconomics. ACE modeling allows researchers to choose a form of microeconomics appropriate for the issues at hand, including breadth of agent types, number of agents of each type and nested hierarchical arrangements of agents. It also allows researchers to consider interactions among agents simultaneously with agent decisions and to study the dynamic macro-interplay among agents. Researchers can relatively easily develop ACE models with large numbers of heterogeneous agents, and without any equilibrium conditions having to be imposed. Multiple equilibria can be considered, since equilibrium is a potential outcome rather than an imposed requirement. In addition, stability and robustness analyses can be conducted simultaneously with an analysis of solutions.

2.4 The current status of ACE

Regarding subsequent popularity, agent-based simulation has become increasingly popular as a modeling approach in social sciences because it enables one to build models where individual entities and their interactions are directly represented. As compared to variable-based approaches using structural equations, or system-based approaches using differential equations, agent-based simulation offers the possibility of modeling individual heterogeneity, representing explicitly agents' decision rules and situating agents in geographical or another type of space.

Agent-based models are diffusing in many disciplines, from biology to chemistry to economics. In economics it has already been accepted as a modeling tool in the areas of finance, studies involving chaos and in studies involving group behaviors such as the consumption of common pool environmental resources. In addition, it is used as a tool in studying industrial dynamics. In the areas of industrial dynamics, it is used for studying firm behavior and the firm creation process. It is also used as a tool in studying evolution of income and wealth distribution.

Annual conferences exclusively devoted to this area include the Workshop on the Economics of Heterogeneous Interacting Agents (WEHIA; since 1996), the Workshop on Agent-Based Approaches in Economic and Social Complex Systems (AESCS; since 2002),the Conference on Agent-Based Models of Market Dynamics and Consumer Behaviour, and the Workshop on Multi-Agent Systems: Theory and Applications (MASTA; since 2000).

Other conferences, such as Computing in Economics and Finance (CEF; since 1992), the International Workshop on Computational Intelligence in Economics and Finance (CIEF; since2001)and the International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS; since2004) have also devoted quite a significant portion of their sessions and papers to this area.

Journals which have a sharp focus on this area are the *Journal of Artificial Societies and Social Simulation*, the *Journal of Economic Dynamics and Control*, *Journal of Economic Behavior and Organization, Nonlinear Dynamics, Psychology, and Life Sciences* and *Journal of Computational Economics and Knowledge Engineering Review*. Most of the

issues dealt in the two volumes of the *Handbook of Computational Economics* are focused on ACE.

3. The rationale for using ACE to study bank loans and income distribution links

The representative agent-based micro-foundation for macroeconomics is challenged as an inappropriate approach for studying the relationship between access to bank loans and income distribution on the following grounds: (i) financial intermediation requires the simultaneous existence of financial surplus and deficit units in an economy, and (ii) inequality implies the simultaneous existence of poor and rich in an economy which are inherent and inevitable features of an economic system that is composed of heterogeneous interacting agents. In both cases, how the representative agent can be used to transfer micro-behavior to macro-behavior is not clear theoretically. In addition, by a third rationale, the mainstream approach to economic analysis does not provide a unified framework for analyzing the link between access to bank loans and income distribution.

The agent-based approach is used for building models with a large number of heterogeneous agents, where the resulting aggregate dynamics is not known a-priori and outcomes are not immediately deducible from individual behavior. This approach is characterized by three main tenets: (i) there is a multitude of objects that interact with each other and with the environment; (ii) objects are autonomous (hence, they are called agents), no central or 'top-down' control over their behavior is admitted; and (iii) the outcome of their interaction is numerically computed (Bargigli and Tedeschi, 2012).

Agents in ACE models can span all the way from passive features of the world with no cognitive function for decision makers with sophisticated cognitive abilities who actively gather and process data. For example, as illustrated in Tesfatsion and Judd (2006: Chapter 16), an ACE macroeconomic model might include structural agents (such as a spatial world), institutional agents (such as a legal system, corporations, markets) and cognitive agents (such as entrepreneurs, consumers, stock brokers and government policymakers).

Agents can also be composed of more elementary agents in various forms of a hierarchical organization. For example, an ACE macroeconomic model might include the following hierarchy of nested agent refinements: national economy $\rightarrow$ {financial sector, business sector, household sector, government sector, foreign sector}; financial sector $\rightarrow$ {commercial banks, insurance companies, stock brokers, bond dealers}; commercial banks $\rightarrow$ {employees, shareholders}; employees $\rightarrow$ {salaried workers, wage workers}; and so forth, where $\rightarrow$ indicator shows the hierarchical relations of agent refinements.

The ingredients necessary for signifying successful agent-based models are detailed in Gatti et al. (2011). These are:

1. The list of agents that populate the model. Generally, pre-determined sub-sets of the population identify groups or classes of agents characterized by specific macroeconomics roles.
2. The structure of each agent, which consists of:
    - A list of the state variables that describe the agent in every period of time horizon (which translates into a step of the simulation). 'Snapshots' of the

actual conditions of the agent in a given period, that is, the vector of levels of state variables concerning the specified agent in that period, which is the internal state of the agent.

- A list of possible actions (levels of control variables) that agents can perform. The actions will affect not only their internal states but also the internal state of other agents as well. Agents belonging to the same class have the same macroeconomic role and thereby have similar structures. They may be characterized, however, by a specific level of one or more microeconomic (state or control) variables.

3. A network of interactions that links the agents within the group and between groups. The between group interactions typically occur in virtual or geographically characterized markets.

Damaceanu (2013: 3) provides a complete list of steps required to build an agent-based model as: a set of agents (A), initializations (I) and simulation specifications (R), which are required steps in order to validate an agent-based model. More specifically, the required steps are: (1) an analysis of pure theories of economics, (2) defining the objectives of research and the precise tasks of the model, (3) building the conceptual model, (4) validation of the conceptual model, (5) transformation of the conceptual model in a computerized model using a software platform, (6) the operational validation of the computerized model, and (7) the analysis of experimental results and interpretations from an economic point of view.

Accordingly, aggregate behavior in an agent-based model can take many forms. For instance, it can result in equilibria, it can produce cycles and patterns, it can produce bubbles and crashes, and it can even sometimes produce chaos. Most agent-based models produce multiple types of aggregate phenomena. Locally, a model might produce patterns, but globally the same model might produce equilibrium. In some cases, we can determine whether an agent-based model will result in equilibrium, a pattern, or chaos, but often the only way to determine the outcome is to construct the model in a computational platform, run it, and see what arises as a result.

4. Agent-based model of links between access to bank loans and income distribution

The model, with its evolutionary roots (Nelson and Winter, 1982), belongs to the growing body of literature on agent-based models (Tesfatsion and Judd, 2006; LeBaron and Tesfatsion, 2008) that are addressing the properties of macroeconomic dynamics.

As mentioned by LeBaron and Tesfatsion (2008), for an ACE model to facilitate an understanding of a real-world macro-economy, three criteria must be met. First, the model must include an appropriate empirically based taxonomy of agents. Second, the scale of the model must be suitable for the particular purpose at hand. Third, model specifications must be subject to empirical validation in an attempt to provide genuine insights into proximate and ultimate causal mechanisms.

Therefore, successful agent-based models are those that begin with minimal (elementary) building blocks consisting of main agents of the economy along with their behavior. In this study we use building blocks which could be considered as a typical representation

of a small economy like that of Ethiopia (Figure1). Figure2 is a diagrammatic representation of the sequence of actions by agents.

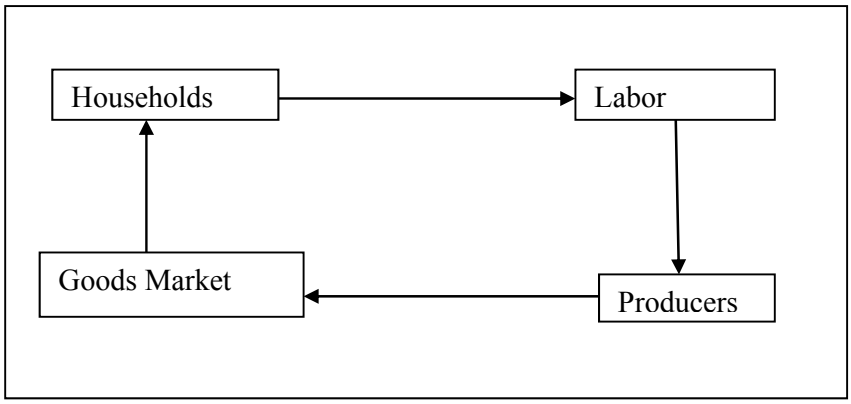


Figure 1. A simple artificial small economy

In Figure 1, the direction of the upper horizontal line and the right vertical line indicate the supply of labor to the labor market and ultimately to the producers respectively while that of the lower horizontal and left vertical lines respectively indicate supply of goods to the goods market and ultimately to consumers. The monetary receipts from labor and goods markets are in the opposite directions.

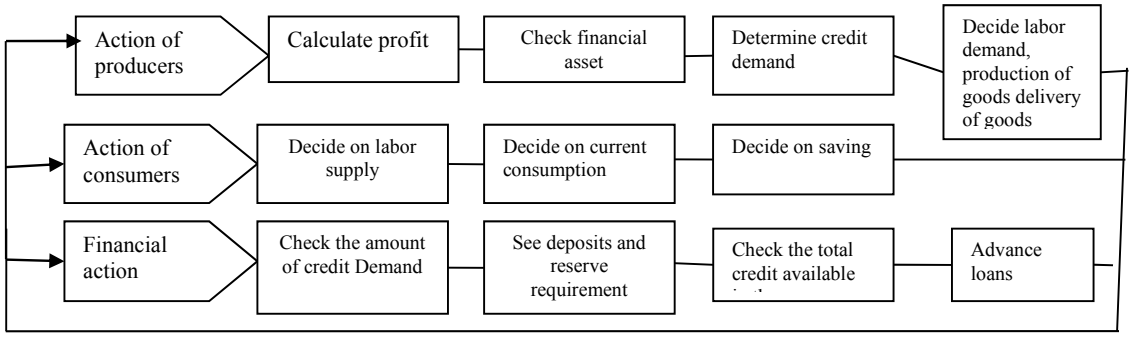


Figure2.Sequence of actions by agents in a small economy

4.1 Household (worker) agents and the labor market

Households supply labor to the labor market. They work for producers to get money to buy goods from the goods market. Regarding labor market, unemployment in Ethiopia is one of the highest in Africa (more than 20 per cent) and as such, job search in the labor market can be described in the following simple way. Each person who is not employed engages in a job search. Job searchers can be successful in two ways: (i) connection or relation-based employment, and (ii) announcement-competition based employment. In each case, the employer accepts the searcher as a new worker if and only if the job searcher is ready to accept the wage offered by the employer. It is a take it or leave it type of labor market. The job searcher's priority is to be employed first and everything

else follows next. This means, the first best choice would be to work according to her/his area of expertise and offered salary, the next best would be to work according to her/his very similar area of expertise and offered salary and so on. Once the job searcher is in the labor market, she/he will acquire experience and opt for the best by interacting with potential employers. This is where the notion of consumer-producer interaction is introduced.

Wage rates evolve according to some adaptive rules. No assumption of labor market clearing is imposed. The aggregate labor demand is computed by summing up the labor demand of producers. The aggregate labor supply is exogenous and inelastic. Aggregate employment is then the minimum interaction between labor demand and supply (disequilibrium condition). Unlike the case of developed economies, periodic wage indexation and unemployment benefits are not applicable in most developing economies including Ethiopia. Rather, wages are set through negotiations between trade unions and employers and their associations, usually on the basis of institutional and economic factors. The major economic factor in wage formation is change in average labor productivity at time t, ΔQ_{avt} relative to the previous period's productivity, Q_{avt-1} written as:

(1) $$W_{it} = W_{i,t-1}\left(1 + \psi\frac{\Delta Q_{avt}}{Q_{avt-1}}\right)$$

where, W_{it} and $W_{i,t-1}$ are current and previous period's wage rates respectively, ψ is a weighing parameter which could be negative or positive based on the prevailing situation in the economy and therefore can change over time.

4.2 Producer (firm) agents and the goods market

There are N producers denoted by the subscript iat time t. Entry and exit takes place according to market share and liquid asset positions of the firms. Firms with near-zero market share and/or net negative liquid assets are eschewed from their industry and replaced by incumbent ones. Therefore, N varies from time to time according to entry and exit rates.

There are n different type of goods, and m different types of labor (skills). Labor of type 1 can be used only to produce good 1. However, there is a possibility for labor type 1 to produce good type 2 and so on. Time is discrete, indexed by t = 1, 2, 3, …., T.

The technology of each producer is denoted by A_{it}, which is derived as a coefficient of labor productivity. Given monetary wage, W_{it} the unit labor cost of production is written as:

(2) $$c_{it} = \frac{W_{it}}{A_{it}}$$

Firms with a fixed mark-up over the cost $\mu_i > 0$ pricing rule, set prices, p_{it} as:

(3) $$p_{it} = (1 + \mu_i)c_{it}$$

where the mark-up itself evolves according to the following adaptive behavior: producers fix price by applying a variable mark up (μ_i) over the latter. The variations in mark-ups are regulated by the dynamics of a firm's market share (f_i). Firms raise (cut) the mark-

up whenever the growth rates of their market share are positive (or negative). The variable mark-ups are determined as:

$$(4) \qquad \mu_{it} = \mu_{i,t-1}\left(1+\nu\frac{f_{i,t-1}-f_{i,t-2}}{f_{i,t-2}}\right)$$

where $0 \le \nu \le 1$ is a weighing parameter. The process in turn implies that a producer's mark-up rates fluctuate around a sort of peg represented by the initial mark-up rate $\overline{\mu(0)}$. Thus, by turning up and down the level of the initial mark-up rate one can vary the long-term income distribution between wages and profit. Prices are one of the key determinants of a producer's competiveness. The other is the level of unfulfilled demand. If firms cannot fully meet their demand quantities, their competitiveness in market shares evolves following a replicator type dynamics operating under conditions of imperfect information, so that even if the product is homogenous, firms may charge different prices (Rotemberg, 2008 and the literature cited therein). At the end of each period, producers obtain profits, Π_{it}, as:

$$(5) \qquad \prod_{it} = S_{it} - PC_{it}$$

where S_{it} are total sales revenue, PC_{it} defines total production costs. The investment choice of the producers and their profits determine the evolution of their stock of liquid assets, NW_{it} is obtained from the following relation:

$$(6) \quad NW_{it} = NW_{i,t-1} + \Pi_{it} - cI_{it}$$

where cI_{it} is the amount of internal funds by producer i to finance its investments and production expenditure in period t, under the condition that internal funds are less than or equal to the stock of liquid assets:

$$(7) \quad cI_{it} \le NW_{i,t-1}$$

Producers plan their production (Q_{it}) quantity following a simple adaptive demand expectation (D_i^e):

$$(8) \qquad D_{it}^e = D_{i,t-1}$$

where $D_{i,t-1}$ is the past demand which is actually faced by firm i. The desired level of production Q_{it}^d is computed by adding the desired inventories V_{it}^d and actual stock of inventories V_{it}^a to the expected demand:

$$(9) \qquad Q_{i\,t}^d = D_{i\,t}^d + V_{it}^d - V_{i,\,t-1}^a$$

Finally, producers' profits are determined as:

$$(10) \qquad \Pi_{it} = S_{it} - c_{it} Q_{it}^{\,d}$$

where all variables are as defined before.

4.3 Credit demands of producers

Producers have to finance their investments as well as their production costs, as they pay workers' wages in advance because they must pay at least some of their factors of production before they sell products and receive their revenues. This means that they require liquidity in the form of money. The higher their liquidity, the more smoothly the production process works (Ramey, 1993).In line with a rich number of theoretical and empirical papers, for example Stiglitz and Weiss (1992), Greenwald and Stiglitz(1993), Hubbard (1998), and in line with institutions, the imperfect capital markets assumption pertains strongly. This implies that financial structures of the producers matter. More specifically, external funds are more expensive than internal ones and producers may be credit rationed. Producers finance their production and investments using first their stock of liquid assets. If this does not fully cover the total production and investment costs, they borrow from banks. The total production and investment expenditures of producers must satisfy the resource constraint:

$$(11) \quad S_{it} - c_{it}Q_{it}^{d} + EI_{it}^{d} + RI_{it}^{d} \leq NW_{i,t-1} + CD_{it}$$

where $c_{it}Q_{it}^{d}$ is total production cost, EI_{it}^{d} is expansion investment, RI_{it}^{d} is replacement investment, $NW_{i,t-1}$ is the stock of liquid assets and CD_{it} is credit demand by a producer. Producers have limited borrowing capacity. As a matter of prudence, banks respond to credit demanded by each producer by observing the producer's past sales and according to a loan-to-value ratio $(0 \leq \lambda \leq 1)$(see Eq 12) and the maximum credit available to the economy is set through a credit multiplier rule with the multiplier equal to k. Therefore, the maximum credit available to the economy at time t, MC_t is given by Eq 13:

$$(12) \quad CD_{it} \leq \lambda S_{i,t-1}$$

$$(13) \quad MC_t = k\left(\sum_{i=1}^{n} NW_{i,t-1}\right), k > 0$$

The key condition for Eq 13, namely the reasonable value of k should be determined based on an understanding of the institutional and regulatory arrangement of the monetary authorities. For example, in Ethiopia, currently in addition to the reserve requirement, there is a credit regulation or the National Bank of Ethiopia (NBE) bill, according to which each commercial bank is forced to buy a NBE bill of value 0.27 unit for each unit of loan dispersed. NBE declares that the private commercial banks in Ethiopia are reluctant to advance loans to finance long-term private investment projects. Instead, they prefer to finance services and short-term trading, for example, import and export activities. This is part of a new phenomenon, namely import-based business driven development, which hampers local production. The NBE bill is channeled to the Development Bank of Ethiopia, a public bank responsible for financing long-term investment projects. Therefore, the actual value of k can be any value greater than zero.

A complete understanding of the architecture of credit relationships in economic systems is of primary importance for building economic models related to bank loans in general and agent-based models in particular. This will help researchers understand the credit debt network that consists of nodes and links. One of the challenges in studying the bank-credit relationship in Ethiopia is that specific firm-bank connections are not public information. The only information one can obtain from banks, firms and the Central

Statistical Agency (CSA) survey is the amount of loans advanced by banks, bank credit and total bank loans for each firm respectively.

This study makes use of the following facts: According to the latest CSA survey, 611 and 1,943 medium and large scale manufacturing firms were operational in 1996 and 2009 respectively. Regarding the banking industry, there were 19 commercial banks of which 16 were private and three were public banks. The Commercial Bank of Ethiopia is the biggest commercial bank in Ethiopia. The Development Bank of Ethiopia finances large-scale commercial farms and the manufacturing sector. The construction and business bank advances loans to construction and business activities. Currently microfinance institutions also play a role in advancing loans to firms. Financing long-term investment projects is left to the Commercial Bank of Ethiopia.

Unlike a well-developed financial system which sees interest rate as one of the monetary policy instruments, the monetary policy in Ethiopia is often driven by institutional factors rather than economic factors. The only visible monetary policy instrument in Ethiopia is the reserve requirement ratio.

5. The extension of the original model

In standard macroeconomics, aggregate productivity is estimated as residual. But how can we interpret the policy content of such a residual? What is the connection between firm level productivity and aggregate productivity? Understanding productivity at the firm level and linking it to productivity growth at the macro-level is important because it affects how we model and interpret the aggregate productivity dynamics. In this section the original and restrictive model is extended to incorporate an analysis of the link between firm level productivity, aggregate productivity and functional income distribution. This will enable us to understand how resource allocation at the firm level may affect income distribution at the macro-level.

We can begin with basic accounting decompositions of aggregate productivity growth into establishment and industry levels. Literature considers some form of decomposition of an index of industry level productivity. The direct method of obtaining an aggregate productivity index from the firm level productivity index is the most commonly accepted approach. Thus aggregating the productivity index using weighted average (A) at the firm and industry levels is obtained as:

$$(14) \qquad A_{jt}^{\Gamma} = \sum_{i=1}^{N} f_{it} A_{it}^{\Gamma}$$

$$(15) \qquad A_{t}^{\Gamma} = \sum_{j=1}^{M} f_{jt} A_{jt}^{\Gamma}$$

where, i=1,2,3,….N, j=1,2,3, …, M and t =1,2,3,…,T. In Eq 14, A_{jt}^{Γ} is the aggregate industry productivity index of industry j A_{it}^{Γ} is the productivity of firm i, and f_{it} is the output share of firm i. In Eq 15, A_{t}^{Γ} is the aggregate productivity, and f_{j} is the market share of industry j.

After adding the value of the aggregate productivity index, A_{j}^{Γ} from Eq 15 into Eq 1, it will yield dynamics of evolution of labor shares at the macro-level as:

$$W_t = W_{t-1}\left(1+\psi\ \frac{\Delta A_t^{\Gamma}}{A_{t-1}^{\Gamma}}\right) \quad (16)$$

Eq16suggests that, at the aggregate level, the total wage evolves according to the terms in the bracket. The parameter ψ is another factor that takes into account institutional and political factors involved in negotiating wages which is fixed by the modeler. The evolution of wages and, therefore, functional income distribution varies directly with a change in productivity and inversely with the previous productivity level at the macro-level. It should be noted that macroeconomic models that deal with aggregate production functions do not provide such interpretations. The next task is to introduce bank loans into the wage evolution term.

The mechanism by which monetary variables are transmitted to the real economy's output remains a central topic of debate in macroeconomics. And yet, there is no clearly agreed upon functional relationship that can clearly show the effects of monetary policy on the economy. The standard questions starts by asking why firms demand money and more specifically why firms demand bank loans.

The existence of time lag (lack of synchronization) between selling of goods and provision of services and the receipt of payments from those activities necessitates firms to hold money during the intervening period. The theoretical base of this argument is developed by many economists such as Davidson (1978) who starts by asking why transactions in organized markets must be time related. He comments that time is a device that prevents everything from happening at once. Production takes time, and therefore in a market-oriented economy most production transactions along the non-integrated chain of firms involve forward contracts. The financing of such forward production cost commitments requires entrepreneurs to have money available to discharge these liabilities at one or more future dates before the product is sold, delivered, payment received and the position is liquidated (Davidson, 1978).

Kerry and Davidson (1980) contend that past literature on a firm's demand for money offers an array of divergent models to explain the sources of this demand. One reason for this diversity is the absence of a general organizing principle to cover all possible models for explaining a firm's money demand (Kerry and Davidson, 1980)and in a well-defined sense in which real balances may be said to be a factor of production (Fischer, 1974).

A firm obtains liquidity by either borrowing from banks, in the form of bank loans (L) or by floating bonds in the open market (Ramey, 1993). However, we cannot apply the second option for developing economies such as Ethiopia where firms do not float bonds to finance their expenditure; instead they resort to bank loans. The most direct way is to view money as a factor of production and its absence is understood to deter firms' production decisions and activities.

However, it is interesting to know how money should enter the production function. It is clear that the use of an aggregate production function (for example, the Cobb-Douglas production function) is inconsistent with ACE. This begs an additional question to be answered. That is, to ask what type of production function will we have to use in specifying the production function and estimation of productivity growth at the firm and aggregate levels?

If aggregation is not possible, Temple (2006) says that the obvious solution must be to disaggregate the relation. According to Temple, many of the empirical frameworks used by economic growth and productivity growth researchers do not intrinsically require aggregation of different kinds of inputs and therefore in the words of Temple, 'in the case of growth accounting, there is nothing to stop the researcher writing down' the following production function relationship:

(17) $Q = F(K_1, K_2, ..., K_m, L_1, L_2, ..., L_n)$

where there are different types of capital inputs and n different types of labor inputs. This approach has been developed and made operational by Jorgenson and co-authors in a series of contributions, some of which are collected in Jorgenson (1995). This makes clear an important point: production theory and growth accounting do not inherently require aggregation of different types of inputs, or for that matter, a single form of output. Instead, it is lack of data that will typically restrict the applied researcher to use simpler methods (Temple, 2006).This was explained previously because a firm must pay at least some of its factors of production before it receives its revenues; it requires liquidity in the form of money. The higher a firm's liquidity, the more smoothly the production process works, so an increase in bank loans increases output.

Following Temple, Felipe and McCombie (2010), and also noting that bank loans is one factor of production, a firm's production function can be generalized as:

(18) $Q_{it} = Q_{it}(K_{it}, N_{it}, L_{it})$

where, Q_{it}, K_{it}, N_{it} and L_{it} are the production and vectors of capital, labor and bank loan type levels of the i^{th} firm in year t. The generic production function in Eq 17 is meant to capture in a very general way the effect of bank loans on a firm's productivity. Assuming the production function is homogenous of degree one, the total change in productivity, ΔQ_{av} from time t-1 to t is obtained by taking the total differential on both sides of Eq 18:

(19) $$\Delta A_t^{\Gamma} \square\, dQ_{it} = \frac{\partial Q_{it}}{\partial K_{it}} dK_{it} + \frac{\partial Q_{it}}{\partial L_{it}} dN_{it} + \frac{\partial Q_{it}}{\partial L_{it}} dL_{it} = MPK(dK_{it}) + MPN(dN_{it}) + MPL(dL_{it})$$

One can arrive at the following point. Changes in average productivity from time t-1 to t can be understood as indicated in Eq 17, where MPK, MPN and MPL are the marginal productivities of capital, labor and bank loans respectively, where changes are taken from time t-1 to t. Because in real terms, marginal values cannot be determined at a point in time by changing variables of interest because we cannot perform laboratory experiments to generate data at a point in time. The data generating process in economics is quite different from that of natural science. Outputs and associated inputs are recorded over time, usually annually. So the marginal values from an economic dataset should be computed on the basis of changes over time. This is more intuitive because in the real world of the data generation process, we observe changes in firms' outputs and inputs over a time period.

Substituting Eq 19 in the wage evolution equations from Eq 16 yields Eq 20:

$$W_{it} = W_{i,t-1}\left(1+\psi\frac{\Delta A_t^{\Gamma}}{A_{t-1}^{\Gamma}}\right)$$

$$= W_{i,t-1}\left(1+\psi\{\frac{MPK(dK_{it})}{Q_{av,t-1}}+\frac{MPN(dN_{it})}{Q_{av,t-1}}+\frac{MPL(dL_{it})}{Q_{av,t-1}}\}\right)$$

$$\frac{(Q_{it}-Q_{t-1})/(K_{it}-K_{i,t-1})}{Q_{i,t-1}/K_{i,t-1}}dK_{it}=\left(\frac{Q_{it}-Q_{i,t-1}}{Q_{i,t-1}}\right)\left(\frac{K_{i,t-1}}{K_{it}-K_{i,t-1}}\right)dK_{it}=\varepsilon_{Q,K}dK_{it}$$

$$\frac{(Q_{it}-Q_{i,t-1})/(N_{it}-N_{i,t-1})}{Q_{i,t-1}/N_{i,t-1}}dN_{it}=\left(\frac{Q_{it}-Q_{i,t-1}}{Q_{i,t-1}}\right)\left(\frac{N_{i,t-1}}{N_{it}-N_{i,t-1}}\right)dN_{it}=\varepsilon_{Q,N}dN_{it}$$

$$\frac{(Q_{it}-Q_{i,t-1})/(L_{it}-L_{i,t-1})}{Q_{i,t-1}/L_{i,t-1}}dL_{it}=\left(\frac{Q_{it}-Q_{i,t-1}}{Q_{i,t-1}}\right)\left(\frac{L_{i,t-1}}{L_{it}-L_{i,t-1}}\right)dL_{it}=\varepsilon_{Q,L}dL_{it}$$

where, $\varepsilon_{Q,K}$, $\varepsilon_{Q,N}$ and $\varepsilon_{Q,L}$ are elasticities of output with respect to capital, labor and bank loans for the i[th] firm respectively. Substituting the elasticities obtained from Eq 14 yields Eq 20, namely the wage evolution expressed as:

(20) $$W_{it}=W_{i,t-1}\left(1+\psi\{\varepsilon_{Q,K}dK_{it}+\varepsilon_{Q,N}dN_{it}+\varepsilon_{Q,L}dL_{it}\}\right)=W_{i,t-1}\left(1+\Omega\right)$$

Eq 20 resembles Eqs 1and 16. However, Eq 20 is more intuitive and manageable to write in the NetLogo[8]environment. It says the evolution of wage is determined by economic and institutional factors represented by the composite factor, Ω. Theoretically, one expects $0 \le \Omega \le 1$.Initially normalizing the differentials dK_{it},dN_{it} and dL_{it} to 1 will leave the wage evolution equation unaffected.

Expression of the evolution of labor income at the macro-level is obtained by successive aggregations. This is achieved by weighing W_{it} by employment share of each firm (SHL_{it}) over N firms within an industry. This will resulting an expression for the evolution of labor income at the industry level (W_{jt}) and the expression of evolution of wage at the macro-level (W_t) is obtained by weighing W_{jt} with the employment share of each industry (SHL_{jt}) over M industries within the manufacturing sector as in Eq 21:

(21) $$W_{jt}=\sum_{i=1}^{N}SHL_{it}W_{it}\text{ , and }W_t=\sum_{j=1}^{M}SHL_{jt}W_{jt}$$

[8]NetLogo is a community developed program written in Java virtual machine. It is particularly well suited for modeling complex systems developed over time.

How variations in functional income distribution transmit into personal income distribution depends on: (1) the concentration of capital income, and (2) relationship between the share of capital income and that of wage income. Adler and Schmid (2012) took the case of Germany and noted the following three conditions:

In the first condition, they assumed an identical income structure for all individuals. Here, changes in the functional distribution of income did not alter the personal distribution of income. In the second condition, they contrasted two extreme types of income structures. Individuals are supposed to exclusively earn labor or capital income. Changes in the functional distribution of income lead to strong changes in the personal distribution of income. The final case combined rather extreme set-ups of the first and the second cases. Here, individuals gained both labor income and income from asset flows. However, the respective shares differed among individuals.

Noting these conditions, the first condition is not realistic because different income structure sexist in Ethiopia. The third condition is more realistic. However, owing to the problem of data availability it cannot be an option either. The only feasible option lies in the second condition.

In Figure 3A, the vertical axis is the cumulative share of income earned whereas the horizontal line is the cumulative share of people from the lowest to the highest incomes. However, area B needs to be divided in two sections as B1 and B2 where B=B1+B2, which must be equal to the sum of income from labor plus income from capital. The Gini coefficient is equal to the area marked A divided by the sum of the areas marked A and B, that is, 'Gini'[9]=A/(A+B). It is also twice the area A due to the fact that the sum of A and B is half (A+B=0.5, since the axis scale is from 0 to 1) where A is the area between the Lorenz curve and the 45 degree line and B is the area between the Lorenz curve and the horizontal line.

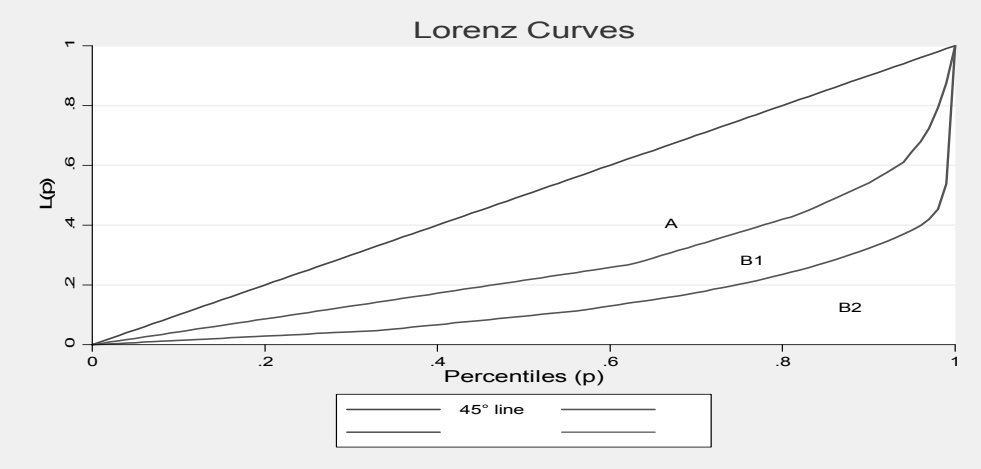


Figure 3A. Functional income distribution labeled 'Gini' defined as the ratio of A and A+B

[9]The 'Gini' is meant to represent the personal income distribution known as Gini in standard literature as emergent from functional income distribution.

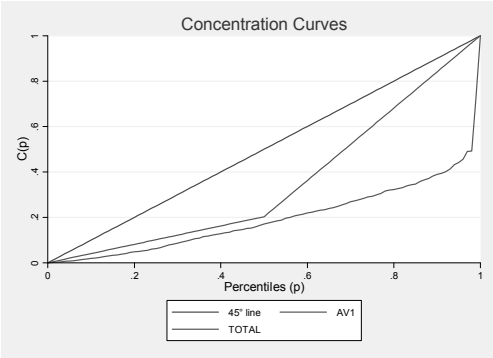
The vertical axis is cumulative share of income earned whereas the horizontal line is the cumulative share of people from the lowest to high incomes. However, area B needs to be divided into two sections as B1 and B2 where B= B1+B2 which is equal to the sum of income from labor plus income from capital.

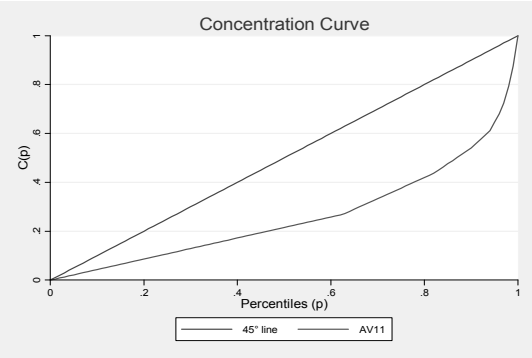
We note that the functional and personal income distributions are consistently linked if and only if area A is the share of profit and area B is the share of labor. Area A is the share of producers whereas area B is the share of consumers. The higher area A the higher the inequality because in reality the number of producers in any economy is less than the number of consumers. It should be noted that in estimating the Gini coefficient, no distinction is made between holders of wages and profits. Income distribution includes both groups and area A indicates distance to line of full equality.

Pointing out the inequality in the agricultural and urban population and the evolution of inequality at the national level are important. The concern here is the generalization of national income distribution from functional income distribution. More specifically, one could ask the validity of generalizing the whole population from the urban population. This explanation is to be sought from an established predicament. As suggested by Kuznets (1955), the agricultural population is more or less homogenous as compared to the industrial population and therefore, functional income distribution is a driver of personal income distribution at the national level.[10]

The level of inequality between the workers themselves is another concern that requires examination. This will allow us to understand the heterogeneity income distribution among different agents in the economy. To achieve this, firm level data from CSA is used. There is a section in CSA on the number of workers in a given salary group where we find 11 salary brackets. The lowest salary bracket in the 1996 survey was (75,105) Ethiopian Birr while the highest salary bracket for the same year was (1500, 2000) Ethiopian Birr. For 2009, the lowest salary group in the survey was (200,400) while the highest salary group was (1600, 2000) Ethiopian Birr. It is also worthwhile to mention that there is a salary greater than the upper salary bracket of 2000 in all the cases.

For each year the average salary of each salary bracket is computed and labeled as AVI, where I = 1, 2, 3, …, 11. For example, for each year, AV1 is the average salary of the first salary bracket and the AV11 is the average salary of the eleventh salary bracket.





[10]This is dealt in detail in the second paper, which is the empirical validation of this one.

Figure 3B: Concentration curves for the total and the lowest salary groups (left) and the highest salary group (right)

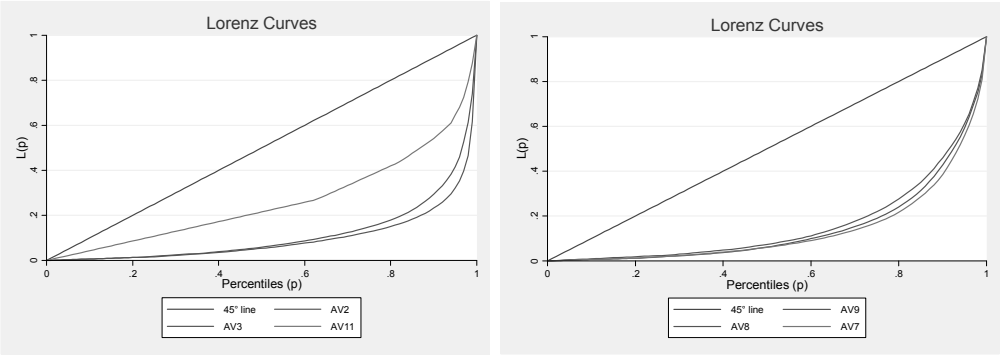


Figure 3C.Concentration curves for the second and highest salary brackets (left) and the third, seventh and the highest salary brackets (right)

In the interest of space, inequality indices for limited salary bracketsare indicated in Figures 3B and 3C. Thesecurves inform us of the level of inequalities between different income groups.The purpose here is tolearn the pattern of inequalities between different groupsof workerswhich will help us understand the sources of hetrogenities in inequalitiesandtheir evolution over time.

The immediate examinationofthese curves tells us that inequality levels in the lower salarybrackets are greater than those in the higher salary brackets. This is revealed from the curves -- all the concentration curves for the lower salary groups lie to the south-eastof thehighersalarybrackets.ForexampleAV1 lies below AV2 and so on.Wealso observe that the agregate inequality curve, the curve labled TOTAL on the left hand side ofFigure 3B lies above AV1, implying that the agregate indicesconceal some evidence regarding income inequalities.

This suggests thatthe higher the salary bracket, less is ineqaulityand therefore as society moves to midle and higher incomes, there are some explicit/implicit sources of income. For example,incomes from capital which can be sources for more inequailty within lower income groups (because low income groups do not have income from capital) but less inequalities within higherincome groups (because high income groupshave income from capital). Aswe move from the lower salary bracket to the higher salary bracket, we also observe that some workers are entitled to other sources of income.

6. Simulation results and analysis

6.1 Initialization and the simulation environment

A separate algorithm is developed to simulate the economy described in Sections 4 and 5. To capture the effect of firms' access to bank loans, the program is executed first for firms with access to bank loans and then for those without access to bank loans according to the matching algorithm. This step of the matching algorithm is based on firm level information.

Table 1 shows the initial values of artificial state variables and parameters required to run the simulation. The initial values are assigned based on economic intuition. The use of artificial variables and parameters has an advantage because the use of such artificial values will detach the modeler from manipulating the simulation subjectively (Gatti et al., 2011). An additional rationale is that the assignment of the initial value does not affect the dynamics of the system. Despite these arguments in favor of assigned parameters that are possibly based on empirical findings found in literature the results can be far from true. The use of real data and cautious validation of the model outcome is supposed to circumvent such problems.

Some firms are unable to receive bank loans because they do not fulfill the loan requirements set by lending banks. For example, in 1996 there were 611 medium and large scale manufacturing firms of which only 67 had access to bank loans while in 2009, only 257 of the 1,943 firms had access to bank loans. The average number of workers was 92 per average firm. Therefore, without loss of generality, assigning the number of worker agents to 100 and those of firms to 100 may not affect the output and thereby not produce results that are far from true.

While the true value of Ω computed from the data is 0.13 (computed from real data), we used 0.01(see Table 1). On the other hand, the average employment share of each firm is 0.12 with overall, between and within standard deviations of 0.053, 0.037 and 0.045 respectively. The average market share is 0.037 with overall, between and within standard deviations of 0.017, 0.0784 and 0.143 respectively.

From these explanations it can be seen that the assignment of the initial values does not match the values obtained from real data. This is partly due to the rationale explained earlier and (to shield the modeler from manipulating the results).

Currently agent-based modelers are coming up with different simulation software which is in the process of continuous improvements in computational powers, quality and speed. This paper used the NetLogo software. NetLogo is a programmable modeling environment for simulating natural and social phenomena. It was authored by Uri Wilensky in 1999[11] and has been in continuous development ever since at the Center for Connected Learning and Computer-Based Modeling.

There are two types of procedures in this simulation: commands and reporters. A command is an action that an agent must execute. A reporter calculates a result and reports it. The simulation has different number runs per simulation period with the following control parameters: random-seeds (rs) = {-3,-2,-1,0,1,2,3}, number of producers = {1,2,3,.., 100}, and number of consumers = {1,2,3,..,100}. Each run measures the mean values of output, output prices, profits, money income to workers, market share of producers and the Gin index.

[11] Different versions of NetLogo are freely downloadable from http://ccl.northwestern.edu/NetLogo/ NetLogo version 4.0.5 is used in this paper.

Table 1. Initialization of state variables and simulation parameters

Reference	Description	Initial value assigned
W_t	Wage	500
Ω	Parameter	0.01
CD_{it}	Initial bank loan to firm	500
$S_{i,t}$	Sales	400
cI_{it}	Internal funds	600
λ	Credit parameter	0.60
FID	Index of income distribution	0
NCON	Number of workers/consumers	1 to 100 in steps of 1
NPRO	Number of producers	1 to 100 in steps of 1
A_i^{Γ}	Firm level output productivity per worker	0.01
Q	Output	300
$\mathrm{NW}_{i,t}$	Liquid asset at time t	1,000
V_{it}^{d}	Desired inventory	0
V_{it}^{a}	Actual inventory	0
$f_{i,t}$	Market share	0.01
$\mu_{i,t}$	Mark-up	0.05
ν	Weighing parameter	1
Price	Initial price for firms' output	1

The economic intuition for varying the number of consumers and producers to 100 has intuitive economic meaning, that is, some workers (consumers) can go out of the labor market while some join the labor market. On the part of the producers (firms), some of them may exit while others enter. Therefore, the indicated number (100) is supposed to capture the net effects.

Another reason for limiting the number of agents (consumers, producers) to these values is due to: first, the limited computational capacity of computers,[12] and second, for a clear interpretation of the simulation results.[13]Consumers and producers interact according to rules specified in the NetLogo computational environment.

[12] It took 12 hours to run this simulation using a corei3 Intel hp computer. So, one can imagine how long it would take to simulate large-scale models. This is acknowledged as one limitation of ACE simulation. To overcome this problem in large-scale ACE projects such as EURACE and ASPEAN they employ parallel connected high capacity computers known as cloud computing.

[13] Note that one of the problems of agent-based modeling is interpretation of the results.

Regarding the simulation period, in all cases simulations proceed as though orchestrated by a command called tick. For each tick, all the agents are given a command to perform. Thus, time is modeled in discrete steps. Each time the step lasts for the same simulated duration. The simulation starts at time step zero and proceeds as long as necessary.

One of the defining features of agent-based models is that the agents have the potential to interact. It is this that separates agent-based models from equation-based modeling in mainstream economics. The codes in the algorithm are the sources of the interaction. The interaction may represent a simple perception of the presence of other agents, to avoid them or to imitate them, or it may involve more sophisticated communication of knowledge, opinions or beliefs, depending on the requirements of the domain being simulated. However, even in the most sophisticated models, it is almost always the case that agent interaction occurs through unmediated and direct agent-to-agent message transfers.

NetLogo is particularly well suited for modeling complex systems developed over time. Modelers can give instructions to hundreds or thousands of agents all operating independently. This makes it possible to explore the connection between the micro-level behavior of individuals and the macro-level patterns that emerge from their interactions. NetLogo performs interactive computation; the number of interactions between each consumer and each producer being equal to the Cartesian product in a two dimensional space. Computation takes place for each consumer-producer interaction and the means of computed values are reported in a separate table. The reported values are investigated by a researcher. In the interest of space, only some of the results are presented here. The outcomes are labeled as 'Gini' explained previously in the context of the relationship between income from wages and capital.

6.2 Simulation results

In order to effectively assess the effects of bank loans on distribution of income and capital returns, three variants of the models were simulated: (1) the original model of Dosi et al. (2013), (2) the extended model without firms' access to bank loans, and (3) the extended model with firms' access to bank loans. Outputs from the simulation are collected and presented graphically in Figures4A-4D. In the figures and the discussion that follows, the labels GINIOR (indicated by the thicker and literally horizontal line), GINIWOBL (indicated by the lined plot literally lying above both plots) and GINIMODBL (the connected line in the middle of the two plots) stand for income distribution indices for: the original model, the model without bank loans and the generalized modified model with bank loans respectively.

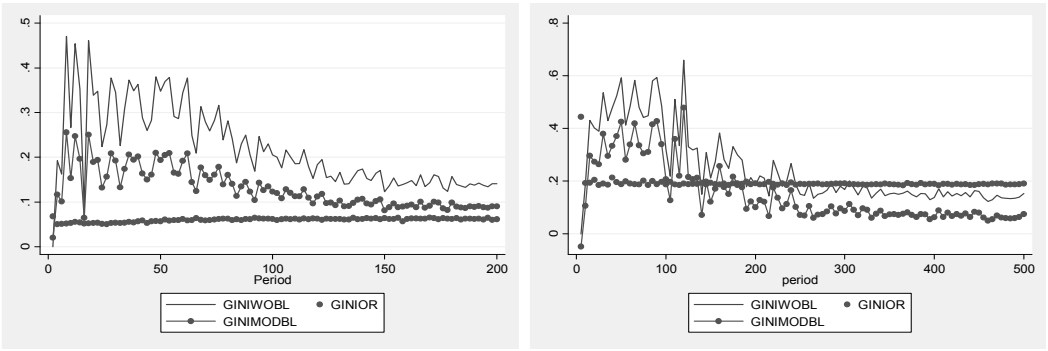


Figure 4A. Simulation with 2 producers and 100 consumers (left) and with 5 producers and 100 consumers (right)

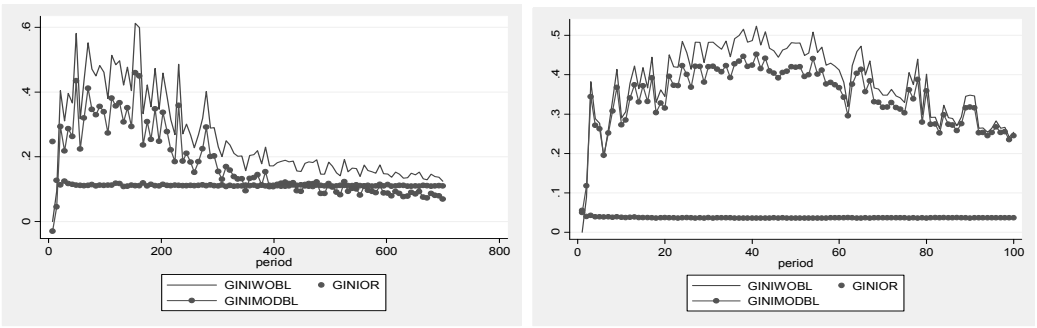


Figure 4B. Simulation with 7 producers and 100 consumers (left) and with 31 producers and 100 consumers (right)

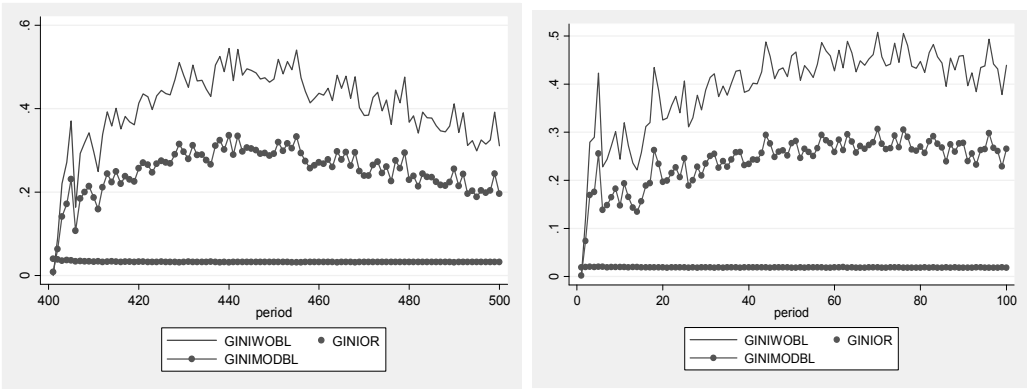


Figure 4C. Simulation with 35 producers and 100 consumers (left) and with 81 producers and 100 consumers (right)

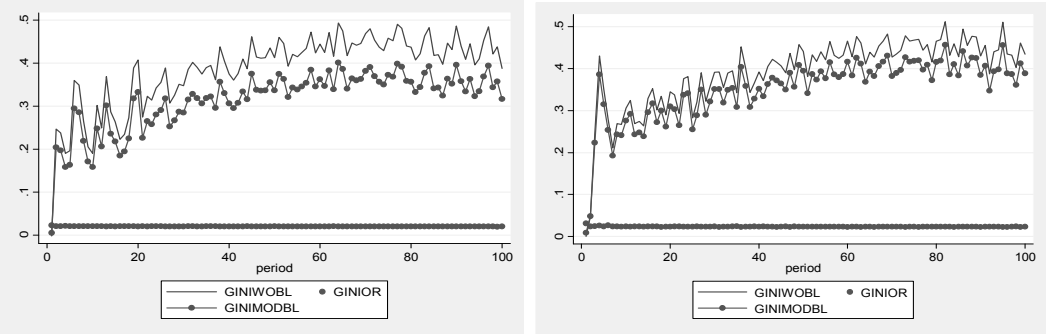


Figure 4D. Simulation with 85producers and 100 consumers (left) and with 90 producers and 100 consumers (right)

Figure 4A-4D. Agent-based simulation results with varying numbers of consumers and producers

Table 2. Statistical distances of simulated outputs (test conducted at the 5 per cent significance level)

Number of producers x Number of consumers	Ho: mean(diff) = 0, Model without bank loan	GINIOR Original model		GINIMODBL Modified model with bank loan	
2x100	GINIWOBL	t-value	p-value	t-value	p-value
5x100		17.067	0.0000	19.6978	0.0000
7x100		3.6764	0.0004	34.7587	0.0000
31 x100		10.696	0.0000	30.3755	0.0000
35 x100		35.871	0.0000	17.4361	0.0000
81 x100		41.122	0.0000	42.7325	0.0000
85 x100		45.160	0.0000	46.9786	0.0000
90 x100		43.047	0.0000	41.7243	0.0000

In addition to the graphic presentations of simulated outputs, tests for differences in outputs from the three scenarios were also conducted. More specifically, the null hypothesis that 'the means of each pair of the simulated output are equal's presented in Table 2. Looking at the t-values and corresponding p-values, it is possible to determine that the outputs from each pair are different both in an economic sense (based on Figures 4A-4D) and statistically (based on the t-values) in Table 2, a number of conclusions can be drawn. In sum, this means that we fail to accept the null hypothesis for each pair of output at the 5 per cent level of significance. The test results suggest that: (a) the original and the modified models perform differently, and (b) bank loans affect functional income distribution.

The contrast between the results from higher simulation periods (Figures 4A-4B) and lower simulation periods (Figures 4C-4D) might give us a clue for hypothesizing. In the short-run the effect of access to bank loans on functional income distribution is clear and positive. However, in the long-run the role of bank loans in affecting functional income distribution seems to diminish.

Looking at the simulation results, all outputs start from zero inequality. This should be understood as a natural experience and a valid result because all the consumers and producers are initially similar with respect to their initial condition when it comes to incomes from wages and capital. However, as time goes on inequality is generated and evolves over time. A careful assessment of each case gives significant evidence on the evolution of inequality.

First, inequality seems to disappear faster when the number of producers is fewer (Figures4A-4B, the left panel). This could be understood in view of the fact that when the number of producers is less, it could be that the economy is populated with more workers with similar income structures because the composition of the economy's value added is more of wage income than income from capital. It could also be the case that this type of society is primitive with low technology and hence low productivity, subsequently less total output (few manufacturing firms) in the economy so that society is more or less homogenous.

Second, from Figure 4B (the right panel), as the number of producers increases, higher inequality prevails over time. However, the modified model with access to bank loans still performs consistently, with respect to our research objective, that is, it lies below the original model's output. We also observe time entering the explanation (Figure 4C, left panel).Even if the number of producers is large, inequality tends to decline faster fora longer simulation period.

Theoretically, the underlying economic cases could be that for a longer simulation period, economic agents learn and adapt to satisfying conditions. For example, workers (consumers) can learn either from their past actions or from their interaction with other workers through observations or information exchange through direct communication and act if they agree with what they have learnt or move away from if they find it does not fit their condition. Similarly, producers (firms) can learn from their past experience adaptively or from other firms and act accordingly or differently. How this process of interaction takes place is developed in the programming stage of the simulation.

Since workers (consumers) or producers (firms) are searching for the best outcomes, it is natural to suppose that they move to their respective satisfying levels, that is, so that incomes from wages and capital will be such that inequality declines faster.

Regarding the statistical distances between outputs from the different models and the subsequent t-tests (Table 2), all the tests fail to accept the null hypothesis that all the models 'outputs are similar. However, it should be noted that even if income distribution is skewed by structure, for a statistical analysis without loss of generality we may assume that the inequality index is normally distributed.

The tests conclude that regardless of the length of the simulation period, the original model, the modified model without access to bank loans and the modified model with access to bank loans perform differently in the evolution of income distribution suggesting that for economies at different levels of development, drivers of evolution of income inequality also differ accordingly.

When projecting this to the policy design, two economies at different levels of development may not necessarily employ similar income distribution policies. A policy that performed well for developing economies may not do the same when it comes to developed economies. Similarly, policies practiced in developed economies which

performed well may not be equally applicable to developing economies. This is unlike the current practice of uniform policy prescriptions followed mainly by international financiers and donors.

7. Summary, conclusion, policy recommendations and future research direction

The sources and distribution of functional income differ among countries by the level of their development. This paper questioned if firms' access to bank loans is one mechanism through which variations in functional distribution can be explained in developing economies. We attempted to answer this question using our modified agent-based model and taking the Ethiopian case. The simulation undertaken and its results suggest that the question was answered affirmatively.

The number of agents (producers and consumers) played a significant role in the results. Regardless of the scale, that is, the variation in the number of producers, the simulation period and specific numbers assigned to pseudo-random (rs), the results obtained from this simulation exhibit the following:

First, the promising result of this study is the emergence of aggregate behavior from agents' local interaction which is consistent with Thomas Schelling's (1978), Micromotives and Macrobehavior, where he argues: 'These situations, in which people's behavior or people's choices depend on the behavior or the choices of other people, are the ones that usually don't permit any simple summation or extrapolation to the aggregates. To make that connection we usually have to look at the system of interaction between individuals and their environment, that is, between individuals and other individuals or between individuals and the collectivity. In addition, sometimes the results are surprising. Sometimes they are not easily guessed. Sometimes the analysis is difficult. Sometimes it is inconclusive. But even inconclusive analysis can warn against jumping to conclusions about individual intentions from observations of aggregates, or jumping to conclusions about the behavior of aggregates from what one knows or one can guess about individual intentions' (Schelling, 1978: 14).

From the shapes of the graphs, one can learn that there is a well-structured emergent pattern and local regularity evidenced in this study. The notion of local regularity is supported by Massimo and Colander (2007) where they argue that conducting scientific research is finding patterns and scientists are always looking for patterns that they can use to structure their thinking about the world around them. Patterns are found in data, which is why science is inevitably a quantitative study.

Second, the original model by Dosi et al. (2013) applied to developing economies is silent on the pattern of income distribution as indicated by the horizontal plot labeled as l (GINIOR) in each graph. However, the extended model with access to bank loans revealed two phenomenon: (a) the model reflected the reality of income distribution as shown by green and blue colors in each graph, and (b) access to bank loans improved income distribution (compare the green and blue colors in each graph where the pattern of income distribution with access to bank loans lies below the pattern without access to bank loans). Regarding the contrast with the original authors, one may explain that since financial markets are well functioning in developed economies, they do not discriminate against economic agents. Therefore, they have a minimal role in shaping income distribution while the opposite holds true in developing economies. If firms do not have

access to bank loans, they have to finance their investments and operational expenditure from internal funds. This is possible by paying low wages and by reducing salary expenditures which are components of total cost. This will in turn reduce the share of output going to labor. Once firm level data supports this finding, it would have very strong policy content; a well-functioning loan market will improve functional income distribution.

Third, the simulation results fit well with the Kuznets inverted U-shaped hypothesis that inequality increases over time, then at a critical point begins to decrease (Kuznets, 1955). By modifying the original model we arrived at some patterns that link firms' access to bank loans to functional income distribution. We believe that our findings will enable policymakers to have more alternatives on their policy menu to fight the challenges of growing inequalities in Ethiopia.

In sum, firms' access to loans improves income distribution by increasing the share of output going to labor. Since functional income distribution is closely associated with personal income distribution (Kuznets, 1955), we can further hypothesize that an economy which eases firms' access to bank loans will promote a more equal society.

From a policy perspective these results suggest that to avoid unfavorable (or undesired) distributional consequences, policymakers will have to pay attention to labor market outcomes and to the dispersion of income types, including distortions induced in the labor market by different policy interventions or by changes in labor market institutions. More importantly, policymakers must understand that existing credit policies have far reaching consequences such as distributional disparities.

Currently, the state owned Commercial Bank of Ethiopia controls more than 50 per cent of the total banking activity in Ethiopia. Its operations mainly focus on government projects. Private commercial banks are reluctant to finance the manufacturing sector; instead they are inclined towards the services sector such as import and export businesses which have faster returns. In a situation where the manufacturing sector is expanding (supposed to account for 25 per cent of the GDP) and becoming a major employer of the expanding population, the government cannot avoid the financial constraints of firms whether private or public. Therefore, bank rules and regulations should target such important distributional issues which support inclusive growth (by, for example, promoting banks to participate in labor market related economic activities and strengthening the human capital of low-income groups) which may prevent an increase in economic disparities.

This study is limited to a small closed economy, focusing on manufacturing firms. It did not look into the fiscal dimensions. Future researches can expand it to a wider scope so that it can be used as a general framework for analyzing the whole economy. One critical area of improvement in the modeling aspect is to understand specific information on the bank-firm relationship which is not public information currently in Ethiopia. This will give specific and detailed information other than what is available at the aggregate level. Availability of data on income sources such as income from wages and capital are useful for understanding income structures. Therefore, establishing this database is another aspect for future studies.

References

Adler, M. and Schmid, K. D. (2012). Factor Shares and Income Inequality - Empirical Evidence from Germany 2002-2008. IAW Discussion Papers N0. 82.

Anderson, P. W., Arrow, K. J. & Pines, D. (1988). *The Economy as an Evolving Complex System*. *SFI Studies in the Sciences of Complexity*. Addison-Wesley Longman.

Arnold, E. and Boekholt, P. (2002). Measuring 'relative effectiveness': Can we compare innovation policy instruments? In Boekholt, P., Innovation Policy and Sustainable Development.

Arthur, W. B., Durlauf, S. N. & Lane, D. A. (1997). *The Economy as an Evolving Complex System II,* Addison-Wesley Longman.

Bargigli, L. and Tedeschi, G. (2012). Major trends in agent-based economics. *Journal of Economic Interaction and Coordination,* 2, 209-22.

Beck, T., Demirgüç-Kunt, A. and Levine, R. (2007). Finance, inequality, and the poor. *Journal of Economic Growth,* 12, 27–49.

Beinhocker, Eric D. (2006). *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics.* Harvard Business Press**.**

Blume, L. E. and Durlauf, S. N. (2006). The Economy as an Evolving Complex System, III. Current Perspectives and Future Directions. *Santa Fe Institute in the Science of Complexity. Santa Fe Institute in the Science of Complexity*, Oxford University Press.

Claessens, S., Perotti, E. (2007). Finance and inequality: channels and evidence. *Journal of Comparative Economics,* 35, 748–773.

Celine, G. and Thomas, L. (2011). A closer look at financial development and income distribution. *Journal of Banking and Finance*, 35 (7), 1698-1713.

Colander, D., Howitt, P., Kirman, A., Leijonhufvud, A. and Mehrling, P. (2008). Beyond DSGE Models: Toward an Empirically Based Macroeconomics. *The American Economic Review*, 98 (2), 236-240.

Colander, D., Föllmer, H., Haas, A, Goldberg, M., Juselius, K., Kirman, A., Lux, T. and Sloth, B. (2007). The Financial Crisis and the Systemic Failure of Academic Economics. *Kiel Institute for the World Economy, Kiel Working Paper 1489.*

Damaceanu, R. C. (2013). *Agent-Based Computational Economics Using NetLogo.* Bentham Science Publishers, Romania.

Davidson, P. (1978). Why Money Matters: Lessons from a Half-Century of Monetary Theory. *Journal of Post Keynesian Economics*, 1(1), 46-70.

Gatti, D., Desiderto, S., Gaffeo, E., Cirillo, P., Gallegati, M. (2011). *Macroeconomics from the Bottom-up,* Springer, Milan.

Demirguc¸-Kunt, A., and Levine, R. (2009). Finance and Inequality: Theory and Evidence. *The Annual Review of Economics,* 1,287–318**.**

Dercon, S., J. Hoddinott and Woldehanna, T. (2011). Growth and chronic poverty: Evidence from rural communities in Ethiopia*. CSAE Working Paper WPS*/2011-18.

Dosi, G. (2011). Economic Coordination and Dynamics: Some Elements of an Alternative "Evolutionary" Paradigm. *Technical Report*. Institute for New Economic Thinking.

Dosi, G., Fagiolo, G., Napoletano, M. and Roventini, A. (2013). Income distribution, credit and fiscal policies in an agent based Keynesian model. *Journal of Economic Dynamics and Control*, 37(8), 1598-1625.

Epstein, Joshua M. and Axtell, R. (1996).*Growing Artificial Societies: Social Science from the Bottom Up.* Brookings Institution Pres.

Farmer, J.D. and Foley, D. (2009). The Economics Needs Agent- Based Modeling. *Nature,* 460,685-687.

Fei, J. C. H., G. Ranis and S.W. Y. Kuo (1978). Growth and the Family Distribution of Income by Factor Components. *The Quarterly Journal of Economics,* 92(1), 17-53.

Felipe, J. and J.S. L. McCombie (2010). What is wrong with aggregate production functions? On Temple's 'aggregate production functions and growth economics'. *International Review of Applied Economics,* 24(6), 665-684.

Field, G. S. (2007). How much should we care about changing income Inequality in the course of economic growth? *Journal of Policy Modeling,* 29, 577–585.

Fischer, S. (1974). Money and the Production Function. *Economic Inquiry*, 12,517-533.

Gimet, C. and Lagoarde-Segot, T. (2011). A closer look at financial development and income distribution. *Journal of Banking and Finance,* 35, 1698-1713.

Greenwald, B. and Stiglitz, J. E (1993). Financial Markets imperfections and business cycles. *Quarterly journal of Economics*, 108(1), 77-114.

Greenwood, J., Jovanovic, B. (1990). Financial development, growth, and the distribution of income. *Journal of Political Economy*, 98, 1076–1107.

Gurley, J. and Shaw, E. (1955). Financial aspects of economic development. *The American Economic Review*, 45,515– 538.

Hartley, J.E. (1997). *The Representative Agent in Macroeconomics*, Routledge, London, New York.

Howitt, P. (2006). Coordination Issues in Long-Run Growth. *Handbook of Computational Economics, Vol II: Agent-Based Computational Economics, ed. Leigh Tesfatsion and Kenneth Judd, 1605–24*. Amsterdam: North Holland.

Hubbard, G.R (1998). Capital-Market Imperfections and Investment. *Journal of Economic Literature,* 36 (1), 193-225.

IMF (2013*). IMF Country Report No. 13/308, The Federal Democratic Republic of Ethiopia,* Staff Report for the 2013 Article IV Consultation.

John Foster J. and Stan Metcalfe (2012). Economic emergence: An evolutionary economic perspective. *Journal of Economic Behavior and Organization*, 82, 420–432.

Jorgenson, D.W. (1995). *Productivity. Postwar U.S. Economic Growth, Vol. 1*, Cambridge, MA: MIT Press.

Kerry V. and Davidson, P. (1980). Money as a Factor of Production: Ultimate Neoclassical Heresy or Keynesian Insight? *Journal of Post Keynesian Economics*, 2(2), 273-282.

Kirman, A. P. (1992). Whom or What Does the Representative Individual Represent? *The Journal of Economic Perspectives,* 6(2), 117-136.

Kuhn, T.S. (1996). *The Structure of scientific Revolutions 3rd edition*, University of Chicago Press, USA.

Kuznets, S. (1955). Economic Growth and Income Inequality. *The American Economic Review,* 45 (1), 1-28.

LeBaron, B. and and Tesfatsion (1996). *Handbook of Computational Economics,* 2nd edn, .Elsevier, North Holand.

LeBaron, B. and Tesfatsion, L. (2008). Modeling Macroeconomics as Open-Ended Dynamic Systems of Interacting Agents. *The American Economic Review,* 98(2) 246-250,

Leijonhufvud, A. (2011). Nature of an economy. *Center for Economic Policy research, Policy Insight, No.53.*

Levine, R. (2005). *Finance and Growth: Theory and Evidence,* in: Handbook of Economic Growth, Eds. Philippe Aghion and Steven N. Durlauf, Elsevier North Holland, pp. 866-934.

Massimo, S. and Colander, D. (2008). *Complexity Hints for Economic Policy***.** Springer-Verlag Italia.

Mark, S. (2006). *Introduction to Post-Keynesian Economics.* Palgrave Macmillan

Nelson, R. and Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge, U.S.

Panico, C., Pinto, A. and Puchet, M. Anyul (2012). Income distribution and the size of the financial sector: a Sraffian analysis. *Cambridge Journal of Economics,* 36**,** 1455–1477**.**

Pesaran, M. H. and Smith, R. P. (2011). Beyond the DSGE Straitjacket: in John Driffill, the future of macroeconomics. *The Manchester School*, l1–38.

Piketty, T. (2014). *Capital in The Twenty-First Century*. The Belknap Press of Harvard University Press.

Rajan, G. R. and L. Zingales (2003). The great reversals: the politics of financial development in the twentieth century. *Journal of Financial Economics,* 69, 5–50.

Ramey, Valerie (1993). How important is the credit channel in the transmission of monetary Beyond the DSGE Straitjacket policy? *Carnegie-Rochester Conference Series on Public Policy,* 39, l-45.

Richiardi, G. M. (2012). Agent-based computational economics: a short introduction. *The Knowledge Engineering Review,* 27(2), 137–149.

Rotemberg, J. (, 2008). Behavioral Aspects of Price Setting and Their Policy implications. NBER Working Paper No 13754.

Sargent, T. (1993). Bounded rationality in macroeconomics. The Arne Ryde Memorial Lectures. Oxford, UK: Clarendon Press.

Schelling, T. (1971). Dynamic models of segregation. *Journal of Mathematical Sociology*, 1, 143–186.

Schelling, T. C. (1978). Micromotives and Macrobehavior, Norton, New York, pp. 137–157.

Schelling, T. C. (2006). Some fun, thirty-five years ago. Handbook of Computational Economics, 2: Agent-Based Computational Economics of Handbook in Economics Tesfatsion L. and Judd K. L., North-Holland, Ch. 37, 1639–1644.

Shimer, R. (2009). Convergence in Macroeconomics: The Labor Wedge**.** *American Economic Journal: Macroeconomics*, 1(1), 280-297.

Stiglitz, J. E. and Weiss, A. (2992). Asymmetric Information in Credit Markets and Its Implications for Macro-Economics. *Oxford Economic Papers*, 44(4), 694-724.

Stiglitz, J. E. (2012). *The price of inequality*, W.W. Norton & Company, Inc., USA.

Stoker, T. M. (1993). Empirical Approaches to the Problem of Aggregation over Individuals. *Journal of Economic Literature,* 31(4), 1827-1874.

Temple, J. (2006). Aggregate Production Functions and Growth Economics. *International Review of Applied Economics,* 20(3), 301-317.

Tesfatsion, L. (2000). Agent-based computational economics: A brief guide to the *literature. http://www.econ.iastate.edu/tesfatsi/.*

Tesfatsion, L. (2003). Agent-Based Computational Economics. *ISU Economics Working Paper No. 1,* Revised August 24, 2003.

Tesfatsion, L. (2007). Agents come to bits: Towards a constructive comprehensive taxonomy of economic entities. *Journal of Economic Behavior &Organization,* 63, 333-346.

Tesfatsion, L. and Judd, K. (2006). *Handbook of Computational Economics II: Agent-Based Computational Economics*. North Holland, Amsterdam

Wilensky, U. (1999). The Center for Connected Learning and Computer-Based Modeling. *http://ccl.northwestern.edu/NetLogo/*