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ACCESS TO BANK LOANS, INCOME DISTRIBUTION AND ECONOMIC GROWTH IN AGENT BASED MODELING: EVIDENCE FROM EVOLUTIONARY PERSPECTIVE

BY
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This is to certify that the dissertation prepared by Atnafu Gebremeskel "ACCESS TO BANK LOANS, INCOME DISTRIBUTION AND ECONOMIC GROWTH IN AGENT BASED MODELING: EVIDENCE FROM EVOLUTIONARY PERSPECTIVE" and submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Economics complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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ACRONYMS AND ABBREVIATIONS

AESCS	Agent-Based Approaches in Economic and Social Complex Systems
ACE	Agent-based computational economics
CATS	Complex adaptive systems
CBBE	Construction and Business Bank of Ethiopia
CBE	Commercial Bank of Ethiopia
CEF	Computing in Economics and Finance
CIEF	Computational Intelligence in Economics and Finance
CIRAS	Computational Intelligence, Robotics and Autonomous Systems
CSA	Central Statistical Agency
DBE	Development Bank of Ethiopia
ECB	European Central Bank
GMM	Generalized Method of Moments
GoE	Government of Ethiopia
IMF	International Monetary Fund
JIBS	Jönköping International Business School
LDE	Logistic Diffusion Equation
MASTA	Workshop on Multi-Agent Systems: Theory and Applications
MoFED	Ministry of Finance and Economic Development
NBE	National Bank of Ethiopia
NGO	Non-governmental organizations
OLS	Ordinary Least Square
RA	Representative agent
RLS	Recursive Least Square
SACCO	Saving and credit cooperatives
SIDA	Swedish International Development Cooperation Agency
WEHIA	Workshop on Economics of Heterogeneous Interacting Agents

Access to Bank Loans, Income Distribution and Economic Growth in Agent Based Modeling: Evidence from an Evolutionary Perspective

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Abstract

This doctoral dissertation consists of three inter-related studies which constitute its main text, with introductory and summary chapters. The three main studies share a common feature in that they investigate the link between access to bank loans, income distribution and productivity growth. The second chapter is a theoretical framework that uses agent-based computational economics (ACE) to detect the link between access to bank loans and functional income distribution. The third chapter uses Ethiopian firm-level and national income data to validate the second chapter. The fourth chapter investigates the effect of functional income distribution on productivity growth from an evolutionary economic perspective.

The second chapter (first study) focuses on Dosi et al.'s (2013) agent-based model which assumes that a well-functioning banking system exists and that industries are composed of both capital and non-capital goods' producing sectors. As such, monetary policy has a minimal role in impacting functional income distribution leading to an active use of macroeconomic policy. Chapter 2 modifies this model to capture the realities of developing countries where the banking system's supply of services is smaller than what is considered 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, Chapter 2 argues that it is possible to utilize firms' economic actions and their access to bank loans to explain how income inequalities are generated and evolve over time. Theoretically the chapter finds that personal income distribution is an emergent phenomenon. This result is in agreement with Thomas Schelling's 'Micromotives and Macrobehaviour,' where he established aggregate behavior as an emergent phenomenon. Its major conclusion is that access to bank loans at the firm level improves income distribution in society.

The third chapter (second study) empirically validates the theoretical results obtained in Chapter 2 (first study). It employs the descriptive output and econometric (external as is usually said) validation techniques as an indirect identification strategy to examine the link between access to bank loans and income distribution. It uses data from the Ethiopian Central Statistical Agency (CSA) on medium and large scale manufacturing and national personal income distribution data from the Ethiopian Ministry of Finance and Economic Development (MoFED). Its major conclusions are: (i) firms' access to bank loans is one mechanism through which income distributional issues can be explained, (ii) firms' financial structures matter, that is, whatsoever the source of funds, if they are used as investments in fixed capital, the functional income distribution improves, and (iii) functional income distribution is strongly associated with personal income distribution. The chapter will contribute to policy and also enrich the limited literature on the finance-inequality relation.

The fourth chapter (third study) links functional income distribution to productivity growth. Its main focus is on examining how functional income distribution can influence the evolution of productivity thereby promoting economic growth. It employs Nelson and winter's (1982) evolutionary economic

framework, evolutionary theory of economic change and the subsequent developments in the field of evolutionary economic modeling. These are used jointly with the evolutionary econometric approach which sees economic growth as an open ended process. The major conclusion of the fourth chapter (third study) is lack of strong evidence of evolution (intra-industry selection) to foster productivity growth and re-allocation (structural change).

Thus, the three studies not only shed light on the inter-relationships between access to bank loans, income distribution and productivity growth through a deep analysis of the concepts, theories and their usefulness, but also empirically investigate the nature of their causal relationships and estimate their effects. These two aspects will contribute to the growing literature on ACE.

CHAPTER I
INTRODUCTION TO THE THESIS

1.1 Motivation and Scope

This dissertation deals with issues of bank loans and their effects on income distribution and economic growth. Its aim is to investigate: (1) the link between access to bank loans and income distribution in agent-based computational economics, (2) the empirical validation of a link between access to bank loans and income distribution in (1), and finally (3) income distribution and economic growth from an evolutionary economic perspective.

The problems of economic science can be categorized under two major themes. First, the nature and source of income or wealth, and second, how the generated income and wealth should be distributed to the factors which caused it, that is, labor and capital. Ricardo (1821) called the second problem as one of the principal problems of political economy, while Blaug (1996: 467) emphasizes the second question as, 'The great mystery of the modern theory of distribution is why anyone regards the share of wages and profits as an interesting problem'.

In the early stages of economic development, developing economies focused on the problems of expanding their economic activities and increasing outputs. However, in the process of economic expansion, the problem of equity in income distribution became a common economic challenge in these economies, attracting the attention of economists and policymakers. 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 wide-ranging studies on growth-inequality and poverty relationships, Heshmati (2004, 2006) investigates the growing literature on economic

inequalities as a result of an increasing interest in measuring and understanding the level, causes and development of income inequalities and poverty. In particular, Heshmati (2004) argues that establishing a link between economic growth, inequality and poverty is not the ultimate goal; instead the redistribution that follows is.

In economic theory, income distribution is understood as personal income distribution and functional income distribution. Field (2007) classifies personal income distribution as related to income inequality, poverty analysis, income mobility and economic well-being. Functional income distribution, which is the focus of my dissertation, is attributed to post-Keynesian thinking and is about distribution of income between wages and capital income. Dosi et al. (2013) note that functional income distribution is closely associated with personal income distribution suggesting the use of the same concept of income distribution in relation to functional income distribution. This dissertation builds on this claim.

Fei et al. (1978) provide a comprehensive methodology for a statistical decomposition of family income inequality in terms of components such as wages, income from agricultural activities and property income and numerically illustrate the methodology with Taiwanese income data for the period 1964 to 1972. In Pyatt et al. (1980) and Shorrocks (1983), we find a rigorous formulation of the relationship between the Gini measure of inequality in total incomes across families and corresponding measures of inequality in components of total income such as wages, income transfers and others.

Friedman (1953) has alerted us on the inadequacy of the traditional theory of distribution saying that it is concerned exclusively with the pricing of factors of production and the distribution of income among cooperating resources classified by their productive functions. Friedman argues that this has little to say about the distribution of income among individual members of society, and there is no corresponding body of theory that does. This absence of a satisfactory theory of the personal distribution of income and of a theoretical bridge

connecting the functional distribution of income with personal distribution is a major gap in modern economic theory. This dissertation aims to investigate this link and find a breach to fill the gap.

The Government of Ethiopia (GoE) stipulates economic growth as essential in reducing poverty and improving or reducing income distortions. However, even if it has achieved its growth objective by registering an annual economic growth rate of 7 to 8 per cent, the belief that the growth will reduce income inequalities has not materialized. In fact, the very process of growth in Ethiopia is reflected by widespread poverty and rising income inequalities.

The poverty head count index (share of people with incomes below a national poverty line) was 45.5 per cent in 1995, 42.2 per cent in 1999, 38.9 per cent in 2004 and 29.6 per cent in 2011. But Dercon et al. (2011) show a reversal in this trend in that the poverty head count index was 55 per cent in 1995, 36 per cent in 1999, 35 per cent in 2004 and 52 per cent in 2009. The deviation between the two studies could be due to the differences in sample size (large sample size for the World Bank) and a data point of 1,148 in Dercon et al. (2011). According to Ethiopia's Progress towards Eradicating Poverty (an interim report on the Poverty Analysis Study, 2010-11), between 2004-05 and 2010-11, income inequalities measured by the Gini coefficient showed a slight decline from 0.30 in 2004-05 to 0.298 in 2010-11. During the same period, the average economic growth rate was 11.3 per cent (MoFED, 2010, 2013).

The shares of the manufacturing sector in the GDP were 4.0, 4.1, 4.4, 4.6, and 4.8 per cent in 2011, 2012, 2013, 2014 and 2015 respectively, while those of the medium and large scale manufacturing sector were 2.6, 2.8, 3.1, 3.4 and 3.8 per cent in 2011, 2012, 2013, 2014 and 2015 respectively.

However, it may be argued that since the share of the manufacturing sector is low relative to that of the agricultural sector, inferring the personal distribution of income from functional distribution of income which is derived from the manufacturing sector is debatable. However, the debate can be retorted by the

intention of this study which seeks for the relative emergence of inequalities rather than focusing on the absolute magnitudes.

A look at the share of industrial income using Ethiopian firm level data on the medium and large scale manufacturing firms indicates that during 1996 and 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. This 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 the number of industrial wage 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.

While who gets what refers to the personal distribution of income across individuals, functional distribution is a distributional issue across suppliers of productive factors. This is because of the distributive consequences and their wider implications being more important than its causes. Thus the use of functional income distribution by accounting for different factors of production reduces bias in an analysis of inequalities limited to only working incomes.

Moreover, contemporary research's emphasis has almost completely shifted from a study of the causes of inequalities to a study of the facts and of their consequences for various aspects of economic activities. One such activity could be productivity growth and hence economic growth. This allows not only for an analysis of the direct effects but also the indirect and total effects of different channels of functional income generation and distribution.

In their essay, Robert and Thomas (2005) consider the 'who' of 'who gets what,' but distribution concerns other questions that bear on our inquiry. They forwarded Aghion and Bolton's (1997) emphasis as: first, 'what do they get' asks a mostly empirical question about what is being distributed, and statistical techniques for characterizing its dispersion. Second, 'why do they get what they get' is a theoretical question, an attempt to explain the economic (and sometimes legal) causes of a given distribution. Third, 'does the dispersion of what they get have real economic consequences of its own,' treats distribution as a cause, rather than just an effect. It asks whether too much inequality causes adverse economic outcomes, as when the inability of the poor to borrow decreases opportunities of higher productivity thereby lowering the rate of economic growth.

While all aspects of inequalities including economic, political and social are important determinants of the quality of life and well-being which reinforce one another in a complex and inter-related process of cause and effect, the question of the impact of income inequality on economic growth remains central to discussions on development strategies and policies. This is due to the fact that economic growth could favor the rich and hence widen the gap between the wealthy and everyone else in society, or it could be favorable to the poor and lessen inequalities. The impact of inequalities on welfare and well-being in the context of developing countries with underdeveloped channels of taxing and redistribution is a serious factor of underdevelopment and inequity.

Thus, keeping these issues in mind, we can raise the following questions: Despite real economic growth, why do we observe widening inequities? How does the distribution of income affect the macro-economy, particularly productivity growth? Could firms' access to financial resources in general and access to bank loans in particular play a potential role in improving income distribution? And finally how do we answer these questions? These questions suggest that there are both theoretical and empirical demands for studying the

issue in more detail and conducting tests based on real production and income data.

Researches in macroeconomics are largely concentrated around investigating the determinants of economic growth with less emphasis on the distributional aspects. However, the issue of income distribution is equally important because social conflict arising due to income inequalities may incite economic instability which could potentially harm the growth process. 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, an interest in distributional issues is not there only for its own sake but also for understanding the effect of income distribution on the broader macroeconomic performance. A comprehensive understanding of income distribution and its effects on macroeconomic performance is provided by Stiglitz (2012) and Piketty (2014).

During the last two decades, many economists have been preoccupied with studies that aim to develop theoretical models to trace empirical facts for these questions. They have been devoted to obtaining explanations for differences in individuals' living standards across countries and regions within a country or between countries. The emphasis has been on investigating the dynamics of these differences over time and poor countries (regions or states in a country) catching up with the rich ones (usually known as growth econometrics or growth regression). These issues have been and still remain intensive research programs in economic science in general and in macroeconomics in particular.

In the standard paradigm of income distribution, the size distribution of income and hence the degree of inequality in incomes arises out of a functional distribution of income paid to different types of factors of production in the form of wages and salaries, rents and royalties and interest and profits. In turn, supply, attributes and ownership of factors of production, for example, participation in the labor force, its educational and skills profile, the concentration of ownership of and investment in financial and physical assets and claims on rents derived

from land and natural resources are all highly affected by institutional factors peculiar to each country which are rooted deeply in its history.

The observed differences in patterns of income distribution among countries seem too vast to be explained simply by differences in factor endowments or factor attributes and therefore cannot be fully accounted for by such influences as market imperfections, economies of scale or effects of the external sector. Further, it is recognized that the influence of institutional factors on income distribution is likely to be large.

Heshmati (2006) summarizes that a non-uniform increase in wage inequalities, technical change biased against unskilled workers and the government's effective and productivity enhancing redistributive policies have resulted in the heterogeneous development of inequalities among industrialized countries. In addition to geographic factors, institutional structure and democracy also play a role in economic development and inequalities among countries (we can find more in Heshmati 2004 and 2006 and the literature cited therein).

Generally, economists hold very different views on the role of finance in economic performance including that of improving income distribution. On the one hand, prominent researchers believe that the financial sector merely responds to economic development adjusting to changing demands from the real sector and therefore this is overemphasized (Robinson, 1952; Lucas, 1988). On the other hand, equally prominent researchers believe that financial systems play a crucial role in alleviating market frictions and hence influencing savings rates, investment decisions, technological innovations and therefore long-run growth rates (Schumpeter, 1961).

By providing two famous quotes by Robinson and Schumpeter on these different views, Demirgüç-Kunt (2008) summarizes these arguments. Robinson argues, 'Where enterprise leads finance follows', whereas Schumpeter (1961) observed 'The banker, therefore, is not so much primarily a middleman. He authorizes people in the name of society (to innovate)'. This suggests that accounting for

different productive factors and an analysis of their complex and inter-relationship effects undoubtedly enhances our understanding of functional income distribution in an analysis of inequality and productivity.

The issue of the role of finance in enhancing economic growth is well known (for example, Gurley and Shaw, 1955; Mackinnon, 1973; Rajan and Zingales, 2003). On the other hand, the question of the role of finance in the distribution of generated wealth remains largely unexplored (Céline and Thomas, 2011). Demirgùc and Levine (2009) note how economists have overlooked the impact of finance on inequality.[1]However, the structure and performance of a country's financial sector greatly affects income distribution (Jovanovic, 1990; Levine, 2005; Beck et al., 2007; Claessens and Perotti, 2007; Gimet and Lagoarde-Sego, 2011; Dosi et al., 2013). But first, the channel and direction of influence that finance is linked to income distribution are not well established and second related research suggests mixed results. We can find more on this issue in Claessens and Perotti (2007) and the associated literature therein. My dissertation is an attempt to find answers to the questions raised earlier.

In existing literature, the direction and strength of the link between inequality and economic growth is also mixed. For example, Persson and Tabellini (1994) and Bassett et al. (1999) argue that inequality is harmful for growth. In their paper 'Social Conflict, Growth and Income Distribution', Benhabib and Rustichini (1996) demonstrate that despite the predictions of the neo-classical theory of economic growth, poor countries were observed to invest at lower rates and have not grown faster than rich countries. They studied how the level of wealth and the degree of inequalities affect growth and show how lower wealth can lead to lower growth and even to stagnation when the incentives to capital accumulation are weakened by redistributive considerations. Therefore, it would be academically demanding to investigate the link between income distribution

[1]For example, they show that the three volumes of the *Handbook of Income Distribution* do not mention the possible connection between income inequality and finance.

and productivity and the subsequent growth effect. This issue in particular is investigated in Chapter 4 of this thesis.

This dissertation explores the use of agent-based computational economics (ACE). By the 1990s, there had been major developments in macroeconomics: a methodological shift from a representative agent based micro-foundation and general equilibrium to a complex adaptive systems (CATS) approach. The latter 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 (more on this can be found in Dosi 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 purpose for which it was intended, that is, (i) escaping the Lucas critique, and (ii) building micro-founded macroeconomic models, both of which did not materialize (Hartely, 1997). In particular, when it comes to issues of finance and income distribution, the representative agent based micro-foundation for macroeconomics is not theoretically sound because of 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 an economic system that is composed of heterogeneous interacting agents. In both cases, how the representative agent can be used to pass micro-behavior to macro-behavior is not theoretically clear.

Agent-based models are interesting in relation to growth-inequality discussions for two reasons: first, they manage to handle inequalities, and secondly they tend to produce inequality (more on this in Bruun, 2002). A more elaborate argument runs as follows: There are four main arguments why research on the relationship between inequality and growth can benefit from an agent-based simulation

analysis. First of all, standard literature uses representative agents, which in principle precludes any relationship between inequality and growth. Second, it is very hard to verify the theories empirically since there is no great variance in equality within time series data (Perotti, 1992; Furman and Stiglitz, 1995). As a third point, existing literature treats inequality as an initially given exogenous factor whereas in agent-based literature, inequalities are generated endogenously. This allows the feedback effect between growth and inequality. A fourth argument in favor of agent-based models is their ability to perform experiments in particular, political experiments. By producing experimental data, the relation between growth and inequality can be studied and manipulated under different sets of assumptions. Therefore, we must seek an approach that is different from the standard approach (more on this is explained in Beinhocker, 2007 and Farmer and Foley, 2009).

Heshmati and Lenz-Cesar (2013) argue that ACE breaks the paradigms and overcomes the limitations of classical economics by applying an agent-based simulation to study the economy as an evolving system of autonomous interacting agents.

On issues of growth of productivity and the subsequent economic growth, the basic paradigm in mainstream economic theory, namely that individuals take decisions in isolation using only the information received through some general market signals such as prices, is built in the general equilibrium model. However, as is well known, this model guarantees neither stability nor uniqueness of equilibrium. Since the latter is essential for macroeconomists who wish to use comparative statistics, they have to avoid this fundamental problem by resorting to what has become the standard paradigm in modern macroeconomics, that is, the representative agent (RA) framework.

The basic assumption under RA is that the behavior of the aggregate can be treated as the behavior of an average individual. The use of such an approach has been frequently contested and has several obvious disadvantages. For example, it

means that one has to ignore communication and direct interaction among agents and it ultimately defines away the problem of coordination (Leijonhufvud, 1992; Hahn and Solow, 1995). In this setting, interaction and coordination occur only through prices. The role of prices is undoubtedly important, but the price mechanism alone can work only if information is complete; in such a case, one can ignore the influence of other coordination and interaction mechanisms. Here again, these difficulties can be sidestepped by assuming that a sector of the economy can be described by a RA.

There is no simple, direct, correspondence between individual and aggregate regularities. It may be that in some cases aggregate choices correspond to those that could be generated by an individual. However, even in such exceptional cases, the individual in question cannot be thought of as maximizing anything meaningful from the point of view of society's welfare.

The approach in this study is exactly the opposite of the RA approach. Instead of trying to impose restrictions on aggregate behavior, by using, for example, the first order conditions obtained from the maximization program of a representative individual, this study argues that the structure of aggregate behavior (macro) actually emerges from an interaction between the agents (micro).

In other words, statistical regularities emerge as a self-organized process at the aggregate level: complex patterns of interacting individual behavior may generate certain regularity at the aggregate level. The idea of representing a society by one exemplar denies the fact that the organizational features of the economy play a crucial role in explaining what happens at the aggregate level.

It is assumed that the way in which markets are organized has no influence on aggregate outcomes. Thus aggregate behavior, unlike that of biological or physical systems, can be reduced to that of a glorified individual. Such an idea

has, as a corollary, the notion that collective and individual rationality are similar.

In order to overcome these limitations, it is argued here that collective outcomes be thought of as a result of an interaction between agents who may have rather simple rules of behavior and who may adapt rather than optimize. Once one allows for direct interaction among agents, macro-behavior cannot, in general, be thought of as reflecting the behavior of a 'typical' or 'average' individual (we can find more explanations in Kirman, 1992, 2004; and in a lot of other associated literature).

Banerjee and Duflo (2005) summarize that the mainstream economic growth theory assumes the existence of an aggregate production function whose existence and properties are closely tied to the assumption of optimal resource allocation within each economy. The key fact is the enormous heterogeneity in rates of return to the same factor within a single economy, a heterogeneity that dwarfs cross-country heterogeneity in economy-wide average returns.

The key assumption behind the construction of the aggregate production function is that all factor markets are perfect in the sense that individuals can buy or sell as much as they want at a given price. With perfect factor markets (and no risk) the market must allocate the available supply of inputs to maximize total outputs (as extensively found in Gatti et al., 2007 and the literature cited therein).

An important and related approach in this study is to break the mainstream growth paradigm by exploring the 'evolutionary approach' through economic literature. Here the interest is in the collective result of a situation in which myopic individuals with limited comprehension and rationality feel their way forward. This sort of idea discussed by Nelson and Winter (1982) is clearly related to a view of the economy as having self-organizing properties.

Alchain (1950) brought out the evolutionary approach as an alternative framework in economics. He started by proposing a suggestion for modifying an

economic analysis to incorporate incomplete information and uncertain foresight as axioms. According to Alchain, this approach dispenses with profit maximization and it does not rely on predictable individual behavior that is usually assumed as a first approximation in standard textbook treatment.

The suggested approach embodies the principles of biological evolution and natural selection by interpreting economic systems as an adaptive mechanism which chooses from among the exploratory actions generated by the adaptive pursuit of ‘success’ or ‘profit’.

Krugman (1996) articulates economics as what individuals do: not classes, not correlations of forces but individual actors. This is not to deny the relevance of higher levels of analyses, but they must be grounded in individual behavior. Thus, methodological individualism is of essence. He further notes that individuals are self-interested. He extends his argument saying that there is nothing in economics that inherently prevents us from allowing people to derive satisfaction from others' consumption, but the predictive power of economic theory comes from the presumption that normally people care about themselves.

Krugman emphasizes that individuals are intelligent; they do not neglect obvious opportunities for gain. It is often asserted that economic theory draws its inspiration from physics and that it should become more like biology. If that is what you also think, you should do two things. First, read a text on evolutionary theory, like John Maynard Smith's *Evolutionary Genetics*. You will be startled at how much it looks like a textbook on microeconomics. Second, try to explain a simple economic concept, like supply and demand, to a physicist. You will discover that our whole style of thinking, of building aggregative stories from individual decisions, is not at all the way they think (Krugman, 1996).

1.2 Contributions of this dissertation

This dissertation also examines the link between functional and personal income distribution. At the center of the study are firms and their access to bank loans. By modeling the role of bank loans on firms' production and employment decisions, the study examines the effect of access to bank loans on income distribution and the effect of income distribution on economic growth (growth of productivity). The contribution of this dissertation can be seen from the following aspects:

First, functional income distribution is becoming the center of conflict and attracting the attention of economists and policymakers.[2] We use the Ethiopian medium and large scale manufacturing firm level data to explain mechanisms behind the functional income distribution and try to link this to personal income distribution at the macro level.

Second, this thesis will contribute to the limited literature base that links access to bank loans to functional income distribution.

Third, on the methodological side, unlike the standard representative agent based micro-to-macro passage, the micro-to-macro passage in ACE takes place from agents' individual decision-making processes which are a result of satisficing[3] rather than that of optimizing behavior bounded in rationality, adaptive rather than perfect foresight and out of equilibrium interactions rather than an

[2]On August 16, 2012, the South African police intervened in a labor conflict between workers at the Marikana platinum mine near Johannesburg and the mine's owners, the 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 primarily concerned wages: the miners had asked for a doubling of their wage from 500 to 1,000 Euros a month. 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 the income from production should be divided between labor and capital has always been at the heart of distributional conflict (see Piketty 2014 for details).

[3] See Nelson and Winter (1982), Arnold and Boekholt (2002) and Marc (2007). The term 'satisficing' is coined by Herbert Simon. The tendency to satisficing shows up in many cognitive tasks such as playing games, solving problems and taking decisions where people typically do not or cannot search for the optimal solutions (Simon, 1982).

equilibrium analysis. In ACE, macro-behavior emerges from micro-behavior providing empirical facts from developing countries taking the case of Ethiopia, the study contributes to explanations of the current methodological controversies in economics science.[4] The researcher is convinced that a successful application of ACE can be considered as a contribution by itself. Thus, the findings of this dissertation will have significant policy implications in an era when economic policymakers feel that they have been abandoned by current economic models.[5]

1.3 Organization of the dissertation

This dissertation is organized as follows. The following chapter is a theoretical framework for an artificial economy using ACE. The model is validated using different validation techniques and real world data in the chapter that follows. Then, it uses the underlying framework in Chapter 4 to investigate growth from evolutionary perspectives. Chapter 5 gives the conclusion. The structure of the dissertation is depicted in Figure 1.

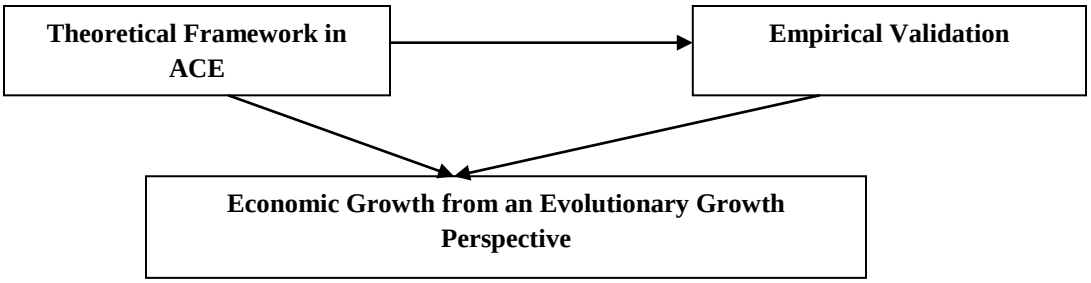


Figure 1. The structure of the dissertation

[4]Nobel Prize 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 (see Bruun and Luna, 2000).

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

CHAPTER II

THE LINK BETWEEN ACCESS TO BANK LOANS AND INCOME DISTRIBUTION IN AGENT BASED MODELING: A THEORETICAL FRAMEWORK

2.1. Introduction

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 development 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.

The 2013 official 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.

The Ethiopian banking system currently consists of 18 commercial banks out of which two are public banks, the Commercial Bank of Ethiopia (CBE) and the former Construction and Business Bank of Ethiopia (CBBE) which is now incorporated with CBE, the Development Bank of Ethiopia (DBE). The remaining 16 are privately owned commercial banks. In addition, there are 31 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 disbursement of loans by CBE, on average, 40.37 per cent of the loans went 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 disbursement to the manufacturing sector, while on average only 28.18 per cent of the country's loan disbursement went to the manufacturing sector. Private

commercial banks are inclined to finance services, for the most part 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' activities 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 have 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.

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 chapter aims at contributing to existing theoretical 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 from bottom-up, through the repeated local interactions of autonomous agents channeled through socioeconomic 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 (Dosi 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 policy makers. 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., 2011), 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[6]. 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[7].

The rest of the chapter is organized as follows. Section 2.2 explores the ACE literature. Section 2.3 discusses the appropriateness of ACE for studying the relationship between bank loans and income distribution. Section 2.4 presents the original model while Section 2.5 extends the original model to fit a developing country's realities. Section 2.6 presents the results.

2.2. ACE: the foundation, evolution and current status

2.2.1 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

[6]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 (Bruun and Luna, 2000).

[7]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.,1997).

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.

2.2.2 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).[8] The 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).[9]

Now, the advent of the fast computational and programming techniques and critiques of traditional macroeconomic models coupled with the global financial

[8]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 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.

[9]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).

crisis that started in 2007 has facilitated ACE to emerge as a new paradigm in macroeconomics. [10] 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 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.

[10] 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).

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.

2.2.3 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.

2.2.4 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 Behavior, 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; since 2001) and the International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS; since 2004) 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.

Regarding the application of ACE for investing complex dynamic evolving systems and economic interaction between economic agents which cannot be handled by the standard classical economic mythologies, Heshmati and Lenz-Cesar (2013) employed ACE to investigate cooperative behaviors of firms in innovation activities in manufacturing firms in South Korea. They introduced an agent-based simulation model representing the dynamic processes of cooperative R&D in the manufacturing sector of South Korea. They defined firms' behaviors according to empirical findings on a data set from the internationally standardized Korean Innovation Survey in 2005. They defined simulation algorithms and parameters based on the determinants of firms' likelihood to participate in cooperation with other firms when conducting innovation activities.

Heshmati and Lenz-Cesar (2015) utilized an agent-based simulation model to conduct a public policy simulation of firms' networking and cooperation in innovation. Their simulation game tested the differences in sector responses to internal and external changes, including cross-sector spillovers, when applying three different policy strategies to promote cooperation in innovation. Their simulation model defines firms' behavior according to empirical findings from an analysis of determinants of the firms' participation in cooperation in

innovation with other organizations using a Korean Innovation Survey. Their exercise indicates possible appropriate policy strategies that can be applied depending on the target industries. They have applied a few policy scenario examples and showed how the results may be interpreted and noted that agent-based models are found to have a great potential in decision-support systems for policy makers.

Lenz-Cesar and Heshmati (2012) argued that ACE modeling is useful to understand the concept of innovation networks has been mentioned and emphasized in many studies, especially in literature on evolutionary economics. They also noted that few studies have focused on modeling the processes by which these networks are formed and determining their outcomes. They extended their argument saying that complexity of the dynamics involved and the heterogeneity of the agents make it hard to model innovation networks' activities using traditional techniques. Thus, Agent-based Computational Economics (ACE) modeling attempts to break the paradigms and limitations of classical economics through the application of agent-based simulation to study the economy as an evolving system of autonomous interacting agents.

2.3. 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.

2.4. 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

Figure 2.2 is a diagrammatic representation of the sequence of actions by agents.

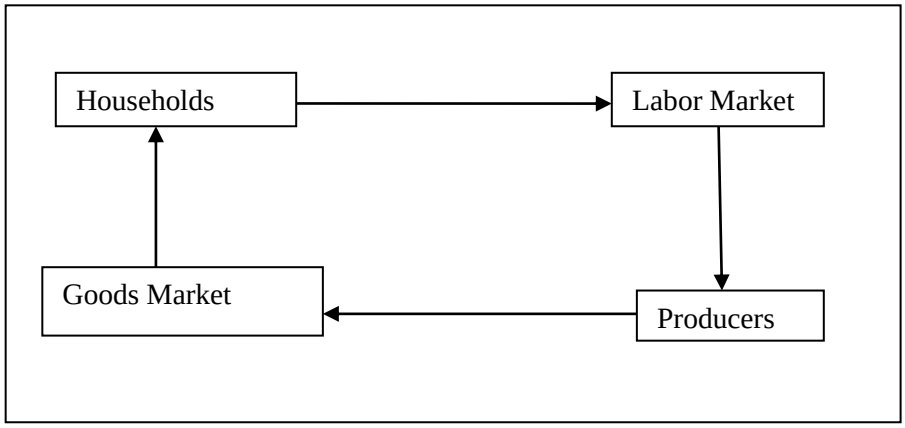


Figure 2.1. A simple artificial small economy

In Figure 2.1, 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.

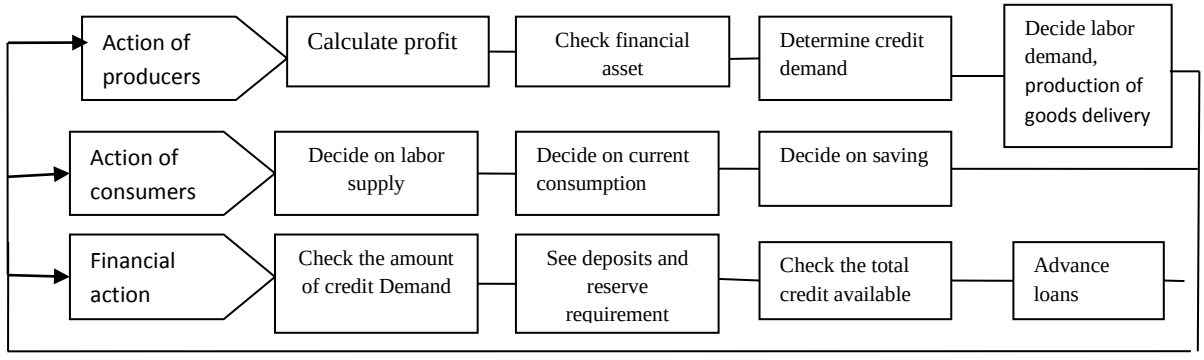


Figure 2.2. Sequences of actions by agents in a small economy

2.4.1 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:

$$W_{it} = W_{i,t-1}\left(1 + \psi \frac{\Delta Q_{avt}}{Q_{avt-1}}\right) \quad (2.1)$$

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.

2.4.2 Producer (firm) agents and the goods market

There are N producers denoted by the subscript I at 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:

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

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

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

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:

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

where $0 \leq \nu \leq 1$ 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:

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

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:

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

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:

(2.7) $$cI_{it} \leq NW_{i,t-1}$$

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

(2.8) $$D_{it}^{e} = D_{i,t-1}$$

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 $V_{i,t-1}^{a}$ to the expected demand:

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

Finally, producers' profits are determined as:

(2.10) $\Pi_{it} = S_{it} - c_{it}Q_{it}^{d}$

Where all variables are as defined before.

2.4.3 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:

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

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.2.12) 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.2.13:

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

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

The key condition for Eq.2.13, 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 system, there are 18

commercial banks of which 16 are private and two are 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.

2.5. 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:

(2.14) $A_{jt}^{r} = \sum_{i=1}^{N} f_{it} A_{it}^{r}$

(2.15) $A_{t}^{r} = \sum_{j=1}^{M} f_{jt} A_{jt}^{r}$

where, i = 1,2,3,….N, j=1,2,3, …, M and t = 1,2,3,…,T. In Eq.2.14, A_{jt}^{r} is the aggregate industry productivity index of industry j, A_{it}^{r} is the productivity of firm i, and f_{it} is the output share of firm i. In Eq.2.15, A_{t}^{r} 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}^{r} from Eq.2.15 into Eq.2.1, it will yield dynamics of evolution of labor shares at the macro-level as:

(2.16) $W_t = W_{t-1}\left(1 + \Psi \frac{\Delta A_t^r}{A_{t-1}^r}\right)$

Eq.2.16 suggests 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:

(2.17) $Q = F(K_1, K_2, \dots K_m, L_1, L_2, \dots, L_n)$

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 are one factors of production, a firm's production function can be generalized as:

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

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.2.17 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.2.18:

$$(2.19)\quad \Delta A_t^r = dQ_{it} = \frac{\partial Q_{it}}{\partial K_{it}} dK_{it} + \frac{\partial Q_{it}}{\partial L_{it}} dN_{it} + \frac{\partial Q_{it}}{\partial L_{it}} dL_{it}$$

$$= MPK(dK_{it}) + MPN(dN_{it}) + MPL(dL_{it})$$

One can arrive at the following point. Changes in average productivity from time t-1 to t can be understood as indicated in Eq.2.17, 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. 2.19 in the wage evolution equations from Eq.2.16 yields Eq. 2.20:

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

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

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

$$= \mathcal{E}_{QN} dK_{it}$$

$$\frac{(Q_{it}-Q_{i,t-1})/(N_{it}-N_{i,t-1})}{Q_{i,t-1}/N_{i,t-1}}dN_{it} = \left(\frac{Q_{it}-Q_{i,t-1}}{Q_{i,t-1}}\right)\left(\frac{N_{i,t-1}}{N_{it}-N_{i,t-1}}\right) = \mathcal{E}_{QN}dN_{it}$$

$$\frac{(Q_{it}-Q_{i.t-1})/(L_{it}-L_{i,t-1})}{Q_{i,t-1}/L_{i,t-1}}dL_{it} = \left(\frac{Q_{it}-Q_{i,t-1}}{Q_{i,t-1}}\right)\left(\frac{L_{i,t-1}}{L_{it}-L_{i,t-1}}\right)dL_{it} = \mathcal{E}_{QL}dL_{it}$$

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.2.14 yields Eq.2.20, namely the wage evolution expressed as:

$$(2.20)W_{it} = W_{i,t-1}(1+\Psi\{\mathcal{E}_{Q,K}dK_{it}+\mathcal{E}_{Q,N}dN_{it}+\mathcal{E}_{Q,L}dL_{it}\}) = W_{i,t-1}(1+\Omega)$$

Eq.2.20 resembles Eqs 2.1and 2.16. However, Eq.2.20 is more intuitive and manageable to write in the NetLogo[11] 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 result in 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.2.21:

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

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

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 2.3A, 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, measured in terms of value added term. The Gini coefficient is equal to the area marked A divided by the sum of the areas marked A and B, that is, 'Gini'[12] = 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)

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

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.

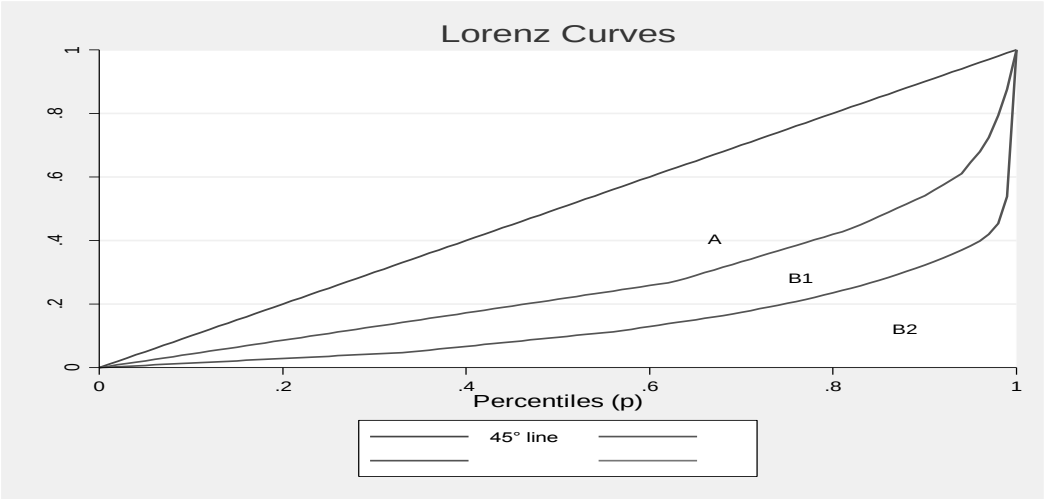


Figure 2.3A. Functional income distribution

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.

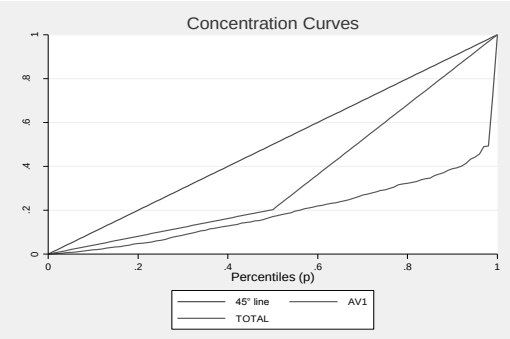
We note that the functional and personal income distributions are consistently linked if and only if area A is the share of profit and area B is the share of labor. Area A is the share of producers whereas area B is the share of consumers. The higher area A the higher the inequality because in reality 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 (wages and profits sum up to the valued added). Income distribution includes both groups and area A indicates distance to line of full equality.

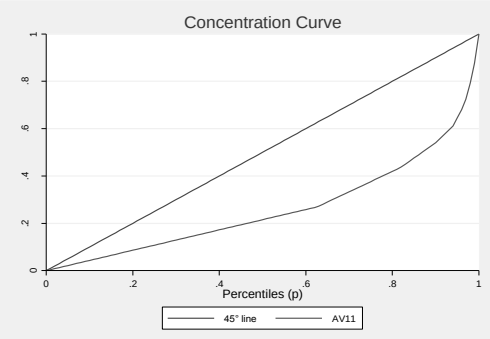
Pointing out the inequality in the agricultural and urban population and the evolution of inequality at the national level are important. The concern here is the generalization of national income distribution from functional income

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[13].

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.





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

Figure 2.3B. Concentration curves for the total and the lowest salary groups (left) and the highest salary group (right)

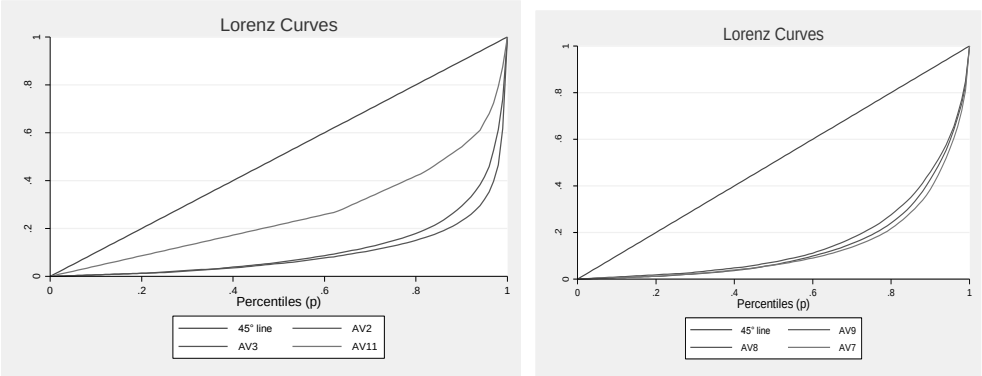


Figure 2.3C. Concentration curves for the second and highest salary brackets (left) and the third, seventh and the highest salary brackets (right)

In the interest of space, inequality indices for limited salary bracketsare indicated in Figures 2.3B and 2.3C. These curves inform us of the level of inequalities between different income groups. The purpose here is to learn the pattern of inequalities between different groups of workers which will help us understand the sources of hetrogenities in inequalities and their evolution over time.

The immediate examination of these curves tells us that inequality levels in the lower salary brackets 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 the higher salary brackets. Forexample AV1 lies below AV2 and so on.We also observe that the agregate inequality curve, the curve labled TOTAL on the left hand side of Figure 3B lies above AV1, implying that the agregate indices conceal some evidence regarding income inequalities.

This suggests that the higher the salary bracket, less is ineqaulity and 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 higher income groups (because high income groups have income from capital). As we move from the lower salary bracket to the higher salary bracket, we also observe that some workers are entitled to other sources of income.

2.6. Simulation results and analysis

2.6.1Initialization and the simulation environment

A separate algorithm is developed to simulate the economy described in sections 2.4 and 2.5. 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 2.1 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 2.1). 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[14] 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.

Table 2. 1. Initialization of state variables and simulation parameters

[14] Different versions of NetLogo are freely downloadable from http://ccl.northwestern.edu/NetLogo/ NetLogo. I used version 4.0.5.

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
$\mathrm{NW}_{\mathrm{i},t}$	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[15] and second, for a clear interpretation of the simulation results.[16] Consumers and producers interact according to rules specified in the NetLogo computational environment.

[15] 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.

[16] 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.

2.6.2 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 Figures 2.4A-2.4D. 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.

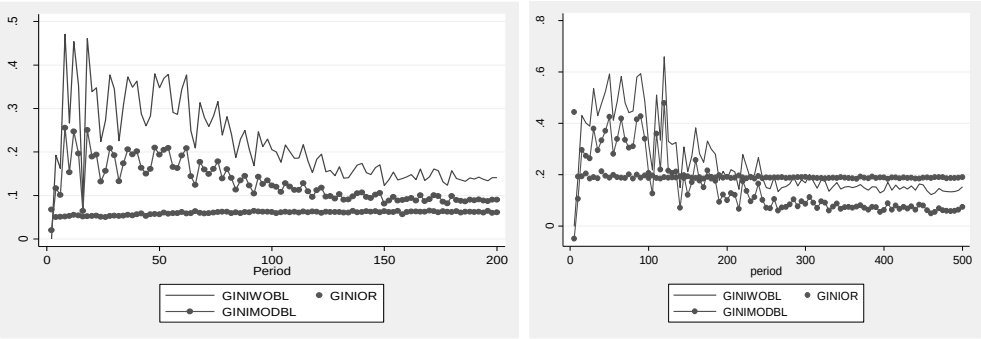


Figure 2.4A. Simulation with 2 producers and 100 consumers (left) and with 5 producers and 100 consumers (right).

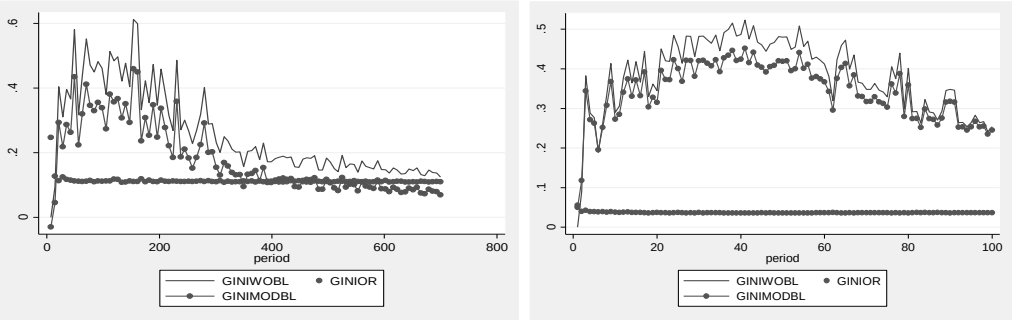


Figure 2.4B. Simulation with 7 producers and 100 consumers (left) and with 31 producers and 100 consumers (right).

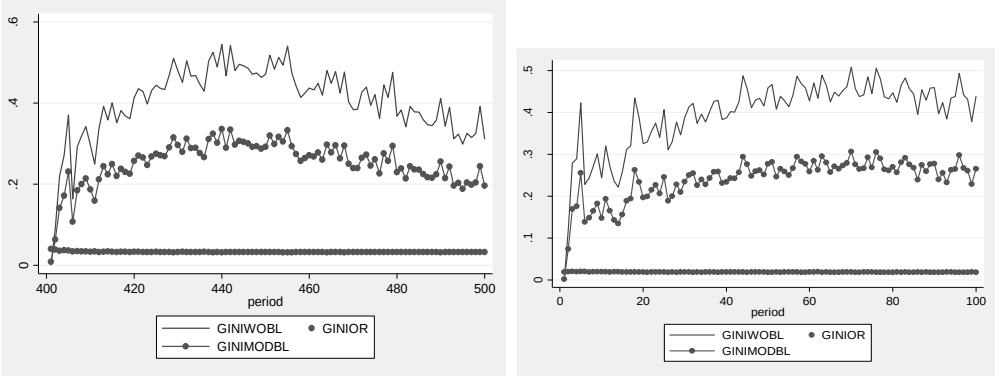


Figure 2.4 C. Simulation with 35 producers and 100 consumers (left) and with 81 producers and 100 consumers (right).

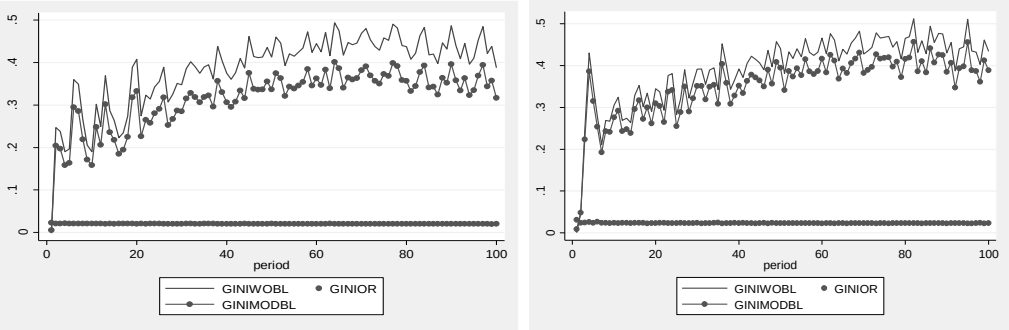


Figure 2.4D. Simulation with 85producers and 100 consumers (left) and with 90 producers and 100 consumers (right).

Figure 2.4A-2.4D. Agent-based simulation results with varying numbers of consumers and producers

Table 2. 2. Statistical distances of simulated outputs

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 2.2. 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 2.4A-2.4D) and statistically (based on the t-values) in Table 2.2, 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 2.4A-2.4B) and lower simulation periods (Figures 2.4C-2.4D) 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 (Figures 2.4A-2.4B, 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 2.4B (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 2.4C, left panel).Even if the number of producers is large, inequality tends to decline faster for a 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 2.2), all the tests fail to accept the null hypothesis that the outputs of all models are statistically generated from the same population. The selection of the classical t-statistic is based on argument 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.

CHAPTER III

THE LINK BETWEEN ACCESS TO BANK LOANS AND INCOME DISTRIBUTION IN AGENT BASED MODELING: EMPIRICAL VALIDATION

3.1. Introduction

The main goal of any empirical validation is to evaluate the capabilities possessed by theoretical models to examine if they reflect some real world stylized facts. Thus, taking our ACE model to investigate the compatibilities between the results obtained from theoretical simulations and what the data speaks comprises this validation study.

This chapter examines whether the agent-based computational economics (ACE) model in chapter two is able to generate statistical properties which reflect the properties of the real data. Operationally, the whole process of validation is to investigate how good a model is. Noting that models are generally considered satisfactory if and only if they are able to reproduce empirical evidence and statistical regularities to some extent, the right question to be posed is in fact empirical in nature: are the micro-rules driving the evolution of income distribution supported by empirical evidence from the actual data? The answer we give for this question is essential to decide whether our model is valid or not.

Given the simulated results in chapter two, the validity of our claims remains to be dealt with. Achieving good emerging phenomenon from theoretical simulation is a necessary condition while empirically validating these emergent phenomena with real data using different validation techniques is a sufficient condition for accepting a model as a valid one for further analysis. The main objective here is to empirically investigate if those regularities obtained in the

preceding chapter can be justified by real data. Therefore, this chapter answers the following questions:

a) Is there any association between access to bank loans and income distribution?
b) Is there any association between functional income distribution and personal income distribution?
c) Is the model plausible given our understanding of the processes?
d) Does our ACE model inform us about the evolution of inequality?

The rest of the chapter is organized as follows. Section 3.2 presents the theories of income distribution. Section 3.3discusses the methodology and identification strategy for validating our ACE model, the data and main results. Section 3.4 summarizes the main features of the chapter.

3.2. Theory of income distribution: Literature review

In the 2000 edition of the *Handbook of Income Distribution*, Atkinson and Bourguignon mention that one of the fundamental questions that motivated the systematic study of economics was: Why are some countries rich and some poor? He further points out that this may well be correct according to the motivations of some of the leading economists who are interested in economic growth starting with this puzzle.

However, for a large majority of mankind who, at least until fairly recent times, had little opportunity to obtain firsthand knowledge of the economic conditions in foreign countries, one would have thought that a more obvious question would have been: Why are some people rich and some poor? This question might naturally have come to mind as individuals went about their everyday business in a world of large inequalities of income and standard of living (Atkinson and Bourguignon, 2000).

The theory of income distribution deals with the explanation of who earns what, who owns what, and why. In simple terms, it is about how income and wealth have changed over time. The details are documented in the introductory chapters of Reynolds (2006).

Literature on income distribution is as old as economics itself. This is evidenced by the fact that revolutionary literature on income distribution goes back to the 1950s and 1960s. In fact, the whole issue of economic science is concentrated around the how questions, that is, how to generate wealth and how to distribute the generated wealth among the population. It is also one of the most controversial areas in economic theory that has been pushing economists and policymakers to conflicts and bringing greater awareness of the inadequacies of economic analyses. The reasons are provided by Sahota (1978) as:

First, the old and persistent battleground of capital theory is involved. Second, distribution theory lies at the crossroads between the microeconomics of the value theory and the macroeconomics of theory pertaining to national income, the general price level and the general level of employment. The inconsistencies and lack of integration within these two fields are inevitably reflected in a curious composite of the income distribution theory. Third, distribution theory has suffered acutely from a number of conflicts concerning methodology in economic analyses. Fourth, more sharply perhaps than in any other field of theory the study of income distribution meets head on the question of the scope of economic analysis and its tools for it runs immediately into problems of the political, as distinct from the strictly economic, elements which determine income shares.

Friedman (1953), states that the traditional theory of distribution is concerned exclusively with the pricing of factors of production and the distribution of income among cooperating resources classified by their productive functions. It has little to say about the distribution of income among individual members of society and there is no corresponding body of theory that does this.

This absence of a satisfactory theory of the personal distribution of income and of a theoretical bridge connecting the functional distribution of income with personal distribution is a major gap in modern economic theory.

In Friedman's view, the functional distribution of income has been primarily treated as a reflection of choices made by individuals through the market: the value of factors is derived from the value of the final products that they cooperate in producing; and the value of final products in turn is determined by choices of consumers among the alternatives that are technically available.

Theoretical literature on income distribution is very vast. Nevertheless, in the interest of space, this review does not pretend to be exhaustive. Instead, it focuses on the two major concepts of income distribution: personal and functional. Thus, influential literature on the two concepts is presented in sequel.

3.2.1 Theories of personal income distribution

Under this theory, there are different explanations, majority of which are based on individual characteristics and behaviors: ability theory, stochastic theory, individual choice theory, human capital theory and inheritance theory of income distribution. Sahota (1978) provides a detailed account on this theory.

The ability theory: In Sahota (1978), we can find an elaboration for this theory as among the oldest of all theories of personal income distribution. He also states that under this theory, it is believed that mental and physical abilities are distributed normally, just as various physical traits such as weight and height of the human body are distributed normally. A natural inference from this is that incomes are also distributed normally.

Statistical evidence does not sustain such an inference, however, and the shattering blow to this belief came from Pareto's (Sahota, 1978) empirical findings, according to which incomes were distributed not normally but lognormally and the skewness to the right had a flat tail, meaning substantial

unequal distribution. Since then economists have been engaged in reconciling and explaining the discrepancy between the distribution of abilities and incomes, and their research has been the source of many theories. The development of the modern theory of human capital, however, has all but obscured the ability basis of income inequalities (Sahota, 1978).

The stochastic theory: Is also one of the oldest theories of income distribution which relies for the skewed shape of income distribution mainly on chance, luck and random occurrences. For example, to an econometrician, a theory structured on random errors with no systematic and predictable forces seems ridiculous. Yet the theory is based on the statistical law of probability.

The general idea of this theory is that even if a generation started from a state of strict equality of income and wealth, inequalities of the degree of Pareto distribution could emerge due to stochastic forces. The theory provides a stamp of scientific respectability to age-old myths that the goddess of fortune is blind, poverty hits at random, none is destined to abjection from birth and the sons of poor families have the same chances for success as anyone else.

The individual choice theory: Is an optimizing model of income differences. The theory was developed by Friedman (1953) and may be regarded as the pioneer of the modern human capital theory. According to this theory, the distribution of measured incomes at a point in time is, to an important extent, determined by individual choice among opportunities that yield both different combinations of cash income and non-pecuniary advantages, and different profiles of cash income over time.

The theory applies even when choices are made under certainty. However, Friedman developed this theory in the form of choices under uncertainty of income prospects. The theory is formulated for individuals' choices among different occupations involving different, but insurable risks. These choices are based on the actuarial expectation of utility (not income) from these occupations.

The human capital theory: The modern time of the human capital theory was conceived and developed largely but not exclusively by the Chicago School, starting around the turn of the decade of the 1950s under the intellectual inspiration of Theodore W. Schultz. Since then, it has grown into a colossus, enriching all branches of economic analyses-- microeconomics, labor economics, capital theory, growth theory, agricultural economics and, above all, income distribution theories.

From the start, research has been focused on two complementary fronts: on one front, Schultz, Denison, Griliches and following them many others used the human capital framework to analyze the sources of productivity and growth. On the other front, Becker, Mincer and their followers focused on the general theory and the earnings distribution theory of human capital. The latter authors clarified the relevant costs of the human investment process and analyzed school and post-school investments; spelled out the optimizing decision rules for such investments; and derived implications for earning differences among skill categories across occupations and over age categories.

The human capital theory is developed largely in a competitive setting. Thus, of the two earlier stated classical postulates of labor incomes, human capital theorists accept the principle of equalizing differences and competitive labor markets and pay scant attention to the principle of non-competing groups.

The inheritance theory: The previous theories are addressed primarily to earned incomes. It has been observed that unearned or property incomes are more unequally distributed, even though their shares in overall personal incomes have declined in the past century. It is believed that inheritance is the major source of property class perpetuation. Hence, a theory of distribution that does not include an analysis of property income will present only a partial picture.

For instance, Johnson (1973) notes that estates are built not only from inheritance, but also through current accumulation. Moreover, inheritance need

not occur in material form only. Parents can bequeath earning power either by passing on material capital or human capital.

3.2.2 Theories of functional distribution of income

It is inspiring to read the following sentence by Blaug (1996: 467): 'the great mystery of the modern theory of distribution is why anyone regards the share of wages and profits as an interesting problem'. This suggests that we study issues related to functional income distribution.

Interest in the distribution of income is central in economics. Classical economists were concerned with the issue of how an economy's output is divided among the various classes in society, which, for David Ricardo (1821), was the principal problem of the Political Economy. While classical economists were primarily interested in the functional distribution of income among factors of production (wages, profits and land rents), in modern societies distributional concerns focus at least as much on the personal (or size) distribution of income. In contrast to its paramount importance in 19th-century classical economics, however, income distribution became a topic of minor interest in recent decades. Atkinson and Bourguignon (2001: 7265) note that in the second half of the century, there were times when interest in the distribution of income was at low ebb and economists appeared to believe that differences in distributive outcomes were of second order importance compared to changes in overall economic performance.

However, it remained silent for decades because it was assumed away in standard macroeconomic treatments as constant and straightforwardly derived from and easily explained by a Cobb-Douglas production function (Mankiw, 2007; Hogrefe and Kappler, 2013).

The constancy of the labor share is stated in Kaldor (1955) as in the long-term properties of economic growth; the shares of national income received by labor

and capital were roughly constant over long periods. The stability of time-series data on factor shares has long encouraged economists to look favorably on models that attribute the same aggregate technology to all countries. In particular, these data have frequently been invoked to justify the use of Cobb-Douglas functional forms. The historical basis of this assumption is that the United States (US) data revealed constant factor shares over a long time. Now, it has become theoretical and a policy concern. The wisdom that factors' shares remain constant over a period is challenged.

The assumption of the existence of the aggregate production function of the Cobb-Douglas type has a far-reaching implication for the evolution of economic theory of income distribution. Constant factor share has been accepted comfortably in empirical researches. However, the existence of such an aggregate production function has been persistently challenged (McCombie, 1987; Felipe, 1998; Felipe and Holz, 2001 and Temple, 2006).

Particularly, in Temple (2006), it is documented that because aggregate production functions do not exist except in unlikely special cases, any economic theory that makes use of them is of no scientific value. Any researcher willing to place a false premise at the heart of his analysis can draw no useful conclusions (Temple, 2006: 303).

In fact data shows a declining share of factors. For example, Jacobson and Occhino (2012) observe that labor income has been declining as a share of total income earned in the United States for the past three decades while Francese and Granados (2015) observe that the labor's share of income in a group of seven countries has been declining since the 1970s while inequality has been on the rise. On average, the wage share declined by 12 per cent whereas income inequality increased by 25 per cent in some advanced economies in barely three decades.

The analysis of factor income shares was the subject of 90 per cent of the papers presented at a conference of the International Economic Association in 1965

(Marchal and Ducros, 1968; Glyn, 2009). The dominant theme was that factor shares were important for the macroeconomic performance of economies because they are linked to the potential profit squeeze problem, that is, real wages growing faster than productivity (Glyn and Sutcliffe, 1972; Eichengreen, 2007).

Therefore, now it is apparent that the issue of functional income distribution has come on to the policy arena. For example, in 2006 Ben Bernanke, the Chairman of the Federal Reserve, expressed the hope that corporations would use some of the profit margins to meet demands from workers for higher wages, and in 2007 Germany's finance minister asked European companies to give a fairer share of their soaring profits. Interest in these contrasting trends has deepened since the onset of the financial crisis, driven in part by the rescue of financial institutions by many governments together with rising unemployment and inequalities (Francese and Granados, 2015).

A good number of the theories of personal income distribution emphasize human characteristics. However, Walker (2007) points out that economic theory recognizes that income distribution is affected by more than just human characteristics. He further points out that the size distribution of income and hence the degree of inequality of incomes arises out of a functional distribution of income paid to different types of factors of production in the form of wages and salaries, rents and royalties and interest and profits.

Interest in an analysis of factor shares returned in the early 2000s. Atkinson (2009) cites three reasons for this growing attention: first, the analysis of factor shares is useful for understanding the link between incomes at the macroeconomic level (national accounts) and incomes at the individual or household levels; second, factor shares can potentially help explain inequalities in personal incomes (at least partly, if certain types of income are mainly received by some type of economic agents); and last, they address the concern of social justice with the fairness of different sources of income.

The root of the theory of functional income distribution is the classical economics one which focused on the distribution of income between the main factors of production. What Ricardo had in mind when he made his remark about the principal problem being how these main factors were to be defined was of course a matter of judgment, but classical economists saw them as being labor, capital and land, whose incomes were wages, profits and rent respectively.

The fact that this definition of the three main categories of income should have met with such general acceptance among economists must be seen as a reflection of the fact that this particular functional distribution represented the main class division of society in the late 18^{th} and early 19^{th} centuries into workers, capitalists and landowners.

In contrast to the neo-classical theory that was developed a century later, the theory of functional distribution did not build on a unified theoretical structure. It is therefore natural to present the theory in three parts, corresponding to the three main categories of income.

Wages: In the great work of Adam Smith, the division of labor is the driving force for increasing productivity (this is well known by the pin factory model, Book one of the Wealth of Nations: 1776). Economists predict this increase in productivity to a corresponding increase in labor incomes. However, Smith was aware of the shortcoming of his conclusion as he pointed out that the division of labor was limited by the extent of the market (p. 35). Therefore, even if specialization may by itself be expected to lead to higher productivity and wages, the demand side of the market limits the extent of specialization.

In classical economic theory, wage is determined by the market clearing equilibrium condition. Under this framework, if there is an increase in the supply of capital or land, the labor demand curve shifts to the right. In the short-run, labor supply is approximately inelastic, so that wages rise. But the rise in wages calls forth increased supply through an expanding population. The labor force accordingly increases until a new long-run equilibrium is reached where wages

have come back to the level of subsistence, sometimes referred to as the natural price of labor.

According to Ricardo (1821), it is when the market price of labor exceeds its natural price, that the condition of a laborer is flourishing and happy, that he has it in his power to command a greater proportion of the necessaries and enjoyments of life, and therefore to rear a healthy and numerous family. When, however, by the encouragement which high wages give to an increase in population, the number of laborers is increased, wages again fall to their natural price, and from a reaction sometimes fall below it.

Profits: In the classical school, profits are regarded as the rate of return on capital, defined as the rate of interest plus a risk premium that varies with the nature of the capital. Actually, Ricardo gave a more general version of this definition when he stated that a capitalist would take into consideration all the advantages that one type of investment possessed over another.

He may therefore be willing to forego a part of his money profit in consideration of the security, cleanliness, ease or any other real or fancied advantage which one employment may possess over another.

This is very similar to Adam Smith's theory of compensating wage differentials implying a symmetric treatment of equilibrium in the market for labor and capital. But this broad concept of the rate of return does not in fact play much role in the work of Ricardo or of any other classical economist.

According to classical theory, therefore, profit must be seen as the reward per unit of capital that accrues to an individual capitalist. But for a complete theory of the distribution of income from capital, one would also need a theory of the individual distribution of the ownership of capital because the income from capital accruing to an individual capitalist will be equal to the rate of return times the amount of capital owned. The determination of the ownership structure was an issue that did not receive much attention from classical economists, and

therefore their theory of the distribution of income within the capitalist class must be considered to be incomplete. This was an issue that did not seem to be of much concern to them. The question that formed part of Ricardo's principal problem was the determination of capital's share of national income, not the sub-division of this share among individual capitalists.

Rent: In the classical school, rent was the income of landowners, defined as the rental rate per unit of land times the number of units in the possession of an individual landowner. The most influential statement of the theory of rent was contained in Ricardo's Principles (1821). Land varies in terms of its quality or productivity. The price of corn (Ricardo's term for agricultural produce more generally) is determined by the cost of the labor and capital required to produce a unit of corn on the land with the lowest quality, that is, the land on the margin of cultivation. On this land rent is zero.

What is likely to happen to the functional distribution of income in a growing economy? Ricardo's view is best explained by starting from his theory of rent. Beginning with a time when wages are above the level of subsistence, the population will expand, the demand for corn will increase and the margin of cultivation will be extended. The share of rent in national income will accordingly go up, and so will the share of labor, even after the wage rate has returned to its level of subsistence. The implication of this is that profits will fall and eventually, because of a weakening of the incentive to invest, bring the process of expansion to a halt.

In summary, it is evident that tremendous strides have been made in income distribution theory over the last two decades. These advances have opened up entire new areas for further research, inductive and deductive alike. While they have increased awareness among many economists of the inadequacy of economics as it stands today, we are far better off than we were before. We have more tools with which to work, more accurate knowledge of economic processes

and adjustments in distribution as in other fields and new pointers that may help us in the tremendous tasks that lie ahead.

3.3. Methodology and identification strategy

Fagiolo, Moneta, and Windrum (2007) noted that models in economics as in any other scientific discipline isolate some features of an actual phenomenon in order to understand it and to predict its future status under novel conditions. These features are usually described in terms of causal relations and it is usually assumed that some causal mechanism (deterministic or stochastic) has generated the data. They called this causal mechanism the 'real-world data generating process' (rwDGP). A model approximates portions of the rwDGPby means of a 'model data generating process' (mDGP). The extent to which mDGP is a good representation of rwDGP is evaluated by comparing the simulated outputs of mDGP with real-world observations of rwDGP. This procedure is called empirical validation (Fagiolo, Moneta, and Windrum, 2007; Delli Gatti**,** Desiderio**,** Gaffeo**,** Cirillo**,** and Gallegati**,** 2011).

As Leigh Tesfatsion points out in her important website on agent-based computational economics,[17] the validation of ACE models is becoming one of the major points in the agenda of those researchers who work according to the agent-based approach. In literature, looking at the main methodological aspects, there are three different ways of validating computational models.

Tesfatsion (2006), Fagiolo et al. (2007), Bianchi, Cirillo, Gallegati, and Vagliasindi (2007) and Delli Gatti et al. (2011) have provided insightful discussions on the validation of agent-based models. Particularly, Bianchi et al. (2008) note that validation as an intermediate step is necessary for improving the model in order to make predictions and they outline three different ways of validating computational models:

[17]http://www.econ.iastate.edu/tesfatsi/empvalid.htm.

1. Descriptive output validation: Matching computationally generated output against already available actual data. This kind of validation procedure is probably the most intuitive one, and it represents a fundamental step towards a good model's calibration;
2. Predictive output validation: Matching computationally generated data against yet-to-be-acquired system data. Obviously, the main problem concerning this procedure is essentially due to the delay between the simulation results and the final comparison with actual data. This may cause some difficulties when trying to study long time phenomena. In any case, since prediction should be the real aim of every model, predictive output validation must be considered an essential tool for an exhaustive analysis of a model meant to reproduce reality (Bianchi et al., 2008); and
3. Input validation: Ensuring that the fundamental structural, behavioral and institutional conditions incorporated in the model reproduce the main aspects of the actual system. Bianchi et al., (2008) label such validation as *ex-ante* validation; the essence of input validation is that the researcher, in fact, tries to introduce the correct parameters in the model before running it. The information about parameters can be obtained by analyzing actual data. Input validation is obviously a necessary step that one has to take before calibrating the model (Bianchi et al., 2008).

Following the formalization proposed by Mark (2007), we let R to be the observed real world data and M is the model output, five general cases of goodness of fit are possible:

1. No intersection between R and M, $R \cap M = \emptyset$: the model is useless;
2. The intersection $R \cap M$is not null: the model can display some real world phenomenon but not others, and can exhibit behaviors that do not historically occur: the model is said to be useful;

3. M is a sub-set of R, $M \subset R$: the model is accurate, but incomplete;
4. R is a sub-set of M, $R \subset M$: the model is complete, but inaccurate (or redundant, since the model might tell something about what could yet happen in the world);
5. M is equivalent R, $M \Leftrightarrow R$: the model is complete and accurate.

All in all, the model is said to be useful if it can exhibit at least some of the observed historical behaviors; to be accurate if it exhibits only behaviors that are compatible with those observed historically; and to be complete if it exhibits all the historically observed behaviors (a good explanation is available in Fagiolo et al., 2007).

Another approach in the validation of artificial simulation results is provided by Schram (2005) where he points out that the artificiality of a laboratory simulation is placed in the context of the tension between external and internal validity. Schram notes that most economists consider internal validity to be most important. A proper evaluation of the 'artificiality criticism' (a lack of external validity) requires distinguishing the various goals that experimentalists pursue. External validity is relatively more important for experiments searching for empirical regularities than for theory-testing experiments. As experimental results are being used more often in the development of new theories, a methodological discussion of their external validity is becoming more important (Schram, 2005). External validation is similar to the descriptive output validation technique.

The internal validity of an experiment refers to the ability to draw confident causal conclusions from the research. An internally valid design will yield results that are robust and replicable. External validity refers to the possibility of generalizing the conclusions to situations that prompted the research. There is an obvious tension between the two. Where internal validity often requires abstraction and simplification to make the research more tractable, these

concessions are made at the cost of decreasing external validity (Loewenstein, 1999).

Having defined the relationship between the model and the real world system being modeled, what remains to be explained is the way in which a validation procedure can be operationally conducted. Looking at the main methodological aspects developed in this still young but rapidly increasing literature, one can stumble at different taxonomies that classify alternative empirical validation procedures according to different paradigms (Fagiolo et al., 2007).The most common approach in such an exercise is to first validate and calibrate a model.

The relationship between validation and calibration is that validation represents a set of techniques meant to verify if the model is able to reproduce the actual phenomena for which it has been designed within a satisfactory range of accuracy. Calibration represents the ensemble of statistical techniques aimed at improving the precision of the parameters' values used in simulations, according to a backward process that flows from the model's predictions and actual data towards the model's parameters (Fox, 1989). From this point of view, calibration should be seen as an ameliorative development that logically follows validation: first one tests the goodness of fit of the simulation model with respect to actual data by means of a broad constellation of parameters. Then, if the model is deemed satisfactory, one tries to improve its fitting by intervening on the precision of parameters (Delli Gatti et al., 2011: 43).

As mentioned earlier, the objective of this chapter is to validate the model described in the preceding chapter where the results indicated that there is an association between access to bank loans and functional income distribution; more specifically we found that any factor that hinders access to bank loans has a potential negative effect on income distribution. This chapter seeks the counterpart for this claim from firm level data. It aims to examine if the firm level data shows any relation between firm's access to bank loans and functional

income distribution and more specifically if firms' access to bank loans affects the share of the total value of output going to labor and capital.

A descriptive output validation method is similar to the external validation method. On this ground and owing to its clarity and ease of interpretation, this chapter analyzes descriptive output validation and econometric validation techniques.

In recent years, we have witnessed increased interaction between agent-based computational economics (ACE) and econometrics. Thus we exploit this new trend of interaction between agent-based models and econometrics. While the link can be bi-directional, most of the work developed so far follows the direction from econometrics to ACE and has gradually consolidated ACE by shaping its econometric foundation (Chen, Chang and Du, 2012). However, what is perhaps equally important and interesting is the reverse direction, that is, the potential influence of ACE on econometrics. One issue that has long concerned econometricians is the problem of aggregation over individuals, in particular when these individuals are heterogeneous and their composition is dynamically changing (Stoker, 1993; Gallegati et al., 2007). ACE, as a micro-macro model, serves as an ideal approach for studying this problem.

Intuitively, ACE can help econometrics in a micro-macro approach. This micro-macro approach has been reviewed by Stoker (1993) as an approach to address the aggregation problem. The ACE model, as a computational model, provides us with a greater flexibility to deal with various levels of aggregation over individuals. Unlike many other micro-macro models, it does not have to make very stringent assumptions regarding individual behavior in order to have a tractable aggregation. This advantage enables us to include more realistic behavioral aspects of individuals into the aggregation, such as learning and interactions. By using an agent-based consumption asset-pricing model (Chen, Huang and Wang, 2008), demonstrate how the ACE model can help solve the

aggregation problem. As far as predictive validation is concerned, we hope to develop it or leave it as a potential area of research for the future.

3.3.1Description of the data

This study uses firm-level data from the CSA database for 1996–2009. CSA collects data of Ethiopian medium and large scale manufacturing firms. There are several different sections out of which we obtained firms satisfying the data needed for this study.CSA conducts annual surveys. However, the published data availability is limited up to the year 2009.

As of 2009, there were 39 industrial groups with a total of 1,943 firms. Each survey has different important sections from which a researcher can extract information relevant to her/him. There are cases where we find that a firm with a unique identification number has two or more establishments under it. Since most of the decisions are made at the firm level, we took the data aggregated at the firm level.

Following the 1992 economic reform, the banking sector started expanding gradually both in the number of newly entering banks and the quantity of loans advanced to different sectors. As a result the manufacturing sector started receiving bank loans which have been increasing over the period. The number of large and medium scale manufacturing firms varied from 447 in 1996 to 1,947 in 2009 and 2,170 in 2011. While only 67 out of 611 firms had access to bank loans in 1996, only 257out of 1,947 firms had access to bank loans in 2009.

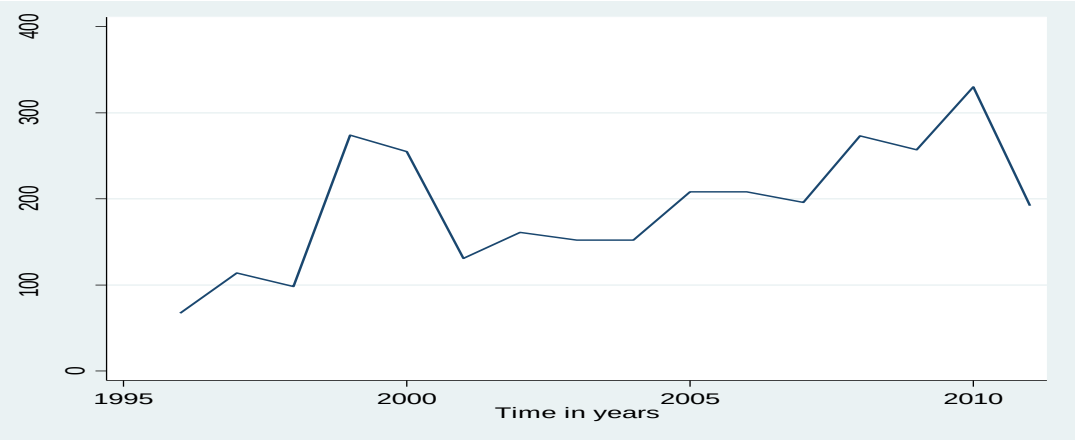


Figure 3. 1. Number of firms with access to bank loans

From Figure 3.1, there is a clear indication that the number of firms with access to bank loans increased during the period for which firm level data is available. However, looking at the trend alone may not enable us to arrive at any conclusion. What is more relevant for us is the portion of the bank loans that is directly related to investments in capital goods which affect productivity, employment creation and profitability of firms which in turn has a direct impact on functional income distribution.

To identify the channel through which bank loans affect functional and hence personal income distribution, we observe the data on the number firms, number of firms with access to bank loans (FWBL), investments in fixed capital from bank loans (INOFCFBL), investments in working capital from bank loans (INOWCFBL), investments in fixed capital from own funds (INFCFOF) and investments in working capital from own funds (INOWCFOF) and the data on national income distribution.

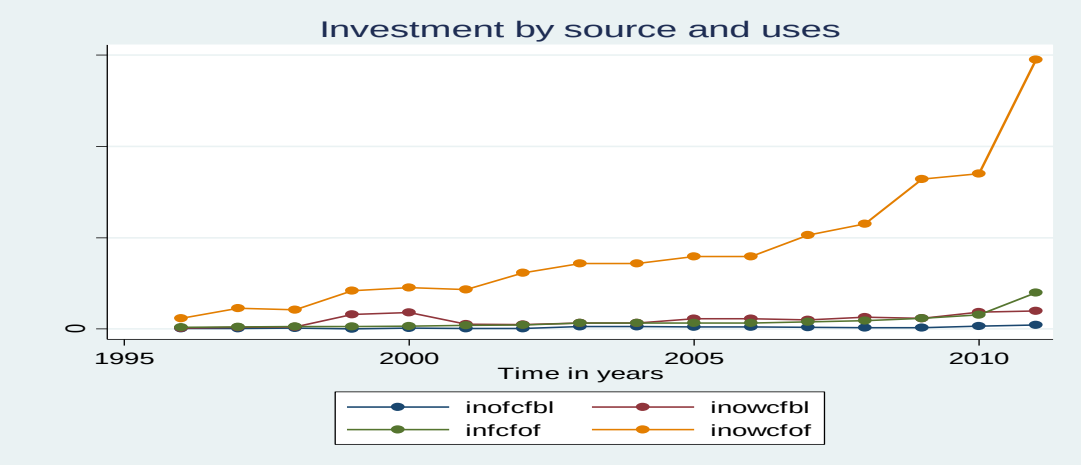


Figure 3. 2. Investment by source and type

Figure 3.2 shows the sources and uses of funds by those firms which have access to bank loans. It is an increasing trend with INOWCFOF being the largest (140), INOWCFBL (15.8), INFCFOF (13) followed by INOFCFBL (2.57),[18] as the smallest.

There is also a geographical dimension of firms' access to bank loans. For example, firms with access to bank loans are concentrated in Addis Ababa. In 1996 and 2004 respectively 65 and 54 per cent of the firms which had access to banks were located in Addis Ababa. An analysis of the extent to which this information helps us in identifying the mechanisms that link bank loans to functional income distribution is discussed in the following section.

3.3.2 Descriptive output validation

The descriptive output validation technique compares the conclusions drawn from the simulated data with the one that is extracted from real data. This step is important in that it helps a researcher understand if the information extracted from the real data generating process is consistent with the one obtained from the

[18]The figures in brackets are in billion Birr invested during 1996-2009 by all firms with access to bank loans.

model data generating process. This technique relies on graphical and statistical explorations, including whether the conclusions drawn from the simulated output can be interpreted in terms of real data.

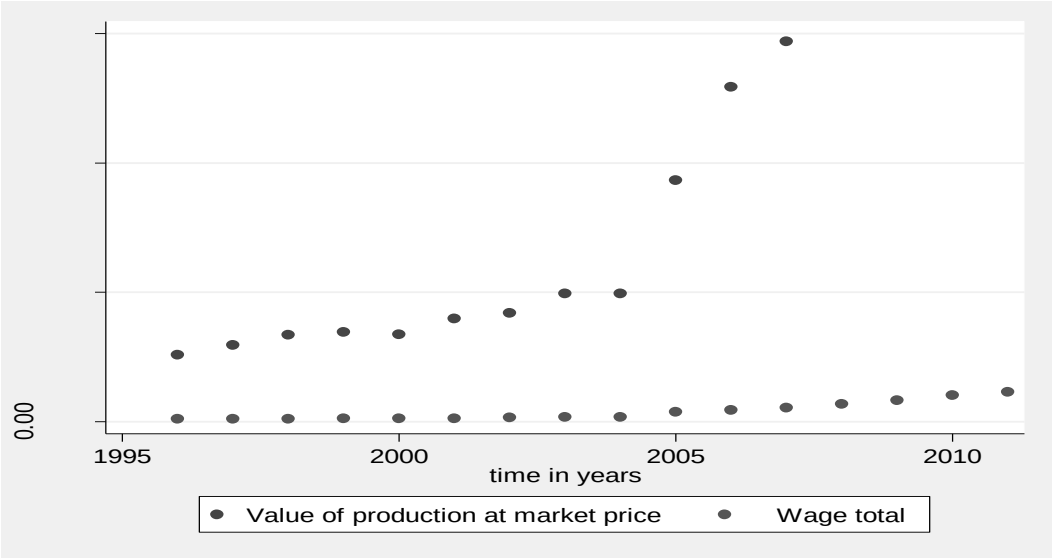


Figure 3. 3. Market value of production and total wages measured in Birr

Figure 3.3 characterizes the extent to which the market value of the manufacturing output and total wage payments grew over time. While there is no distinct economic reason to argue that both values should be closer to each other with a smaller distance, it is possible to question the extent to which they are apart.

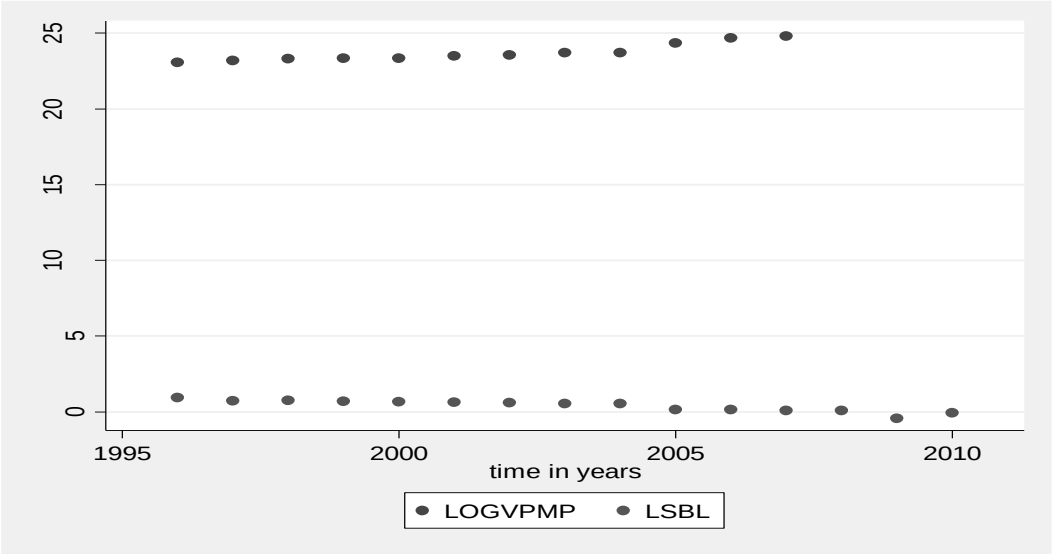


Figure 3. 4. Log of value of production and labor share

In Figure 3.4 the logarithmic transformed value of production and the fraction of it received by labor in the form of wage payments (labor share) tend to move in opposite directions. Even after taking the log of the total output, we observe non-linearity in the relationship between log of total value added and labor's share. This suggests that there should be a clear non-linear relationship between the level value of the total output and labor share. The gap between the total value added and the fraction of it going to labor is widening in an exponential manner. Such a large difference between the value of production and the fraction of it received by labor should be reflected in personal income distribution at the national level.

2005 left traces of significant socioeconomic events in Ethiopian history. Following the 2005 national elections, the government started aggressive reforms for economic expansion without noticing their implications on distributional issues. The government started realizing the distributional issues in recent years where it clearly articulated this in the second Growth and Transformation Plan.

Next, labor share is computed and averaged across firms for each year for firms with access to bank loans. The national income distribution data is obtained from the Ministry of Finance and Economic Development. We superimposed the labor share of firms without access to bank loans, the labor share of firms with access to bank loans and the national Gini coefficient data on the same plot (Figure 3.5).

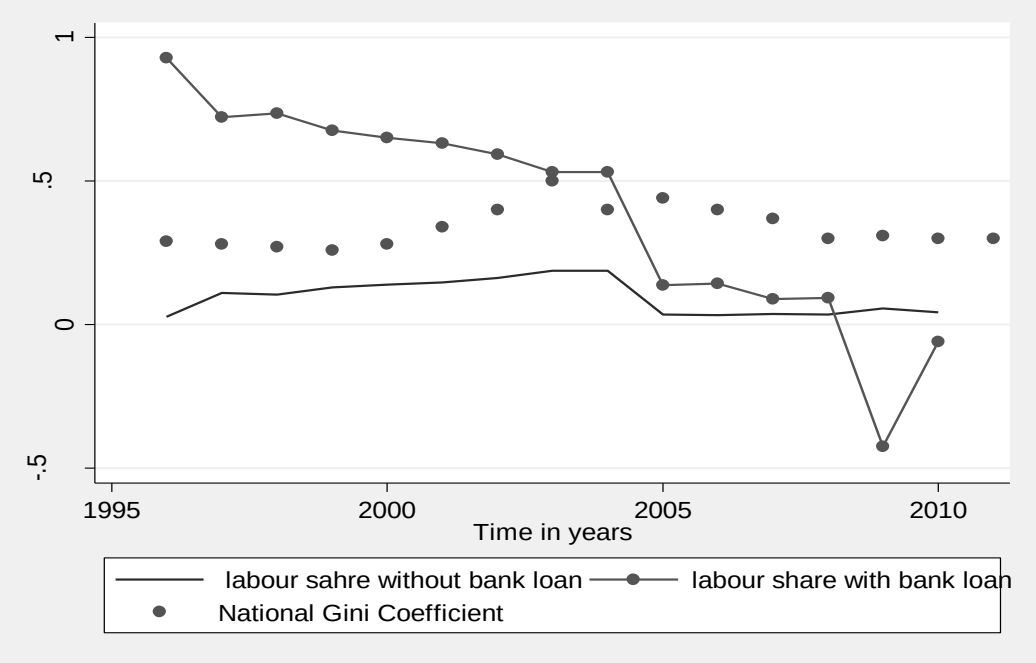


Figure 3. 5. Functional income distribution and personal income distribution

It is informative from the superimposed plots in Figure 3.5 that in the early years, the labor's share was higher which started declining later. This can be explained on the ground that the early years were a transition period from state planning to free market where the publically owned manufacturing firms were under the process of privatization. Under public ownership, the focus was not profits; rather it was on supplying goods to society. So during those years while labor enjoyed a relatively higher share, the enterprises were relatively at a disadvantaged economic position, even to the extent of facing bankruptcy. More

interesting is that under all conditions, labor's share when firms had access to bank loans was greater than without access to bank loans.

However, the decline in labor's share during the latter periods could be attributed to private ownership of firms and the motive to receive a lion's share of the output which is the nature of modern capitalist production systems; this is also the basis of contemporary debates on conflicts arising from income inequalities.

We can also observe an association between functional and personal income distributions in Figure 3.5. Initially, when labor's share was relatively higher, personal income distribution (the Gini measure) was low. However, gradually as labor's share deteriorated, personal income distribution also deteriorated (the Gini coefficient rises). This is in line with the theoretical argument that functional income distribution drives personal income distribution. There could be many economic and institutional factors responsible for the evolution of this phenomenon. Our next task is to investigate if firms' access to bank loans is one such factor.

Table 3.1.Correlation matrix: Labor share of value added and sources and uses of finance

	LSHBL	LGINOWCFOF	LGINFCFOF	LGINOWCFBL	LGINOFCFBL
LSHBL	1				
LGINOWCFOF	-0.8885*	1			
LGINFCFOF	0.9008*	0.9566*	1		
LGINOWCFBL	-0.6366*	0.8137*	0.6790*	1	
LGINOFCFBL	0.5363*	0.5776*	0.6859*	0.2133	1

Source: Own computation,* indicates significance at 5 per cent.

The size and sign of the correlation coefficients between functional income distribution (REALSH), sources and uses of funds by firms provide us important information on the association between bank loans and functional income distribution (see Table 3.1). Functional income distribution is positively correlated to investment in fixed capital from own funds (LGINFCFOF*)* and

investment in fixed capital from bank loans (LGINOFCFBL). But the functional income distribution is negatively correlated to investments in working capital from own funds (LGINOWCFOF*)* and investment in working capital from bank loans *(*LGINOWCFB*).* The correlation coefficients are significant at the 5 per cent level. Using Figure 3.5 and Table 3.1 enables us to draw the following findings:

First, access to bank loans affects firms' performance in general and functional income distribution in particular. When firms have access to bank loans, there is improvement in the share of output received by the labor.

Second, not only access to bank loans but also firms' performances are affected by their financial structures. More specifically when both bank loans and/or internal funds are used for investments in fixed capital, we observe improvements in functional income distribution. However, when bank loans and/or internal funds are used for working capital, we observe deterioration in functional income distribution. We may explain this phenomenon from the point of view of the firms' capacities for expansion and /or operations at full capacity. When firms invest in fixed assets, they expand their operations which enable them to employ more labor which increases labor's share. However, when firms invest in working capital, it is an indication of operations below full capacity. Operations below full capacity may be due to constraints such as shortage of raw materials, problems related to demand for their produce and poor market infrastructure. Under such circumstances firms are forced to reduce expenditures say by laying-off temporary workers (in Ethiopia firms cannot lay-off permanent workers by law) and prohibiting overtime work. Such decisions by firms must reduce the labor's share.

Third, since there is a very close association between functional and personal income distribution, we conclude that both access to bank loans and firms' financial structures affect personal income distribution (using Figure 3.2 and Table 3.1). More importantly, under the condition where firms have access to bank loans and when bank loans and internal funds are employed for financing

investment projects, by first improving functional income distribution this also improves personal income distribution.

The conclusion that if firms' access to bank loans and firms' financial structures are correlated to functional income distribution and functional income distribution is correlated to personal income distribution, then firms' access to bank loans and firms' financial structures are correlated to personal income distribution may seem at first a conclusion drawn by transitivity property. However, we know that this correlation is not transitive. To investigate if our conclusion can be supported by more convincing evidence, we resort to first, theoretical intuition and second, from real data.

The assertion that firms' access to bank loans improves functional income distribution in favor of labor requires meaningful interpretation and explanation. One intuitive explanation is that if firms' access to bank loans enables them to operate at full capacity, the probability that they will be profitable is high so that they have financial capacity to increase the wages and salaries of their employees. The relatively increased incomes enable workers to have relatively better access to public and private services like education for their children, access to improved healthcare, access to modern communication networks and facilities whose cumulative effect is to foster the income of the working population which in turn creates better opportunities for them. This will further improve personal income distribution at the national level.

In sequel, we explore information from the CSA dataset to see if access to bank loans is a binding constraint or at least one of the binding constraints. CSA data tells us that about 61.3 per cent of the firms reported that they had attempted to get bank loans and had not been successful. Where evidence exists, their direct association or their link to the mechanisms deriving functional income distribution is examined. This is achieved by investigating the yearly CSA survey containing questions and their respective responses relevant for our purpose. It is interesting to learn that the nature and type of questions and

responses to them show a clear pattern in problems changing over the period and this by itself may indicate some evidence. In each survey, firms are asked to respond on the major problems which they see hindering their operations. We realize that the questionnaire is changed from time to time hinting at changes in the business environment under which the firms operate because had there not been changes in the business environment, including changes in the nature of the constraints and obstacles, there would not have been changes in the nature of the survey.

From the list of responses, the ones related to bank loans are of interest to us. The general outline of the questions is: the major problems, the three major problems, the first major problem, the second major problem and the third major problem to which the firms respond according to the order of importance.

- 1996-2000: Three major problems that prevented operating at full capacity, first major problem faced by the establishment at present, second major problem faced by the establishment at present, third major problem faced by the establishment at present.
- 2001-2002: First major problem which prevented the establishment from operating for a full year. Second major problem which prevented the establishment from operating for a full year, third major problem which prevented the establishment from operating for a full year.
- 2003-2005: Reason for not solving the loan problem, first major problem faced by the establishment at present, second major problem faced by the establishment at present, third major problem faced by the establishment at present, problems faced during exports, reasons for using imported raw materials.
- 2006-2010:Three major problems that prevented operating at full capacity, reason for lack of market, factory made attempts to take loans,

reason for not solving the loan problem, reason for using imported raw materials.

According to this identification strategy, lack of a market, lack of working capital, problems of bank loans and shortages of electricity were among the top barriers for firms. The remaining barriers related to shortage of raw materials and problems related to workers. Regarding barriers related to loans, firms reported insufficient loan amounts, stringent loan requirements and long loan procedures. Thus, we confirm that firm information is in line with our previous arguments.

Table 3.2. Firms' responses to loan related constraints

Reasons for not solving the loan problem	Percent
Permitted loan was not sufficient	36.2
Unable to provide loan requirements	14.8
High interest rate	4.3
Loan duration is short	3.0
Loan procedure takes a long time	19.7
Others	22.0

Source: Own compilation from CSA data.

The information extracted from the dataset indicates that an inadequate loan size ranked as a major reason (about 36.2 per cent of the responses) (see Table 3.2 and Figure 3.6).

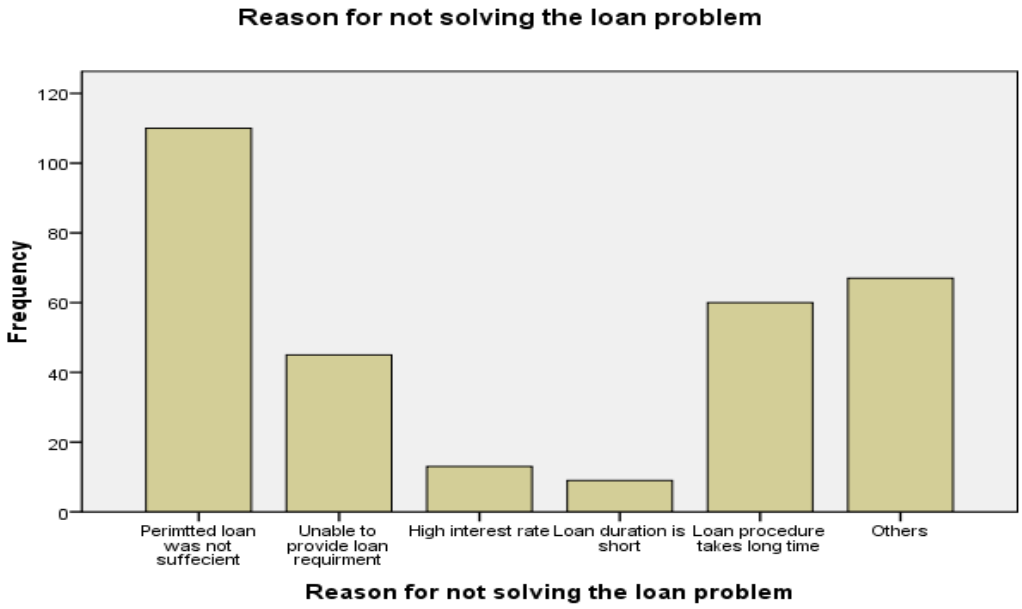


Figure 3. 6. Firms' responses on reasons for not solving the loan problem

3.3.3 Econometric validation

As explained in Section 3.3, the ACE and econometric approaches can learn from one another. Thus, in this section we examine if our findings from descriptive and graphical validation techniques are supported by the econometric method. In sequel, the key variables involved in our econometric validation technique are explained (see Table 3.3).

Heshmati (2003 and the associated literatures therein) is an excellent and extensive survey on productivity growth. It presented alternative methods for measuring productivity growth. This study has immensely benefitted from his survey in general and particularly from the section that deals with decomposition of Total Factor Productivity (TFP) growth (see Heshmati, 2003: 81), which is the welfare-theoretic basis for measuring productivity growth which reports that "The productivity growth is interesting in that it decomposes TFP growth into separate aggregate components: (i) the pure productivity effect, ignoring change

in output composition among industries, (ii) the effect of changing shares of industries over time (Baumol effect), and (iii) the effect of different productivity levels due to changing shares of employment on aggregate productivity (Denison, 1967)" (Heshmati, 2003).

This is perfectly consistent with the forthcoming chapter that deals with evolutionary economics that is based on the argument that for a constant participation rate, it can be modeled as a change in firm-level mean real output per employee weighted by the firm's employment share in the population of firms in the economy. In Holm (2014) this is referred to as the evolution of labor productivity. The subsequent section is based on this foundation, operationalzing total factor productivity in real terms that is the ratio of total firms' outputs to the number of directly engaged employees at firm level.

Wages (WAGES, dependent variable): Is the annual wage payment to workers at the firm level. It entered the regression with log transmutation. The purpose is to examine if the evolution of wages is linked to sources and uses of bank loans and the rest of the variables. The explanatory variables are now discussed.

Labor productivity, lagged (TFPQ): Is computed at the firm level in physical terms. The rationale is to see how labor incomes are linked to productivity. In Ethiopia, there is no wage indexation and in the simulated economy wages are negotiated between the owners of capital and the trade union. Again it entered the model with its log transformation.

Firm market share within industry (MARKSHARE): In our ACE model, firm's market share was taken as one factor responsible for evolution of prices. It would be interesting to see if market share can enable firms to increase production, employ more labor and subsequently to pay more wages.

Table 3.3. GMM estimation result: Dependent variable log of wages

Variable	Coefficient	Robust std.err	Z	P >[z]
LWAGES (L1)	0.135	0.040	3.38	0.001
LAGLGTFPQ	0.020	-1.41	0.158	0.158
DELTFP	-0.033	0.010	-3.23	0.001
MARKSHARE	0.212	0.133	1.59	0.111
LGINFCBL	0.424	0.053	7.90	0.000
LGINFCOF	1.073	0.1218	8.81	0.000
LGINVWCBL	0.123	0.013	9.40	0.000
_cons	7.152	0.582	12.28	0.000

Arellano-Bond dynamic panel-data estimation

Number of obs = 5,770

Group variable: eid , Number of groups = 1,401, Time variable: year

Obs per group: min = 1. Avg = 4.1184

max = 12

Number of instruments = 84

Wald $chi^2_{(7)} = 275.44$

Prob > chi^2 = 0.0000

Investments in fixed assets from bank loans (INFCBL): We have argued that if bank loans are used for investments in fixed assets that will encourage more employment and subsequently more labor income. Again, it entered with logarithmic transformation.

Investments in working capital from bank loans (INVWCBL): Investments in working capital are about operations at full capacity. If firms are unable to finance their operations from their own funds, they resort to bank loans. This should have a positive impact on more labor work hours say in terms of

prolonged work hours(through over time) or more employment. In all cases, the labor's share should improve.

Examining the econometric results indicated in Table 3.3, we tried to draw some evidence in support of our statistical and graphical validation. To start with, the evolution of the wages equation was a positive factor of the previous period's wages in an adaptive fashion. The estimated parameter entered with a positive and significant sign. We may accept this without ambiguity.

Results from Table 3.1 and Table 3.3 are consistent with regard to the sign and size of the correlation coefficient (Table 3.1) and the estimated parameter (Table 3.3). Thus, the interpretation on the effect of the use of bank loans for investments in fixed assets is direct, that is, the labor's share is affected positively both in an economic and statistical sense. Since investments in fixed assets means expanding existing operations, a firm either creates more employment opportunities or facilitates condition for the existing labor force to earn higher wages thereby improving functional income distribution. Subsequently, this has a positive effect on personal income distribution at the national level.

However, the use of bank loans for working capital did not appear consistently in both validation techniques, that is, where it affected negatively in the simple correlation a positive value was reported in the econometric results. This will remain an issue for further investigation.

Now does our ACE model fit the criteria proposed by Mark (2007)? Using the criteria described in Section 3.2, we answer this question affirmatively. We investigate each case turn by turn.

We cannot accept the first criterion because the model is not completely useless as it has something to say about the real world phenomenon that existed in real data. The second case cannot hold either because the model displays some real world phenomenon behavior that occurred historically. The fifth case cannot be accepted because the model cannot be claimed complete and accurate. This

should be valid because there is no model in economics that matches real world data on a one-to-one basis and there is no data in economics which perfectly matches economic model/models on a one-to-one basis. However, we need to discuss the third and fourth criteria. Consider the third criterion. We noted that the ACE simulation result indicated a positive association between firms' access to bank loans and functional income distribution and this result is supported by real data.

However, we also noted that there are obstacles such as electricity, marketing problems and shortage of materials other than bank loans which hinder firms from operating at full capacity. Looking at the fourth criterion, the model is not complete because it does not tell us every story in the real data. The model also says something which has already happened and hence we cannot accept the fourth criterion. Therefore, we can conclude that the third criterion can best judge our model as accurate but incomplete.

However, how can one draw a robust conclusion about personal income distribution by studying functional income distribution? The full question to be asked is: what is the justification for studying functional income distribution which is concerned with a predominantly industrial population to draw a conclusion about personal income distribution at the national level which also includes the non-industrial population, predominantly the agricultural population? One may provide two explanations for this question: first, from economic theory, and second, from the Kuznets income distribution puzzle which is based on historical evidence.

First, theoretically the drivers for variations in income distribution in the agricultural and industrial sectors are different. More specifically, the factors are more homogenous in the agricultural sector than they are in the industrial sector. Agricultural technologies, once innovated and diffused, take longer to innovate the next generation of technologies and expand the technological frontier further, that is, the technological cycle is long. During the intervening period, variability

in productivity remains constant across the agricultural population leaving less variability in income distribution. Secondly, Kuznets (1955) provided two sources of a puzzle in secular income distribution. The first source of the puzzle relates to the concentration of savings in the upper-income brackets. Kuznets argued that other conditions being equal, the cumulative effect of such an inequality in savings would be the concentration of an increasing proportion of income-yielding assets in the hands of the upper groups-- a basis for larger income shares of these groups and their descendants. The second source of the puzzle in a secular income structure which according to Kuznets lies in the industrial structure of income distribution. Kuznets discusses, first, all other conditions being equal, the increasing weight of urban population means an increasing share for the more unequal of the two component distributions. Second, the relative difference in per capita income between rural and urban populations does not necessarily drift downward in the process of economic growth; there is some evidence to suggest that it is stable at best, and tends to widen because per capita productivity in urban pursuits increases more rapidly than in agriculture. If this is so, inequality in the total income distribution should increase (Kuznets, 1955).

3.3.4 Further evidence on income distribution from firm-level data

Jacobson and Occhino (2012) state that income inequality increases when labor and capital incomes become more dispersed, or when labor's share of the income declines in favor of capital income. To measure the size of these effects, they proposed to decompose the Gini index as the weighted average of the concentration indices of labor and capital income with the weights equal to the two income shares.

The concentration index measures how concentrated labor or capital income is at the top of income distribution. The ratio pertaining to total income is a weighted average of concentration ratios of the components of income (with weight equal

to the proportion of a component of income in total income). These two decompositions of concentration ratio are of help in judging the importance of different sub-populations or of different components of income as sources of inequality in the distribution of income in a population (Rao, 1969).

The inequality index may be decomposed into different income components:

(3.1) $$GINI = \sum_{n=1}^{k}(SHARE_n \; X \; CONCI_n)$$

In Eq. 3.1, $SHARE_n$ and $CONCI_n$ stand for the share of income component n in the total income and concentration indices of income component n respectively. Here, n ranges from k = 1, 2. We expand Eq. 1 as:

(3.2) $$GINI = (SHARE_{LI} \; X \; CONCI_{LI}) + (SHARE_{CAI} \; X \; CONCI_{CAI})$$

The first and the second terms on the right hand side of Eq. 3.2 stand for the components of the Gini coefficient from labor and capital incomes respectively. Finally, the Gini index for the whole industrial population is computed under both scenarios, that is, when firms have access to bank loans and when they do not have access to bank loans. This will enable us to understand how functional income distribution is linked to and can influence personal income distribution and the role of bank loans in this process.

Table 3.4 indicates the shares of incomes from labor and capital and their respective concentration indices. It is constructed by computing yearly shares of labor and capital incomes and concentration indices of each income complement from 1996 to 2008.

In Table 3.4, SHAREL and SHARECA are shares of labor and that of capital incomes in total incomes respectively. CONIL and CONCI are concentration indices of labor and capital incomes respectively. WBL and WOBL stand for firms with and without access to bank loans respectively. The following paragraphs summarize some important results on how income inequality evolved over the study period.

Table 3.4. Decomposition of Gini coefficient by income source and factors shares using the Rao (1969) approach.

Year	SHAREL		SHARECA		GINI	
	WBL	WOBL	WBL	WOBL	WBL	WOBL
1996	0.929	0.0281	0.070	0.971	0.539	0.771
1997	0.723	0.110	0.276	0.889	0.544	0.798
1998	0.736	0.105	0.263	0.894	0.528	0.795
1999	0.675	0.129	0.324	0.870	0.554	0.747
2000	0.650	0.139	0.349	0.860	0.549	0.767
2001	0.632	0.147	0.367	0.852	0.537	0.811
2002	0.592	0.163	0.407	0.836	0.591	0.738
2003	0.531	0.187	0.468	0.812	0.636	0.745
2004	0.531	0.187	0.468	0.812	0.636	0.745
2005	0.137	0.034	0.862	0.965	0.600	0.808
2006	0.144	0.034	0.855	0.965	0.633	0.793
2007	0.088	0.036	0.911	0.963	0.740	0.895
2008	0.093	0.036	0.906	0.963	0.691	0.774

First, as indicated in column 2 of Table 3.4, the share of labor was higher in the earlier years. However, it started declining with time. This may be owing to the fact that Ethiopia was a centrally planned economy before 1991, the year when the incumbent military government was replaced by the current government. Even if society was poorer than it is now, income disparities were also less. Further, the previous economic environment was characterized by the existence of trade unions which were relatively stronger than the firms' managements. This was due to the fact that there was a very strong connection between the leaders of the trade unions and the government's ideology, which enabled trade unions to be very influential when it came to negotiating for salary increments. However, as the new government started gradual liberalization which included privatizing publically owned enterprises, the trade unions under the new economic policy become weaker relative to firms' managements as compared to the previous regime. The new economic policy gave priority to expansion than to distributional concerns and this speeded up the evolution of income inequality.

Second, additional information that can be tracked from the dataset is that the labor's share is greater than the capital share when firms have access to bank loans than when they do not. This is reflected in columns 2-3 in Table 3.4 respectively. However, capital share tends to decline with access to bank loans and tends to increase without it. In all cases the concentration indices of labor are less than those of capital (see Figure 3.7).

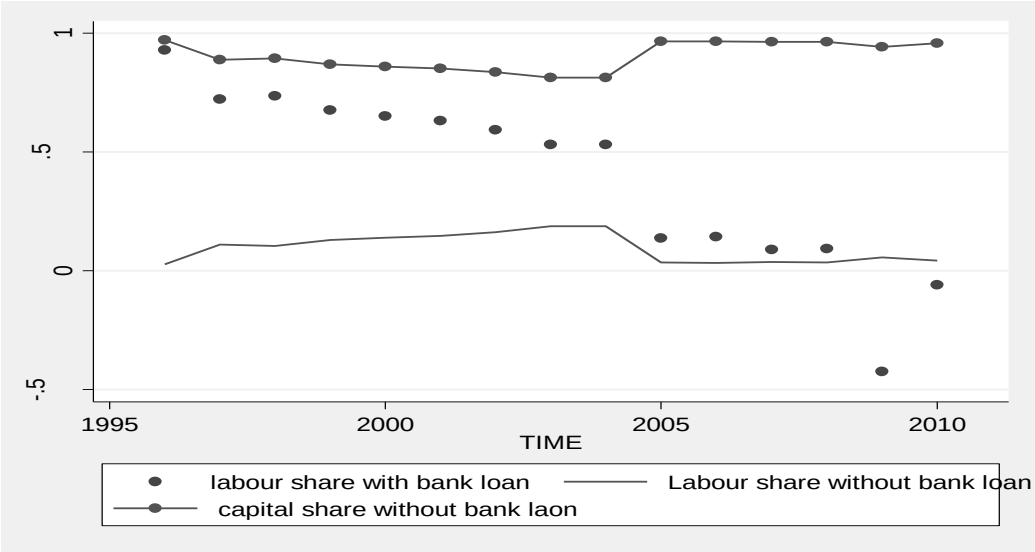


Figure 3. 7. Labor and capital shares with and without access to bank loans

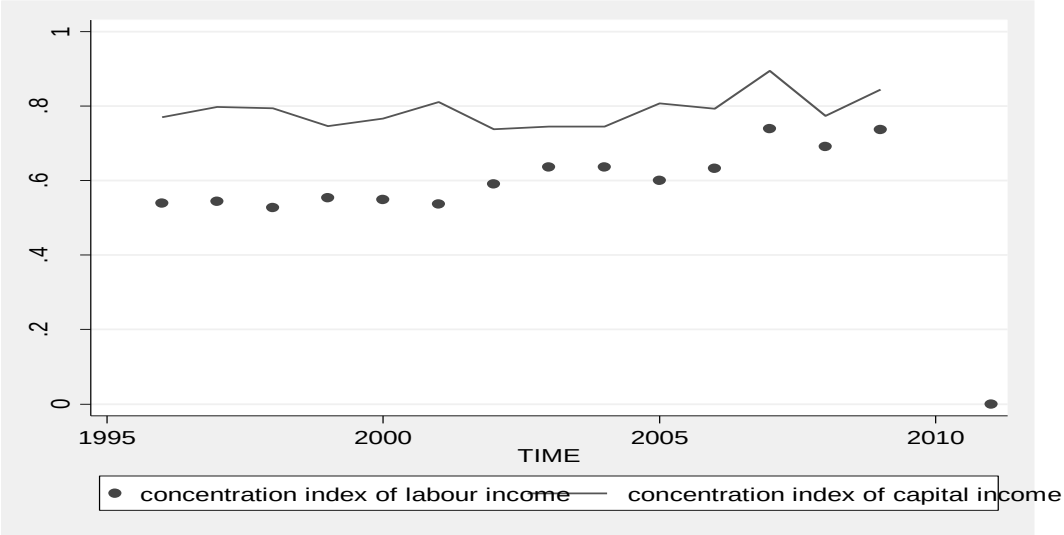


Figure 3. 8. Concentration indices of labor and capital incomes

Related to this is, the concentration index of incomes from capital are greater than those of incomes from labor. This may loosely mean that incomes from capital are more concentrated at the top of the income distribution than incomes from labor. This should be a sound observation because the wage earning groups are less likely to have income from other sources such as capital (see Figure 3.8).

Third, the personal income distribution measured by the Gini index is less when there is access to bank loans than without it, implying access to bank loans improves income distribution.

Fourth, more generally, disregarding the limited applicability of the Gini coefficient, the measure of inequality increased from 0.771 to in 1996 to 0.845 in 2008, that is, inequality increased by 10.59 per cent from 1996 to 2008.

The final observation is that Gini coefficients from the Ethiopian national MoFED dataset and the one obtained by decomposing from wage and capital incomes and their respective concentration indices follow the same pattern. However, the two Gini coefficients differ in size in that the computed one is greater than the official figure. This is indicated in Figure 3.9.

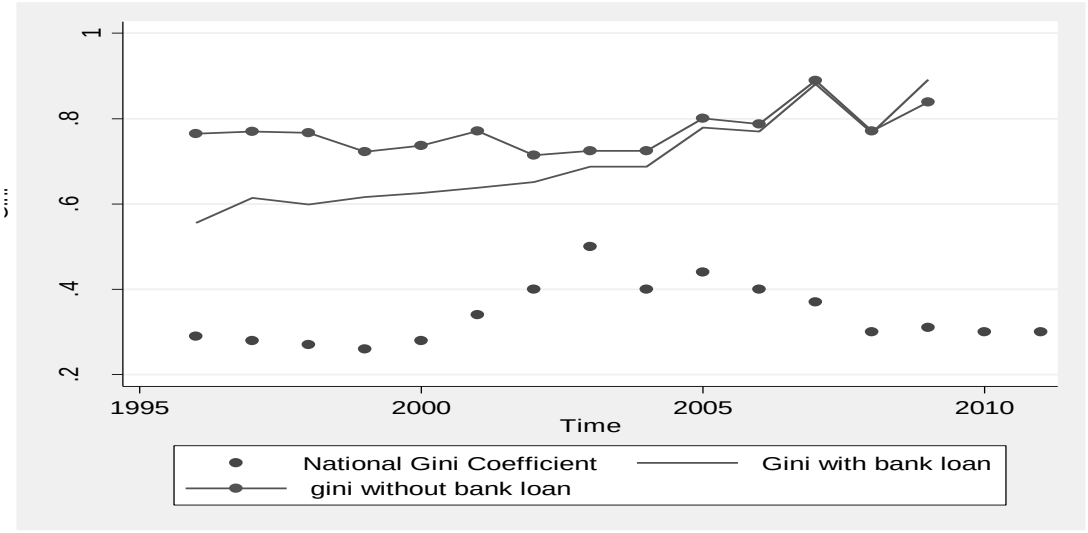


Figure 3. 9. Gini obtained from the national dataset (scattered) and computed from functional income distribution (line and connected)

From Figure 3.9 we can track an important argument that functional income distribution is strongly associated with personal income distribution. However, the one obtained from firm-level data is greater than the nationally available personal income distribution. For example, the mean of national income distribution and the one obtained by decompositions are 0.34 and 0.69 with standard deviations of 0.07 and 0.10 respectively. The correlation coefficient between the two is 0.34 implying that functional income distribution is closely associated with personal income distribution which has very strong policy content.

3.3.5 Empirical evidences from other studies

Generally, empirical literature on bank loans and income inequalities is scarce. An empirical study focusing on firm data by Ayyagari, Demirgüç-Kunt, and Maksimovic (2008) shows that indirectly affecting their growth, access to finance ranks as one of the top three barriers for growth (the other two being crime and political instability) with finance as the most robust of the three. They also note that limited finance appears to hurt smaller firms more as

compared to their larger counterparts. They report that estimates of the effects of lack of financing constraints suggest that small, medium and large firms grew slower by 10.7, 8.7 and 6.0 percent respectively in 1996-99 (Beck, Demirgüç-Kunt, and Maksimovic, 2005). This lower growth suggests that lack of access to financing increases inequality indirectly.

Delis, Iftekhar and Kazakis (2014 and the associated literatures therein) is an excellent empirical account on the relationship between bank regulation and income inequality. The authors exposed the exiting literature on finance-inequality linkages, the relationship between finance and the distribution of income which they claim to generally agree that improvements in financial markets, contracts, and intermediaries reduce income inequality because financial development affects the degree to which an individual's future income is the result of talent and good investment ideas or inherited income.

Their study links, for the first time, the full array of banking regulations with income inequality. They showed that the banking liberalization policies contribute significantly to containing income inequality. However, they also reported that the pattern is not similar across all regulatory policies, countries with different levels of economic and institutional development, and market- versus bank-based economies.

Clarke, Xu and Zou (2006) investigated panel of 91 countries between 1960 and 1995 to study the macro-level; they used private credit to GDP ratio to measure financial sector developments. They reported that there was a negative and possibly a non-linear relation between the log (Gini) and log (private credit).

More empirical evidence is provided by Claessens and Perotti (2007) who in general conclude that the number of firms that complain about lack of financing generally declines as financial development measured by private credit to GDP increases.

CHAPTER IV

INCOME DISTRIBUTION AND ECONOMIC GROWTH: EMPIRICAL EVIDENCE FROM AN EVOLUTIONARYGROWTH PERSPECTIVE

4.1. Introduction

The question of how inequality is generated and how it evolves over time has been a major concern of economics for more than a century. Yet the relationship between inequality and the process of economic development is far from being an agreed area of research. In developing economies, it is a challenge for both academic and policy circles. Thus, there is a demand for academicians to investigate this problem and it is an issue that needs to be dealt with by policymakers.

Thus, the study of income distribution should not be undertaken for the sake of study but for its wider implications on economic performance. One aspect of economic performance that is affected by it is economic growth because its growth inequality linkage is both important and controversial.

It is important because policymakers need to understand the way in which an increase in output will be shared among different groups within an economy and the constraints that this sharing may put on future growth. Its controversial aspects arise from the fact that it has been difficult to reconcile the different theories, especially since empirical evidence has been largely inconclusive (Cecilia, 2010). For example, Barro (1990) and Persson and Tabellini (1994) argue that moderate redistribution promotes growth whereas a high degree of redistribution will have a negative impact on growth.

On the effect of inequality on growth, the conventional textbook approach is that inequality is good for incentives and therefore good for growth, even though

incentive and growth considerations might be traded off against equity goals. On the other hand development economists have long expressed counter-arguments.

For example, Todaro (1997) provides four general arguments why greater equality in developing countries may in fact be a condition for self-sustaining economic growth: (a) dissaving and/or unproductive investments by the rich, (b) lower levels of human capital held by the poor, (c) demand pattern of the poor being more biased towards local goods and (d) political rejection by the masses.

Overall, the view that inequality is necessary for accumulation and that redistribution harms growth has faced challenges from many fronts. For example, Alesina and Rodrik (1994) and Persson and Tabellini (1994), combine political economy arguments with the traditional negative incentive effect of redistribution. These authors maintain that inequality affects taxation through the political process when individuals are allowed to vote in order to choose the tax rate (or, equivalently, vote to elect a government whose programs include a certain redistributive policy). If inequality determines the extent of redistribution, it will then have an indirect effect on the rate of growth of the economy.

In their paper 'Social Conflict, Growth and Income Distribution', Benhabib and Rustichini (1996) explore the effect of social conflict arising due to income distribution on both short-run and long-run economic growth rates. According to them, despite the predictions of the neo-classical theory of economic growth, poor countries were observed to invest at lower rates and have not grown faster than rich countries. They studied how the level of wealth and the degree of inequality affects growth and showed how lower wealth can lead to lower growth and even to stagnation when the incentives to domestic accumulation are weakened by redistributive considerations.

Perotti (1996) contends that equality has a positive impact on growth while Rehme (2006) argues that redistributing governments may have a relatively stronger interest in technological advances or high economic integration.

He observes a positive association between redistribution and growth across countries.

While we can find vast literature on income inequalities and economic growth similar to the ones mentioned earlier, they exclude the role of firms and the mechanisms behind them for the creation and evolution of the links between income distribution and economic growth. However, the existence of firms and their actions are recognized in economic theory.

Thus, our introduction of firms into such an analysis is not arbitrary. Firms play a central role as sources of growth and in the economic evolution process. This argument is theatrically consistent with one of the questions in economics (Coase, 1937). Thus, any analysis which omits the role of firms in the creation and evolution of income distribution in the growth process cannot make a complete description. More specifically, empirical evidence on how firms' financial structures can influence their productivity and thereby drive economic growth is scarce. This study tries to bridge this gap.

Two crucial questions arise for policymakers which have policy relevance. The first is whether inequality is a pre-requisite for growth. And the second concerns the effects of growth promoting policies on inequality, and in particular under which circumstances a conflict between the two objectives may emerge.

Thus, this paper takes firms as a hub for generating macroeconomic regularities. Firms generate link between sources and uses of funds, productivity, income distribution and structural transformation in the market process. We explore the dependence of macroeconomic productivity growth on firm-level productivities. We examine if functional distribution can potentially affect growth. The growth of productivity, output and employment are determined mutually and endogenously. More specifically, this chapter answers the following questions:

a) How do functional distributions affect productivity growth?

b) Does access to bank loans affect intra and inter-firm reallocation of labor?
c) Can we find evidence of structural change, that is, reallocation of labor from less productive to more productive industries?
d) Can we draw some theoretical results and what policy lessons can we draw from this?

The rest of the chapter is organized as follows. Section 4.2 is an excursion into economic growth theories. Section 4.3 deals with evolutionary economics and economic growth from an evolutionary perspective. Section 4.4 deals with econometric modeling in the presence of evolutionary change; it also presents empirical evidence and is followed by Section 5 which presents empirical results from Ethiopia. Section 4.6 gives a conclusion.

4.2. Theory of economic growth

Economic growth is a dominant area of theoretical and empirical research in economics in general and in macroeconomics in particular. For example, Nelson (1996: 7) points out that from the beginning of modern economics as a field of study, economic growth has often been the central area of inquiry, but on and off. During the early decades, Hahn and Matthews (1964) presented the most comprehensive survey on the contributions that had been made to the theory of economic growth beginning with Harrods's article in 1939. Salavadori (2003) emphasizes that an interest in the study of economic growth has experienced remarkable ups and downs in the history of economics. It was the central issue in classical political economy from Adam Smith to David Ricardo, and then in the critique by Karl Marx (Nelson, 1996; Salavadori, 2003).

The growth theory waned (Nelson, 1996), moved to the periphery during the so-called marginal revolution (Salavadori, 2003). Undoubtedly one of the reasons for this was that formal theory had developed which focused on market equilibria. The concern was with what lay behind demand and supply curves and

how these jointly determined the observed configuration of outputs, inputs and prices. The troubled economic times after World War I, in particular the great depression, also tended to pull the attention of economists towards analyzing shorter-run phenomenon such as balance of payments disequilibria, inflation and unemployment.

There was a renaissance of interest in long-run economic growth after World War II. One reason for this was that the new national product data was first available for United States, and later for other advanced industrial nations. This for the first time allowed economists to measure economic growth at the national level (Nelson, 1996).

In modern times, the starting point for any study of economic growth is the neo-classical growth model which emphasizes the role of capital accumulation. This model, first constructed by Solow (1956) and Swan (1956), shows how economic policy can raise an economy's growth rate by inducing people to save more. But the model also predicts that such an increase in growth cannot last indefinitely. In the long run, a country's growth rate will revert to the rate of technological progress, which neo-classical theory takes as being exogenous. Underlying this long-run result is the principle of diminishing marginal productivity, which puts an upper limit on how much output a person can produce simply by working with more and more capital given the state of technology. Aghion and Howitt (1992, 1998) provide a splendid presentation on this.

4.2.1The neoclassical growth theory

In the neo-classical framework, the notion of growth as increased stocks of capital goods was codified as the Solow-Swan growth model, which involves a series of equations that show the relationship between output, labor-time, capital and investment. This was the first attempt to model long-run growth analytically.

According to this theory, the role of technological changes became crucial and even more important than the accumulation of capital.

It assumes that countries use their resources efficiently and that there are diminishing returns to capital and labor. From these two premises, the neo-classical model makes three important predictions: first, increasing capital relative to labor creates economic growth, since people can be more productive given more capital. Second, poor countries with less capital per person grow faster because each investment in capital produces a higher return than in rich countries with ample capital. Third, because of diminishing returns to capital, economies eventually reach a point where any increase in capital no longer creates economic growth.

The model also notes that countries can overcome this steady state and continue growing by inventing new technology. In the long run, output per capita depends on the rate of saving, but the rate of output growth should be equal to any saving rate. In this model, the process by which countries continue growing despite diminishing returns is ‘exogenous’ and represents the creation of new technology that allows production with fewer resources. As technology improves, the steady state level of capital increases and the country invests and grows.

The strengths of the neo-classical approach for economic growth are considerable. Neo-classical theory has provided a way of thinking about the factors behind long-run economic growth in individual sectors and in the economy as a whole. The theoretical structure has called attention to historical changes in factor proportions and has focused an analysis of the relationship between those changes and factor prices. These key insights and the language and formalism associated with them have served effectively to guide and to give coherence to research that has been done by many different economists around the globe. The weakness of the theoretical structure is that it provides a grossly inadequate vehicle for analyzing technical change.

The fundamental problems with neo-classical explanations of economic growth are that: (1) despite much empirical efforts at the neo-classical production function, the model still faces problems in explaining considerable inter-plant and international differences in productivity as well as differences between developed economies. Even more striking is evidence for single industries, showing big sectoral productivity gaps between different countries (Hodgson, 1996) and (2) increasing capital creates a growing burden of depreciation. It is also noted that the economic life of capital assets has been declining. In particular, the orthodox formulation offers no possibility of reconciling analyses of growth undertaken at the level of the economy or the sector with what is known about the processes of technical changes at the microeconomic level. Hodgson (1996) has a detailed account of this and similar arguments.

4.2.2 Endogenous growth theory

In response to some of the problems in the standard neo-classical growth theory, the idea of an endogenous growth theory emerged in the works of Romer (1986, 1987, 1990, 1994), Lucas (1988) and a second generation variant pioneered by Aghion and Howitt (1992, 1998).They developed the endogenous growth theory which includes a mathematical explanation of technological advancement.

This broke from the preceding neo-classical thinking by encompassing learning by doing and knowledge spill-over effects. In these models, cumulative divergence of national output and productivity becomes more likely than convergence and thus seems to correspond more adequately to available data.

However, the amended aggregate production function is still at the conceptual foundation of the endogenous growth models, typically embodying features such as increasing marginal productivity of knowledge but diminishing returns in the productivity of knowledge (Hodgson, 1996).

Therefore, overall there are constant returns to capital and economies never reach a steady state. Growth does not slow as capital accumulates, but the rate of growth depends on the type of capital that a country invests in. Research done in this area has focused on what increases human capital (for example, education) or technological change (for example, innovation).

4.3. Economics as an evolutionary science and economic growth from an evolutionary perspective

4.3.1 Why an evolutionary approach in economics?

Evolutionary theory in economics is as old as economics itself. It was pioneered by Veblen (1898) when he asked, 'Why is economics not an evolutionary science?' and suggested that the only rational approach for economists was to assume economies to evolve. Otherwise, he argued, we can describe economy but have no effective theory of change and development. Veblen started his argument by asserting that all modern sciences are evolutionary sciences (p. 374) and Boulton (2010) reinforced Veblen's suggestion by stating that 'evolutionary economics is the only rational proposition'.

The renaissance in evolutionary economics in the past two decades has brought with it a great deal of theoretical developments and interdisciplinary import (Dopfer and Potts, 2004).

Inspired by the Veblen's theory, evolutionary economics has become one alternative approach to economic analysis involving complex economic interactions. Recent contributors include Nelson (1974), *Neoclassical vs Evolutionary Theories of Economic Growth: Critique and Prospectus*. More importantly, Richard Nelson and Sidney Winter's seminal work: *An Evolutionary Theory of Economic Change* (1982), Dopfer's *The Evolutionary Foundations of Economics* (2005) and Beinhocker's *The Origin of Wealth, Evolution, Complexity, and the Radical Remarking of Economics* (2006) are recent advancements in the theory of evolutionary economics.

The questions to be answered before using an evolutionary theoretical framework to understand how economies grow are: What is evolutionary economics? Why evolutionary economics? What are the theoretical foundations of evolutionary economics? Where do economies come from? (Beinhocker, 2006). How do the behaviors, relationships, institutions and ideas that underpin an economy form, and how do they evolve over time?

Beinhocker has argued that questions about origins play a prominent role in most sciences because as it would be difficult to imagine modern cosmology without the Big Bang, or biology without evolution, it would be hard to believe that economics could ever truly succeed as a science if it were not able to answer the question 'Where do economies come from?'

Yet the question of the origin of economies has not played a central role in traditional economics which has tended to focus on how an economy's output is allocated rather than how it got here in the first place. The process of economy formation presents us with a first-class scientific puzzle and one of the sharpest distinctions between traditional economics and what is described as Complexity Economics (Beinhocker, 2006).

But what is evolution in economic science? A relatively narrow definition of evolution is by the change in the mean characteristics of a population (Andersen, 2004). Economic growth, that is, the aggregate change in real output per person, is a consequence of increasing the productivity of the factors of production and of technological change in a very wide sense. For a constant participation rate, it can be modeled as a change in firm-level mean real output per employee weighted by the firm's employment share in the population of firms in the economy. In Holm (2014) this is referred to as the evolution of labor productivity.

The key ideas of evolutionary theory are that firms at any time are viewed as possessing various capabilities, procedures and decision rules that determine what they do given external conditions. They also engage in various 'search'

operations whereby they discover, consider and evaluate possible changes in their ways of doing things. Firms, whose decision rules are profitable, given the market environment, expand; those firms that are unprofitable contract. The market environment surrounding individual firms may be in part endogenous to the behavioral system taken as a whole; for example, product and factor prices may be influenced by the supply of output of the industry and the demand for inputs (Nelson and Winter, 1982).

According to Holm (2014), economic evolution is an open-ended process of novelty generation and the reallocation of resources. Selection is the sorting of a population of agents (firms) that is implicit to their differential growth rates. Firms perform innovations and develop knowledge in attempts to gain decisive competitive advantages over competitors, but firms are only intentionally rational agents with limited information and innovation, or more generally, learning may thus also lead to decreased productivity. Firms prosper or decline as a result of the interaction between their own learning activities, the learning activities of competitors and the external factors that set the premises for the interaction. We can find more on this in Dosi and Nelson (2010) and Metcalfe (1998). Safarzyńska and Bergh (2010) is also an excellent survey.

Holm (2014), explores how the evolution of productivity or any other characteristic in a population of firms can be described. According to him, evolution can be understood as the sum of two effects, which is referred to by different names in literature: inter-firm or reallocation or selection effect and intra-firm or learning or innovation effect. To this, the effects of entry and exit are added but as far as entry is the introduction of new knowledge by entrepreneurs and exit is the disappearance of an inferior firm, these effects are also learning and selection. As a stylized depiction of economic evolution Holm (2014) expressed evolution as the total effect of selection, learning, entry and exit.

Whereas inter-firm selection is driven by the process of competition, inter-industry selection is driven by the process of structural change, which is somewhat different. Productivity understood as physical efficiency is important in competition among firms which produce homogenous products, for example, within industries. This is less the case with heterogeneous outputs because computing physical efficiency for heterogeneous products does not make sense because as the composition of demand changes over time, not least as a consequence of economic growth in itself, relative prices change as well, and this affects inter-industry selection (Holm, 2014).

Holm has emphasized the importance of indicating the basic differences between standard growth theories and growth theories in evolutionary economics. Evolutionary economists (for example, Richard Nelson, Eric Beinhocker, Geoffrey Hodgson and John Foster) strongly argue that an evolutionary framework is more encompassing than standard approaches. Carlsson and Eliasson (2003) note that economic growth can be described at the macro-level and never explained at that level. Economic growth is basically a result of experimental project creation and selection in a dynamic market and in hierarchies, of the capacity of the economic system to capture winners and losers. Castellacci (2007) gives an excellent review on the evolution of evolutionary theories in economics which is presented in Table 4.1.

Metcalfe and Foster and Ramlogan (2006) explored an evolutionary theory of adaptive growth. They supposed economic growth as a product of structural change and economic self-transformation based on processes that are closely connected with but not reducible to the growth of knowledge.

The dominant connecting theme is enterprise, the innovative variations it generates and the multiple connections between investment, innovation, demand and structural transformation in the market process. Metcalfe and Foster explored the dependence of macroeconomic productivity growth on the diversity of technical progress functions and income elasticities of demand at the industry

level, and the resolution of this diversity into patterns of economic change through market processes. They show how industry growth rates are constrained by higher-order processes of emergence that convert an ensemble of industry growth rates into an aggregate rate of growth. The growth in productivity, output and employment is determined mutually and endogenously, and its value depends on variations in the primary causal influences in the system.

Table 4.1. Contrast between New growth theories and evolutionary growth theories

Issues	New Growth Theories	Evolutionary Theories
What is the main level of aggregation?	Aggregate models based on neo-classical micro-foundations (methodological individualism)	Towards a co-evolution between micro-levels and macro-levels of analysis ('non-reductionism')
Representative agent or heterogeneous individuals?	Representative agent and typological thinking	Heterogeneous agents and population thinking
What is the mechanism of creation of innovation?	Learning by doing and searching activity by the R&D sector; radical innovations and General Purpose Technologies	Combination of various forms of learning with radical technological and organizational innovations
What is the dynamics of the growth process? How is history conceived?	History is a uniform-speed transitional dynamics	Towards a combination of gradualist and dynamics: history is a process of qualitative change and transformation
Is the growth process deterministic or unpredictable?	'Weak uncertainty' (computable risk): stochastic but predictable process	'Strong' uncertainty: non-deterministic and unpredictable process
Towards equilibrium or never ending	Towards the steady state	Never ending and ever changing

4.3. 2 Econometric modeling in the evolutionary economic framework

Evolutionary economics in general and evolutionary econometrics in particular are not an arbitrarily choice. It is both relevant and has theoretical foundations. Its relevance is driven by the nature of that which is supposed to be integrated with the previous two papers to form an integrated dissertation. The theoretical basis for such a modeling is drawn from a self-organization approach and analyzed by the logistic diffusion growth model.

Evolutionary economics and the subsequent developments of its estimation techniques have enabled researchers to explore the advantages of evolutionary economics. This methodology is offered to construct an econometric model in the prescience of a structural change of an evolutionary type. Evolutionary economics has, in its various approaches, been concerned with economic processes that arise from systems which are subject to on-going structural changes in historical time. Foster and Wild (1999a) identified three characteristics that all evolutionary representations of economic processes seem to share:

- A system that is undergoing a cumulative process of structure building, which results in increasing organization and complexity, cannot easily reverse its structure;
- In the face of this time irreversibility, structure can change in non-linear and discontinuous ways in the face of exogenous shocks, particularly when the relevant evolutionary niche is filled; and
- An evolutionary process of on-going structural change introduces an increasing degree of fundamental uncertainty. Thus, a great deal of structure-building involves the installation of protective repair and maintenance sub-systems.

Based on these arguments, we use a logistic diffusion equation offered by Foster and Wild (1999b) as a theory of historical process. In real terms it is rooted in

the Bernoulli Differential Equation of the type shown in the Appendix. The last line in EqA1 is a Logistic Differential Equation of First Order (LDEFO). Based on the Eq A1 in Appendix 2, Foster and Wild (1999b) have developed an econometric model in the presence of evolutionary change as:

$$(4.1) \quad \frac{dX}{dt} = b\left(1 - \frac{X}{K}\right)$$

In Eq. 4.1, b is the net, that is, it allows for deterioration or deaths, firm entry-exit rate, or diffusion coefficient and K is the carrying capacity of the environment, for example, total industry or economy's market size, employment or output over which each firm will compete to capture as much of it. K is a constraint, for example, the total sales of an industry and X could be a firm's sales so that X/K is the firm's market share.

Two points must be raised about Eq.4.1. First X/K can be understood as any share. If we are to work at the macro-level, we may interpret X/K as the ratio of GDP to capital stock. This ratio is less than 1 because at any point in time the total national output is some fraction of inputs, the magnitude of the fraction depending on the productivity of the economy.

Eq.4.1 can be expanded to employ the existing econometric framework for estimation. Foster and Wild (1999b) have acknowledged that the application of the Logistic Diffusion Equation (LDE) of this type has been common in literature on the economics of innovation, following the pioneering work of Griliches (1957). However, economists have tended to view LDE in terms of disequilibrium adjustment from a stable equilibrium state to another in economics of evolutionary growth theory.

As it stands, Eq.4.1 depicts a smooth process tending towards infinite time. Only in a discrete interval version of the LDE can we generate the kinds of discontinuities that we can see in historical data. However, discrete interval dynamics are not pronounced features of most aggregated economic data. Thus, it is unlikely in most cases that we can generate a discontinuity endogenously.

Now it is convenient for the purposes of an econometric investigation to rearrange Eq.4.1 in the following way to obtain the Mansfield (1981) variant, employed in many such studies. Dividing both sides of Eq.4.1 by K and rearranging, we arrive at:

$$X_t - X_{t-1} = X_{t-1} b \left(1 - \frac{X_{t-1}}{K}\right) + u_t$$

(4.2) $InX_t - InX_{t-1} = b - bX_{t-1}/K + e_t \ \ where\ e_t = u_t/K$

The transformation into approximation in Eq.4.2 allows the logistic equation to be estimated linearly and the error term is corrected for bias because of the upward drift of the mean of the X-series.

Eq. 4.2 offers a representation of the endogenous growth of a self-organizing system, subject to time irreversibility and constrained by boundary limits. To come up with the complete econometric model, Foster and Wild qualified their argument in the following ways:

a) Regulation in the economic system can restrict economic agents and their organizations to particular market niches. This means, again, that the principle of competitive exclusion is significantly weakened. For example, governments restrict the issue of bank licenses, which preserves a niche which non-bank financial institutions have difficulty entering. Typically, competition in the economic sphere is overlaid by 'public interest' regulations that attempt to limit competition;

b) Economic sub-systems rely on an interaction with the wider economic system in order to engage in trade. Thus, the K limit for a particular system will tend to rise continually in line with the general expansion of economic activity; and

c) Increasing politicization of an economic system will lead to more predator-prey-type interactions. This will tend to occur in saturation phases of LD growth. Thus, we do not always witness smooth transitions

from one LD growth path to another but, instead, Schumpeterian 'creative destruction', dominated by conflict and discontinuous dissipation of an accumulated structure (that is, a rapid fall in *K*).

Taking into account these qualifications, the authors arrived at the following LDE which is suitable for application in economics:

$$(4.3)\ InX_t - InX_{t-1} = [b(.)]\left[1 - \left\{\frac{X_{t-1}}{K(.)} - a(.)\right\}\right] + e_t$$

Thus, b and K are now, themselves, functions of other variables. The function b(.) allows for factors that affect the diffusion coefficient, rendering it non-constant over time and K(.) takes account of factors in the greater system that expand or contract the capacity limit faced by the system in question. The resource competition term, *a*(.), is now a more general functional relationship than the simple mechanism containing, for example, relative prices and existing demand for a particular product, the general economic condition in the environment.

A potential problem with Eq. 4.3 is that, as X tends to its limit, growth in X will tend to 0 so that the impact of factors in b(.) will also tend to 0. This is unlikely to be the case, so it is more appropriate to allow exogenous variables that affect the diffusion rate, to influence the rate of growth of X with the same strength at all points on the logistic diffusion:

$$(4.4)\ InX_t - InX_{t-1} = [b(.)]\left[1 - \left\{\frac{X_{t-1}}{K(.)} - a(.)\right\}\right] + b(.) + e_t$$

As it stands, Eq.4.4 could be viewed as a disequilibrium process tending to an equilibrium defined in terms of K(.) and a(.). However, such an equilibrium interpretation differs from that in conventional usage. The non-stationary process modeled by Eq. 4.4 represents neither a mean reversion process in the presence of a deterministic trend, nor a co-integrated association between X and variables in K(.) and a(.), in the presence of a stochastic trend.

The stationary state to which the logistic trajectory tends is the limit of a cumulative, endogenous process, not a stable equilibrium outcome of an unspecified disequilibrium mechanism following an exogenous shock. The functions K(.) and a(.) allow for measurable shocks to the capacity limit and b(.) encompasses the effect of exogenous shocks which alter the diffusion rate.

One final development is necessary. Although an equilibrium correction mechanism is inappropriate in this type of a model, homeostasis will occur in the short period around what can be viewed as a moving equilibrium.

Eq. 4.4 relates to the momentum of a process and, as such, some path dependence is likely to exist in the sense that the system in question will still have a (decelerating) velocity even if all endogenous and exogenous forces impinging on the system cease to have an effect.

This is likely to be stronger the more non-stationary the variable in question is and the shorter the observation interval. Imposing a simple AR (1) process, we get:

$$(4.5)\ InX_t - InX_{t-1} = [b(.)]\left[1 - \left\{\frac{X_{t-1}}{K(.)} - a(.)\right\}\right] + b(.) + c(InX_t - InX_{t-1})_{t-1} + e_t$$

In conventional treatments of path dependence in time-series data, constructs such as the 'partial adjustment hypothesis', concerning the presumed disequilibrium movements of levels of variables, are used to rationalize the use of lagged dependent variables. Inclusion of a lagged dependent variable requires upward revision of the estimated coefficients on explanatory variables in order to obtain their 'equilibrium' values. Here, the interpretation is different, but related. Instead of viewing a lagged dependent variable as evidence of sluggishness, we view its presence in our growth specification as evidence of momentum in the process (Foster and Wild, 1999b). In Eq. 4.5 we can note that the left hand side

is equivalent to the growth rate of series X. In this paper, it could be the growth rate of productivity.

4.3.3Empiricalevidence of evolutionary econometrics

Empirical literature on evolutionary economics is scarce. However, there are some works which focus on the macro-level, for example, Foster (1992, 1994) and Hodgson (1996).

Foster (1992) looked into a new perspective on the determination of sterling M3 using econometric modeling under the presence of evolutionary change. First he obtained a logistic diffusion model from the first order differential equation. Next he modeled the evolution of M3 in log-linear specification in the form of evolutionary econometrics. He noted Ordinary Least Square (OLS) and Recursive Least Square (RLS) as favored estimation methods in such a condition. He estimated over 1963 to 1988 datasets obtained from the UK monetary authority. He concluded that it was possible to understand the determination of M3 by viewing it as money supply, rather than a money demand, magnitude which is an outcome of a historical process. Such a process has been modeled as institutionally driven and subject to evolutionary change.

In Foster (1994), we can also find an evolutionary macroeconomic approach stressing institutional behavior used for estimating a model for Australian dollar M3.The conclusion is that since Australia and UK have the same cultural and institutional heritage, evolutionary econometrics has captured a similar M3 creation process in both countries implying the appropriateness of an evolutionary approach for studies involving the diffusion process.

The most interesting out of these is Hodgson (1996) as it is the most direct theoretical and empirical research in long-term economic growth. He argues that his work is in part inspired by the work of institutional economics such as Nelson and Winter, Thorstein Veblen (who was the first to suggest the use of

economics as an evolutionary analogy taken from biology). His empirical estimation starts by placing major stress on institutional disruptions such as wars or revolutions and on the existence of political institutions such as existence of multi-party systems.

Hodgson used a regression analysis to provide some preliminary empirical validation for his ideas. He admitted that it was not a fully-fledged macroeconomic model, saying that the available data were crude and limited to provide a more ambitious and adequate test. He used real GDP per worker-hour as the index of productivity from Madison's data and summarized his findings as: First, two kinds of disruptions (disruption of extensive foreign occupation of home soil and revolution) seem to be significant in determining and eventually advancing productivity growth. Second, there is evidence that the growth trajectory is determined by the timing of industrialization. Third, a relatively stable international order is found to be significant and positively related to growth.

Another is that of Stockhammer, Onaran and Ederer (2008) who estimated the relationship between functional income distribution and aggregate demand in the Euro area. They modeled aggregate demand as: aggregate demand (AD) is the sum of consumption (C), investment (I), net exports (NX) and government expenditure (G). All variables are in real terms. In their general formulation, consumption, investment and net exports are written as a function of income(Y), the wage share (Ω) and some other control variables (summarized as z). These latter are assumed to be independent of output and distribution. Government expenditures are considered to be a function of output (because of automatic stabilizers) and exogenous variables (such as interest rates). However, as this paper focuses on the private sector, this will play no further role in our analysis. Aggregate demand thus is:

(4.6) $AD = C(Y, \Omega) + I(Y, \Omega, z_1) + NX(Y, \Omega, z_{NX}) + G(Y, z_G)$

Their basic assertion for the inclusion of income distribution into consumption, investment and net export and government expenditure terms in Eq. 4.6 is: in the consumption function wage incomes (W) and profit incomes (R) are associated with different propensities to consume. The Kaleckian assumption is that the marginal propensity to save is higher for capital incomes than for wage incomes; consumption is therefore expected to increase when the wage share rises. They argue that Keynesian as well as neo-classical investment functions depend on output (Y) and the long-term real interest rate or some other measure of the cost of capital. The latter is part of z_1. In addition to output and interest rate, they argue that investment is expected to decrease when the wage share rises because future profits may be expected to fall. Moreover it is often argued that retained earnings are a privileged source of finance and may thus influence investment expenditures.

They claim that first, the policy implication of their findings is that wage moderation in the EU is unlikely to stimulate employment. They suggest that wage moderation leads to a (moderate) contraction in output. Since an expansion in output can be regarded as a necessary (but not sufficient) condition for an expansion in employment, wage moderation (at the EU level) is not an 'employment-friendly' wage policy. Their second implication refers to wage coordination; they contend their findings suggest that demand is wage-led in the Euro area. This finding does not extend to individual Euro member states.

This paper takes the advantage of the formalization of evolutionary economics by Foster and Wild (1999) and Foster (1994, 2014).

4.4. Empirical results

4.4.1 The data and variables

The objective of this section is to examine if firms' access to bank loans has any effect on growth through[19] its effects on functional income distribution. The dataset is the medium and large manufacturing industries complied by the Central Statistical Agency of Ethiopia (CSA). The available panel data covers 1996 to 2009 with 611 and 1,943 firms in 1996 and 2009 respectively.

If access to bank loans first affects functional income distribution and if functional income distribution affects productivity growth that would imply that facilitating access to bank loans might ultimately foster growth of the economy. To achieve this objective, we first explore the real firms over the period on some key variable and econometrically estimate Eq. 4.5 using the Generalized Method of Moments (GMM). Finally alternative policy simulation scenarios are performed to understand the full effect of bank loans, income distribution and productivity growth linkage.

First, from firm-level data, the parameters of interest are computed for each firm for each year. These are:

- Employment share (EMPSHAFIRM): Is supposed to capture if there is an indication of structural change, that is, the movement of labor from less productive to more productive sectors;
- Market share (MKTSHARE): This is the available resource over which firms have to compete. It is through this competition process that decisions to invest on productivity fostering factors are undertaken;
- Output share (OUSHA): Firms can also compete over industry output; and
- Productivity growth (GROWTHPRO): Is the main variable of interest. Its growth rate is understood as the growth of mean characteristics in

[19] In evolutionary growth framework, growth is mainly understood as growth of any mean characteristics (in our case productivity growth).

evolutionary economics. Thus, growth is perceived to mean growth of productivity.

Based on these variables, this paper tries to draw some inferences about the connection between access to bank loans, functional income distribution and productivity growth.

4.4.2. Results from data exploration

The evolution of employment shares, market shares, output shares and growth of productivity are shown in Figures 4.1-4.4 respectively. The purpose of these figures is to learn if there is any indication of a structural transformation process within the manufacturing sector. If there is a change in the structure of production in the manufacturing sector, we expect the labor share to be continuously shifting within the industry. The shift should take place from low productivity to high productivity industries. This would mean higher labor productivity and consequently higher labor incomes which will form a positive feedback loop with productivity.

From Figure 4.1, we observe movements for employment share within the industries only for 11 industries. We identified these industries from the data as:

- Production, processing and preserving of meat, fruit and vegetables
- Manufacture of animal feed
- Manufacture of non-metallic NEC
- Manufacture of basic iron and steel
- Manufacture of other fabricated metal products
- Manufacture of pumps, compressors, valves and taps
- Manufacture of other general purpose machinery
- Manufacture of batteries
- Manufacture of bodies ofmotor vehicles
- Manufacture of parts and accessories

- Manufacture of furniture

From the firm level dataset, it was possible to learn that most of the firms within these industries had access to bank loans. For example, overall, the 105 firms within the production, processing and preserving of meat, fruit and vegetable industries had access to bank loans. In the manufacture of animal feed industry, out of 98 firms 37 had access to bank loans. Generally, all the indicated firms had access to bank loans during the years of observation. In Figure 1 we can observe that in these industries, there is a significant movement (fluctuation) in employment share. The only exceptions are spinning, tanning and publishing industries in which all firms had access to bank loans. However, any indication of movements in the employment share is not displayed.

One can argue that the employment share must be taking place within the same sector (industries) and not across industries. If the reallocation of labor was taking place across industries, we could have observed variations in the employment share in the rest of the industries, but this is not evidenced.

Whether these industries are high productivity sectors and hence growth and equality promoting is also another area of enquiry. But looking at the face value alone, we may tentatively conclude that in particular those industries related to metallic manufacturing are connected to the government (Figure 1 in Appendix 1).

Figure 2 displays how market shares in each industry have been evolving. We can observe that market share was almost constant over the observation period. This may tell us of a lack of strong competition among similar firms. The economic reason could be, for example, unsatisfied demand in the goods market (Figure 2 in Appendix 1).

Referring to Figure 3, firms' shares in total industry output is more pronounced than the market share. This may tell us the underlying market structure which

subsequently might have an effect on functional income distribution and productivity growth (Figure 3 in Appendix 3).

It has been discussed that firms are at the heart of an evolutionary approach to economic growth and growth of productivity at the firm level is a key to economic growth. We can see from Figure 4 that there are fluctuations in the productivity growth rate(from -20 per cent to 10 per cent). We can also note that, for example, the productivity growth for production, processing and preserving of meat, fruits and vegetables remained positive, which might be an indication of the effect of access to bank loans (Figure 4 in Appendix 1).

4.4.3 Econometric results

This section deals with the econometric estimation of the logistic differential equation in Eq. 4.5. The variables entering the model are of two nature: the evolutionary component and the exogenous component.

We estimated Eq.4.5 using firm level panel data. To achieve this, the data was transformed (logarithms, growth rates, lags and differences) so that the transformed data was consistent with the evolutionary econometric framework.

The dependent variable is change in the mean characteristics (growth of productivity). The explanatory variables are growth in labor share (GRWTHLSHARE***)***, the complement[20] of the output share (COMPVOUSHA***)***, technically one minus output share to fit the first term in Eq.4.5, complementary market share (COMPMKTSHARE), again, the same interpretation as before so that it is consistent with Eq.4.5, lagged change in labor productivity (LAGDELTFP***)*** which represents the last term of Eq.4.5 and finally, employment share of each firm (EMPSHAFIRM**)**.

[20] Here the complement of variable x is equal to (1- x) (see the first term of the right hand side in Eq. 4.5 in Section 4.

For the evolutionary approach, once the logistic differential in Eq.4.5 is formulated, it can be estimated using the standard panel data econometric techniques (random effect, fixed effect or GMM) which do not require separate treatment here. The reported results are with Wald chi-square value of 773.57 with six degree of freedom and probability value of (p> chi2) of 0.0000 (Table 4.2).

The estimated result indicates all explanatory variables entered the estimation with statically significant estimates. As expected productivity is positively affected by the growth in labor share. However, the employment share entered with a negative and statistically significant coefficient. We may interpret this as lack of labor movement from low productive to high productive industries.

Table 4.2. GMM estimation result. Dependent variable: growth of productivity.

Variable	Coeff.	Std. Error	z	P>[Z]
GRWTHLSHARE	.00052	0.0001	3.47	0.001
COMPVOUSHA	-5.626	0.409	-13.75	0.000
COMPMKTSHARE	4.251	0.456	9.32	0.000
LAGDELTFP	-0.412	0.0203	-20.20	0.000
EMPSHAFIRM	-4.068	1.556	-2.61	0.009
Cons	0.9196	0.421	2.18	0.029

CHAPTER V

SUMMARY OF THE THESIS, CONCLUSIONS, POLICY RECOMMENEDATIONS AND FUTURE RESEARCH DIRECTIONS

This chapter summarizes the main idea of the dissertation presented in the earlier chapters by giving a chapter-wise summary and conclusions of the research.

The introductory chapter discussed exiting literature on income distribution and its various implications on economic performance taking the case of productivity growth by emphasizing drivers of functional income distribution. It speculated if firms' access to bank loans was among the instigators of inequalities.

While a detailed account of relevant literature is given in respective chapters, dominant views about the role of finance in general and that of access to bank loans and functional income distribution in particular are presented in the introductory chapter. The chapter also speculated on the existence of a positive relationship between firms' access to bank loans and functional income distribution.

From the methodological point of view, the introductory chapter proposed agent based computational economics as an appropriate alternative for studying economic problems involving heterogeneously interacting economic agents. On the growth side it proposed dealing with evolutionary economics that considers firms as the center of growth of productivity. It sees economic growth as an open ended process rather than dealing with models which are a result of a model closing process from the mainstream economic framework.

These arguments of the introductory chapter pave the way for subsequent chapters which constitute the main text of the thesis. The main text is designed to take the arguments given in the introductory chapter forward. The premise of the introductory chapter is appealing from the point of view of the major findings in the chapters that follow.

The sources and distribution of functional income differ among countries by the level of their development. The second chapter questioned if firms' access to bank loans was one mechanism through which variations in functional income distribution can be explained in the developing economies. I answer this question using the modified agent-based model and taking the Ethiopian case. The simulation and its results suggest that the agent-based model is a suitable approach for analyzing functional income distribution and the proposed question is answered affirmatively.

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

First, the promising result of this study is the emergence of aggregate behavior from agents' local interactions which is consistent with Thomas Schelling's (1978: 14), '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.'

From the shapes of the graphs in Figure 2.4A-2.4D in chapter 2, one can learn that there is a well-structured emergent pattern and local regularity in this study. The notion of local regularity is supported by Massimo and Colander (2007) when 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 GINIOR in each graph (see Figure 4 in Chapter 2). However, the extended model with access to bank loans reveals two phenomena: (a) the model reflects the reality of income distribution as shown by different colors in each graph, and (b) access to bank loans improves income distribution (compare the different colors in each graph where the pattern of income distribution with access to bank loans lies below the pattern without access to bank loans). The contrast with the original authors can be explained thus: 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 expenditures from internal funds. This is possible through cost reduction measures in the form of paying low wages and by reducing salary expenditures which are components of total cost. This in turn will reduce the share of output going to labor. Once firm level data supports this finding, it will have very strong policy content; a well-functioning loan market will allow improvements in functional income distribution.

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

In sum, firms' access to loans improves income distribution by increasing the share of output going to labor in the form of wages. 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 higher productivity, pay to workers and a more equal society.

From a policy perspective these results suggest that in order 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 functional income distributional disparities.

Currently, the state owned Commercial Bank of Ethiopia controls more than 50 per cent of the total banking activity in the country. Its operations mainly focus on government projects. Private commercial banks are reluctant to finance the manufacturing sector; instead they are inclined towards service sectors such as import and export businesses which have faster returns. In a situation where the manufacturing sector is expanding (it is 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 at the same time may prevent an increase in economic disparities.

This study is limited to a small closed economy, focusing on manufacturing firms. It did not look at 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 understanding specific information on the bank-firm relationship which is not public information 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 returns to capital are useful for understanding income structures. Therefore, establishing this database is another aspect for future studies.

Chapters 3 and 4 show that it is possible to understand how income distribution is associated with firms' access to bank loans. I viewed firms' access to bank loans as one mechanism that shaped the evolution of personal income distribution through functional income distribution. Unlike most previous studies where monetary aggregates are considered for understanding the link between financial development and economic performance, the innovation in this paper is that it tries to understand the mechanism that links bank loans to income distribution using combined firm level and national data.

Chapter 3 empirically answers the question on the possibility of a positive association between firms' access to bank loans and functional income distribution, which was already answered by the agent-based computational economics (ACE) model positively. I explored the use of the external validation technique, the most commonly used methodology for validating ACE models of the type used in Chapter 2.

The major finding is that firms' access to bank loans is one mechanism that derives functional income distribution in favor of labor share. Using Central Statistical Agency and national datasets I found that access to bank loans was among the most frequently encountered constraints by firms. When firms had access to bank loans, there were two uses: investments in fixed capital and investments in working capital. Whether the source was a bank loan or own funds, if there were investments in fixed capital, the labor's share was positively associated with the source. However, when both sources were utilized for working capital the labor's share declined. The use of funds for working capital may be viewed as working under full capacity which forces firms to reduce payroll expenditures by cutting overtime work and laying-off temporary workers. These decisions have direct negative effect on functional income distribution implying the role of firms' financial structures in addressing distributional problems if the government has to use monetary policy instruments such as credit policy to create a society with distributional justice.

We can find empirical support for these findings. However, since they link monetary aggregates to GDP ratio (which is the usual measure of financial development) to income distribution, it is vague in understanding the underlying mechanisms that create the distributional phenomenon.

Doing economics is doing science. Doing science is finding patterns and scientists are always looking for patterns that they can use to structure their thinking about the world around them. Guided by our ACE model, I tried to understand how access to bank loans at the micro-level was linked to inequalities at the macro-level.

The policy implications of this study are that financial access matters. More specifically, when firms are not financially constrained, their motive for expanding operations or operating at full capacity can promote equality. Therefore, in addition to their stabilization role monetary policies should consider this dimension of inclusiveness through their credit policies. Thus, future research should focus on more sophisticated empirical methods which are necessary for estimating agent-based models directly.

The basic research question in Chapter 4 is explaining how the firm-level labor share affected firm and industry level productivity and how it affected aggregate productivity in an economy taking the case of Ethiopia.

The most direct interpretation of the estimated result is that the evolution and change in mean characteristics (change in productivity) were positively affected by the growth of functional income distribution (the growth in labor share) even if the economic sign of the coefficient was of a small magnitude, its statistical significance was quite acceptable.

The other variable of interest here is employment share of each firm within an industry, which entered the model with a negative sign but a statistically significant coefficient. In economic terms, the positive and negative coefficients of labor share within a firm and employment share of each firm within the industry tell us very important information about structural change within the manufacturing sector in Ethiopia.

If structural change was evident, employment share would have entered with a positive effect. However, it did not. Therefore, this does not support the popular view of the structural bonus hypothesis which postulates a positive relationship between structural change and economic growth. This hypothesis was based on the assumption that during the process of economic development, economies upgrade from industries with comparatively

low to those with a higher value added per labor input. For example, Timmer and Szirmai (2000) have a detailed explanation on this.

Instead, the result is supported by an almost opposite mechanism, where structural change has a negative effect on aggregate growth; this is revealed by Baumol's hypothesis of unbalanced growth. Intrinsic differences between industries in their opportunities to raise labor productivity (for a given level of demand) shift ever larger shares of the labor force away from industries with high productivity growth towards stagnant industries with low productivity growth and accordingly higher labor requirements. In the long-run, the structural burden of increasing labor shares from getting employed in the stagnant industries tends to diminish the prospects for aggregate growth of per capita income. Baumol (1967) serves as key literature on this subject.

When the complement of firms' market share enters the regression result with a positive sign, the actual market share will have entered with a negative sign which has a direct and clear economic meaning. This implies that since firms may try to capture the market through nominal ways (for example, price competition or advertising or any other institutional arrangements) this will harm productivity. My major conclusion is lack of strong evidence for intra-industry selection.

The policy lesson learnt is that access to bank loans is of great importance to firms. In particular those industries (spinning, tanning and publishing industries) in which all firms had access to bank loans revealed movements in employment share, which is evidence of the structural transformation of the industry.

There are reasons why it is important to introduce appropriate public loan policies, that is, ensuring a lending channel of monetary policy to work without breaks and constraints. First, a credit aggregate can be a better indicator of monetary policy than an interest rate or a monetary aggregate in Ethiopia. Second, monetary tightening that reduces loans to firms can have negative distributional consequences, particularly for those firms for whom bank loans are a primary source of finance. Thus, ease of access to bank loans can have economy-wide distributional consequences. More specifically, the credit policy should be such that manufacturing firms get better access to bank loans and in sufficient amounts.

Based on the results presented here, the suggested future research directions include developing complex multi-sectoral and multi-agent ACE and evolutionary economic models with their respective direct estimation techniques.

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Appendix 1 Evolution of shares

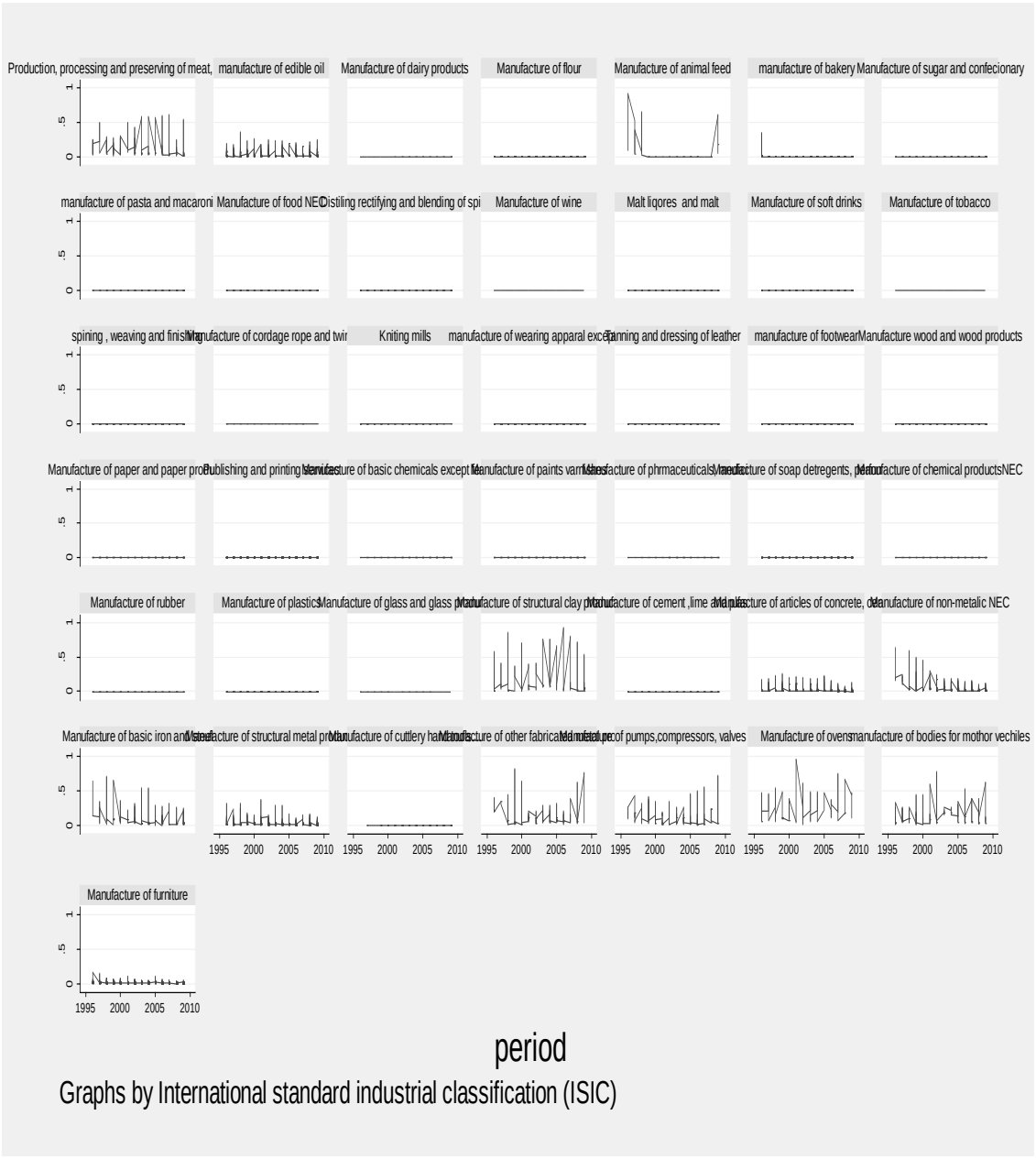

Figure 1.Evolution of employment share

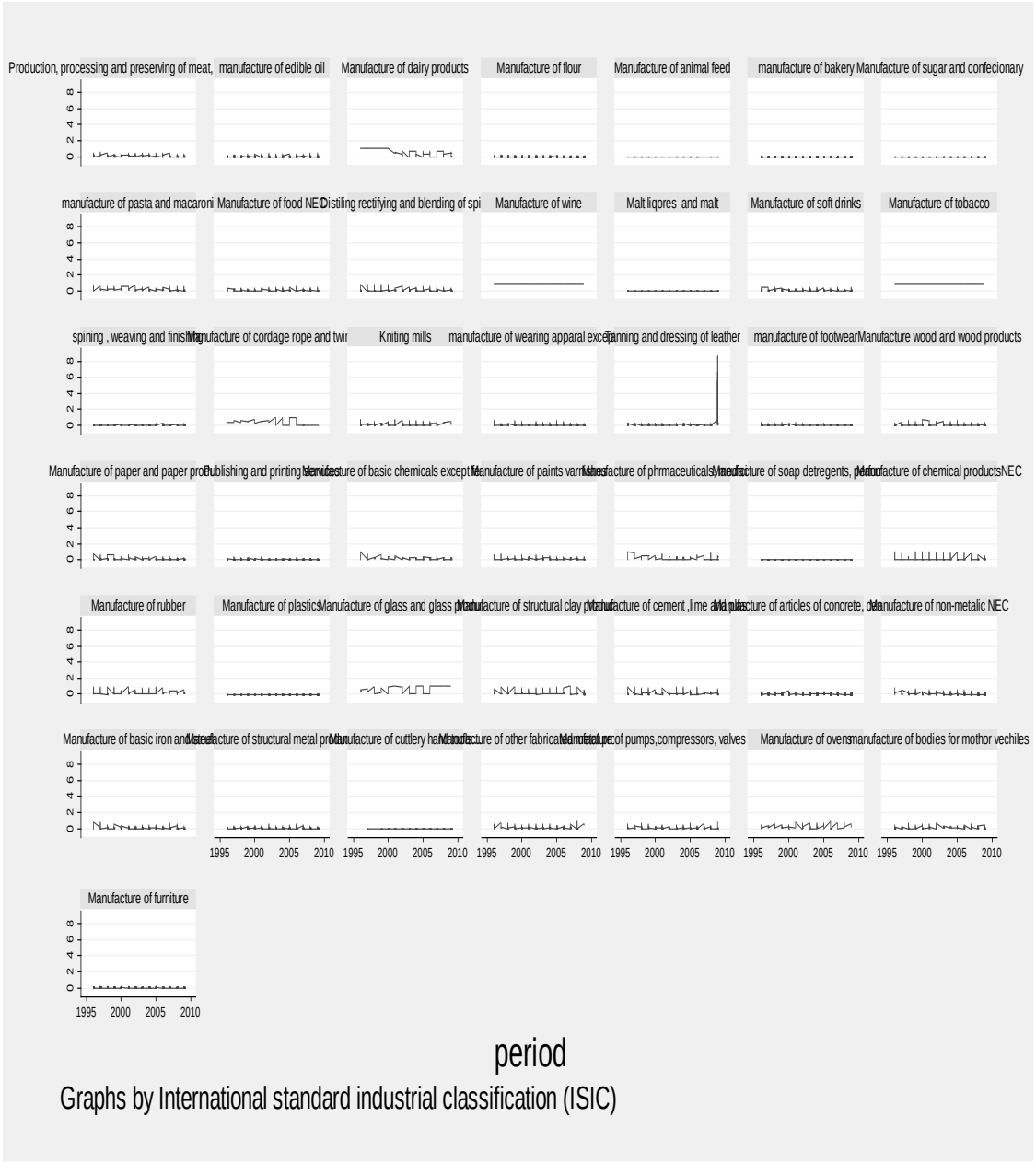

Figure 2.Evolution of market share

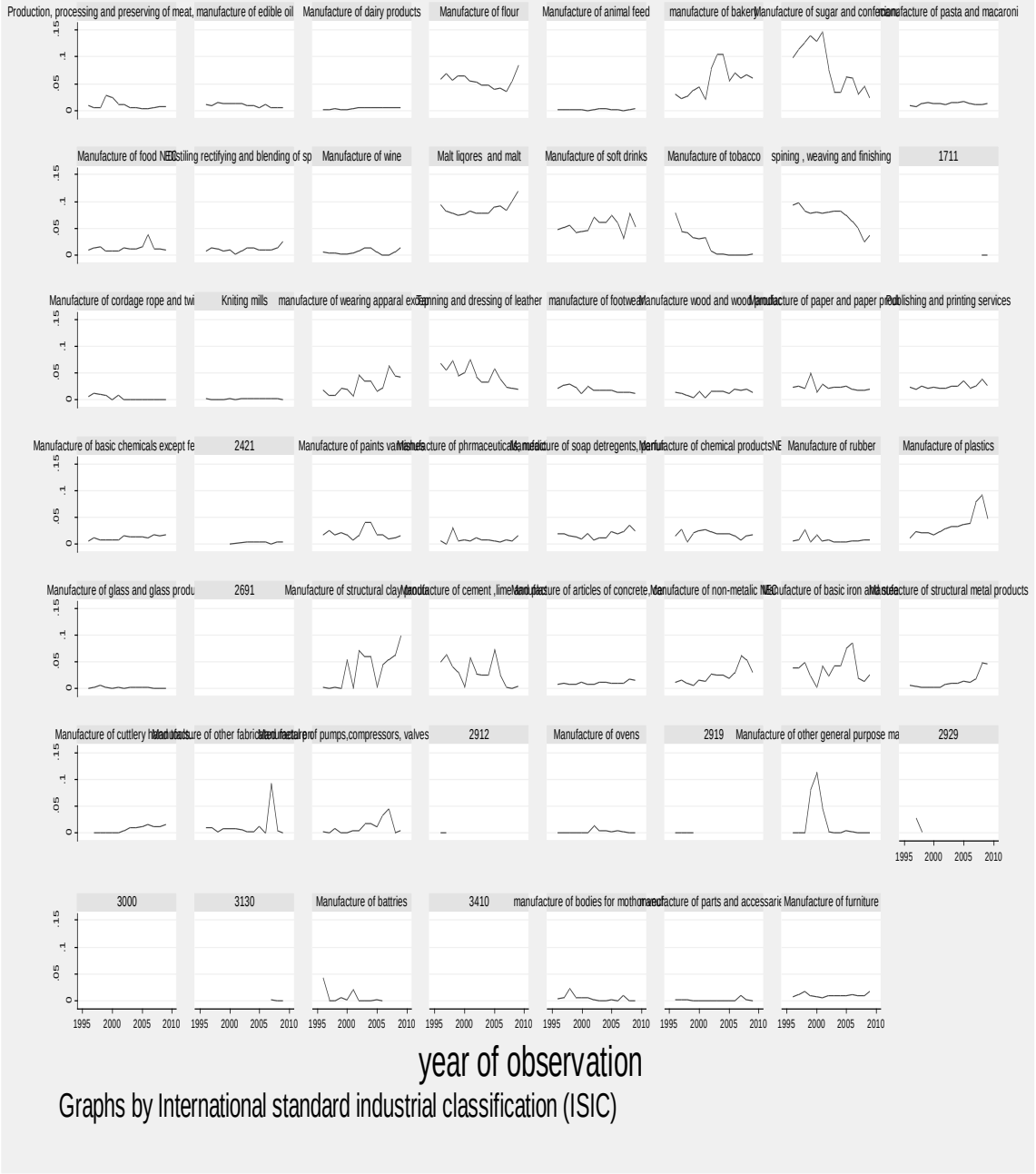

Figure 3. Evolution of output share at the industry level

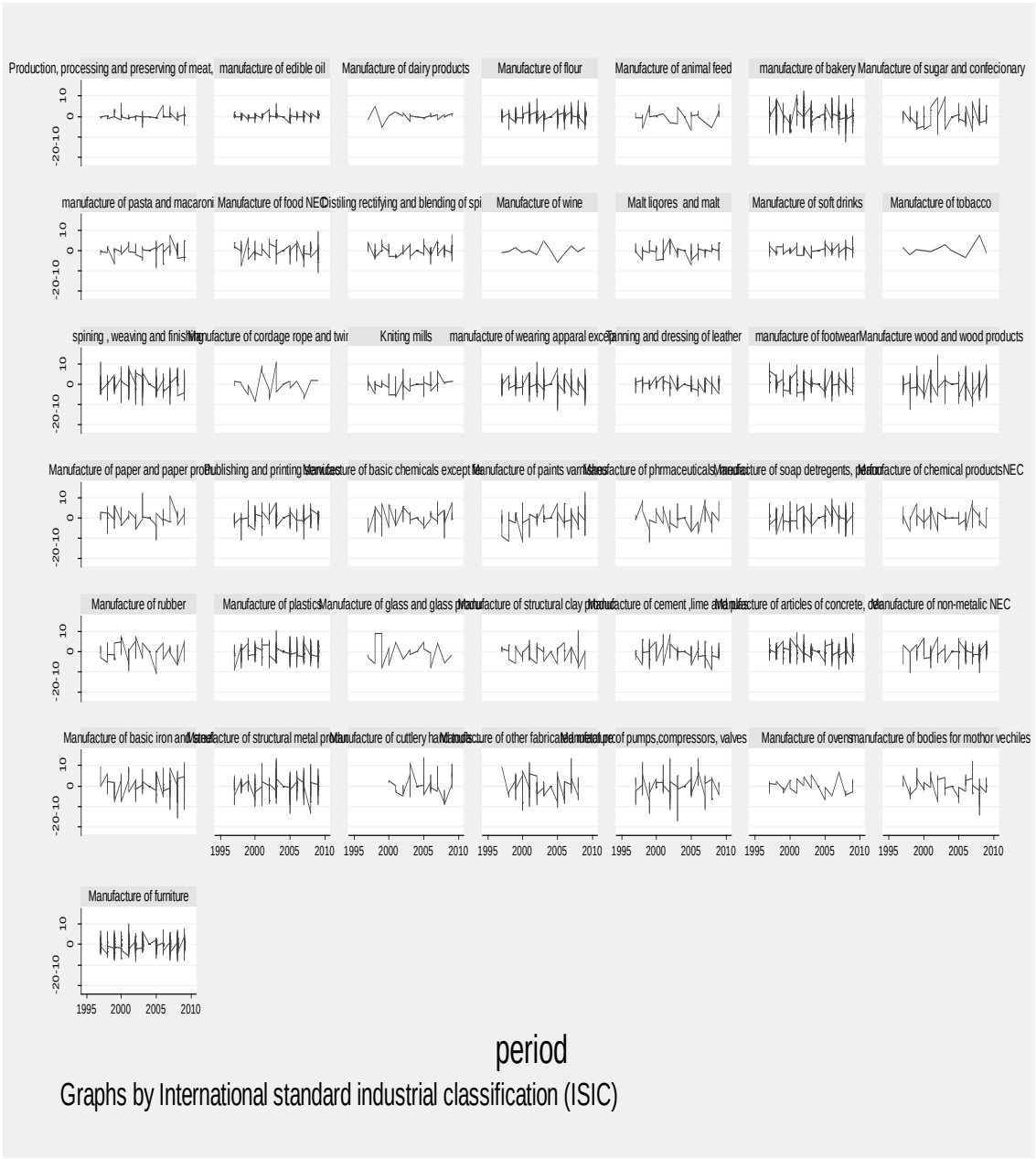

Figure 4. Evoltuionof productivity growth

Appendix 2 Mathematical derivation

$\dot{X} + a(t)X = b(t)X^r$, if $r = 1$, it is easily separable and becomes

$\dot{X} + a(t)X = b(t)X^r$ and introducing $Z = X^{1-r}$

$\dot{Z} = (1-r)X^{-r}\dot{X}$

But $\frac{\dot{X}}{X} + a(t) = b(t)X^{r-1} \Rightarrow \dot{X} = (b(t)X^{r-1} - a(t))X$

Therefore,

$\dot{Z} = (1-r)X^{-r}X = (1-r)X^{-r}\left(b(t)X^{r-1} - a(t)\right)X$

(Eq A2) $\dot{Z} + (1-r)a(t) = (1-r)b(t)$