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How applicable are the New Keynesian DSGE models to a typical Low-Income Economy?*

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Abstract

This paper assesses the applicability of new Keynesian DSGE models to a typical low income economy like those in Sub Saharan Africa. To this effect, we first review the development, criticisms and recent advances in DSGE modeling. Then we assess the implications of the assumptions of the standard open economy New Keynesian DSGE model within the context of the economic environment of a typical low income economy. Our assessment shows the following two points. First, though there are many criticisms to these models, most recent advances seem to have addressed most of these criticisms. However, there are still some outstanding criticisms that are serious challenges not only to DSGE models but also to all conventional economic models. Second, the current tendency of applying these models to explain or predict economic phenomenon in low income countries without incorporating the structural specificities of these countries cannot be justified. In stead, for these models to be helpful to understand the economic events in low income countries, most of their components must be changed or modified so that these models capture some salient specificities of low income economies. In this study we identify some of these components and suggest the possible changes or modifications.

JEL classification: E32, F41, O55

Keywords: New Keynesian DSGE, Open economy macroeconomics, Fluctuations, Sub-Saharan Africa

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Macroeconomics was developed in, and for, industrialized countries. Both theory and policy were concerned with how monetary and fiscal policy should be used in industrialized economies to attain full employment, control inflation, and stabilize economic activity. ... Developing countries often use this corpus of knowledge, with its competing schools of thought, *without any significant modification*. But it's by no means clear that applying these theories to developing countries is either justified or appropriate. (Stiglitz et al, 2006: 52, Empasis added)

1 Introduction

The debates on the applicability of conventional (macro) economic models to explain or predict economic events in developing countries date back to 1960s. The literature attributes this to the emergence of center-periphery argument of the 1950s of Raul Prebisch and others who argued that policy recommendations emanating from the then conventional economic models are detrimental to poor (peripheral) countries. However, the analytical works have gained momentum since early 1980s as many were interested in investigating why the Structural Adjustment Programs, championed by the international financial institutions were not working as expected¹. The issue at the heart of the controversy is that macroeconomic models, like any other economic models, are developed on the basis of the underlying socioeconomic and political environments and try to explain how different agents (households, firms and governments) interact within that assumed environment. That is, there are well defined behaviour of economic agents, the institutions that govern the interaction among these agents and the structure of the economy that constitute the economic model. Hence, applied to an environment that is quite different from the one on the basis of which they are developed, these models may provide wrong explanations and predictions of the economic events. As well expressed in the opening quotation,

¹Leff and Sato (1980) discuss other reasons for this increasing interest in macroeconomic modeling of low income countries at the time. They mention, for example, new research results on some aspects of the macroeconomy of these countries like the theory of financial repression by Shaw (1973) and McKinnon (1973).

conventional macroeconomic models are built on the assumed behavior of the economic agents and underlying institutions in advanced countries. Not surprisingly, policies that are guided by such conventional models when applied to low income economies might turn out to be ineffective and, still worse, they can bring about unintended negative results. This is well illustrated by Porter and Ranny (1982) who construct an IS-LM-AS-AD model of a typical low income economy based on a list of characteristic features that make such an economy different from a typical developed economy. Their analysis of various policy instruments in this simple but enlightening model shows that some standard policy instruments have sometimes opposite outcomes when applied to a low income economy compared to their consequences in an advanced economy. Likewise, Leff and Sato (1980) posed a specific question of macroeconomic adjustment after a shock to show, using the standard IS-LM framework, how standard policy prescriptions do not work for a typical developing economy. These old results concur with recent argument by many such as Stiglitz et al (2006).

The issue is that economic agents in developed countries, on the basis of the behavior of whom conventional macroeconomic models are developed, interact within a macroeconomic environment that is significantly different from the one their low income economy counterparts operate in. The institutions governing the interactions of economic agents in developed countries are either non-existent or at their early stage of development or, even more important, there are different sets of institutions that govern the economic interactions in low income countries. In other words, low income countries like those in Sub Saharan Africa (SSA) have their own peculiar characteristic features that they share among themselves (see Agenor and Montiel, 2008; Stiglitz et al, 2006; Porter and Ranny, 1982; and Leff and Sato, 1980). The models to be employed to explain or predict economic events in these economies must, therefore, incorporate these characteristic features. The implication is that the conventional macroeconomic models require some form of modification or change to be meaningfully applied to these economies.

The New Keynesian version of dynamic stochastic general equilibrium (DSGE) models (also referred to as New Neoclassical Synthesis, Goodfriend and King (1997)) have become the main workhorse of macroeconomic research. These models, as will be discussed

in detail in section 2, combine the New classical and Real Business cycle (RBC) theories with that of the New Keynesian economics. They inherit the microfoundation, rational expectations, and general equilibrium traits from RBC DSGE modeling while market imperfections, sticky wages and prices are fingerprints of the New Keynesian economists. Thus, the New Keynesian DSGE models are based on the assumption of rational economic agents: households, firms and governments who maximize their objective functions intertemporally (though sometimes reference is made to the rule-of-thumb agents - as will be discussed in section 3) to explain how the whole economy responds to different shocks in the short-run. The behavioral equations representing each economic agent and assumptions about some basic institutions (like the structure of the financial markets, the operation of different input and output markets, the integration of the economy to the international financial/asset markets, etc) are, therefore, crucial building blocks of the models and the explanative and predictive capacity of the models depend on specifications of these behavioral equations and institutions. This poses some questions that we try to address in this paper: Do the building blocks of the New Keynesian DSGE models capture the behaviour of economic agents in low-income countries? If not, what are the reasons: Differences in the behaviour of economic agents or the economic environment? What modifications or changes are needed to meaningfully apply these models to economic environments of such countries and how can one best introduce them?

The main objective of this paper is, therefore, to critically assess the basic elements of open economy New Keynesian DSGE model and examine these elements within the context of the macroeconomic environment of a typical SSA economy. This will enable us to evaluate whether the standard New Keynesian DSGE model can be directly applied to the economies of SSA or require modifications to be practical for such economies.

The organization of the paper is as follows. In section 2 we make closer examination of the historical development, the criticisms and recent developments of New Keynesian DSGE models. In section 3 we discuss the component parts of the standard open economy New Keynesian DSGE model and assess the implications of the assumptions that underlie each component when applied to a typical SSA economy. This discussion attempts to establish whether the standard open economy New Keynesian DSGE model can be applied

to low income economies or need modifications to be practical to such economies. In section 4 we discuss the works conducted so far in an attempt to construct and estimate New Keynesian DSGE models for SSA countries. Section 5 concludes.

2 Review of standard New Keynesian DSGE model

2.1 Historical developments

The DSGE models are macroeconomic models that grew from the researches pioneered by Kydland and Prescott (1982). These models have micro-foundations which their antecedent Keynesian models were blamed to lack as the former are based on the explicit assumption and modeling of intertemporal optimization behavior by economic agents under their respective constraints. That is, households maximize their life-time utility subject to a sequence of lifetime budget constraints, while firms maximize profit subject to input prices and technology. Economic agents are also assumed to be forward looking and, hence, form rational expectations about future value of macroeconomic variables of interest. This addressed the Lucas critique against the macroeconometric models that were dominant research methods in use at the time. The Lucas critique can be stated as follows: evaluation of a proposed policy based on macroeconometric models with parameters estimated from past data is futile since the structure of the economy *ex post* is different from *ex ante*, given economic agents that are forward looking. Lucas (1976:41) argues that “given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models”. The argument is that the policy change affects the behavior of economic agents and the constraints under which they maximize as a result of which the parameters of the model will also change or, in simple words, the parameters are not policy invariant. The DSGE model addresses this problem as the parameters that govern the behavior of economic agents are policy invariant, if the model is correctly specified (Cogley and Yagihashi, 2010)².

²The qualification in this statement deserves attention. Cogley and Yagihashi (2010) argue that the policy invariance argument of the structural parameters in DSGE models is based on the idea that the

The basic DSGE model developed in the tradition of RBC economics assumes that markets always clear and both booms and busts in the economy are the results of optimal intertemporal decisions by economic agents. According to this basic RBC model, random and large shocks in technology are assumed to be the main causes of economic fluctuations that are propagated by intertemporal substitutions between labour and leisure, on the one hand, and between consumption and saving, on the other (Snowdon and Vane, 2005:294-344). This model further asserts that these fluctuations in aggregate variables are due to real factors and monetary fluctuations cannot explain them, or as is commonly referred to as in the literature, money is neutral. Furthermore, according to this model, any fluctuation in aggregate variables is optimal since it is the outcome of decisions of rational economic agents and hence, by implication, there is no need for economic policy to correct these fluctuations.

However, the assertion of the neutrality of money did not escape the challenges of many economists whose arguments have been based on the prevailing solid empirical evidence. There are many empirical works that documented the importance of monetary fluctuations in explaining fluctuations in real macroeconomic variables contrary to the assumption of the basic RBC model that money is neutral (see references in Gali, 2008 and Woodford, 2003). This argument about the non-neutrality of money is well stated in Fernandez-Villaverde (2010:5) when he argues that “after one finishes reading Friedman and Schwartz (1971) *A Monetary History of the U.S.* or slogging through the mountain of Vector Autoregressions (VARs) estimated over 25 years, it must be admitted that those who see money as an important factor in business cycles fluctuations have an impressive empirical case to rely on”. The argument about the non-neutrality of money is crucial since it implies that either prices and/or wages are not flexible or economic agents suffer from money illusion or both. Again these are in contradiction with the RBC wisdom³.

DSGE approximating models are correctly specified. In this case, they argue that the parameters are approximately policy invariant. But, in case of incorrectly specified models there will be no ground for this claim of approximate invariance.

³It is important to note that the New Keynesian economics introduced the existence of the nominal and real rigidities that emanate from the decisions of rational economic agents to help explain how changes in monetary policy affect real variables. Rational economic agents worry only about real values and therefore do not suffer from money illusion. As will be discussed in the next section this is one of important

Cognizant of these weaknesses of the RBC version of the DSGE models, economists continue to introduce different extensions. Most of these are attempts to incorporate the New Keynesian assumptions of imperfect competition where economic agents have some form of market power in input and output markets unlike the RBC model where perfect competition is assumed. For various factors such as menu costs, aggregate demand externalities, coordination failure, staggered contracts etc (Snowdon and Vane, 2005:357-432) that are well entrenched in the New Keynesian literature, in the short run firms do not automatically adjust their prices in response to changes in economic conditions. In addition, the New Keynesian economics shows that different imperfections and institutional arrangements in the labour market lead to rigidity of wages in the short-run which is contrary to perfectly flexible wages in the basic RBC model. This implies that prices and wages are rigid in the short-run, and most importantly these rigidities are the outcome of the decisions of rational economic agents who attempt to maximize their respective objective functions. That is, the rigidities are now given micro-foundations which they were blamed to lack in the Keynesian paradigm. The existence of these rigidities in nominal wages and prices in the short-run implies that monetary policy can affect real activities since changes in the money supply will not result into the same proportionate change in prices as argued by the proponents of New-classical and RBC economics.

This extended model, referred to as the New Keynesian DSGE model, maintained the basic elements of the RBC model such as the rational expectations, and the general equilibrium assumptions as a result of which Goodfriend and King (1997) coined the phrase “New Neoclassical Synthesis” to these class of macroeconomic models. They argue that

The New Neoclassical Synthesis inherits the spirit of the old, in that it combines Keynesian and classical elements. Methodologically, the new synthesis involves the systematic application of intertemporal optimization and rational expectations as stressed by Robert Lucas. In the synthesis, these ideas applied to the pricing and output decisions at the heart of Keynesian models, new and old, as well as to the consumption, investment, and factor supply decisions that are at the heart of classical and RBC models. (p. 232)

drawbacks of the New Keynesian DSGE models.

Over the years a lot of elements have been incorporated by researchers adhering to both sides so that these models better mimic the real world. Nevertheless, the applicability of these models to policy analysis was constrained by the difficulty to estimate their parameters from actual data. Consequently, researchers were entirely relied on calibration of the parameters where the parameters are derived based on some theoretical properties (the balanced growth path property) of the economy or borrowed from other econometric studies or previously calibrated models. This method led to a protracted debate among macroeconomists the discussion of which we will defer to the next section. However, recent developments seem to show that this is no longer the problem, at least since the influential works of Smet and Wouters (2003 and 2007) and Christiano, et al (2005). It is now common to see small and medium scale models being estimated for different countries. The fact that these models not only are estimated from actual data but also are competitive to the VAR models that are blamed to lack theory, according to the proponents of DSGE models (see, among others, Christiano et al 2011; Ferdinand-Villaverde, 2010; Gali, et al 2011) made them popular at central banks and policy research institutions⁴. However, despite the success stories claimed by the adherents, there are criticisms to these models which are gaining momentum since the recent economic crises. Next we will turn to discuss these growing criticisms together with the recent advances in some detail.

2.2 Criticism and recent developments in DSGE models

The enormously growing number of books, research papers, and commentaries, some of them by prominent macroeconomists who in one way or another contributed considerably to the development of the current conventional macroeconomic models, show the extent of dissatisfaction to the conventional economic models and the DSGE models, in particular. Some of the criticisms to these models are as old as the models and others are new. The recent global financial crisis has also contributed considerable momentum to the criticisms of these models as can be witnessed from the number of critical publications over the last couple of years. The critics argue that the DSGE models performed poorly both in

⁴For the list of Central Banks and multilateral institutions that employ DSGE models for policy analysis and forecasting, see the references in Tovar (2009).

predicting the crisis and in providing policy prescriptions on how to end the crisis. At the same time the last couple of years witnessed considerable advance in the DSGE modeling some of which addressed the concerns of the critics. In this section we present both the criticisms against DSGE modeling and recent advances in these models some of which are attempts to redress the caveats.

As indicated above, there are many works that challenge the DSGE modeling. Perhaps, an exhaustive critical evaluation of the New Keynesian DSGE models is by Meeusen (2009 and 2010) who discusses a list of shortcomings of these models that make them incapable of capturing the features of real world economy and, therefore, make them incapable of performing their role of explaining and predicting economic events. The most critical of these shortcomings, according to Meeusen (2010: 12-20) are: the failure of these models to capture heterogeneity of economic agents, the absence or ad hoc nature of financial sector, the modeling of uncertainty, absence of involuntary unemployment in the models, the linearization and the empirical validations of these models. We will try to discuss each of these criticisms together with reactions from DSGE modeling so that we can have some view of the current state of these models. This will also enable us to see how these models fare compared to available alternatives. Our discussion shows that most of these criticisms are important challenges but not lethal. The most serious challenge to DSGE modeling (for that matter all conventional economic models) is the one casted by school of behavioral economics that rejects not only rational expectation formation but also the assumption of rationality of economic agents in their decision making. We argue that this is lethal since all economic models are based on the central assumption that economic agents are rational, driven by economic motives, and make calculated decisions to make the best possible out of what they have, given the circumstances. Rejection of this central assumption, we believe, is the disastrous criticism to economic models in general.

2.2.1 The Representative Agent

Recent criticisms revitalized the argument about the inappropriateness of the assumption of a representative agent that underlies the DSGE models (see, for example, Colander, et al, 2008; Meeusen, 2010; Solow, 2008). The criticism against the representative agent

is as old as the DSGE models themselves (see, Kirman, 1992; Hartley, 1996 and 1997). The works in the DSGE framework are based on the household sector of the economy being represented by an infinitely lived representative household that maximizes life-time utility. The production part of these models is also represented by a representative firm that maximizes discounted profit. Though the introduction of the representative agent into macroeconomic model is to address the Lucas Critique and provide macroeconomics a microfoundation, critics show how it failed to achieve these goals (Hartley, 1997 and Meeusen, 2010). It is argued that the real economy is populated by economic agents of differing means and ends and hence cannot be represented by a representative agents. This view is more clearly and strongly forwarded by Solow (2008:243)⁵ as follows:

After all, a modern economy is populated by consumers, workers, pensioners, owners, managers, investors, entrepreneurs, bankers, and others, with different and sometimes conflicting desires, information, expectations, capacities, beliefs, and rules of behavior. Their interactions in markets and elsewhere are studied in other branches of economics; mechanisms based on those interactions have been plausibly implicated in macroeconomic fluctuations.

The critics argue that a model that does not account for this heterogeneity cannot explain the performance of the real economy. Likewise, Colander et al (2008) argue that attempts to induce generalizations from the representative economic agents about an economy populated by heterogeneous agents are erroneous as they suffer from the fallacy of composition. The argument is that one cannot fully understand the aggregate behavior by studying the behavior of an agent since the interaction among agents is what matters most. In their words, “Any meaningful model of the macro economy must analyze not only the characteristics of the individuals but also the structure of their interactions” (p. 237).

As it is indicated even by critics (see Meeusen, 2010,), it is not because the representative agent represents the whole range of heterogeneity in an economy, instead it is an

⁵It seems that the arguments in Solow (2008) lack logical consistency as discussed in Chari and Kehoe (2008) since he inclines towards very simple intuitive models and at the same time models that should capture many varieties of economic agents and the complex interactions among them.

approximation to overcome the difficulty of aggregation that introduction of heterogeneity entails. Hence, the assumption of the representative agent is an approximation. It is clear that the real world is full of heterogeneity - heterogeneity is the rule and homogeneity is exception. However, the more one thinks about capturing more of the heterogeneity in a model, the more it becomes unmanageable and even meaningless. Models are abstractions and they are to help understanding the world and not to represent the whole world.

The weakness of the representative agent paradigm and the importance of heterogeneous agents have been recognized in DSGE modeling and attempts have been made to develop techniques to solve such models (den Haan, 1996 and 1997; Krusell and Smith, 1997, 1998 and 2006, and Rios-Rull 1997). These attempts have gained momentum in recent years and there are many works coming out on solving and simulating DSGE models with heterogeneous agents (see Maliar, et al 2010 and Reiter, 2009 and the references in these papers).⁶ These studies have developed different algorithms for solving, simulating and checking the accuracy of DSGE models with heterogeneous agents. Their accessibility and applicability to analyze policies and investigate economic events empirically is something to be seen in the near future.

2.2.2 Labour market frictions and involuntary unemployment

The early works in DSGE models do not have labour market frictions and involuntary unemployment. This is understandable given the underlying tenets of the RBC economics. Their antecedents, the New Keynesian DSGE models, until recently have failed to address this issue of involuntary unemployment, a weakness that is acknowledged by prominent economists in these school (see, Blanchard, 2009; Blanchard and Gali, 2010; Gali 2011). For instance, Blanchard (2009:216) explains this weakness as “striking (and unpleasant) characteristic” of the standard New Keynesian DSGE model. This is one of the inheritances that the New Keynesian DSGE models inherited from the RBC models since in the later all markets, including the labour market, always clear and therefore unemployment in the economy is only voluntary. Furthermore, according to these latter models the

⁶In addition to many separate works that attempt to address this issue, many most recent works can be found in 2 dedicated issues of the Journal of Economic Dynamics and Control (Vol 34, No. 1 (2010) and Vo. 35, No. 2 (2011)).

change in employment is at the intensive margin as workers, based on their intertemporal preferences, decide to work more or less hours or their decisions to participate in market activities or not.

Recent works in DSGE modeling, in part in response to these criticisms, have come up with many ways of introducing labour market frictions and involuntary unemployment in to these models. It is now common to see models with labour market frictions that incorporate different variants of the search and matching labour market models in the tradition of Diamond-Mortensen-Pissarides (see, among others, Blanchard and Gali, 2010; Christiano, et al 2010a and 2010b; Gertler and Trigari, 2009; Gertler et al 2008; Sala et al 2008; Trigari, 2007). The search and matching approach allows to model an economy with involuntary unemployment at equilibrium. Some of these works answer the questions raised by others like Blanchard (2009) modeling both the adjustment of labour at the extensive margin and the existence of involuntary unemployment at equilibrium. These recent works in New Keynesian DSGE models that incorporate the labour market frictions are significant developments. The estimated versions of these models are also promising in fitting the data (Christiano, et al 2010; Gali et al, 2011 and Gertler, et al 2008).

2.2.3 The Financial market

The New Keynesian DSGE models are criticized also for their lack of systematic treatment of the financial sector frictions (Blanchard, 2009; Meeusen, 2010; Woodford, 2010). In most of the influential works, there are no commercial banks and other financial intermediaries. There are simplistic and ad hoc assumptions where the households directly lend to the public sector and hold bonds though, in many instances, there are no definitions of how the bonds themselves evolve. Woodford (2010) argues that the current macroeconomic models failed to explain the financial crisis since the institutional frameworks of financial intermediaries that are assumed in the existing macroeconomic models such as the frequently cited Bernanke et al (1999) are completely different from the institutions that are at work currently in the real world. According to Woodford, the financial intermediaries that are assumed in the few of the works that tried to introduce the financial sector into macroeconomic models are banks that collect short term deposits and provide

long term loans abiding by regulatory frameworks which are completely different from the non-bank financial institutions that were dominant at the eve of the financial crisis. In the later system the financial intermediaries generate funds by selling securities which implies that the regulatory systems designed for banks cannot affect them. In this respect, it seems that the macroeconomic models were lagging behind the innovations in the financial sector and hence not surprising if they could not explain or predict what is happening in the economy due to events in this crucial sector. Given the role that the financial sector plays and the place of the financial intermediaries in the policy transmission mechanism, and most importantly the place of the financial sector in the recent economic meltdown, it is imperative for macroeconomic models to capture how this sector works and how it interacts with the real economy. Recently there are many works, though follow different approaches and emphasize different issues, that attempt to fill this gap by incorporating the financial markets with various institutional setups and frictions into the New Keynesian DSGE models (see, for example, Adrian and Shin, 2011; Christiano et al 2010; Curdia and Woodford 2009; Gerali et al, 2010; Gertler and Kiyotaki, 2011).

2.2.4 The Solution methods

The common practice in the DSGE modeling is linearization of the non-linear models to solve and estimate them. This is due to the difficulty to solve the original non-linear models as a result of which researchers resort to approximating them with their linear versions. Most often, Taylor expansion of the optimality conditions of the model around the steady-state values of the variables, which is referred to as log-linearization, is made. The critics argue that linearizing the non-linear models amounts to stripping of these models their real world attributes (see, Lim and McNelis, 2008; Meeusen, 2010). It is also argued that this method can be helpful only when the deviations of the economy from the steady-state values are small. In other words, this method is local approximation (Lim and McNelis, 2008; Meeusen, 2010). Furthermore, according to Lim and McNelis (2008:12), the solutions obtained through log-linearization of these models “will overstate the volatility of the macroeconomic aggregates”.

However, there are many works that introduced alternative methods to solve these

models with their nonlinearity. One of these methods that is becoming popular is the projection method which employs different approximating functions to solve the DSGE models without linearizing them (see Lim and McNelis, 2008 for a textbook treatment of solving New Keynesian DSGE models by projection method, and Judd, 1991; Judd et al, 2010; Pichler, 2011 for application of projection method to RBC models). The fast developments in the techniques of solving these models seems that the criticism about application of linearized approximation will not be a serious challenge to the future of the DSGE models.

2.2.5 Empirical Methods

The DSGE models are also criticised on the grounds of the empirical method. The most commonly used method is the calibration method where parameter values are derived from the equilibrium conditions of the model by imposing the properties of balanced growth path. This is a tradition being followed in DSGE modeling since the early RBC models such as Kydland and Prescott (1982) and has been criticized since then (see, for example Hansen and Heckman, 1996; Hoover, 1995; Sims, 1996; Solow, 2008; Meeusen, 2010). Some of the criticisms are on the entire idea of calibration and others on the testability of the results of the calibration exercises. There are also critics who argue that using the long-run properties of the economy (balanced growth path) to calibrate the model to analyze short-run fluctuations is not appropriate. However, the proponents of the calibration method argue that this exercise is correct since both short-run and long-run analysis deal with the the same facts and hence need to be coherent (Kydland and Prescott, 1996; Cooley, 1997). For example, Cooley (1997:57) argues

The reason for this is that we know most developed economies display the characteristics of balanced growth. Since both growth and fluctuations are features of the data for all economies, we would like any theory of the latter to be consistent with the former. This strongly suggests that we do not want to have separate models for growth and fluctuations.

Recent developments seem to overcome the problems associated with calibration as the estimation techniques are developed and many small and medium scale New Keynesian

DSGE models are estimated from actual data. However, the application of Bayesian method though theoretically appreciated, in practice criticized. According to Blanchard (2009), Bayesian method can help to overcome the problem of near nonidentification since the method allows the use of additional information in setting the priors of the parameters. He argues that in practice priors are passing from one work to another when there is no ground justifying their being borrowed.

2.2.6 Rationality and Rational Expectations

As we highlighted at the beginning of this section, the most organized critics to the conventional macroeconomic models is the school of behavioral economics. The criticisms from this school are serious challenges not only to DSGE modeling but also to all conventional economic models that are based on the assumption of rational economic agents and rational expectations (see Akerlof, 2007, 2002; Akerlof and Shiller, 2009; De Grauwe, 2010a, 2010b, 2010c, 2010d). The literature in this emerging field has one unifying element. That is, rejection of the rational expectations hypothesis and the rationality of economic agents that underlie most modern economic models including the DSGE models.

According to the rational expectations hypothesis, economic agents make the best use of the pieces of information available to them and they do not make systematic error and, therefore, on average their expectation is consistent with that of the economic model. Akerlof and Shiller (2009) argue that macroeconomic models that are in use so far have not been in a position to help understanding the causes of recessions and depressions mainly because of the assumption of rationality of economic agents and rational expectations. For them economic agents could be non-rational and are driven by “animal spirits” than forming rational expectations for their decision making process. Hence, they argue that the failure of modern macroeconomic models emanates from the fact that these models do not capture the “animal spirits” that drive the economy. No conventional economic model that is based on rational economic agents, forming rational expectations and acting out of purely economic motives, is immune to their criticisms. For them most of the economic instabilities that the economy experiences are the results of human beings acting in ways that are inconsistent with the rational, and self-interest driven behaviors assumed in the

conventional models. Akerlof (2002:428) asserts this position more clearly when he argues that

reciprocity, fairness, identity, money illusion, loss aversion, herding, and procrastination help explain the significant departures of real world economies from the competitive, general equilibrium model. The implication, to my mind, is that macroeconomics *must* be based on such behavioral considerations.(Emphasis in the original).

If non-economic factors are more important in explaining decisions by economic agents, then the assumption of rationality that underlies modern economic models does not make sense. Writing few years later during the recent financial crisis, Akerlof and Shiller (2009) argue that the current macroeconomic models can explain at best only one of the four possible stories of the performance of the economy. That is, since modern macroeconomic models are based on the assumption of rationality of economic agents they can explain “How does the economy behave if people only have economic motives, and if they respond to them rationally?” (Akerlof and Shiller, 2009: 168). But, according to them, this is only one of four possible questions that the macroeconomic model should answer about real economic agents, the other three being rational economic agents possessing non-economic motives, irrational economic agents who possess economic motives, and irrational economic agents driven by non-economic motives. They argue that these three questions that are not explained by the modern macroeconomic models explain most of the instabilities in the real economy. If one concurs with these authors, then it is not surprising that the modern macroeconomic models failed to forestall the onset of the recent crisis and also if they fail to provide policy makers with sound policy prescriptions to pull the economy out of the crisis. Hence, unless we model these non-rational behaviors and non-economic motives which characterize the economic agents in the real world we cannot be in a position to understand the performance of the real economy.

However, the “animal spirits” is the catchall word as there are a variety of elements in it. For example, Akerlof and Shiller (2009) mention confidence, fairness, corruption money illusion and stories to be motives for the real people and hence elements of the set “animal spirit”. Others, such as Schwartz (2010) give components of the animal spirits

to be cognitive, emotional, cultural, and visceral factors. This might explain why there is no unifying model of this school of macroeconomic thought which is as some argue is overdue (Schwartz, 2010). Furthermore, given the fact that these factors are interdisciplinary by nature, it is not clear as to whether a unifying model that captures these factors and can be applicable for empirical economic analysis comes out.

There are attempts to build a model that captures part of the elements of the animal spirit that are mentioned above. One of these attempts is by De Grauwe (2010a, 2010b, 2010c, 2010d). De Grauwe (2010b), for example, replaces the rational expectations assumption in the standard DSGE model with simple rules that allow agents to learn from their experiences. The idea in De Grauwe is not a question of whether economic agents are rational or not. In stead, it is about rational economic agents that are not as foresightful as in the rational expectations framework - economic agents who have limitations in processing the pieces of information available and hence can possibly commit systematic error. Furthermore, these agents learn from their experiences and choose expectations that worked well for them. Hence, the rejection of rational expectations does not necessarily mean embracing irrationality. According to De Grauwe, agents use simple rules that guide their decisions, learn from experience and this is the rational thing that economic agents can do. "They do this not because they are irrational, but rather because the complexity of the world is overwhelming. In a way it can be said that using heuristics is a rational response of agents who are aware of their limited capacity to understand the world" De Grauwe (2010b:415). This model, where rational expectation is replaced by some simple rules, is a promising step as it addresses one of the three questions that the mainstream model does not address.

2.2.7 Summary

As we tried to discuss in the preceding few pages, the dissatisfaction with the mainstream macroeconomic models has been growing at a considerable rate over the last few years. The last few years also witnessed the largest proportion of the criticisms mainly due to the failures of the mainstream models to predict and explain the recent crisis. On the other hand, the proponents of these models do not seem to be convinced and shaken by

the criticisms posed which can be seen from the aphorism quoted in Chari (2010:2) “A useful aphorism in macroeconomics is: ‘If you have an interesting and coherent story to tell, you can tell it in a DSGE model. If you cannot, your story is incoherent’”. This tone of satisfaction in the progress of modern macroeconomics as a result of advances in DSGE modeling is shared by many (see, for example, Chari, et al 2009; Chari and Kehoe, 2008; Ferdinand-Villaverde, 2010; Woodford, 2009).

Our assessment of the DSGE models shows that though there are many weaknesses that are pointed out by the critics there are also considerable improvements in these models. Furthermore, some of the criticisms are weaknesses that apply to the whole of economics as a discipline and not only to DSGE models. For instance, the issues raised by behavioral economics require restructuring of economics and not only macroeconomics. A glance at the history of macroeconomic thought shows that one could reasonably be optimistic that the recent economic crisis, the poor performance of the mainstream macroeconomic models in predicting and explaining the crisis reflected in the dissatisfactions that we discussed above and many others might lead to evolution of a new paradigm in the near future. But for the time being the New Keynesian version of the DSGE modeling seems the only well organized method for applied research in the short-run economic fluctuations.

Given this background, we now turn to closely assessing the component parts of these models so that we can understand whether they are directly applicable to the SSA economies or need modifications. That is, we examine each of the characterizations of the economic agents and the environment in which they operate within the context of a typical low income country in order to know the types of modifications required to make the models applicable to such an economy⁷.

⁷Agenor and Montiel (2008) make extensive survey of the characteristic features of developing countries that make them different from developed countries and empirical studies on the behavior of economic agents in developing countries.

3 Component parts of DSGE models in the context of SSA economy

The basic component parts of the standard open economy New Keynesian DSGE model are the preference of the households which captures the intertemporal utility maximization; technology capturing the relationship between different inputs to produce output by profit maximizing monopolistically competitive firms, the monetary authority that exercises its power through different monetary policy instruments, and the economy's integration and interaction with international financial/asset markets. The optimization decisions by these economic agents can be combined to give the three basic equations that describe the economy (Blanchard, 2009). The first order condition of the intertemporal utility maximization problem by the households gives the IS curve of the economy (demand), the optimal price setting decisions by profit maximizing monopolistically competitive firms gives the Phillips curve (supply), and from the objective of the monetary authorities the reaction function or monetary policy rule is derived. Lets look closely into the assumptions that underlie these component parts and see the implications to a typical SSA economy.

3.1 Households: Consumption

In the standard models, the objective function of the households is captured by a utility maximization subject to sequence of budget constraint. The utility is derived from consumption of goods and services as well as leisure. This preference specification in most of the models is based on the assumption of intertemporal consumption smoothing as in the life cycle/permanent income hypothesis. That is, households smooth consumption through transferring resources across periods which requires access to financial markets so that households save/lend when they produce or earn above and over their current consumption and dissave/borrow when their current income falls short of their consumption expenditure. This amounts to saying that households have a smooth consumption path irrespective of the variability of their income flow.

This assumption is contestable for households in a typical poor country like those in most of SSA since these households might not be able to smooth consumption even if

they want to do so for various reasons. First, most of the population in the region lives in rural areas participating in primary production be it agriculture or mining, earning subsistence income. Second, even when the income level is higher than their consumption expenditure they save in the form of non-financial assets or what De Soto (2000) refers to as “dead capital” that cannot easily be converted into liquid assets for consumption when they need it due to institutional hurdles or absence of market institutions. Furthermore, these households due to the nature of their livelihood and the economic environment they face credit constraints. This implies that low income that is bare subsistence reinforced by the absence of well functioning financial markets, hence unavailability of different financial assets, seem to make intertemporal resource transfer very difficult in a typical poor economy.

Contrary to these stylized facts, many empirical studies on the consumption behavior of households in developing and low income countries report the existence of consumption smoothing (see Wolpin, 1982; 1990; Schmidt-Hebel et al., 1992; Morduch, 1995; Rosenzweig and Wolpin, 1993; Rosenzweig, 2001). According to these studies, low income households do smooth consumption even when they live in a world of liquidity constraints via accumulation and decumulation of assets. These studies are conducted in different countries using different methodologies but their overall findings show that households in developing countries, indeed, smooth their consumption which is in line with the assumption of the intertemporal optimization models. Given the stylized facts we raised with respect to the nature of income and the credit market characteristics faced by households in SSA countries, the evidence reported raises questions.

However, even if one subscribes to the assertion that low-income households smooth their consumption via transferring their assets across periods, one needs to check the role that interest rates play in the process of saving and dissaving. The intertemporal optimization assumption that underlies the DSGE models implies that households accumulate more when the rate of return is higher than their rate of time preference which at the optimal of the consumer gives the well known consumption Euler equation. This has very important implications for the applicability of DSGE models to these economies. The aggregate demand part of the DSGE models, as discussed above, is the consump-

tion Euler equation derived from the first order conditions of the optimality of households consumption and saving decisions. This equation links current consumption and future expected consumption via real interest rate. This link breaks down if there is no link between interest rate and intertemporal substitution in consumption. The literature on the saving behavior of households in low income countries shows that the elasticity of saving to changes in interest rates is very low (see Ogaki et al., 1996). This low responsiveness of private savings to changes in real rate of interest in low income countries forces one to question the argument that saving in these countries is induced by the intertemporal optimization motive. One convincing explanation, instead, is what Carroll (1997) refers to as “buffer-stock” saving behaviour. In this case, households save because they face high income uncertainty and prefer to consume more had they known their future income with certainty. One thing seems clear: the intertemporal optimization assumption that is based on consumption smoothing does not apply to the majority of households in SSA.

Economists recognized that this assumption of symmetry of preferences or an economy populated by identical households that smooth consumption intertemporally and representing them by infinitely lived representative household is problematic even for developed economies. It is more problematic assumption to make for a typical SSA economy. One way that this problem is addressed is through introduction of two types of households in to the model economy. That is, to assume that the economy is composed of two types of households: optimizing and non-optimizing households (Campbell and Mankiw, 1989, 1991; Mankiw, 2000; Gali et al., 2004; Ratto, et al 2009; Bosca, 2011; Calciago, 2011). In this characterization of households, some households behave as the representative household commonly used in the standard models. These households have access to financial markets, do not face credit constraints, behave rationally, have longer planning horizon and, therefore, smooth their consumption through transferring resources across periods. The non-optimizing households (referred to as rules-of-thumb or non-Ricardian consumers) each period consume their current income. There are different reasons given as to why households deviate from the life-cycle/permanent income hypothesis even in developed countries. Mankiw (2000) argues that the rule-of-thumb consumers exist due to naivety on the side of the households or rational households facing binding borrowing con-

straints or because households attach higher weight to their current income when forming their expectations about their future income.

Currently, the rule-of-thumb consumers are introduced in DSGE models that are dealing with specific questions (like effects of fiscal policy) rather than as a permanent part of the models. The introduction of rule-of-thumb consumers when modeling the economies of SSA has clear importance over the standard optimizing representative household model. This is so since such households who consume their current income due to either subsistence level of income or liquidity constraint represent the largest proportion of households in SSA.

3.2 Households: The labour market

Labour is the most valuable asset for the majority of households in most economies of the world. The performance of the market for this asset is, therefore, very important to understand how the whole economy operates. This is even more appealing to the case of low income countries where income from labour services represents the only or the largest proportion of livelihood. For such households, their wellbeing depends on not only whether they are employed (working) or not but also on whether their labour earns a reasonable income. This argument does make much sense for SSA, one of the regions where the majority of working poor (people who are working but earn very low income) of the world live. Hence, understanding the operation of the labour markets in these economies and incorporating the dynamics of these markets into the model of the whole economy seem crucial to understand how different shocks affect different households or social groups. It also helps to know how employment/unemployment responds to different global and domestic shocks.

However, as discussed in the previous section, until recently the DSGE models do not have the labour market dynamics. Most of the works based on the standard New Keynesian models assume that the labour market is perfectly competitive as a result of which any unemployment in the economy is assumed to be voluntary. Again, as we highlighted in that section, recently we have been witnessing considerable improvement in this area. However, as we will show in what follows, none of the works that attempt to incorporate

labour market into DSGE models deals with the problems and specificities of the labour markets of SSA.

Labour markets in SSA have their own peculiar characteristics that need emphasis. For instance, the inflexibilities in these markets are of different types than those observed in the labour markets of developed economies. Kingdon, et al (2006) identify and assess three attributes of labour market flexibility within the context of African economies, namely; downward flexibility of real wages overtime, the tendency for wages to respond to unemployment rates, and the extent of wage differentials across sectors and firms. Their findings show that African labour markets could be seen as flexible in terms of downward flexibility of wages and responsiveness of wage rates to unemployment rates. However, they report that there exists compelling evidence to conclude that labour markets in Africa are rigid in terms of wage differentials among sectors and/or firms. That is, there is high paying sector (formal sector) with better working conditions, on the one hand, and low paying sector (informal sector), on the other hand, in the same economy. It is worth mentioning that it is not the mere coexistence of labour markets with different attributes (the duality) that makes the labour markets in Sub Saharan Africa peculiar, but the fact that the informal sector (low paying sector) employs the largest proportion of the labour force of the countries. The share of this sector as a percent of non-agricultural employment in Sub Saharan Africa, the largest of all regions in the world, is about 80 percent on average (ranging from 40–97 percent) (Charmes, 2000; Blunch et al., 2001 and OECD, 2009).

This duality – the formal sector with relatively higher wages and the informal sector with lower wages serving as employer of last resort - as argued by Kingdon, et al (2006) and other works, is the feature that all labour markets in Africa share among themselves. Hence, we believe that in order to understand the effects of various financial and trade shocks on the macroeconomic performance of the countries in the region this duality of the labour market needs to be introduced into the open economy New Keynesian DSGE model.

To our knowledge, Castillo and Montoro (2010) and Mattesini and Rossi (2009) are the only works that attempt to incorporate duality of labour markets into New Keynesian DSGE model. The sources of duality assumed in these works are different. In Mattesini

and Rossi (2009) the duality arises from the coexistence of a Walrasian labour market characterized by perfectly flexible wages with a unionized labour market characterized by rigid real wages. In Castillo and Montoro (2010), by contrast, the existence of duality is due to the coexistence of formal and informal labour markets in an economy where both formal and informal labour markets are characterized by some frictions. The setup in Castillo and Montoro (2010) implies that firms have the options of employing workers on the basis of formal contract and hence the benefits and obligations associated with it or employ workers on informal basis. Both of these works deal with a closed economy New Keynesian DSGE model. To our knowledge, there is no work that addresses the duality of labour market in an open economy New Keynesian DSGE framework. To understand the effects of domestic and external shocks it is imperative to rely on the open economy models and therefore the dual labour market should be introduced into the open economy New Keynesian DSGE models.

Furthermore, the duality in the labour markets of SSA countries is different from the dualities discussed in the aforementioned two papers. Of the two works discussed above, the labour market in Castillo and Montoro (2010) is more closer to the labour market segmentation in SSA. But unlike the assumption in Castillo and Montoro where the duality emanates only from coexistence of workers employed formally and informally in the same firm, the duality in the economies of SSA is economy wide - as is the case of the dual economy models of Lewis (1954) and works that followed this tradition. For instance, Fields (2009) provides an exhaustive discussion of the nature of labour market segmentation in developing countries that corresponds to those of SSA economies. In this context, there are firms that operate based on only informal labour and others that rely on formal labour market. Indeed, firms operating formally could have workers employed formally or informally as in Castillo and Montoro (2010). But closer examination of the economic structures of the countries in the region and literature on their labour markets show that Castillo and Montoro's setup represents only small section of the economy, if any. The other difference with respect to the labour market in these countries is the wage setting mechanism. The works that incorporated labour market into New Keynesian DSGE models assume either competitive labour markets where the real wage rate is the

marginal product of labour or a wage rate determined via Nash bargaining. Applying these mechanisms in modeling low income countries has its own problem since the largest proportion of the labour force that is in the informal sector is self-employed, or works in the family business or in businesses owned by relatives. As a result, as argued by Ranis (2006), there is some form of income sharing mechanism that applies to this setup where the wage or income share is between marginal and average product of labour. This argument emanates from the fact that the marginal productivity of labour is small in some sectors of the economies in low income economies and even could be closer to zero. The concept of wage is related to subsistence instead of productivity and here comes the idea of income sharing. As well discussed in Ranis the maximum that this income share could be average product. But average product implies no production next time since even for some primitive economic activities one needs to have working capital for next time. This implies that the wage rate or income share is between average and marginal product of labour. The question here is on developing a model that captures this institutional setup.

Hence, we argue that any macroeconomic model that is meant to investigate the effects of various domestic and external shocks should rectify these issues of labour market segmentation and wage setting mechanisms.

3.3 Firms: credit and foreign exchange constraints

The firm side of the New Keynesian DSGE model is given by monopolistically competitive firms who produce goods and services using labour and capital, given the technology and the demand for their products. The standard model assumes that firms do not face credit constraint for investment and working capital and that capital is produced domestically. However, studies show that firms in SSA operate in a completely different economic environment. For instance, Bigsten et al (2003) based on a panel data on the demand and supply of credit in a sample of SSA countries show that of the total number of firms who applied for formal credit from banks only about 25 percent succeed in obtaining credit. The same study also reports that larger firms are more successful in obtaining credit than small and micro enterprises. This is important given the fact that most of the firms in SSA are either small or microenterprises and the lack of access to credit is the reason behind

their size. Like bigsten et al (2003), Fafchamps (2004) in an extensive study of market institutions in SSA documents how the underdeveloped financial markets lead to lack of credit for starting investment or for working capital by entrepreneurs. Fafchamps (2004) also shows that most firms in SSA countries are small and fail to grow to medium and large scale mainly due to the shortage of formal credit to expand investment. Therefore, it is important to consider this constraint while modeling the macroeconomy of the countries in the region.

On the other hand, firms in SSA like those in most of low income countries rely on imported intermediate inputs and physical capital. Therefore, the ability of the country to import these inputs is very important factor in determining the performance of firms in these countries. This brings the availability and cost of foreign exchange to play indispensable role in the production process. To our knowledge, there is only one study that applied the RBC version of small open economy DSGE model to explain business cycle in Africa (Kose and Reizman, 2001) which recognized the importance of imported intermediate inputs though failed to recognize the importance of the availability of foreign exchange and exchange rate for production. There are different studies, though not within the context of the DSGE framework, that show the crucial role that availability and cost of foreign exchange play in the macroeconomic performance of developing and low income countries (Agenor and Monteil, 2008; Polterovich and Popov, 2006; and Porter and Ranney, 1982). For instance, Polterovich and Popov (2006) in their study of the relationship between accumulation of foreign exchange reserve, on the one hand, and investment and growth, on the other, using cross-country regression find strong positive links. That is, developing countries with growing accumulation of foreign exchange reserves show higher growth of investment to GDP ratio and higher GDP growth rates. This, we expect to be true for the economies of Sub-Saharan Africa given the economic structure we mentioned.

Hence, we argue in the line of Porter and Ranney (1982) that for low income countries like those in Sub-Saharan Africa, foreign exchange needs to be considered as an input of production just like labour and capital, since imported capital and intermediate inputs are all dependent mainly on the availability of foreign exchange and then on its price, the exchange rate. The important question is how to capture the effect of exchange rate and

availability of foreign exchange on investment and production within the DSGE framework.

We argue that introducing the availability and cost of foreign exchange constraint to firms can also capture the credit constraint discussed above. The reason is that firms need credit either for initial investment or expansion which entails import of capital or for working capital most of which is for imported intermediate inputs. In all the cases the demand for credit is indirectly demand for foreign exchange.

3.4 Access of the economy to international financial/asset markets

The other basic assumption of the standard open economy DSGE model is the assumption about the access of economic agents to international financial markets. Most works in the standard models assume that households have access to a complete and perfectly competitive international capital markets and hence hold foreign assets. Even those modified versions of the standard model meant to explain business cycles in developing countries (Kose, 2002 and Kose and Reizman, 2001) assumed that households have access to world financial markets. These later studies, however, assumed that these markets are incomplete and economic agents can hold only a single asset. This assumption implies that households can use international capital markets to transfer income across periods to smooth consumption or it amounts to saying that there exists international risk sharing through these markets. This, even for developed countries, is not always true as the recent case of Greece, Ireland and the undetermined future of some other countries witnesses.

Many developing countries have capital controls which make it difficult for households to hold foreign assets. As for African countries, as argued by Stiglitz, et al (2006: 57), they "...have not been able to attract the interest of foreign investors to begin with" let alone to talk about the nature of assets that households hold. A recent study by Hostland (2009) finds that low-income countries have less access to global private debt markets and heavily depend on official development assistance and concessional loans.

There are various explanations for this inability of low income countries to borrow in international markets. Eichengreen et al (2003), for example, attributes it to what they call the "original sin" which is the inability of the countries to borrow in their own currencies. The fact that the loans are denominated in foreign currencies reduces the ability of the

countries to access these markets. Because the ability of the countries to repay their debt is dependent on many factors some of which are beyond their control. Any event that reduces the purchasing ability of the outputs of these countries will influence their debt repayment abilities. Since lenders know this, they are reluctant to lend money to these countries. Eichengreen et al (2003) further argue that the institutional strength, macroeconomic stability, and credibility of policies that are some times referred to as determining the access to loan in own currency do not have strong evidence. Some countries with the same attributes might be discriminated in these markets: some borrowing in own currency others in foreign currency.

The literature on this issue is enormous and factors mentioned to be determinants of access of the country to international credit markets are many. But one thing is clear. That is, low income countries have imperfect access to these markets. As discussed in Eichengreen (2003) and elsewhere in detail this imperfect access to these markets has important implications for the ability of these countries to smooth the effects of shocks.

We argue that macroeconomic modeling for low-income countries must take this imperfect access to international financial markets into account. It is only within such a model that the differential effects of shocks on these countries can be understood.

3.5 Monetary policy

The monetary policy rule that is followed by the monetary authorities in SSA is different from that of standard DSGE literature – the simple and modified Taylor rules. This emanates mainly from the differences in the macroeconomic problems that the monetary authorities in these countries encounter compared to monetary authorities in developed countries. The monetary policy regimes are among the areas where the distinction between developed and less developed countries, like those in SSA, is vividly observed. In the past, as was the case in other developing and low income countries, monetary policy in SSA was characterized by financial repression. Financial repression, as discussed by McKinnon (1973) and Shaw (1973) cited in Agenor and Monteil (2008), is a term coined to express the condition where extensive government intervention in the financial market creates a small financial sector. That is, through direct and administrative controls of the interest

rate on deposits and lending, as well as required reserve ratio, the government creates a situation of credit rationing and development of informal (parallel) credit markets.

Though recent studies report significant moves by many African countries away from the practices of financial repression, still the problems that monetary authorities are confronted with in these countries are quite different from those of their developed country counterparts. Adam et al (2009) elaborate these problems and their implications for the choice of monetary policy rule by most of African countries. According to Adam et al (2009), the change in policy regimes from administrative controls in the foreign exchange and financial markets happened at a time when both prices of export commodities and inflows of official aid and FDI into these countries were increasing. Furthermore, it is almost a stylized fact that the prices of exports of these countries, which are primary commodities, are highly erratic, and studies (e.g. Bulir and Hamann, 2003, and 2008) show that aid flows from developed to low-income countries are also highly volatile. These events are sources of problems for monetary authorities in deciding which monetary policy rule to choose. First, the authorities are concerned with how to maintain the competitiveness of the economy by preventing the exchange rate from appreciation in the face of the inflows discussed above. Second, the monetary authorities in these countries need to decide whether the foreign exchange market intervention to maintain competitiveness should be sterilized to maintain the monetary base which in turn has ramifications on interest rates. Hence, Adam et al (2009: 465) argue that monetary authorities face a trade-off between “nominal (and real) exchange rate volatility on the one hand and high and volatile interest rates on the other, where the latter, in turn, raise concerns about private investment, the lending behavior of the banking system, and the quasi-fiscal burden of increased domestic borrowing”. This trade-off between monetary policy rules in the region is also emphasized by Peiris and Saxegaard (2007). This implies that the simple or modified Taylor rule employed in the DSGE literature where there is a policy interest rate and inflation and output gap are targeted does not seem appropriate for modeling of monetary policy rule in SSA.

The monetary policy rule that takes into account the problems facing many of the SSA countries is the one developed by Adam et al (2009). Though this model is constructed to

deal with the policy responses to manage aid inflows in these countries, it is a reasonable model in capturing the specificity of a typical SSA. Revisiting this model and looking into extensions of it seems productive research avenue in the process of building New Keynesian DSGE model for a SSA economy.

4 Literature on New Keynesian DSGE for SSA

There are few works conducted within the framework of New Keynesian DSGE models for SSA countries, excluding South Africa for which there are many works. Though the models in these works are developed to study various issues and therefore they ought to be evaluated within the context of the objectives they were meant for, we briefly discuss them with respect to the specificities of the SSA economy discussed above.

There are two works that are estimated from actual data of countries. Peiris and Saxegaard (2007) is the first estimated DSGE model for a country in the region. They estimate a New Keynesian DSGE model for monetary policy analysis using data of the economy of Mozambique. Peiris and Saxegaard recognize and incorporate in their model the credit frictions that firms are facing and a version of the monetary policy reaction function developed in Adam et al (2009). According to their model, firms borrow to cover their working capital at a premium where the premium is dependent on their debt to asset ratio. They assume that the loan markets perfectly competitive. However, as discussed previously, firms in SSA face imperfect loan markets. Unlike the traditional Taylor rule, Peiris and Saxegaard (2007) introduce a reaction function for monetary policy where the monetary authority influences the supply of money in the economy through foreign exchange and government bond transactions. Except these two modifications, i.e., the credit constraint faced by firms and the monetary policy rule, this is the standard closed economy New Keynesian DSGE model of Christian, et al (2005) version. Houssa et al (2009) is another work that estimate an open economy version of New Keynesian DSGE model using Ghanaian data. Their model is a version of Adolfson et al (2007) which is itself an open economy version of Christiano, et al (2005). Hence, none of the modifications we discussed above are either discussed or incorporated in this paper.

In a recent work, Berg et al (2010) develop a multi-sector New Keynesian DSGE model

to analyze the macroeconomic effects of a scaling-up of aid and examine the implications of different policy responses. The model captures some features of low-income countries like the efficiency of public capital and realistic monetary and fiscal policy rules. They also model the household sector as consisting of the dynamic optimizing households and the rule-of-thumb households. Berg et al (2010) calibrated for the economy of Uganda. Dagher, et al (2010) calibrated this model to analyze the effect of oil windfalls on Ghanaian economy.

To sum up, there are few works that try to construct and estimate a New Keynesian DSGE models for countries in SSA excluding South Africa. Though some of these works attempted to introduce some specificities of the structure of the economies in the region into the standard model, they do not address the characteristic features we believe are crucial. For example, non of these paper discuss about the labour market and unemployment, which is the pressing problem of the region. Given that the labour market frictions and unemployment are recent developments in the standard model, it is not surprising they are missed in the models developed for the region. Similarly, the foreign exchange constraint that firms face in the countries of the region is not modeled in these papers. Hence, it is our belief that a fruitful model seems to combine the modifications that are already introduced and the modifications we indicated above.

5 Conclusion

In this paper we tried to review the developments of the New Keynesian DSGE models, their criticisms, recent developments and their applicability to a typical low-income country such as those in SSA. Our assessment shows that these models have many weaknesses that are raised by critics some of which are addressed by recent developments in the area. However, the criticism forwarded by behavioural economics is a serious challenge not only to these models but to all conventional economic models that are based on rational economic agents that form rational expectations about future values of key macroeconomic variables. Whether these models will develop to a full fledged empirically applicable framework that can be used to explain and predict the macroeconomy remains to be seen.

On the other hand, though the New Keynesian DSGE models are registering many progresses and redress many of their caveats, the current tendency of applying the same models to all types of economies is not justifiable. In this, we concur with Blanchard (2009:224) who argue that “...models are more similar in the structure than would seem desirable: Roughly the same models are used both in rich and in emerging economies, despite their different structures and shocks”. We argue that these models need modifications and changes to reflect the differences of the economies in their structure and the nature of shocks they face to be of use to specific countries. On the basis of this we identify that the foreign exchange constraint, labour market segmentation, access of the economies to international financial markets, and monetary and fiscal policy rules are among the components of these models that need modification and/or change for these models to be meaningfully applied to low income countries and SSA in particular. Furthermore, these modifications and changes have to be introduced step by step in order to assess the merit of each before all of them can be included into a medium scale model for a typical SSA economy. The advantage of introducing each modification at a time is that it helps isolating the attributes of each and decide on whether the modification is worth introducing.

References

- [1] Adam, Christopher; Stephen O’Connell, Edward Buffie, and Catherine Pattillo(2009) Monetary Policy Rules for Managing Aid Surges in Africa. *Review of Development Economics*, Vol. 13, No. 3: 464–490.
- [2] Adolfson, Malin, Stefan Laséen , Jesper Lindé, and Mattias Villani (2007) Bayesian estimation of an open economy DSGE model. *Journal of International Economics*, 72: 481–511.
- [3] Adrian, Tobias and Hyung Song Shin (2011) Financial Intermediaries and Monetary Economics. In *Handbook of Monetary Economics*, Vol. 3A, edited by Benjamin M. Friedman and Michael Woodford. Elsevier.

- [4] Agenor, P.R. and P.J. Montiel (2008) *Development Macroeconomics*, 3rd ed. Princeton University Press.
- [5] Akerlof, George (2002) Behavioral Macroeconomics and Macroeconomic Behavior. *American Economic Review*, 92(3): 411–433.
- [6] Akerlof, George (2007) The Missing Motivation in Macroeconomics. *American Economic Review*, 97(1): 5–36.
- [7] Akerlof, George and Robert Shiller (2009) *Animal Spirits. How Human Psychology Drives the Economy and Why it Matters for Global Capitalism*. Princeton University Press.
- [8] Alderman, Harold and Christina H. Paxson (1992) Do the poor insure? A synthesis of the literature on risk and consumption in developing countries. World bank Policy Research working papers, WPS 1008.
- [9] Berg, Andrew, Jan Gottschalk, Rafael Portillo, and Luis-Felipe Zanna (2010) The Macroeconomics of Medium-Term Aid Scaling-Up Scenarios. IMF Working Paper, WP/10/160.
- [10] Bigsten, Arne, Paul Collier, Stefan Dercon, Marcel Fafchamps, Bernard Gauthiers, Jan Wellem Gunning, Abena Oduro, Remco Oostendorp, Cathy Patillo, Mans Soderborn, Francis Teal, and Albert Zeufack (2003) Credit Constraints in Manufacturing Enterprises in Africa. *Journal of African Economies*, Vol. 12, No. 1:104-125.
- [11] Blanchard , Oliver (2009) The State of Macro. *The Annual Review of Economics*, 1:209–28. econ.annualreviews.org.
- [12] Blunch, Niels-Hugo; Sudharshan Canagarajah and Dhushyanth Raju (2001) The Informal Sector Revisited: A Synthesis Across Space and Time. Social Protection Unit, Human Development Network, The World Bank. Social Protection Discussion Paper Series, No. 0119.

- [13] Bosaca, J. E., R. Domenech and J. Ferri (2011) Search, Nash Bargaining and Rule of Thumb Consumers. *European Economic Review*, doi:10.1016/j.euroecorev.2011.03.002.
- [14] Bulir, Ales and Javier Hamann (2008) Volatility of Development Aid: From the Frying Pan into the Fire? *World Development*, Vol.36, No.10: 2048–2066.
- [15] Bulir, Ales and Javier Hamann (2003) Aid Volatility: An Empirical Assessment. *IMF Staff Papers*, vol 50, No.1:64-89.
- [16] Colciago, Andrea (2011) Rule-of-Thumb Consumers Meet Sticky Wages. *Journal of Money, Credit and Banking*, Vol. 43, No. 2–3 (March–April 2011): 325-353.
- [17] Campbell, John Y., and Gregory, N. Mankiw (1991) Permanent Income, Current Income, and Consumption. National Bureau of Economic Research Working Paper 2436.
- [18] Campbell, John Y., and Gregory, N. Mankiw (1989) Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence. In Olivier Blanchard and Stanley Fischer, eds., *NBER Macroeconomics Annual 1989*. Chicago University Press.
- [19] Carrol, Christopher D. (1997) Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis. *The Quarterly Journal of Economics*, Vol.CXII No. 1:1-55.
- [20] Castillo, Paul and Carlos Montoro (2010) Monetary Policy in the Presence of Informal Labour Markets. Banco Central de Reserva del Peru, DT. Working Paper series, No. 2010-009.
- [21] Chari, V. V (2010) Testimony before the Committee on Science and Technology, Subcommittee on Investigations and Oversight, U.S. House of Representatives. [http://democrats.science.house.gov/Media/file/CommDocs/hearings/2010/Oversight/20july/Chari_](http://democrats.science.house.gov/Media/file/CommDocs/hearings/2010/Oversight/20july/Chari_Testimony.pdf) Te
- [22] Chari, V.V and Patrick J. Kehoe (2008) Response from V.V. Chari and Patrick J. Kehoe. *Journal of Economic Perspectives*, Vol. 22 No. 1: 247–249.
- [23] Chari, V.V and Patrick J. Kehoe (2006) Modern Macroeconomics in Practice: How Theory Is Shaping Policy. *Journal of Economic Perspectives*, Vo. 20, No. 4: 3–28.

- [24] Charmes, Jacques (2000) The Contribution of Informal Sector to GDP in Developing Countries: Assessment, Estimates, Methods, Orientations for the Future. 4th Meeting of the Delhi Group on Informal sector Statistics, Geneva 28-30 August 2000 <http://www.wiego.org/papers/charmes7.pdf>.
- [25] Christiano, Lawrence, Martin Eichenbaum, and Charles L. Evans (1999) Monetary Policy Shocks: What Have We Learned and to What End? In *Handbook of Macroeconomics*, Vol. 1A, edited by John B. Taylor and Michael Woodford. Elsevier.
- [26] Christiano, Lawrence, Martin Eichenbaum, and Charles L. Evans (2005) Nominal rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, Vol. 113, No. 1: 1-45.
- [27] Christiano, Lawrence J., Mathias Trabandt and Karl Walentin (2010) Introducing Financial Frictions and Unemployment into a Small Open Economy Model. <http://goe.ier.hit-u.ac.jp/JEDC2010/doc/3-1.pdf>.
- [28] Christiano, Lawrence J., Mathias Trabandt and Karl Walentin (2011) DSGE Models for Monetary Policy Analysis. In *Handbook of Monetary Economics*, Vol. 3A, edited by Benjamin M. Friedman and Michael Woodford. Elsevier.
- [29] Cogley, Timothy and Takeshi Yagihashi (2010) Are DSGE Approximating Models Invariant to Shifts in Policy? *The B.E Journal of Macroeconomics*, Vol. 10, Issue 1, Article 27.
- [30] Colander, D., P. Howitt, A. Kirman, A. Leijonhufvud, and P. Mehrling (2008) Beyond DSGE Models: Toward an empirically based macroeconomics. *American Economic Review: Papers and Proceedings*. 98: 236-40.
- [31] Colander, D. (ed.) (2006) *Post Walrasian Macro: Beyond the DSGE Model*. Cambridge University Press.
- [32] Cooley, Thomas F. (1997) Calibrated Models. *Oxford Review of Economic Policy*, Vol. 13, No. 3: 55-69.

- [33] Curdia, Vasco and Michael Woodford (2009) Credit Frictions and Optimal Monetary Policy. http://www.columbia.edu/~mw2230/credit_0709.pdf.
- [34] Dagher, Jihad, Jan Gottschalk, and Rafael Portillo (2010) Oil windfalls in Ghana: A DSGE Approach. IMF Working Paper WP/10/116.
- [35] De Grauwe, Paul (2010a) Booms and Busts: New Keynesian and Behavioral Explanations. CESifo Working Paper No. 3293. www.CESifo-group.org/wp.
- [36] De Grauwe, Paul (2010b) The scientific foundation of dynamic stochastic general equilibrium (DSGE) models. *Public Choice* 144: 413–443. Springer Science + Business Media, LLC 2010.
- [37] De Grauwe, Paul (2010c) *Behavioral Macroeconomics*. Unpublished manuscript, Katholieke Universiteit Leuven.
- [38] De Grauwe, Paul (2010d) Animal spirits and monetary policy. *Econ Theory*, 09 June 2010. Springer-Verlag.
- [39] De Soto, Hernando (2000) *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. Basic Books.
- [40] den Haan, Wouter J. (1996) Heterogeneity, aggregate uncertainty and the short-term interest rate. *Journal of Business and Economic Statistics*, Vol. 14, No. 4: 399-411.
- [41] Eichengreen, Barry , Ricardo Hausmann and Ugo Panizza (2003) Currency Mismatches, Debt Intolerance and Original Sin: Why they are not the same and why it matters. NBER Working Paper Series, Working Paper 10036. <http://www.nber.org/papers/w10036>.
- [42] Fafchamps, Marcel (2004) *Market Institutions in Sub-Saharan Africa: Theory and Evidence*. The MIT Press.
- [43] Fernandez-Villaverde, Jesus (2010) The Econometrics of DSGE models. *SERIEs (Journal of Spanish Economic Association)* 1:3-49.

- [44] Fields, Gary S. (2009) Segmented Labor Market Models in Developing Countries. Cornell University ILR School, ILR Collection. <http://digitalcommons.ilr.cornell.edu/articles/162>.
- [45] Gali, Jordi (2008) *Monetary policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*. Princeton University press.
- [46] Gali, Jordi (2011) Monetary Policy and Unemployment. In *Handbook of Monetary Economics*, Vol. 3A, edited by Benjamin M. Friedman and Michael Woodford. Elsevier.
- [47] Gali, Jordi, Frank Smets and Raf Wouters (2011) Unemployment in an Estimated New Keynesian Model. http://www.crei.cat/people/gali/gsw_april_2011.pdf.
- [48] Gali, Jordi J., David Lopez-Salido, Javier Valles (2004) Rule-of-Thumb Consumers and the Design of Interest Rate Rules. *Journal of Money, Credit and Banking*, Vol. 36, No. 4: 739-763.
- [49] Gan, Wee-Beng, and Lee-Ying Soon (1994) Rational Expectations, Saving and Anticipated Changes in Income: Evidence from Malaysia and Singapore. *Journal of Macroeconomics*, 16:157–70.
- [50] Gerali, Andrea, Stefano Neri, Luca Sessa and Federico M. Signoretti (2010) Credit and Banking in a DSGE Model of the Euro Area. *Journal of Money, Credit and Banking*, Supplement to Vol. 42, No. 6:107-141.
- [51] Gertler, Mark and Nobuhiro Kiyotaki (2011) Financial Intermediation and Credit Policy in Business Cycle Analysis. In *Handbook of Monetary Economics*, Vol. 3A, edited by Benjamin M. Friedman and Michael Woodford. Elsevier.
- [52] Gertler, Mark, Luca Sala and Antonella Trigari (2009) An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining. *Journal of Money, Credit and Banking*, Vol. 40, No. 8: 1713 – 1764.
- [53] Goodfriend, Marvin and Robert G. King (1997) The New Neo-Classical Synthesis and the role of monetary policy. *NBER Macroeconomics Annual*.

- [54] Hansen, Lars Peter and James J. Heckman (1997) The Empirical Foundations of Calibration. *The Journal of Economic Perspectives*, Vol. 10, No.: 87-104.
- [55] Hartley, James E. (1996) Retrospectives: The Origins of the Representative Agent. *Journal of Economic Perspectives*, Vol. 10, No. 2: 169-177.
- [56] Hartley, James E. (1997) The Representative Agent in Macroeconomics. Routledge Frontiers of Political Economy , Routledge, London
- [57] Facts and Artifacts: calibration and the Empirical Assessment of Real-Business-Cycle Models. *Oxford Economic Papers*, 47: 24-44.
- [58] Houssa, Romain, Christopher Otrok and Radu Pustlenghe (2009) A Model for Monetary Policy Analysis for Sub-Saharan Africa. *Open Econ Rev.* Springer Science + Business Media, LLC 2009.
- [59] Low-Income Countries' Access to Private Debt markets. The World Bank Policy Research Working Paper 4829, The World Bank.
- [60] Judd, K. (1992). Projection methods for solving aggregate growth models. *Journal of Economic Theory*, 58: 410-452.
- [61] Judd, Kenneth L., Lilia Maliar, Serguei Maliar (2010) A Cluster-Grid Projection Method: Solving Problems with high dimensionality. NBER Working Paper Series, Working Paper 15965. <http://www.nber.org/papers/w15965>.
- [62] Kingdon, Geeta; Justin Sandefur and Francis Teal (2006) Labour Market Flexibility, Wages and Incomes in Sub-Saharan Africa in the 1990s. *African Development Review*, Vol. 18, No. 3: 392-427.
- [63] Kirman, Alan P. (1992) Whom or What Does the Representative Individual Represent? *Journal of Economic Perspectives*, Vol. 6, No. 2: 117-136.
- [64] Kose, M. Ayhan and Raymond Riezman (2001) Trade shocks and macroeconomic fluctuations in Africa. *Journal of Development Economics*, Vol. 65:55–80.

- [65] Kose, M. Ayhan (2002) Explaining business cycles in small open economies ‘How much do world prices matter?’ *Journal of International Economics*, 56: 299–327.
- [66] Krusell, Per and Anthony A. Smith, Jr.(1998) Income and Wealth Heterogeneity in the Macroeconomy. *Journal of Political Economy*, Vol. 106, No. 5 : 867-896.
- [67] Krusell, Per and Anthony A. Smith, Jr.(2006) Quantitative Macroeconomic models with heterogeneous agents. In Blundell, Newey, and Persson (Eds) *Advances in Economics and Econometrics: Theory and Applications*, Ninth World Congress, Econometric Society Monographs. Cambridge University Press, PP. 298-340. also available at www.econ.yale.edu/smith/paper15.pdf.
- [68] Kydland, Finn. E. and Edward C. Prescott (1982) Time to Build and Aggregate fluctuations. *Econometrica*, Vol. 50, No. 6, pp. 1345-70.
- [69] Kydland, Finn E. and Edward C. Prescott (1996) The Computational Experiment: An Econometric Tool. *Journal of Economic Perspectives*, Vol. 10, No. 1: 69-85.
- [70] Leff, Nathaniel H. and Kazuo Sato (1980) Macroeconomic Adjustment in Developing Countries: Instability, Short-Run Growth, and External Dependency. *The Review of Economics and Statistics*, Vol. 62, No. 2: 170-179.
- [71] Lim, G. C. and Paul D. McNelis (2008) *Computational Macroeconomics for the Open Economy*. The MIT press.
- [72] Lucas, Robert E. (1976) Econometric Policy Evaluation: A Critique. *Carnegie-Rochester Conference Series on Public Policy*, Volume 1: 19-46.
- [73] Maliar, Lilia, Serguei Maliar and Fernando Valli (2010) Solving the incomplete markets model with aggregate uncertainty using the Krusell–Smith algorithm. *Journal of Economic Dynamics and Control*, 34: 42–49.
- [74] Mankiw, Gregory N. (2000) The savers-spenders theory of fiscal policy. *American Economic Review*, Vol. 90 No. 2: 120–125.
- [75] Mattesini, Fabrizio and Lorenza Rossi (2009) Optimal monetary policy in economies with dual labor markets. *Journal of Economic Dynamics and Control*, 33:1469–1489.

- [76] Meeusen Wim (2009) The Economic Crisis and New-Keynesian DSGE models: an Evaluation. *Kwartaalschrift Economie*, 6: 249-276.
- [77] Whither the Microeconomic Foundations of Macroeconomic Theory? <http://www2.econ.iastate.edu/tesfatsi/MicroFoundMacroTheoryCritique.WMeeusen2010.pdf>.
- [78] OECD (2009) *Is Informal Normal?: Towards More and Better Jobs in Developing Countries*. OECD Publishing.
- [79] Peiris, Shanaka J. and Magnus Saxegaard (2007) An Estimated DSGE Model for Monetary Policy Analysis in Low-Income Countries. IMF Working Paper WP/07/282.
- [80] Polterovich, Victor and Vladimir Popov (2003) Accumulation of Foreign Exchange Reserves and Long Term Growth. <http://www.nes.ru/english/about/10th-Anniversary/papers-pdf/Popov-Polterovich.pdf>.
- [81] Pichler, Paul (2011) Solving the multi-country Real Business Cycle model using a monomial rule Galerkin method. *Journal of Economic Dynamics and Control*, 35:240-251.
- [82] Porter, R. and S. Ranney (1982) An Eclectic Model of Recent LDC Macroeconomic Policy Analysis. *World Development*, Vol. 10 No. 9 pp. 751-765.
- [83] Ranis, Gustav (2006) Is Dualism Worth Revisiting? In *Poverty, Inequality and Development: Essays in Honor of Erik Thorbecke*. Edited by Alain De Janvry and Ravi Kanbur. Springer.
- [84] Ratto, Marco, Werner Roeger and Jan in 't Veld (2009) QUEST III: An estimated open-economy DSGE model of the euro area with fiscal and monetary policy. *Economic Modelling*, 26:222-233.
- [85] Reiter, Michael (2009) Solving heterogeneous-agent models by projection and perturbation. *Journal of Economic Dynamics and Control*, 33: 649-665.
- [86] Ríos-Rull, José-Víctor (1997) Computation of Equilibria in Heterogeneous Agent Models. Federal Reserve Bank of Minneapolis, Research Department Staff Report 231.

- [87] Rosenzweig, Mark (2001) Savings Behaviour in Low-Income Countries. *Oxford Review of Economic Policy*, 17:40–54.
- [88] Sala, Luca, Ulf Soderstrom, and Antonella Trigari (2008) Monetary policy under uncertainty in an estimated model with labor market frictions. *Journal of Monetary Economics*, 55: 983– 1006.
- [89] Schwartz, Hugh (2010) Does Akerlof and Shiller’s *Animal Spirits* provide a helpful new approach for macroeconomics? *The Journal of Socio-Economics*, 30: 150-154.
- [90] Sims, Christopher A. (1996) Macroeconomics and Methodology. *The Journal of Economic Perspectives*, Vol. 10, No. 1: 105-120.
- [91] Snowdon, Brian and Howard R. Vane (2005) *Modern Macroeconomics: Its origins, development and current state*. Edward Elgar Publishing Inc.
- [92] Solow, Robert (2010) “Building a Science of Economics for the Real World” Prepared Statement. House Committee on Science and Technology Subcommittee on Investigations and Oversight. http://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/072010_Solow.
- [93] Solow, R. (2008) The State of Macroeconomics. *Journal of Economic Perspectives*, 22:243-249.
- [94] Stiglitz, Joseph E.; Jose Antonio Ocampo, Shari Spiegel, Ricardo Ffrench-Davis, and Deepak Nayyar (2006) *Stability with Growth: Macroeconomics, Liberalization, and Development*. Oxford University Press.
- [95] Tovar, Camilo E. (2009) DSGE Models and Central Banks. *Economics, The Open-Access, Open assessment E-Journal*. Vol. 3, 2009-16, May 6, 2009. <http://www.economics-ejournal.org/economics/journalarticles/2009-16>.
- [96] Trigari, Antonella (2009) Equilibrium Unemployment, Job Flows, and Inflation Dynamics. *Journal of Money, Credit and Banking*, Vol. 41, No. 1:1-33.
- [97] Woodford, M (2003) *Interest and Prices: Foundations of a theory of Monetary Policy*. Princeton University Press

- [98] Woodford, Michael. (2009) Convergence in Macroeconomics: elements of the New Synthesis. *American Economic Journal: Macroeconomics*. Vol. 1 No. 1: 267-279.
- [99] Woodford, Michael (2010) Financial Intermediation and Macroeconomic Analysis. *Journal of Economic Perspectives*, vol. 24, No. 4: 21-44.