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Breaking Free from Dynamic Stochastic General Equilibrium Model: An Alternative Macroeconometric Model for Africa

Alemayehu Geda

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This study introduces the Parsimonious Applied Dynamic Stochastic African Macroeconomic Model (PADS-AfriMod)—a tailored framework for macroeconomic forecasting and policy analysis by African central banks, treasuries, and financial institutions such as the African Export-Import Bank (Afreximbank). In contrast to Dynamic Stochastic General Equilibrium (DSGE) models, rooted in neoclassical, market-clearing assumptions and built for advanced economies, PADS-AfriMod reflects the structural and policy realities of African economies. These include persistent supply constraints, the limited effectiveness of interest rate mechanisms as policy tools, fiscal dominance resulting in deficit monetisation, and heightened vulnerability to external shocks such as commodity-price volatility. Grounded in Post-Keynesian-Structuralist principles and incorporating Keynesian expectations, the model captures structural features such as commodity-export dependence, foreign exchange constraints, and the pivotal role of food supply in inflation dynamics. The equations are estimated using autoregressive distributed lag (ARDL) error correction models with quarterly Ethiopian data (2000–2018) as an illustrative case. PADS-AfriMod performs well in historical tracking, forecasting, and policy simulation. It functions both as a concise representation of medium-sized applied macroeconometric models already used on the continent and as a replicable template for broader application. By critically evaluating the limitations of DSGE models and offering a contextually grounded alternative, this study contributes practical, evidence-based tools to inform policy and promote sustainable growth and macroeconomic stability in Africa.

Keywords: Macroeconomic modelling, African central banks, DSGE models, Keynesian economics, forecasting, structural macro models

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Alemayehu Geda

Sabbatical Research Fellow, African Export-Import Bank, Cairo
Department of Economics, Addis Ababa and Bahir Dar Universities

Abstract

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I. INTRODUCTION

Macroeconomic models serve as indispensable frameworks for forecasting aggregates, assessing shocks, and evaluating policy options. They remain central instruments for central banks, treasuries, and institutions such as the African Export-Import Bank (Afreximbank), which are charged with advancing growth and safeguarding stability. As Barry Diller aptly observed, "No one can solve an issue where there is no economic model yet" (Geda, 2024).

In advanced economies, dynamic stochastic general equilibrium (DSGE) models have become dominant for forecasting and policy analysis. However, their applicability in African economies is severely constrained by structural, institutional, and policy differences, including persistent supply constraints, underdeveloped financial markets, fiscal dominance, and reliance on primary commodity exports. Most African central banks—apart from relatively developed institutions such as the South African Reserve Bank—lack comprehensive macroeconomic modelling tools. Some countries, such as Kenya, rely on medium-sized aggregate demand–aggregate supply (AD-AS)-based macroeconometric models (Geda and Yimer 2022).

This study introduces a Parsimonious Applied Dynamic Stochastic African Macroeconomic Model (PADS-AfriMod) tailored specifically to African central banks, treasuries, and continental institutions such as Afreximbank. Grounded in Keynesian and Post-Keynesian/Structuralist foundations, it incorporates Keynesian expectations and reflects stylised facts of African economies—supply-constrained production, the limited efficacy of interest rates as a monetary policy tool, and pervasive external shocks. A prototype is constructed and tested using Ethiopian quarterly data (2000–2018). Core equations are estimated as single-equation error correction models using the autoregressive distributed lag (ARDL) econometric approach, underscoring the importance of time-series econometrics for applied macroeconomic models (Geda et al. 2024). The model tracks history, forecasts key indicators such as GDP growth and inflation, and supports policy simulation and external shock analysis. It serves two purposes: a succinct representation of existing medium-sized applied macroeconometric models in Africa (e.g., Kenya's KIPPRA-Treasury model) and a template for developing similar models across African economies.

Following the 2008-09 Great Recession, DSGE models failed to predict the crisis and later struggled to explain its causes or guide recovery. Fiscal policies long downplayed in DSGE-inspired policy rules—rebranded as "stimulus packages"—were central to recovery in the United States and Europe, both during the Great Recession and more recently during the COVID-19 pandemic, contradicting DSGE frameworks but aligning with Keynesian and Post-Keynesian perspectives. Views diverged post-2008: some declared DSGE models a failure (Romer 2016); others acknowledged weaknesses and called for major reformulations (Romer 2012; Storm 2021; Cheri et al. 2009; Vines and Wills 2018).

Despite broad recognition of the shortcomings of DSGE modelling—even in developed economies (Char 2010; Vines and Wills 2018)— international financial institutions such as the International Monetary Fund and World Bank continue to advocate its adoption by African ministries and central banks. This study evaluates these models and presents PADS-AfriMod as a more suitable framework for Africa.

The motivation for the study is that increasing promotion of DSGE models in African central banks despite documented failures in developed countries (Romer 2016; Stiglitz 2018; Krugman, 2018; Vines and Wills 2018). Since the 1980s, international financial institutions have shaped macroeconomic policy in Africa (Geda 2019), and in recent years, have trained African central bank economists in DSGE modelling to institutionalize these models continent-wide.[1] These market-clearing, rational-expectation-based models also shape macroeconomic thinking within a laissez-faire framework, despite their poor fit with African realities. They were tried and found wanting in the 1980s and 1990s under the structural adjustment programs promulgated by international financial institutions and do not reflect the successful policy mix used in East Asian industrialization (Geda 2018 2029; Mkandawire 2001; UNECA, 1989). A critical reassessment is warranted. By examining the limitations of DSGE models and presenting an alternative, this paper addresses the need for tools that better reflect African macroeconomic realities.

The paper is structured as follows: Section 2 critiques DSGE models in developed and African contexts, highlighting their theoretical and empirical shortcomings. Section 3 outlines the theoretical framework and equations of PADS-AfriMod. Section 4 describes the econometric approach, focusing on ARDL-based error correction models and alternatives. Section 5 presents the Ethiopian application. Section 6 concludes with implications for African central banks, ministries of finance, and financial institutions, suggesting directions for future research.

2. AGAINST DYNAMIC STOCHASTIC GENERAL EQUILIBRIUM MODELS IN AFRICA: A CRITIQUE

2.1. Major weaknesses of dynamic stochastic general equilibrium models in developed economies

The 2008-09 crisis exposed critical weaknesses in DSGE models, particularly their failure to integrate the financial sector with the real economy. The first key shortcoming of the models is their treatment of the consumption Euler equation linking consumption to asset returns. Often disconnected from financial variables, that treatment leads to poor modelling of asset-price bubbles (Pesaran and Smith 2011; Romer 2016; Romer 2012; Miao 2016). The assumption of a unique deterministic steady state further limits explanations of deviations from fundamentals under rational expectations (Pesaran and Smith 2011; Miao 2016). Representative agent-modelling restricts the capture of financial dynamics (Marglin 2021; Shaikh 2016; Stiglitz 2018; Colander et al. 2008). Despite attempts at repair, (Vines and Wills 2018) reconciling finance and the real economy remains problematic.

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[1] I learned of the use of the models by the International Monetary Fund and the World Bank while presenting a lecture in Arusha, Tanzania on macro modelling to experts from the central banks of thirteen African countries. Some participants had already been trained in DSGE modelling. The lecture was organized by the Macroeconomic and Financial Management Institute for Eastern and Southern Africa. In my presentation, I was critical of the DSGE models in my lecture. During the tea-break, I was challenged by one of the experts that came from Kenya to come-up with an alternative because, she said, “We experts working on applied issues don’t know such theoretical pitfalls,”. “It is your responsibility to inform us.” This exchange became one of the inspirations for this study. It is also worth noting that, before the recent shift toward DSGE models, the International Monetary Fund and the World Bank promoted the International Monetary Fund’s “financial programming model” and the World Bank’s “Revised Minimum Standard Macro Model” (RMSM-X), including its various extensions (X), in developing countries, including those in Africa. RMSM-X combines the World Bank’s simple Harrod-Domar growth model (later reduced to a Solow-type neoclassical growth model) and Polak’s model of “the monetary approach to the balance of payments” which was central to International Monetary Fund practice (Geda 2024).

Second, key parameters of the models—utility function and the intertemporal elasticity of labor supply—often deviate from values observed in micro-econometric studies. This demonstrates deficiency in realism of assumption (Chetty et al. 2011; Geda 2017).

Third, the models assume lagged price adjustment with flexible nominal wages, implying pro-cyclical movement in real wages. This contradicts evidence that wage contracts tend to be longer-term and wage adjustments occur less frequently than price changes (Azaridis 1975; Yellen 1984; Shapiro and Stiglitz, 1984; Stiglitz 1976; Druant et al. 2009). Although New Keynesian models attempt to account for these rigidities, limitations persist.

Fourth, DSGE models often underemphasize fiscal policy. When included, they often predict debt-financed spending will stimulate output and employment and crowd out private consumption via negative wealth effects. This assumption is questionable, as it does not align with the Keynesian income multiplier effect (Rannenberg et al. 2015; Stiglitz 2018; Marglin 2021). Instead, standard DSGE models often predict that increased government spending leads to a decline in private consumption due to negative wealth effects, unless allowing rule-of-thumb (non-Ricardian) households or financial frictions (Rannenberg et al. 2015; Stiglitz, 2017). For a more realistic representation, Rannenberg et al. (2015) and Stiglitz (2018) argue that macroeconomic models should incorporate rule-of-thumb households and financial accelerators, which better capture consumption behavior and the dynamics of economic fluctuations.

Fifth, DSGE models characterize business cycles as steady-state responses to external shocks, including technology, contrasting with classic theories emphasizing endogenous dynamics (Minsky 1982, 1986; Keynes 1936; Kalecki 1971) The latter's frameworks emphasize internal dynamics, particularly shifts in investors' and financial intermediaries' "animal spirits"—marked by optimism during boom phases and caution during downturns, which influence investment decisions (Marglin 2021; Stiglitz 2018; Pesaran and Smith 2011; Kalecki 1971).

Sixth, DSGE models often omit global trade and financial linkages, operating as closed economy frameworks. Small open economy variants exist but remain limited. As Pesaran and Smith (2011) note, "globalization is apparent in many areas except within DSGE models."

Seventh, DSGE models lack robust theoretical foundations reflecting firm, household, and market behaviour, a perspective shared by Stiglitz (2018) and emphasized earlier by Keynes (1936). Stiglitz (2018) noted, if credit availability is more significant than interest rates, models which ignore credit rationing miss essential mechanisms and are based on poor theory that lacks realism of assumption (see also Storm 2021; Hendry and Muellbauer 2018; Colander et al. 2008; Geda 2017).

Eighth, DSGE models are widely criticized for their empirical shortcomings, particularly in developed economies. A key issue lies in the parameter estimation process, which often relies on calibration and Bayesian econometric methods. When applied to DSGE models, these approaches frequently reduce macro-econometrics to curve fitting, using arbitrarily selected moments that fail to align with real-world data. Standard statistical criteria are frequently disregarded (Stiglitz 2018; Korinek 2018).

Stiglitz (2018) draws attention to Korinek's (2018) incisive critique of key empirical shortcomings in DSGE models. These include the unwarranted detrending of variables, arbitrary selection of moments for data comparison, the absence of a robust statistical measure for assessing model fit, and the imposition of constraints that contradict microeconomic evidence—despite claims of micro-foundational rigor (Fernandez-Villaverde 2010). Such empirical weaknesses further erode the credibility of DSGE models, underscoring the need for alternative macroeconomic approaches more attuned to real-world complexities.

Solving DSGE models require significant simplifications (Stiglitz 2018), leading to strong parameterizations such as constant elasticity utility functions. These assumptions are often contradicted by empirical data, particularly regarding identical portfolios and homothetic preferences. Even with these assumptions, large DSGE models can only be solved for linear approximations and small shocks, making it difficult to analyze major economic shocks. Aldred (2019) also highlights the reliance on normal distribution and its limitations in addressing financial uncertainties and crises.

In response to such shortcomings, the Rebuilding Macroeconomic Theory Project initiated by David Vines and Samuel Wills of Oxford University (2016-2018) surveyed leading macroeconomists: the Oxford Review of Economic Policy special issue (2018) summarises diverse views from leading macroeconomists worldwide on the future of macroeconomic modelling, with a particular focus on DSGE frameworks. Some argued to retain and improve DSGE modelling (Blanchard 2018; Lindé 2018), while others call for empirically grounded new better models (Hendry and Muellbauer 2018; Stiglitz 2018; Krugman 2018). Given the depth of analysis, readers are encouraged to consult the journal for a more comprehensive understanding of the debates surrounding macroeconomic theory and its future. Still, among the differing viewpoints, there is a broad consensus that macroeconomic theory needs a new direction.

That direction should bridge short- and long-run macroeconomics, incorporate global economic dynamics (McKibbin and Stoeckel 2018), refine structural Keynesian models with detailed microeconomic foundations in finance (Wren-Lewis 2018; Ghironi 2018; Krugman 2018), adopt interdisciplinary approaches (Haldane and Turrell 2018), and distinguish theoretical from policy models, with the latter emphasizing empirical fit (Blanchard 2018; Vines and Wills 2018).

Several authors advocate for macroeconomics to move beyond simplistic DSGE models that are based on rational expectations (Haldane & Turrell, 2018; Hendry & Muellbauer, 2018; Stiglitz, 2018). Krugman (2018), in fact, argued basic IS-LM models provide better insights into the underpinnings of and policy responses to the financial crisis of 2008-2009 although further research on price dynamics remains necessary (Krugman 2018). Blanchard and Wren-Lewis (2018) recommend separating theoretical and policy models to enhance realism and relevance. Proposed improvements include modifying micro-foundations to incorporate heterogeneous agents, integrating the financial sector, and reducing reliance on the rational expectations hypothesis (Vines and Wills 2018). Given these critiques, it is legitimate to ask why DSGE continues to dominate teaching and practice in industrialized economies.

2.2. Inapplicability of Dynamic Stochastic General Equilibrium models in African economies

Macroeconomic schools of thought have long underpinned policy. Back in 1936 Keynes famously remarked:

> “Practical men who believe themselves to be quite exempt from any intellectual influence are usually the slaves of some defunct economist. …Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler

> of a few years back…The power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas. …it is ideas, not vested interests, which are dangerous for good or evil."

A central concern on the African continent is the enduring influence of the "ideas" of international financial institutions—notably the World Bank, International Monetary Fund, and World Trade Organization—on macroeconomic policy design and implementation. These institutions have championed neoclassical market-clearing frameworks such as DSGE, emphasizing liberalisation, deregulation, and laissez-faire economic policies (Mkandawire 2005; Geda 2019). Beyond prescriptions, these models embody ideological underpinnings that shape institutional architecture and policy orientation at the macro level. This section assesses how core DSGE assumptions distort our understanding of African realities, challenging effective development-oriented macroeconomic policymaking.

First, given their shortcomings in developed economies (Section 2.1), DSGE applicability in developing countries is questionable. Distinct economic, institutional, and political structures shape economic agent behaviour in ways not captured by DSGE models (Taylor 1983; Geda 2002, 2017). Thus, critiques of DSGE models in advanced economies are also relevant for developing nations, including those in Africa (Adam et al. 2009).

Second, market-clearing assumptions employed in DSGE models fit poorly to African economies. African markets often exhibit segmentation and persistent supply constraints (Taylor 1983; Weeks 1989, 2011). The absence of involuntary unemployment in DSGE models is at odds with structural and disguised unemployment common in Africa. Open economy variants of DSGE models typically assume unrestricted access to global financial markets and credit, yet African economies face credit rationing, often influenced by geopolitical factors (Geda 2002).

Third, DSGE modelling fails to adequately capture medium- to long-term growth determinants such as innovation, human and physical capital accumulation, and institutional development. These factors are particularly critical for Africa, where achieving sustained growth and structural transformation remain key challenges. A more comprehensive macroeconomic framework must integrate technological progress, investment in fundamental research, technology transfer, and the development of inclusive political and economic institutions. Short-term stabilisation models should align with these goals or clarify short-run effects. DSGE modelling is fundamentally ill-suited to this task (Storm 2021; Sisay 2011; Stiglitz 2017; Adam et al. 2009; UNECA, 1989).

Fourth, representative agent modelling methodology is not only problematic in its formulation and implications (Box 1) but also in its inability to reflect the heterogeneity of economic agents—a critical aspect of African economies that encompass both formal and informal firms and households (Geda 2017; Taylor 1983; FitzGerald 1993; Box 1). Aggregation of the entire economy into a single sector is particularly problematic where structural change—shifting resources from low-productivity sectors such as agriculture to higher-productivity sectors such as manufacturing—is central (Weeks 1989, 2012). In developing countries, market imperfections (limited access to credit, mismatches in labour market supply and demand, informality) hinder optimal allocation. Short-term macroeconomic models for Africa must incorporate the implications of structural changes.

Fifth, many African economies rely on primary commodity exports for foreign exchange due to historical trade patterns (Geda 2019). Global commodity markets drive their foreign earnings, economic growth and contribute to debt and volatile economic fluctuations. For example, the state of Zambia's economy is closely linked to global copper prices (Geda 2019). The focus of DSGE models on capital, labour inputs, and economic shocks from technological changes neglects a more crucial variable - global commodity price. This limits their applicability in Africa.

Sixth, monetary authorities in these regions face a trade-off between "nominal (and real) exchange rate volatility on one hand and high and volatile interest rates on the other" (Adam et. al 2009). This raises concerns for private investment, the lending behaviour of the banking system, and increased domestic borrowing and indebtedness. The straightforward Taylor rule utilized in DSGE models, in which a policy interest rate responds to inflation and output gaps, may not be appropriate for modelling monetary policy rules in Africa.

Seventh, detailed specifications of these models in Africa are limited and require significant adaptation, as follows:

(i) To account for pivotal variables of inflation dynamics in Africa, the inflation equation may need to be disaggregated into food and non-food inflation, reflecting the significant impact of food supply on inflation rates in many African countries. Inflation needs also to be linked with exchange rate dynamics, and the endogenous money supply (Geda and Tafere 2020). It is also imperative to link these considerations with the policy rule equation, particularly regarding how authorities and the banking system manage the money supply. Such stylized facts are not reflected in standard DSGE models.

(ii) The relationship between demand for goods and services and real interest rates, captured by one of the critical equations in DSGE models for advanced economies, may not accurately represent conditions in Africa, where capital markets are underdeveloped and open market operations are challenging. (Weeks 2010; Geda 2024).

(iii) Standard DSGE models rely on the nominal interest rate as a policy instrument. However, it is an inadequate policy tool in African countries. In Kenya—a relatively advanced African economy with a well-developed financial sector—the nominal interest rate has not proven effective in influencing changes in the real sector. Other policy-tools such as the cash reserve ratio and direct credit have been more effective (Were et al. 2014; Cheng 2006).

(iv), DSGE models assume interest rates can stabilize aggregate demand if appropriately adjusted in response to inflation and output gaps within the policy rule equation. In this model, lowering interest rates aims to provide a policy tool to manage aggregate demand failure and suboptimal firm operations in wealthier nations during economic downturns, as emphasized by Keynes and Kalecki. In Africa, supply bottlenecks often mean demand stimulus (if at all is achieved through interest rate) risks higher inflation and currency depreciation (Geda 2024). Realistic modelling of the supply side of these economies is imperative to adapt them for Africa.

(v) DSGE and AD-AS models often overlook the role of external factors such as climate shocks, commodity prices, and foreign exchange availability (including remittances, aid, and debt-creating flows) in determining the level and variability of economic growth and activity in most African countries.

In summary, there is urgent need for a realistic macroeconomic model tailored to African economies as a viable alternative to DSGE. The next section introduces such a model. The model offers a more accurate representation of Africa's macroeconomic dynamics, enhancing its utility for forecasting and policy analysis across the continent. It can be adapted to country-specific contexts and expanded to medium-scale applied macroeconometric models of 100-200 equations useful for preparing medium-term plans, annual budgets, and policy simulations. This approach aligns with established applied macroeconomic models such as those of the KIPPRA-Treasury and the Central Bank of Kenya and the Zambia's Treasury Macor model, ZAMOD (Geda and Yimer 2022).

3. PADS-AfriMod: A CONTEXTUALLY RELEVANT MACROECONOMIC FRAMEWORK

3.1. Overview of the modelling approach

PADS-AfriMod rests on five key equations. It adapts the standard AD-AS models (Keynes 1936; Hicks 1937; Modigliani 1944), incorporating insights from Mankiw (2014) and Geda and Yimer (2022). Innovations include: (i) introducing time to all variables to render equations dynamic; (ii) adding random error terms to demand and supply equations to make them stochastic; (iii) modifying equations to reflect African economic conditions; and (iv) introducing a policy rule relevant to African monetary and fiscal authorities. Unlike DSGE models, this approach replaces the exogenous money supply assumption with a post-Keynesian perspective on endogenous money (Davidson 1994; Geda, 2024). These innovations yield a dynamic and stochastic model suited to African contexts.

Expectation formation in PADS-AfriMod is Keynesian, approximated by adaptive expectations with fundamental uncertainty. This reflects limited availability of information and capacity for policy makers and agents in developing countries to accurately predict future outcomes amid climactic, political, and global commodity price uncertainties (Geda 2024). It also addresses the impracticality and challenges of the rational expectations hypothesis (Pesaran and Smith 2011; Pesaran 1997). Empirical studies in Africa suggest that even sophisticated economic agents rely more on Keynesian than rational expectations (Geda and Weeks 2018).

Even if economic agents in Africa are assumed to behave according to the rational expectation hypothesis, inter-temporal optimization calculations in DSGE models typically require expectations far into the future (Pesaran and Smith 2011). Survey measures of distant expectations are rarely available. Thus, even with survey measures, it would be necessary to model the expectations formation process to estimate these more distant expectations, which modern DSGE models have failed to capture accurately (Pesaran and Smith 2011). Additionally, Pesaran (1997) argued it is not necessary to assume rational expectations for long-run modelling. Long-run relations can be developed in a theory-consistent manner within an intertemporal optimization framework without assuming rational expectation holds in every period. These long-run relations then form the steady-state solution of the economic model (Pesaran 1997).

Building on the above theoretical arguments on expectations and the empirical realities of African economies, this model adopts Keynesian expectations (Equation [3]) and integrates them into the Fisher equation (Equation [2]).

3.2 The model

The model begins with aggregate demand, given as:

$$Y_t^d = a + Y^d\,[(A[f(r,\varphi,Y)])_t + NX(f[RER, Y, Y^{*TP}, Z)_t] + \epsilon_t \qquad [1a],$$

where Y^d stands for aggregate demand. *A* is absorption, a function of real interest rate (r), profit rate (φ) or expected future return and real income (Y). φ could also be the availability of cash flows when self-financing/inside finance is important, as in Kalecki. (1957). As part of absorption, government consumption (G), investment, both public and private, ($I=I_g+I_p$) expenditures and taxes (T) could be thought to be partly exogenous and captured in the constant term "A" in Equation [1a] and "b_0" in Equation [1b]. The latter is the estimable version of Equation [1a]. They could also be thought of partly as a function of Y (for taxes) and as a function of r, φ and Y for I_g.

NX in Equation [1a] refers to net exports (net exports and imports of goods and non-factor services), set as a function of the real exchange rate, real income (Y) and income of trading partners Y^{*TP}. Real exchange rate is, in turn, defined as the product of nominal exchange rate (e) and the ratio of foreign (P^{*f}) to domestic (P) prices. Using separate import and export unit prices instead of a single price index for foreign prices would provide more detail, as changes in these prices affect the domestic economy differently. Using export prices in equations [1a] or [1b] allows omitting the trading partners' income (Y^{*TP}) from the equation. Z represents other factors affecting imports and exports, such as supply conditions and autonomous imports, proxied by lagged imports and exports. The variable ε_t represents an aggregate demand shock, assumed to be stochastic. In logarithmic form, we can simplify Equation [1b] by deflating all coefficients by ($1-b_2$) in equilibrium,

$$Y_t^d = b_0 + b_1 r_t + b_2 Y_t + b_3 \varphi_t + b_4(e_t) + b_{4a}(P^{*f})_t + b_{4b} P_t + b_5(Z_t) + \epsilon_t \qquad [1b]$$

Equations 2 and 3 define the Fisher real interest rate and expected (E) inflation (ΔP). In Africa, expectation formation is assumed to follow "Keynesian expectation," which includes adaptive expectation and Keynes' concept of fundamental uncertainty' (Geda 2024).

$$r_t = i_t - E_t \Delta P_{t+1} \qquad \text{The Fisher Equation} \qquad [2]$$

$$E_t \Delta P_t = \Delta P_{t-1} + U_k \qquad \text{Keynesian Expectation} \qquad [3]$$

where: U_k is an indicator of the impact of Keynes' fundamental uncertainty and [3] is reduced to adaptive expectation if U_k is zero.

Equations [4a] and [4b] offer the African aggregate supply equation, which, together with Equation [4c], replaces the Phillips Curve equation of a typical AD-AS or DSGE model of developed countries.

$$Y_t^s = [A K_t^{\alpha} L_t^{\beta} e^{\nu_t}] \qquad \text{Aggregate Supply} \qquad [4a],$$

where v_t is the supply shock indicator; K is capital stock, L is labour and A is an indicator of the total factor productivity; α and β are elasticity parameters of capital and labour, respectively.

The production function is represented in a Cobb-Douglas form, with its return to scale being determined by data during the estimation stage. Due to the significant role of food supply in influencing inflation in many countries, this output (Y^s) can be further divided into food and non-food sectors, if needed. In Equation [4a], total factor productivity is further defined as a function of climate change or weather conditions, such as the average rainfall level (R) for countries reliant on rain-fed agriculture, or its deviation from its long-period average, $\bar{R}$. Total factor productivity also depends on foreign exchange (FX) availability, which represents a significant constraint on production activity. This reflects the dependence of African economic growth on global primary commodity prices and capital inflows (Geda 2019). The FX variable can be measured by the negative balance of payments of a country, which in the African context includes private (remittance) and official (aid) transfers, debt-creating flows, foreign direct investment, as well as a country's export price (P_X,) and volume. The variable "A" in Equation [4a] will therefore be substituted with these variables (i.e., with R or (R- $\bar{R}$), P_X and FX). The remaining unexplained portion of "A" (total factor productivity), which is the residual, is assumed to indicate technology or efficiency ("a_0") as usual. In logarithmic and reduced form, Equation [4a] can be represented by Equation [4b].

$$Y_t^s = a_0 + a_1(R - \bar{R})_t + a_2 FX_t + \alpha K_t + \beta L_t + v_t \qquad [4b]$$

By incorporating [4b] into an augmented-Phillips Curve equation, considering both aggregate demand and changes in money supply (or its deviations from expected values due to policy), the aggregate supply equation can be expressed by [4c]. Notably, b_1 in Equation [4c] might also represent capacity utilization rate if there are significant supply-side issues or output restrictions due to foreign exchange problems, as discussed by Ndulu (1986, 1991) and Geda (2002).

$$P_t = EP_{t-1} + a_0 + b_1[Y_t^d - Y_t^s] + b_2 \Delta M_t^s \qquad [4c]$$

Given the assumed adapted expectation framework as a proxy for the Keynesian expectation in the short-run, [4c] could also be given as,

$$\Delta P_t = P_t - P_{t-1} = a_0 + b_1[Y_t^d - \{a_1(R - \bar{R})_t + a_2 FX_t + \alpha K_t + \beta L_t + v_t\}] + b_2 \Delta M_t^s \qquad [4d]$$

An alternative specification to the Cobb-Douglas-based formulation in [4a] and [4b] is to start from a generalized constant-elasticity of substitution production function, for which Equation [4a] is a special case. The function can then be further specified in a trans-log form, which could be used to replace Equations [4b] and its use in Equation [4d]. This specification allows for capturing issues in Africa, such as structural transformation, by letting the elasticity of substitution parameters vary over time (not pursued here).[2]

[2] Given the dynamic nature of growth and structural change in developing countries and the flexibility of a translog specification of production function which accommodates issues of change in the substitution parameter over time, the Cobb-Douglas production function in [4a] for two variables, capital (K) and labour (L), could be re-specified, in logarithms, as a translog production function given by: $LnY = \beta_0 + \beta_k \log(K) + \beta_L \log(L) + \beta_{kk} \log(K)^2 + \beta_{LL} \log(L)^2 + \beta_{Lk} \log(K)\log(L) + \mu_t$

Finally, the policy rule equation given by [5a] substitutes the interest rate-based policy rule of typical DSGE models, highlighting endogenous money, fiscal dominance, and the limited effectiveness of interest rates as a policy tool in Africa.

$$M_t^s = M_{t-1}^s + \rho + \theta_\pi (P_t - P_t^*) + \theta_Y (Y_t - Y_t^*) + \theta_R \Delta Res \qquad [5a],$$

where: Y* is the targeted GDP level (or a growth target), and Y is the actual or realized GDP level (or growth); P and P* show the actual and targeted level of prices as represented by the consumer price index (which can also be given by π and π^* that show actual and targeted inflation rates); ΔRes stands for change in reserves provided in the balance of payment that is related to the net inflow of capital, which also affects the money supply through its effect on the monetary base (from the side of the external sector). ρ stands for the change in money supply unrelated to either the stabilization policy related to P and Y or the change in reserves.

Unlike the conventional monetary policy rule in DSGE models, all theta (θ) parameters in Equation [5a] are anticipated to be positive, with the last parameter being positive if monetary policy sterilization is not implemented. This expectation arises because achieving a GDP growth level higher than the target or warranted level (Kalecki 1954 [2006], 1957) in saving-constrained economies can only occur through deficit monetization or external borrowing, resulting in positive values for θ_y and θ_R. This leads to inflation in food-supply-constrained economies, as observed by Kalecki (1954 [2006], 1957), establishing a positive relationship between price levels and money supply, thus rendering θ_π positive [3]. Additionally, it is important to acknowledge the trade-off between the ambition for rapid economic growth and the potential inflationary pressures in such supply-constrained African economies (Geda 2024). The ρ parameter reflects the money supply growth rate when targets are met, reducing the bracketed terms to zero (excluding the effects of reserve change on money supply). In this case, ρ indicates the normal money supply growth rate, typically aligned with real GDP growth (transaction demand).

From an econometric (estimation) perspective, using price and GDP levels in Equation [5a], rather than their growth rates, simplifies capturing long-run equilibrium and short-term dynamics through cointegration and error-correction models. The specification of Equation [5a] reflects the prevalence of fiscal dominance in African economies, highlighting both the accommodative role and endogenous nature of money supply in such contexts. From a policy standpoint, this formulation can be reconsidered by adopting Equation [5b] instead.[4] Equation [5b] emphasizes that in many African economies—Ethiopia being a prime example—fiscal dominance is the primary driver behind deficit monetization. When monetary policy plays an accommodating role, it often becomes a key source of inflation and rising public debt, especially given the structural bottlenecks

[3] Though difficult owing to fiscal dominance as described in Equation [5b] below and potentially having a contractionary effect on growth, this formulation also shows the need to restrain money supply to stabilize the macroeconomy when both variables (P and Y) are found above their target levels.

[4] An Alternative monetary policy rule: In African countries where the interest rate is believed to be effective as a policy instrument, the change in the money supply given in the policy rule equation [5a] should be replaced by real interest ([i-π], where "i "and "π" stand for nominal interest rate and inflation, respectively. The change in reserves should also be left out in this latter formulation. This yields the typical monetary policy rule used in DSGE models, which is given by Equation [5c].

$$i_t = \pi_t + \rho + \theta_\pi (\pi_t - \pi_t^*) + \theta_Y (Y_t - Y_t^*) \qquad [5c]$$

in the food supply sector (Geda and Tafere 2020). In this environment, money supply becomes an endogenous variable, shaped by the expansionary fiscal stance of governments pursuing ambitious growth targets, and by increased private sector credit (money creation) facilitated through commercial banks. This also aligns with Post-Keynesian interpretations of money supply endogeneity (Davidson 1994; Palley 1996; Lavoie 2009).

If a portion of the fiscal deficit is externally financed, the resulting accumulation of external debt—alongside its future servicing obligations—can feed back into the fiscal imbalance. Simultaneously, changes in the country's net foreign asset position (ΔRes) affect the monetary base, further reinforcing monetary accommodation. In this light, Equation [5b] may serve as a more appropriate fiscal and accommodative monetary policy rule, underscoring the primacy of fiscal policy over monetary policy in much of Africa (Weeks 2010).

$$M_t^s = M_{t-1}^s + \rho + \theta_\pi (Rev_t - Rev_t^*) + \theta_Y (ExP_t - ExP_t^*) + \theta_c (Cr_t - Cr_t^*) + \theta_f (F_t - F_t^*) \quad [5b],$$

where: Rev and Rev* stand for actual and targeted government revenue (excluding both private and official transfers/grants), and Exp and Exp* and Cr and Cr* stand for actual and targeted government expenditure and credit by commercial banks, respectively. F and F* stand for an actual and targeted level of foreign capital inflow, which is the sum of long- and short-term capital inflows (debt-creating flows), FDI, and private and official transfers. In the balance of payment, this could be summarized on a net basis by a change in reserves (ΔRes). All parameters, except θ_π , are positive.

In Equation [5b], (F-F*) could be replaced by the net change in foreign assets (i.e., change in reserves, ΔRes) affecting the monetary base and money supply. "F" is used to highlight potential sources of macroeconomic instability in the external sector. For more insight, "F" can be broken down into debt-creating flows (KI), foreign direct investment (FDI), and official and private transfers (Tr_{Off} and Tr_{pr}), net of the balance of payment deficit (i.e., $F=KI+FDI+Tr_{Off}+Tr_{pr}$; and $\Delta Res = F - BoP$ balance).

To operationalize Equation [5b], policymakers can replace the target variables marked with "*" as well as P* and Y* in Equation [5a] with their one-period lagged values, depending on the availability of information about ExP, Rev, Cr, and "F". This is tantamount to using the expected value of these variables at time "t", with adaptive expectation as a proxy for Keynesian expectation, excluding "fundamental uncertainty." This uncertainty is captured by demand and supply shocks and expert opinions about confidence in "conventional expectation" as noted by Keynes (1936; Geda 2024).

PADS-AfriMod shares some features with modern New Keynesian DSGE modelling but differs fundamentally. The aggregate relationships in DSGE models are derived by aggregating the inter-temporal optimization results produced by micro-level "representative" economic agents (consumption from households and investment from firms). These economic agents perform their optimization tasks within an inter-temporal framework based on the rational expectation hypothesis. These assumptions are considered crucial for New Keynesian and New Classical economists because they provide deep parameters essential for addressing criticisms of large-scale Keynesian macroeconometric models prevalent in the 1960s and 1970s. DSGE models are recognized for constructing macroeconomic models grounded in micro foundations and rational expectations that offer these "deep" parameters and address the "Lucas Critique" (Lucas 1976).

Using micro foundation-based aggregation from representative agent-based micro-level activity to derive macro variables and models significantly deviates from original formulations of how the macroeconomy functions (Box 1). Following the classical tradition of Ricardo and Marx, Keynes and Kalecki focused on the aggregate relationships among macro variables (Keynes 1936; Kalecki 1965, 1971). Consistent with this classical tradition, our model does not claim such micro foundations or representative agent-based modelling and aggregation to achieve macro-outcomes as DSGE models. This is not to suggest that proponents of the Kaleckian and Keynesian approaches disregard micro realities in their macro models. On the contrary, they incorporate these elements creatively to inform their macro models (for example, Kalecki's markup pricing approach in Kalecki (1965) and Keynes' concepts of marginal propensity to consume and the marginal efficiency of capital in Keynes (1936)). More generally, heterodox macroeconomists consider macroeconomic outcomes as emergent properties resulting from interactions at the micro, sectoral, and macro levels (see Box 1). Heterodox economists view macro-outcomes as dependent on historical and institutional contexts, among other factors (Shaikh 2016; Kalecki 1971; Keynes 1936; Taylor 1983; FitzGerald 1993; Geda 2018). These include whether a context is in a developed or developing country (Taylor 1983; Dutt 1992; FitzGerald 1993) and class-based distinctions, in which workers' marginal propensity to save might be zero, unlike that of capitalists and entrepreneurs, as posited by Kalecki and Kaldor. Mainstream economics, in contrast, assumes

Box 1: The whole is more than the sum of its parts: Emergent properties in Macroeconomics

Macroeconomics exists as a distinct field because aggregate outcomes cannot be understood simply as the sum of individual behaviours. The "representative agent" framework in mainstream models assumes that what holds for one individual applies to the economy. In practice, however, the economy is a complex system in which patterns emerge from the interaction of many heterogenous agents within specific institutional and structural settings.

Shaikh (2016) employs an analogy from physics to help clarify this idea. The ideal gas law—PV=nRT—describes how the pressure (P), volume (V), quantity of gas (n) and temperature (T) of a gas relate to one another (R being a constant). This macroscopic relationship was discovered empirically long before scientists understood that gases are composed of countless moving particles (Boyle 1662; Charles 1787; Gay-Lussac 1802) andpresented this as a significant empirical macroscopic hypothesis. With the rise of a new view or finding that gas to be made up of constantly moving particles – referred as the "Kinetic Theory of Gases"-, physicists faced the challenge of linking this reality viewable under a microscope with the well-established aggregate macroscopic law given by ideal gas law formula. To arrive at a solution, they showed that the law does not owe to the properties of any single particle but from the behaviour of many particles colliding with each other and with the container walls, The resulting individuals' masses in a given period are too complex to characterize analytically. Yet the collusions create the pressure exerted by the gas. The greater the volume of the gas, the greater the particles and, hence, the greater the collision with the walls of the container. Similarly, the greater the temperature, the more rapid the motion of the particles, and hence the greater the collision with the walls. Thus, with the help of appropriate statistical techniques, it becomes possible to arrive once again at the same macroscopic law **P.V=R.n.T**, but this time, as a relationship that emerges from the interaction of heterogeneous individual particles among each other and also with the shaping structure of the container's walls. The ideal gas law thus represents an emergent property: a stable aggregate pattern that arises from, but cannot be reduced to individual-level dynamics.

As Shaikh argues, the same principle applies to economic systems. Aggregate macroeconomic relationships, such as the Keynesian consumption function, can emerge from many different micro behaviours and interactions. In his analysis, four distinct consumption theories all produce the same macro-level function. This challenges the notion that macro-outcomes must rest on a single "representative" micro foundation, as assumed in standard DSGE models.

The field of agent-based modelling also supports the theory (Colander et al. 2008). It shows that macroeconomic stability, multiple equilibria, and systemic change can arise from decentralized interactions among heterogenous agents. The macro system both emerges from and influences micro behaviour.

4. ECONOMETRIC APPROACH AND AN ILLUSTRATIVE MACRO MODEL

PADS-AfriMod is designed as a straightforward applied macro model for African central banks, treasuries, and regional financial institutions. Only the aggregate demand and supply equations require detailed estimations via cointegration and error correction models. Parameters for the price and policy-rule equations can be generated from previous studies or estimated by using the ordinary least squares (OLS) technique, since the variables are stationary and do not require the cointegration approach. This data-based approach uses actual data, reflecting real-world conditions. This empirical procedure can be termed the "preferred econometric approach."

4.1. Preferred Approach: Autoregressive distributive lag error-correction model

4.1.1 Estimating the Aggregate Demand and Aggregate Supply Equations

As an illustration, this study estimates ARDL-based error correction models version of equations [1b] and [4b] above. This approach is simple to implement, accommodates I(0) and I(1) variables in a single equation framework, and, since it is formulated in a dynamic error correction models form, captures both short-term dynamics and long-term equilibrium relationships specified in the above five-equations-based theoretical model (Pesaran and Shin 1999; Pesaran, Shin and Smith 2001; Pesaran 1997). It also has excellent properties in small samples. Small sample data size is a common constraint in Africa, where comprehensive long-period time series data is often lacking. The following ARDL-based estimable error correction model equations are derived from the theoretical aggregate demand and supply equations of the model:

$$\Delta Y^{d}_{t-1} = \sum_{j=1}^{k} \delta_{1j} \Delta Y^{d}_{t-j} + \sum_{j=1}^{k} \delta_{2j} \Delta r_{t-j} + \sum_{j=1}^{k} \delta_{3j} \Delta \varphi_{t-j} + \sum_{j=1}^{k} \delta_{4j} \Delta e_{t-j} + \sum_{j=1}^{k} \delta_{j} \Delta p^{*f}_{t-j} + \sum_{j=1}^{k} \delta_{6j} \Delta P_{t-j} + \alpha_1 (\beta_0 + \beta_1 Y^{d}_{t-1} - \beta_2 r_{t-1} - \beta_3 \varphi_{t-j} - \beta_4 e_{t-1} - \beta_5 p^{*f}_{t-1} - \beta_6 P_{t-1}) + \varepsilon_t \quad \text{[E1]}$$

$$\Delta Y^{s}_{t} = \sum_{j=1}^{k} \delta_{1j} \Delta Y^{s}_{t-j} + \sum_{j=1}^{k} \delta_{2j} \Delta R_{t-j} + \sum_{j=1}^{k} \delta_{3j} \Delta FX_{t-j} + \sum_{j=1}^{k} \delta_{4j} \Delta K_{t-j} + \sum_{j=1}^{k} \delta_{5j} \Delta L_{t-j} + \alpha_1 (\beta_0 + \beta_1 Y^{s}_{t-1} - \beta_2 R_{t-1} - \beta_3 FX_{t-1} - \beta_4 K_{t-1} - \beta_5 L_{t-1}) + \varepsilon_t \quad \text{[E2]}$$

All variables in the estimable equations above (E1 and E2) are presented in both level and logarithmic forms, allowing error correction models to capture both long-run theoretical relationships and short run dynamics. For application within the illustrative macroeconomic model developed for Ethiopia, these were estimated using 72 quarterly observations (2000/01–2018/19) for each equation.

4.1.2 Estimating model closure and policy rule equation parameters

Once the two error correction model-based equations [E1] and [E2] are estimated, parameters for the aggregate price equations ([4c] and [4d]) and the policy rule equation ([5a]) can be calibrated from prior studies and empirical data or obtained using a simple OLS estimation on the first differences of all variables. In the Ethiopian application of PADS-AfriMod, the parameters for Equation [4c] are estimated by regressing the change in the price level on changes in money supply and GDP using the OLS technique .The latter serves as a proxy for the aggregate demand-supply gap—an appropriate approach given that supply typically lags demand in an adaptive expectations framework, which in this context approximates Keynesian expectations. Once the parameters b1 and b2 are estimated via Equation [4c], the aggregate supply and demand variables in that equation are replaced with their estimated error correction model versions when constructing the empirical macro model. The macro model is built in EVIEWS platform, though EXCEL offers a more transparent and accessible alternative, particularly for practitioners in ministries of finance and central banks.

Similarly, the parameters for the policy rule equation (Equation [5a]) can be estimated by regressing the change in money supply on changes in price levels, real GDP, and reserves using the OLS technique. This approach effectively replaces the deviation of price and GDP levels from their targets in Equation [5a] with the deviation of their current values from lagged values. This formulation aligns with the empirical counterpart of the adaptive expectations framework assumed in the model. Notably, the adaptive expectations formulation converges toward the Keynesian expectations framework—excluding fundamental uncertainty—as the data frequency increases (e.g., quarterly, monthly, or daily). This procedure is applied here in deriving model parameters for the Ethiopian version of PADS-AfriMod.

The adoption of single-equation error correction models is preferred over system-based estimation due to the complexity introduced by the empirical macro model's 16 variables. Managing such a high-dimensional system using rigorous econometric approaches—such as the structural cointegration vector autoregressive (SCVAR) framework and other system-based estimation methods outlined in Section 4.2—poses significant challenges. System-based estimation of cointegrating vectors becomes unreliable when the number of variables exceeds about eight, increasing the likelihood of an incorrect cointegration rank (Ho and Sørensen 1996). In high-dimensional systems, identifying the cointegrating space using economically meaningful restrictions—ones that are not rejected by the data—is often difficult (Assenmacher-Wesche and Pesaran 2008). This version enhances clarity while maintaining technical precision.

4.2 Alternative estimation approaches

Two alternative estimation approaches merit future research. The first, calibrating model parameters using actual data, common to DSGE models, can be extended by incorporating Bayesian estimation, which provides an empirical framework but has limitations. Specifically, it reduces the role of data and proper econometric (data-generating) methods in model formulation. A more refined variant combines a priori information with Bayesian econometric techniques, ensuring theoretical consistency while allowing for empirical validation.

The second, more rigorous estimation method that merits research is the SCVAR system-based framework (Garratt et al. 1998; Pesaran 1997). This method has partly informed the ARDL-based error correction model approach adopted in this study. One potential drawback of the ARDL approach, as applied here, is its reliance on a strong theoretical structure and single-equation estimation, which does not fully account for the simultaneity of model equations or the identification of structural coefficients from the reduced-form model (Johnston and DiNarod 1997). This limitation can be addressed by employing the SCVAR framework, which treats all endogenous variables within a theoretically informed VAR system. The process begins by defining the macroeconomic long-run structure, as outlined in Section 2, and embedding it within an unrestricted

VAR model. Critical endogenous variables are then estimated simultaneously, incorporating feedback mechanisms through short-run dynamics as dictated by long-run economic relationships (Garratt et al. 1998; Pesaran 1997).[5]

Employing the SCVAR approach to construct a quarterly macro model for the United Kingdom economy, Garret et al. (1998) achieved excellent results. The model, they found, was highly effective for analysing and assessing external shocks. After comparing SCVAR with other macro modelling and estimation approaches, they concluded it offers a strong balance between theoretical consistency in long-run relationships and flexibility in estimating short-run dynamics within a VAR framework. Additionally, they emphasized the transparency of the approach from both theoretical and empirical perspectives, which enhances impulse-response analysis and forecasting capabilities. Similarly, Gali (1992) showed that VAR-based IS-LM-Phillips model can rival DSGE models in successfully tracking the economy of the United States. The dynamic properties of the estimated model, along with its impulse-response analysis, closely align with theoretical predictions and observed economic trends. Given these successful applications, further exploration of this econometric approach in the context of the model developed in this paper presents an exciting avenue for future research.

5. EMPIRICAL APPLICATION: THE ETHIOPIAN CASE

5.1. Model construction and data sources

An empirical PADS-AfriMod for Ethiopia has been developed using the EVIEWS software platform, using quarterly data for 2000/01 to 2018/19. Parameters for aggregate demand and supply are estimated using the ARDL procedure outlined earlier. The OLS technique is applied to estimate parameters for the aggregate price-based model closure equation (Equation [4c]) and the policy rule equation (Equation [5a]). The final macro model consists of 16 variables, four endogenous (aggregate demand, aggregate supply, aggregate price level, and money supply), policy instruments (interest rate and nominal exchange rate) and truly exogenous factors (climate change/rainfall, export and import prices, foreign capital inflows, labor force growth, and reserve changes). Pre-determined variables include lags of imports, exports, profit rate, and capital stock. Exogenous variables were forecast over 12 out-of-sample quarters (2019/20–2021/22) using an ARIMA (autoregressive integrated moving average) model. With these forecasted values, equilibrium values for the endogenous variables are derived by solving the model accordingly. The Appendix provides further details on the approach used to enhance model usability and construct bridging equations needed to solve the model.

5.2. Historical tracking performance

Before use for forecasting, policy evaluation, and external shock impact analysis, the model was repeatedly run and calibrated to align with historical data through minimal adjustments to constants. Figures 1a and 1b illustrate the model's performance in tracking the historical evolution of key

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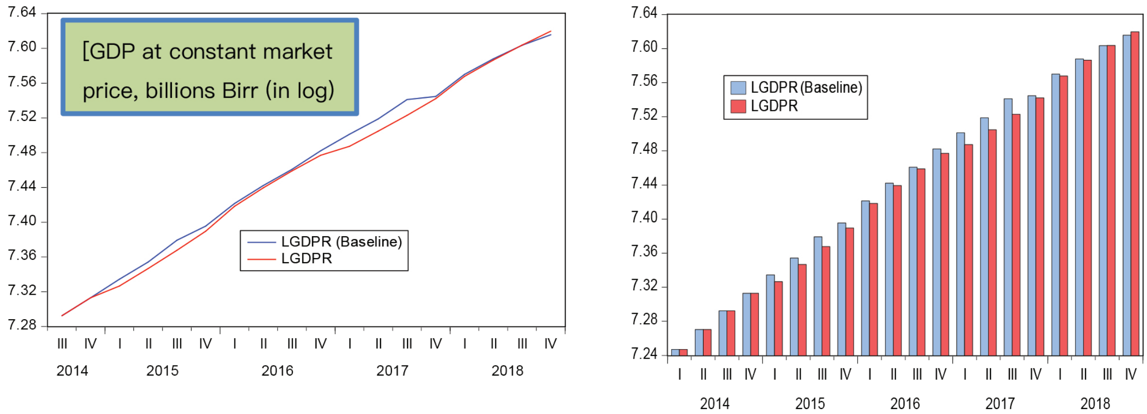
[5] Pesaran (1997) argued that, for the purpose of empirical analysis, "such theory-consistent long-run relations can be embedded within a suitable multivariate dynamic model, such as the VAR model with unrestricted short- run coefficients. Alternatively, the dynamics of the adjustment to long-run equilibrium can be restricted by utilising the intertemporal nature of the underlying optimisation problem as it is done under the rational expectation hypothesis based DSGE models. Which one of these two approaches is followed very much depends on how seriously the investigator takes the short-term predictions of the theory."

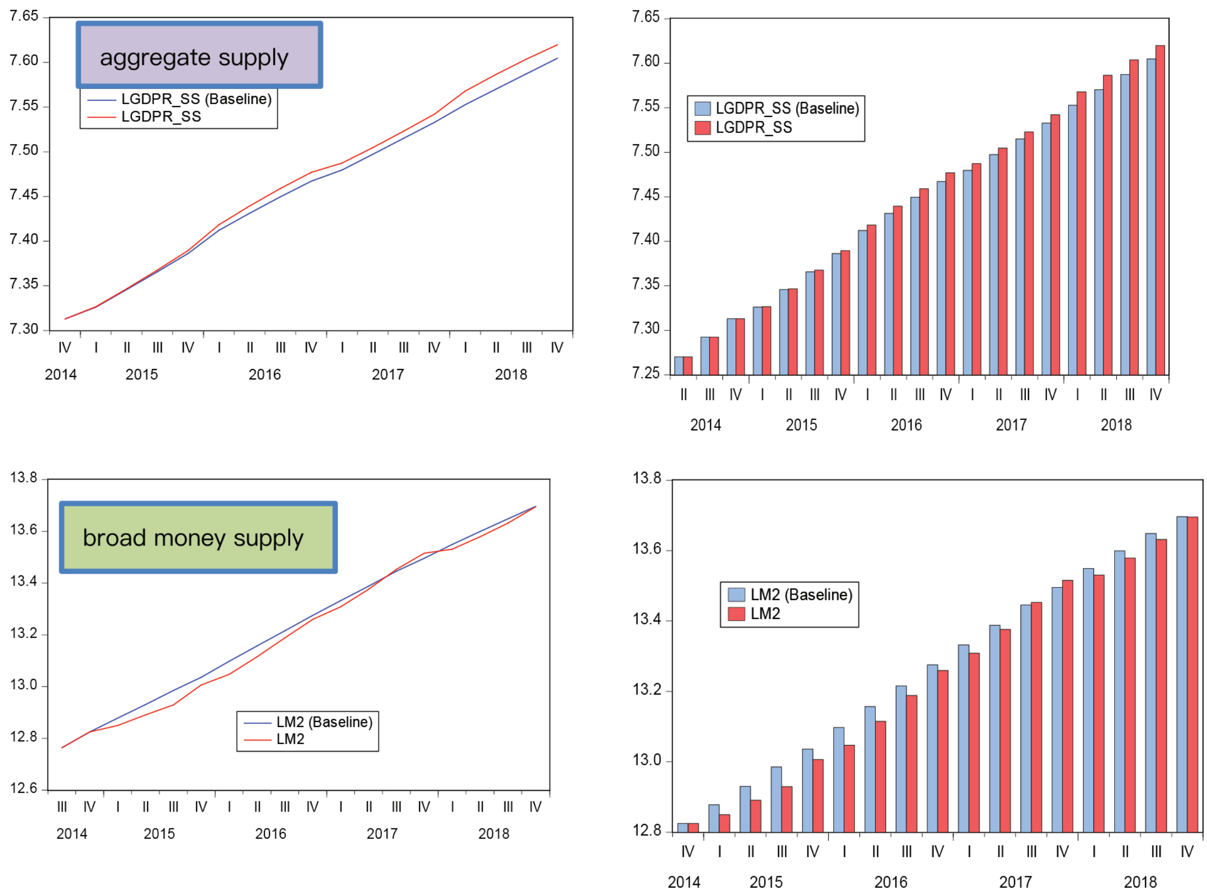
macroeconomic aggregates, including GDP (and thus growth) and prices (and thus inflation; see also Figure 2a). Figure 1b presents similar results for aggregate supply and money supply. The model successfully reproduces historical data for these variables over the period 2014/15–2018/19.

Figure 1a. Model tracking of historical data: GDP/aggregate demand



(Baseline [blue] =model-generated values; and the red = actual values)

Figure 1b: Model tracking of historical data: aggregate supply and money supply



(Baseline [blue= model-generated values; red =actual values)

5.3. Forecasting performance

Given its strong performance in replicating the historical evolution of key macroeconomic variables, the model is used to forecast growth and inflation, leveraging ARIMA-based projections of exogenous variables. Figures 2a-2c illustrate its forecasting accuracy for price levels, inflation (percentage change in CPI), and GDP growth. The model effectively reproduces historical values of these variables through forecasting.

Figure 2a. Forecasting and historical tracking model performance: consumer price index (in logarithms)

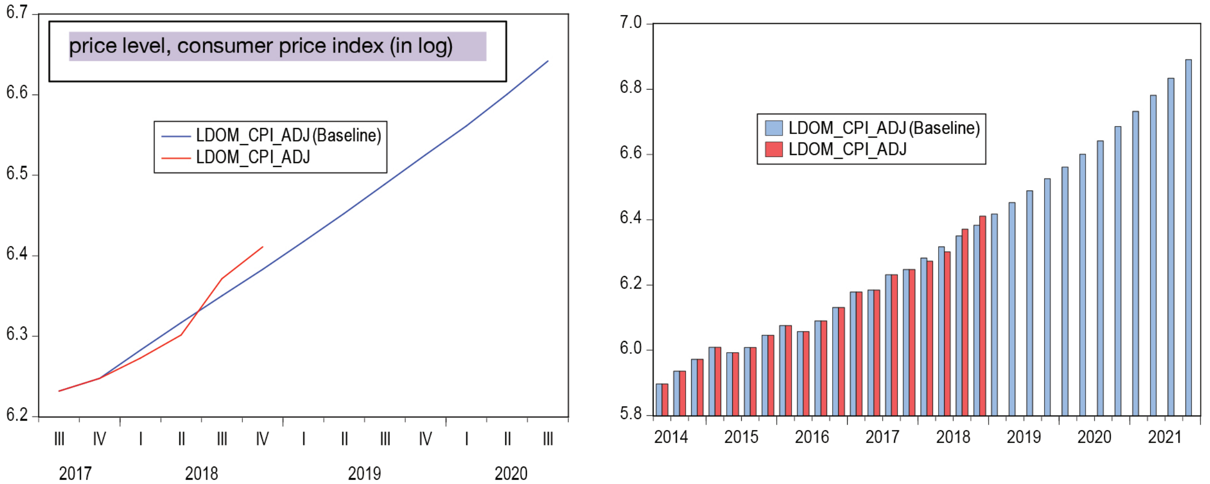


Figure 2b. Forecasting and historical tracking model performance: inflation (2016/17-2021/22)

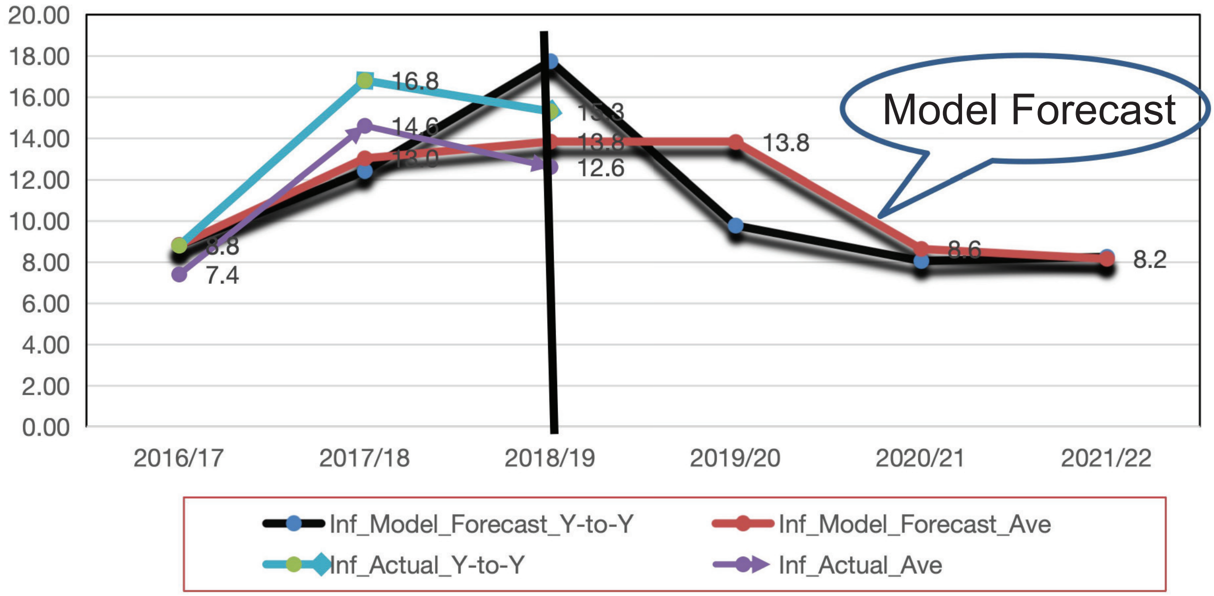
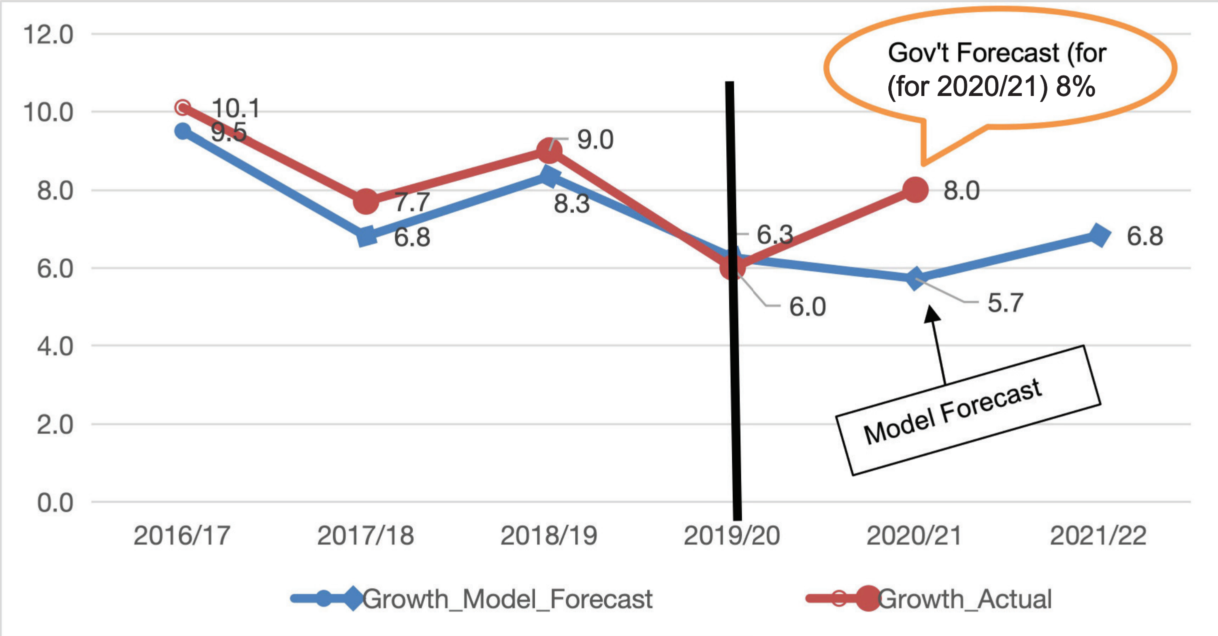


Figure 2c. Forecasting and historical tracking model performance: GDP growth* (2016/17-2021-22)



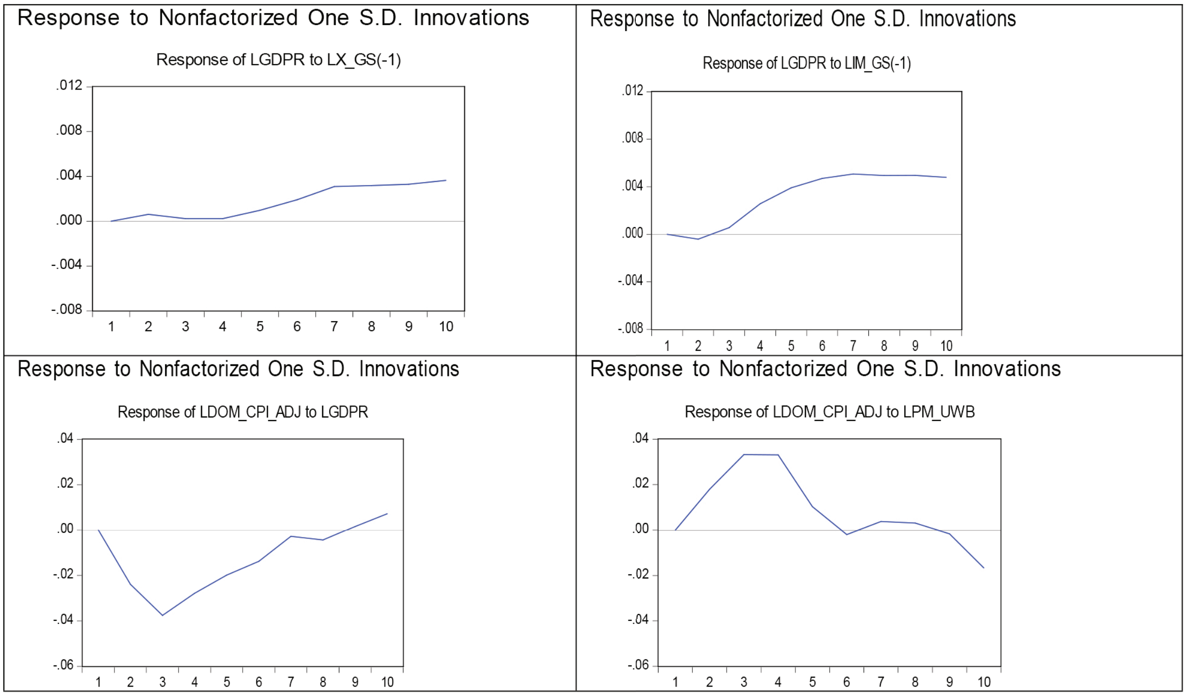
***Note:** The growth forecast for 2020-21 excludes the effect of COVID-19 (fundamental uncertainty). A separate study estimates a pandemic effect of about -5.7 percent in the best-case scenario (Geda 2020a). Including this effect, the model 2020/21 Ethiopian growth forecast is approximately zero—idntical similar to the International Monetary Fund's contemporaneous forecast; the Africa average was -2 percent. The 2019/20 prediction also coincides with the government's forecast (assuming no adjustment for the COVID-19 effect).

5.4. Policy and shock analysis

The model evaluates proposed policies and external shocks through simulation exercises. Two approaches are used. In the first, the macro model is solved under alternative policy and external shock scenarios by adjusting relevant policy and exogenous variables. For example, the model could be used to assess the effects of modifying the nominal exchange rate (a policy variable) or global commodity prices (an external shock). The results from these scenarios would then be compared to the base-run (business-as-usual) scenario to determine the impact of policy changes or external shocks.

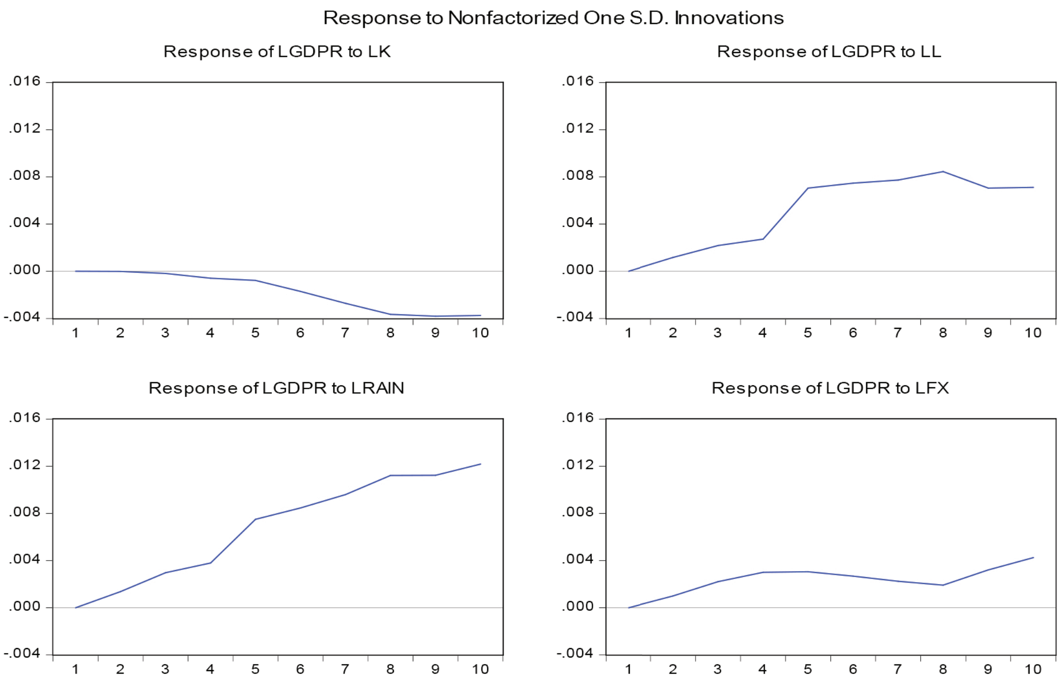
In the second approach, the VAR framework is used to derive error correction model formulations of the model's aggregate demand and supply equations for impulse response analysis. While the SCVAR methodology is particularly suited for this exercise, similar insights can be obtained using the VAR model employed to derive error correction model equations for the Ethiopian macro model. Figures 3a and 3b illustrate the response of real GDP and the price level in Ethiopia to a one-standard-deviation shock in aggregate demand and supply, respectively, demonstrating the model's utility for policy impact and external shock analysis.

Figure 3a: Impulse response: GDP and price response to aggregate demand shock



Legend: LGDPR = real GDP in log; LM_GS= log of import of goods and services; LDOM-CPI= log of domestic prices, CPI; LPM-UMB= log of import unit price; LX_GS=log export of goods and services; LRAIN= log of average annual rainfall; LFX=log of foreign exchange availability; LK=log of capital stock; LL=log of labour supply.

Figure 3b: Impulse Response Analysis: GDP Response to Aggregate Supply Shock



6. Conclusion and Policy Implications

This study develops an applied dynamic macroeconometric model grounded in stylied facts about African macroeconomies. It offers a relevant alternative to DSGE modelling for African central banks and ministries of finance. Recent evidence highlights significant shortcomings of DSGE modelling in forecasting and explaining macroeconomic dynamics—even in developed economies—particularly after the 2008/09 global financial crisis. The reliance on nominal interest rates as a primary policy tool proved ineffective in mitigating economic downturns during both the Great Recession and the COVID-19 pandemic. Given these limitations—along with the inability of DSGE models to reflect the structural realities of African economies—the models are unsuitable for forecasting and policy analysis in an African context. An alternative macroeconomic model tailored to African economies is needed, one that can better support policy analysis and forecasting.

PADS-AFriMod is anchored in Africa's macroeconomic and policy realities and provides a valuable framework for forecasting key variables that African central banks and policymakers can use to inform policy. Its statistical/econometric approach leverages actual time-series data relevant to macroeconomic analysis in African context, supports the assessment of alternative policies and the analysis of external shocks through simulation exercises. By enabling the exploration of policy options to enhance growth and foster stability and by providing both flexibility and simplicity in its implementation, the model supports the mandates of African central banks, treasuries, and policy analysis centers.

While PADS-AfriMod offers a contextually grounded and empirically robust alternative to DSGE models, it is not without limitations. First, reliance on single-equation ARDL-based error correction models, while practical, may constrain capture of complex interdependencies. Second, while the model incorporates key structural features of African economies, its empirical specification is calibrated to Ethiopia and may require significant adaptation elsewhere. Third, the omission of a fully integrated financial sector limits analysis when financial innovation drives dynamics. Future work should expand sectoral disaggregation, integrate financial frictions, and explore multi-country panel estimation.

Applied models are not flawless in their statistical foundations, nor do they achieve the level of scientific rigor seen in purely analytical studies. Even the most advanced models should be viewed as conceptual frameworks rather than definitive solutions. They should be complemented by expert judgement from central banks, treasuries, and macroeconomists monitoring developments in real time. While sometimes criticized for lacking rigorous theoretical foundations, they remain grounded in practical policy analysis and real-world data requirements. In this sense, concerns about scientific rigor may be overstated. As Mankiw (2006) notes, macroeconomists addressing real-world problems function more like engineers. In the same spirit, Blanchard (2018) recommends separating theoretical and applied policy models, with the latter prioritizing empirical performance over pure theory. The application of the model to Ethiopia (2000-2019) demonstrates its utility.

Policy usefulness can be enhanced by integrating PADS-AFriMod with satellite (suite of) models that capture different aspects of the economy such as external sector, inflation, financial/monetary, and fiscal blocks in more detail. Sectoral models tailored to individual country structures (e.g. services for Seychelles, mining for Zambia/Nigeria) could also be developed.

Expanding the theoretical and empirical framework presented in this study would allow for the construction of a medium-sized macroeconometric model suitable for more specialized applications. For instance, central banks could refine the monetary block of the model for policy analysis, while ministries of finance and planning could enhance the fiscal block for budgetary formulation and assessments.

Once such models are developed, their forecasting and simulation properties could be compared against the PADS-AfriMod model. It is hoped this study will serve as a foundation for further research in applied macroeconomic modelling across Africa, fostering collaboration among researchers, central banks, continental financial institutions, and ministries of finance and planning.

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APPENDIX

Notes on Model Construction, Improvement, and Data Use

This PADS-AfriMod framework can be constructed in standard econometrics software such as EVIEWS, as in this paper for Ethiopia. Its usefulness, however, can be enhanced by tuning the model to the specific conditions of each country. In doing so, the following points regarding the need for bridging equations merit consideration.

a) Capital Stock and the Production Function

Once the production function (aggregate supply, AS) in Equation [4] is estimated, using, among other variables, capital stock (K), the macro model in platforms such as EViews must define capital stock as:

$K_t=(K_{t-1}+\Delta K) = (K_{t-1}+\text{Investment})$.

This is essential to capture the supply-side effect of rising investment on the model's endogenous variables.

b) Net Exports and Foreign Exchange Availability

In the aggregate demand (AD) equation in Equation [1b], net exports (NX) need to incorporate net factor payment and current transfers (NFPCT) from abroad. In the EViews version of the model, therefore, net exports should be defined as:

NX= X – IM + NFPCT,

where X represents exports of goods and services, IM imports of goods and services, and NFPCT net wage and other factor incomes, remittances, and aid—components that appear in the balance of payments of many African countries.

A positive NX raises AD on the demand side. On the supply side, NX increases AS through its effect on foreign exchange availability (FX). In Equation [4b], FX enters the supply equation, In the EViews model, FX should be defined as a bridging Equation:

FX=NFPCT+KI,

where KI stands for net capital inflow. KI is, in turn, defined as the negative of the balance of payments (BOP) position:

KI=(-1)*BOP, including both private and official transfers (Tr).

FX should be considered as an exogenous variable and can be forecasted using ARIMA-based modelling methods.

c) Change in Reserves

The change in reserves (ΔRes) in Equation [5a] must be linked to the BOP and capital inflows using a bridging equation:

$\Delta Res = BOP + KI + E\&O$,

where E&O represents errors and omissions in the BOP account. As with FX, E&O may be treated as an exogenous variable and forecast using an ARIMA framework.

d) Export and Import Equations

Export and import equations in Equations [1a] and [1b] are vital determinants of the balance of payments position and foreign exchange availability. In the base model, both are functions only of the real exchange rate. However, in most African countries, exports are heavily constrained by supply-side factors. Thus, in the EViews model, lagged values of exports and imports should be incorporated as indicators of export and import supply capacity. Their path-dependent behaviour is reflected in the estimated version of the aggregate demand equation, which follows an ARDL formulation.

e) Choice of Real Exchange Rate Variable

The preferred real exchange rate variable for this model is commodity-specific, defined as:

(e*Pm/P) for imports, and (e*Px/P) for exports,

where e is the nominal exchange rate, and Pm and Px stand for import and export prices, respectively.

Export prices should reflect the composition of each country's exports. For Ethiopia, for example, this report uses a weighted average of the export prices of coffee [30 percent], oilseeds [15 percent], pulses, chat and flowers [10 percent each], gold [7 percent], and other exports [19 percent]. For Zambia, in contrast, the export price of copper (at 70%) would be central.

A simplified alternative is:

$P^* = w_1 * Pm + w_2 Px$,

where w_1 and w_2 are weights that are based on the import and export shares of total trade (X+M).

However, the disaggregated approach is preferable, as it better reveals the sources of growth variability and economic fluctuations more precisely.

f) Global Demand Proxy

The Y*TP variable used in Equation [1a] is intended to capture global demand for African export commodities. It may, however, be replaced by Px, since global markets, rather than individual trading partners, generally determine export prices. This latter approach is used in the macro model built for Ethiopia in this study.

g) Data Frequency and Estimation Issues

In Ethiopia, macroeconomic data are generated annually and used for policy analysis at that frequency (e.g., budgeting, growth forecasting). Estimating the Ethiopian macro model with annual data is therefore to be left for future consideration. Annual estimation poses degrees of freedom constraints.

To address this issue, this study converts data on annual GDP, rainfall, capital stock, and labour into quarterly series using the EViews method, assuming the quarterly values have a quadratic pattern. The primary data source for the Ethiopian model is the Annual Report of the National Bank of Ethiopia (various issues). The Central Statistical Authority (CSA) is the source for price data.

Headquarters
72B El-Maahad El-Eshteraky Street
Roxy, Heliopolis, Cairo 11341, Egypt
info@afreximbank.com
T +(202) 2456 4100/1/2/3/4

Abidjan Branch
3ème Etage, Immeuble CRRAE-UMOA,
Angle Boulevard Botreau Roussel –
Rue Privée CRRAE-UMOA Abidjan,
Côte d'Ivoire
abidjan@afreximbank.com
T +(225) 2030 7300

Caribbean Office
African Export-Import Bank
Banque Africaine d'Import-Export
Trident Insurance Financial center
Hastings, Christ Church,
Highway 7, Bridgetown,
Barbados BB5156
T +(246) 833 4636

Abuja Branch
Afreximbank African Trade Centre
Plot 1573, off Ralph Shodeinde
Street, Central Business District,
Abuja 900001, P.M.B 601, Garki 2,
Abuja, Nigeria
abuja@afreximbank.com
T: +(234) 9 460 3160

Harare Branch
Eastgate Building, 3rd Floor
(North Wing), Sam Nujoma Street
Harare, Zimbabwe P.O. Box CY 1600
Causeway, Harare, Zimbabwe
harare@afreximbank.com
T +(263) 4 700 904 / 941

Kampala Branch
Rwenzori Towers, 3rd Floor, Wing A,
Plot 6 Nakasero P.O. Box 28412
Kampala, Uganda
kampala@afreximbank.com
T +(256) 417 892 700
+(256) 312 423 700

Yaoundé Branch
National Social Insurance
Fund (NSIF) Headquarters Building,
Town Hall, Independence Square
P.O. Box 405, Yaoundé, Cameroon
yaoundebranch@afreximbank.com

afreximbank.com