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February 2022

KBA Centre for Research on Financial Markets and Policy®
Working Paper Series

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COVID-19 and the Finance-economic Growth Nexus in Kenya[1]

Benjamin O. Maturu

Abstract

We empirically re-examine the finance-economic growth nexus within the context of the COVID-19 pandemic using a financial intermediation model build upon the McKinnon-Shaw financial repression theory. The study findings show that there is a vicious circle of finance and economic growth which is exacerbated by McKinnon-Shaw-like financial repression. The COVID-19 pandemic labour supply shock adversely affects the human capital depreciation rate which in turn adversely affects the employment level in the economy and economic growth thereby compounding the vicious circle. Since the vicious circle cannot resolve itself, using appropriate socio-economic policies to break it is necessary. The authorities must however contend with the observed partial ineffectiveness of fiscal and monetary policies.

1 Revised paper submitted to the Kenya Bankers Association following presentation of the initial draft paper at the 10th Annual Kenya Bankers Association Conference: 22nd -24th Sept. 2021 in Nairobi (Kenya).

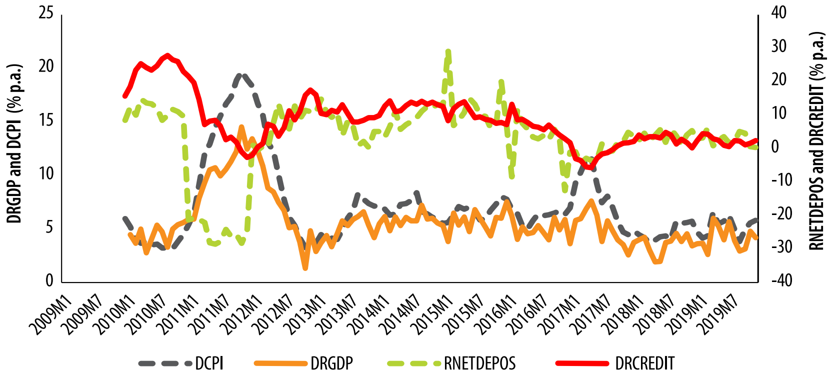
Introduction

When the COVID-19 pandemic arrived at Kenya's shores, over one and a half years ago, Kenya's economy was doing poorly. One would only fear for the worst. Bank credit creation and economic growth had plummeted and there was hardly any fiscal space left for the government to effectively deal with the impending emergence.

For instance, while real economic growth averaged 5.63% per annum in February 2010 - December 2019, it peaked 14.52% per annum in November 2011 when the consumer price index rate of inflation also peaked at 19.72% per annum. The rate of economic growth decelerated to 1.33% per annum in November 2012 when the rate of inflation was 3.25% per annum. During the most part of June 2013-August 2017, real economic growth was above 5% per annum, it stayed below 5% per annum during the most part of the period ending in December 2019.

Meanwhile, real bank credit accelerated from a low of minus 3% per annum in December 2011 to 18% per annum in December 2012. Rather unprecedently, bank credit *decelerated* by 6% per annum in May 2017. It had not recovered fully to its 14% per annum in May 2015 when the COVID-19 pandemic struck in March 2020.

Figure 1: Real bank credit and economic growth, 2009:01-2019:12



Notes: DCPI = consumer price index rate of inflation; DRGDP = real economic growth rate; RBETDEPOS = growth in real bank deposits net of period loan disbursement; and DRCREDIT = growth in real bank credit.

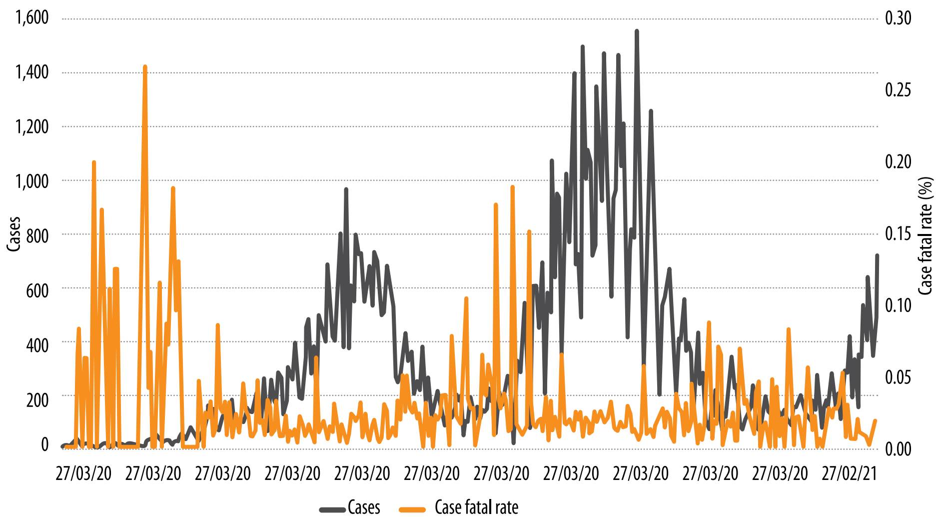
RNETDEPOS is the month-on-month percentage increase in the banking industry's real net deposits i.e. total nominal bank deposits minus the period disbursement of bank credit scaled down by the period value of the consumer price index CPI; and DRCREDIT is the month-on-month percentage change in the principal amount of real bank credit.

Figure 1 shows the strong co-movement between finance and economic growth which is characterized as a vicious circle of finance and growth in Maturu (2021) and which would be exacerbated by the COVID-19 pandemic.

Despite the concerted efforts made by the authorities around the world to get rid of the COVID-19 pandemic, the pandemic has persisted to cause utter devastation to lives and livelihoods. Quick discovery of vaccines not only provided the much-needed hope but forestalled the rather unfortunate episodic COVID-19 experiences of Brazil, India, Italy, Spain, the UK, and the USA.

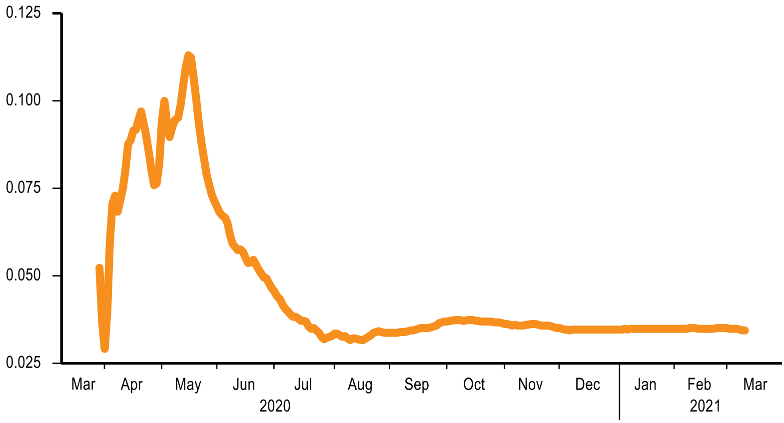
Like most countries around the world, COVID-19 has been persistent in Kenya since the first confirmed case was reported in March 2020. **Figure 2** shows that the highest case fatal rate (CFR) of 0.27 occurred on 1st May 2020. **Figure 3** shows an appreciable COVID-19 shock where the cumulative case fatal rate rose by 387.8% over just about one and a half months with significant potential adverse effects on the economy.

Figure 2: COVID-19 cases and case fatal rate, 27/3/2020-10/3/2021



Source: Plotted by author using data from Kenya Government's Ministry of Health

Notes: Cases = number of people tested for Covid-19 whose results are positive; Case fatal rate= number of deaths among the cases expressed as a proportion of cases.



Source: Plotted by author using data from Kenya Government's Ministry of Health

Figure 3: COVID-19 cumulative case fatal rate, 27/3/2020-10/3/2021

We empirically re-examine the causal relationship between finance, expressed in terms of bank credit, and economic growth in Kenya within the context of the COVID-19 pandemic. Specifically, we seek:

1. To empirically characterize the finance-economic growth nexus in Kenya;

2. To empirically analyse COVID-19 effects on employment, economic growth, bank credit, technological progress and the volume of international trade in Kenya;

3. To empirically analyse the effectiveness of monetary and fiscal policies in Kenya by examining the operational status of the transmission channels and identifying constraints to successful implementation of the policies; and

4. To suggest monetary and fiscal policies for ensuring sustained optimal levels of bank credit creation and economic growth in Kenya.

We proceed to reviewing literature in section 2 upon which we discuss the methodology including specification of the extended core financial intermediation model in section 3. We then present the empirical analysis framework in section 4 upon which we present and discuss the model estimation results in section 5. We conclude the study in section 6.

2.0 Literature review

We consider literature on development finance, economic growth, and the interdependence between development finance and economic growth.

2.1 Development finance

A readily accessible discussion of the role and meaning of development finance including such concepts as financial intermediation and maturity transformation is provided by Kitchen (1986). There is no doubt that the McKinnon-Shaw financial repression model is a classic development finance model. Advanced by McKinnon (1973) and Shaw (1973), the central theme is that too low real interest rates on savings discourage saving, and by extension, investment. Considering that, in equilibrium, savings are equal to investment, which is the accumulation of physical capital that is a factor of production, the role of development finance in economic growth is clear.

The results obtained by Oluleye (2017) show that the investment-to-output ratio, which represents the savings ratio in equilibrium, increases with real interest rates on savings and decreases with increasing bank lending interest rates. The applicable elasticities are 0.186 and -0.195, respectively. The evidence supports the McKinnon-Shaw financial repression model since an increase in the real interest rates on savings increases the opportunity cost of holding cash balances thereby motivating households to increase savings to earn the inceased real rate of return. Much as an increase in bank lending interest rates motivates banks to mobilize more bank savings to create more credit, higher lending interest rates renders the credit relatively more expensive and therefore less affordable as to constrain bank lending and savings.

Barring the potential multicollinearity problem which could impair estimation of the elasticities of real demand for money with respect to the investment-to-output ratio and real output, the elasticity of demand for money with respect to the opportunity cost of money, which is estimated at -0.132 with a calculated t-stat value of 10.51 in the short run money demand function and -0.168 in the long run money demand function, is correctly signed and statistically significant. The results are therefore also supportive of the McKinnon-Shaw financial repression hypothesis where a decrease in real interest rates on savings discourages saving.

Latter studies by, for instance, Kapur (1976) and Mathieson (1980) show that the cause of financial repression is not limited to too low real interest rates. Financial repression can be caused by reserve ratio requirements. Intuitively, reserve requirements not only limit banks' capacity to create credit but also increase the funding cost of bank credit; especially when the required reserves are not adequately remunerated.

We also infer from the Fisherian equation, see Fisher (1977), that price instability and monopsonistic banks in the deposit mobilization market can cause financial repression. That is because high expected rates of inflation, given certain levels of the nominal interest rates on savings, results in low real interest rates. That point is underlined by Vogel and Buser (1976) and the situation is even worse when monopsonistic banks set too low nominal interest rates on savings. Monetary authorities, whose core responsibility is to ensure low stable rates of inflation, have the potential of contributing positively to elimination of financial repression.

Kenya's short-lived experience with regulated deposit and lending interest rates under the Banking (Amendment) Act 2016 (RoK, 2016) shows that controlling and regulating lending interests matter too. Seeking to promote relatively cheaper bank credit for small and medium enterprises, Kenya's National Assembly initiated legislation leading to the enactment of the Act. Bank lending to the private sector plummeted beginning Oct. 2015 when the Banking (Amendment) Bill 2015 was introduced in the National Assembly and the situation got worse upon enactment of the Act on in Sept. 2016 that the Act had to be repealed in November 2019.

As discussed in Maturu (2021), households' real disposable incomes are too low to save due to a relatively heavy tax burden. The problem of inadequate real disposable incomes is compounded by inefficient payment and settlement of government financial obligations to the private sector which impairs households' and business enterprises' cash flows to the extent that they cannot effectively service existing bank loans nor borrow more as their creditworthiness wanes with poor cash flows.

Consequently, gross non-performing loans increase with bank credit repayment default and refinancing risks. Banks become more risk-averse in lending and as they price the credit and refinancing risks into lending interest rates, bank credit become more expensive. Where the banks cannot price the risks into lending interest rates, banks become more risk averse and therefore exceedingly reluctant to lend to potential borrowers that they perceive to be too risky to lend to. Bank credit ends up being constrained by lack of effective demand and supply.

Kenya's experience with reserve ratio requirements is a long one. Presently, at 2.5% of bank deposits, the non-remunerated reserve ratio requirement is relatively small by historical standards but quite significant in its implications for the funding cost of bank credit creation.

2.2 Economic growth

Clearly, the finance-growth nexus comprises finance and economic growth but relatively more explicit emphasis is placed on finance in the McKinnon-Shaw financial repression model. For richer analysis and completeness, the basic McKinnon-Shaw financial repression model should be extended to explicitly incorporate economic growth.

Towards that end, we follow the dynamic stochastic general equilibrium modelling strategy, which is widely used among modern central banks, and in which the New classical growth model is applied as exemplified in Christiano, Eichenbaum and Evans (2005). In that case, domestic intermediate goods are produced by monopolistically competitive firms by means of physical capital stock and labour using the same constant returns to scale production function.

The intermediate goods are then aggregated into the domestic final good using a Dixit-Stiglitz-like aggregator (Dixit and Stiglitz, 1977). For analytical convenience, the domestic final good is branded into consumption and investment goods to meet market demand at no additional production cost. Applying basic or current market prices to the branded goods and aggregating yields aggregate demand for the domestic final good. That is reminiscent of the Keynesian equilibrium condition in the determination of the national income using the expenditure approach.

We exploit the idea of a labour-augmenting shock to incorporate the COVID-19 labour supply shock, which "adversely augments" labour as a factor of production, into the analysis. Like the physical capital depreciation rate, we consider the COVID-19 labour supply shock to be a human capital stock depreciation rate.

2.3 Procyclicality of bank credit

There are two key features of the causal relationship between development finance and economic growth. The first one is mutual causation where causality flows from development finance as provided in the McKinnon-Shaw financial repression model with feedback from economic growth to development finance. Maturu (2021) finds evidence which is supportive of a vicious circle of development finance and economic growth during the decade ending in December 2019.

The other feature is an outcome of studies seeking to appreciate the finance-growth nexus leading to the global financial and economic crises of 2008/09 where sub-prime bank lending caused a financial crisis in the USA with contagion effects across the globe. The financial crisis metamorphosized into an economic crisis of global proportions. This strand of the literature includes, for instance, Wheeler (2019), Bertay, Demirgüç-Kunt, and Huizinga (2013), Zaid, ur Rehman, and Imran (2020), Jeong (2009) and Saibalm (2020). A common theme and result among this set of literature is that bank lending is procyclical.

According to Wheeler (2019), procyclicality lending means *"supply-driven changes in lending that amplify the business cycle"* to pose systemic risk of the type witnessed under the global financial and economic crises of 2008/09.

The study findings in Bertay, Demirgüç-Kunt, and Huizinga (2013) and Zaid, ur Rehman, and Imran (2020) show that the structure of the banking system matters for the procyclicality of lending. While Bertay, Demirgüç-Kunt, and Huizinga (2013) find that lending by private banks is relatively more procyclical than lending by state banks, Zaid, ur Rehman, and Imran (2020) show that unlike conventional banking, whose lending is procyclical, lending by Islamic banks is not and has potential to stabilize bank lending thereby moderating systemic risks that would arise from excessive lending.

Jeong (2009) examines the extent to which procyclicality of bank lending changed after the 1997-98 financial crisis and hints at the macroprudential policy solution for procyclicality. The results show that,

> *"... [after] the 1997-98 financial crisis, the procyclicality of bank behaviour in corporate lending augmented substantially. We also find that banks' heavy reliance on wholesale funding may be partly responsible for the substantial increase in procyclicality."*

> *" ... after LTV [loan to value] ratio regulation was introduced in 2002:3, the procyclicality of bank behavior in household loans decreased dramatcally."*

Like Jeong (2009), Saibalm (2020) finds that banks which depended more on wholesale funding of their lending not only cut back lending by a greater amount during periods of economic downturn but were also more procyclical in lending. Wheeler (2019) explains that tightening of capital adequacy requirements in a bid to check inadequate provisioning for non-performing loans constrains lending during economic down turns.

We note from the literature review that for comprehensive analysis of the causal relationship between development finance and economic growth, there is need to extend the McKinnon-Shaw financial repression model to incorporating endogenous determination of economic growth. That paves way to consideration of the COVID-19 pandemic labour supply and the global supply chain shocks.

3.0 Methodology

3.1 Broad methodological issues

Consistent with the lessons learnt from the literature review, we apply a financial intermediation model which nests the McKinnon-Shaw financial repression model. We extend the basic McKinnon-Shaw financial repression model to include an endogenously determined economic growth in which the COVID-19 pandemic labour supply shock is embedded. We therefore build upon the core financial intermediation model advanced in Maturu (2021) by explicitly incorporating into it the external economic sector and the domestic production sector.

We use a counterfactual-factual approach where the counterfactual scenario is one in which there is no COVID-19 pandemic. In the factual scenario, the COVID-19 pandemic effects apply. Using this approach makes it easier to identify the COVID-19 pandemic economic effects.

To obtain the counterfactual scenario, we use data drawn from a period that is sufficiently far removed from the arrival of the COVID-19 pandemic to estimate the financial intermediation model and assume that the structure and operations of the economy do not change significantly during the transition period between the model estimation period and the COVID-19 pandemic period. That means that, were it not for the COVID-19 pandemic, the structure and operations of the economy during the COVID-19 pandemic period would have been adequately represented by the model estimation results.

We are then left with two options for estimating the economic effects of the COVID-19 pandemic. Firstly, and this is the preferred option because it is less involved, we apply a marginal analysis. Secondly, we estimate the total effect under the counterfactual and factual scenarios to a given economic indicator and then subtract the counterfactual scenario effect from the total effect under the counterfactual and factual scenarios to obtain the COVID-19 pandemic effect.

Certainly, the COVID-19 pandemic poses a demand shock as well. For instance, the

COVID-19-induced loss of employment reduces households' purchasing power through loss of wage income. The loss in purchasing power leads to a decrease in aggregate demand for goods and services. To simplify the analysis, we abstract from the COVID-19 pandemic demand shock by assuming that markets clear continuously consistent within the *"general equilibrium"* feature of dynamic stochastic general equilibrium models. Given the assumption, domestic final output coincides with domestic aggregate demand and suffice it, therefore, modelling domestic final output and demand falls in place.

To simplify the analysis further, we assume that the COVID-19 pandemic labour supply shock and the global supply chain disruption shock track each other closely to the extent that they carry the same information since they are collinear. Thus, $CvD_t = CvD_{is,t} = CvD_{sc,t}$. In the special case when $CvD = CvD_{is,t} = CvD_{sc,t} = 0$, there is no COVID-19 pandemic consistent with the counterfactual scenario. Otherwise, COVID-19 exists when $0 < CvD_t = CvD_{is,t} = CvD_{sc,t} < 1$.

3.2 Specifying the Finance-economic Growth Model

3.2.1 Modelling economic growth

We follow the two-phase modelling strategy applied in Christiano, Eichenbaum and Evans (2005). In the second phase of production, a perfectly competitive firm, which is infinitely lived, aggregates domestic intermediate goods into the domestic final good using the Dixit-Stiglitz-like aggregator function as provided by (3.1). See Dixit and Stiglitz (1977).

Our model is an extension of the Financial Policy Analysis System (FPAS) which has been used at the Central Bank of Kenya. See Andrle et. al. (2013).

$$y_t = \left(\int_0^1 (y_{i,t})^{1/\lambda}\, di \right)^{\lambda}, \qquad \forall 1 < \lambda < \infty \qquad (3.1)$$

Where,

$$y_{i,t} = A_t (K_{i,t})^{\alpha} ((1 - [\delta_N + CvD_{ls,t}]) N_{i,t})^{1-\alpha} \qquad \forall 0 < \alpha < 1 \qquad (3.2a)$$

Equivalently,

$$y_{i,t}=A_t\left(\frac{K_t}{\Gamma}\right)^{\alpha}\left((1-[\delta_N+CvD_{ls,t}])\frac{N_t}{\Gamma}\right)^{(1-\alpha)} \quad \forall 0<\alpha<1 \tag{3.2}$$

Where,

y_t is the domestic final good/output;

$\lambda, \forall 1<\lambda<\infty$ is the gross price markup in the domestic goods market;

$y_{i,t}, \forall i \in (0,1)$ is the i^{th} domestic intermediate good;

A_t is the state of aggregate technology;

$K_{i,t}, \forall K_{i,t} \equiv \frac{K_t}{\Gamma}$ is the quantity of physical capital stock used in production by the i^{th} domestic intermediate good producing firm where K_t is the physical capital stock in the economy and Γ is the number of firms in the economy which are of the i^{th} domestic intermediate good producing firm's size;

$N_{i,t}, \forall N_{i,t} \equiv \frac{N_t}{\Gamma}$ is the quantity of human capital stock used in production by the i^{th} domestic intermediate good producing firm where N_t is the level of employment, expressed in terms of the number of employees, in the economy;

α is the capital share of y_t;

$\delta_{N,t}$ is a labour-augmenting shock in the pre-COVID-19 pandemic period and which, analogous to the conventional physical capital depreciation rate δ_K that applies to the physical capital stock in the economy, is conceptualised as a human capital depreciation rate; and

$CvD_{ls,t}$ is the COVID-19 pandemic labour supply shock.

In equilibrium, demand for the i^{th} domestic intermediate good is provided by (3.3).

$$y_{i,t}=\left(\frac{P_{y,i,t}}{P_{y,t}}\right)^{\frac{\lambda}{1-\lambda}} y_t \tag{3.3}$$

Where the price of the domestic final good $P_{y,t}$ is equal to the price of the i^{th} domestic intermediate good $P_{y,i,t}$ plus the average cost of the organizer which is a fraction $\phi_{org,y}$ of $P_{y,i,t}$.

$$P_{y,t}=(1+\phi_{org,y})\ P_{y,i,t}\,,$$

$$\forall 0<\phi_{org,y}<\infty \qquad (3.4)$$

And, setting $P_{y,i,t}$ equal to the gross price markup to the marginal cost of production,

$$P_{y,i,t}=\lambda(\alpha)^{-\alpha}(1-\alpha)^{-(1-\alpha)}(P_{K,t})^{\alpha}((1-[\delta_N+CvD])\ W_t\ )^{(1-\alpha)} \qquad (3.5)$$

In equilibrium also, the i^{th} domestic intermediate good producing firm chooses the quantity of its factors of production which ensure that the capital-labour ratio is upheld. Thus,

$$\frac{W_{i,t}}{P_{k,i,t}} = \frac{\alpha}{(1-\alpha)}\ \frac{K_{i,t}}{(1-[\delta_N+CvD])^2\ N_{i,t})} \qquad (3.6a)$$

Since the intermediate good producing firms use the same technology and experience the same production costs, the same factor prices apply across firms in the economy. In the aggregate, therefore, if we use

$K_{i,t}\equiv \frac{K_t}{\Gamma}$ and $N_{i,t}\equiv \frac{N_t}{\Gamma}$,

$$\frac{W_t}{P_{k,t}} = \frac{\alpha}{(1-\alpha)}\ \frac{K_t}{(1-[\delta_N+CvD])^2\ N_t)} \qquad (3.6)$$

For (3.6) to be determinate as an equation of N_t, we proceed to specify how the factor prices $P_{k,t}$ and W_t and physical capital stock K_t are determined.

We assume that the physical good producing firm is perfectly competitive. It therefore earns normal profits by ensuring that it recovers its production cost that comprises the price of old physical capital $P_{K,i,t-1}$, physical capital depreciation expense $\delta_k P_{K,i,t-1}$, the price of domestic final investment goods $P_{I,i,t}$ and the capital adjustment cost $\delta_I\ P_{I,i,t}$. Thus,

$$P_{K,i,t}=(1+\delta_k)P_{K,i,t-1}+(1+\delta_I)P_{I,i,t} \qquad (3.7a)$$

In the aggregate,

$$P_{K,t}=(1+\delta_k)P_{K,t-1}+(1+\delta_I)P_{I,t} \qquad (3.7)$$

Where, to simplify the analysis, we express $P_{I,t}$ in terms of $P_{y,t}$.

$P_{I,t}=\emptyset P_{AC,t}$,

$$\forall 0<\emptyset<1 \tag{3.8}$$

The domestic final output market prices $P_{AC,t}$ expressed in terms of the domestic final output basic prices $P_{y,t}$ and the net effective indirect taxation rate $\tau_{indir,t}$,

$$P_{AC,t}=\left(1+\frac{\tau_{indir,t}}{100}\right)P_{y,t} \tag{3.9}$$

Intuitively, where , $P_{AC,t}=\emptyset P_{I,t}+(1-\emptyset)P_{CPI,t}$,

$P_{CPI,t}=(1-\emptyset)\ P_{AC,t}$

$$\forall 0<\emptyset<1 \tag{3.10}$$

For ease of analysis, we assume that the i^{th} domestic intermediate good producing firm sets the nominal wage rate $W_{i,t}$ equal to the marginal product of labour $MP_{N,i,t}$. We therefore refrain from using other wage determination models such as the bargained wage approach advanced by, for instance, Gertler and Trigari (2009) that is too involved.

$$W_{i,t}=MP_{N,i,t}=\alpha^{\alpha}(1-\alpha)^{1-\alpha}\ A_t(W_{i,t}\ P_{K,i,t})^{\alpha} \tag{3.11a}$$

Equivalently, upon re-organization and simplifying,

$$W_{i,t}=(1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}\ (A_t)^{\frac{1}{1-\alpha}}\ (P_{K,i,t})^{\frac{\alpha}{1-\alpha}} \tag{3.11b}$$

In the aggregate,

$$W_t=(1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}\ (A_t)^{\frac{1}{1-\alpha}}\ (P_{K,t})^{\frac{\alpha}{1-\alpha}} \tag{3.11}$$

The law of motion of aggregate physical capital stock in the economy K_t is provided by (3.12) in which δ_I is the physical capital adjustment cost expressed as the fraction of the investment good I_t that goes to waste during installation of the goods into new physical capital.

$$K_t=(1-\delta_K\ )\ K_{t-1}+(1-\delta_I)INVST_t \tag{3.12}$$

Where,

$$K_t=\int_0^1(K_{i,t})\ di,\forall i \tag{3.13}$$

In furtherance of the McKinnon-Shaw financial repression model, we apply the equilibrium condition that total real investment I_t is equal to total real savings S_t in the economy. To simplify the analysis, we assume that S_t is equal to a scale factor $\varphi, \forall 0<\varphi<\infty$ of total real bank credit in the economy $rcredit_t$. The idea here is that bank credit is not necessarily the only source of development finance in the economy. Not unless $\varphi=1$.

$$INVST_t \equiv S_t = \varphi * rcredit_t \qquad \forall \varphi, 1 \leq \varphi < \infty \qquad (3.14a)$$

Using the outer equal terms,

$$INVST_t = \varphi * rcredit_t, \qquad \forall \varphi, 1 \leq \varphi < \infty \qquad (3.14)$$

Intuitively, where the structure of the domestic non-tradable final good price $P_{ac,t} = \emptyset P_{I,t} + (1-\emptyset) P_{CPI,t}$, see (10), follows from the structure of the domestic non-tradable final good,

$$\bar{y}_t = \emptyset INVST_t + (1-\emptyset)\, C_t \qquad (3.15)$$

Where, domestic final output at market prices $\bar{y}_t$,

$$\bar{y}_t = P_{AC,t}\, y_t \qquad (3.16)$$

Intuitively, from (3.15), C_t is equal to the fraction $(1-\emptyset)$ of $\bar{y}_t$. Thus,

$$C_t = (1-\emptyset)\bar{y}_t \qquad (3.17)$$

To incorporate the external economic sector into the analysis, we assume that domestic final output is equal to total real expenditures on it. We therefore specify a production-side Keynesian-like national income determination equilibrium condition provided by (3.18a) where, in the absence of the COVID-19 pandemic, $CvD_{sc,t}=0$.

$$\bar{y}_t = C_{p,t} + I_{p,t} + G_t + [1 - CvD_{sc,t}](xpo_t - mpo_t) \qquad (3.18a)$$

Where,

$\bar{y}_t$ is the domestic final output at constant market prices;

$C_{p,t}$ is the domestic final private consumption goods at constant market prices;

$I_{p,t}$ is domestic final private investment goods at constant market prices;

G_t is total government expenditure on consumption and investment goods at constant market prices;

xpo_t are exported goods and non-factor services at constant market prices;

mpo_t are imported goods and non-factor services at constant market prices;

xpo_t-mpo_t is the domestic currency value of the trade account balance at constant market prices; and

$CvD_{sc,t}$ is the COVID-19 pandemic global supply chain shock.

For the ease of further analysis, we re-write (3.18a) as an expression of the size of fiscal operations G_t . Thus,

$$G_t=\bar{y}_t-(C_{p,t}+INVST_{p,t}+[1-CvD_{sc,t}](xpo_t-mpo_t)) \quad (3.18b)$$

Ideally, the domestic private sector's share of domestic final output, which is the disposable income $y_{dis,t}$, is either consumed $C_{p,t}$ or saved where the savings $S_{p,t}$ are equal to investment $INVST_{p,t}$. Thus,

$$y_{dis,t}=C_{p,t}+INVST_{p,t} \quad (3.18c)$$

Using (3.18c) in (3.18b),

$$G_t=\bar{y}_t-(y_{dis,t}+[1-CvD_{sc,t}](xpo_t-mpo_t)) \quad (3.18)$$

Conceptually, where τ_t is the effective net nominal taxation rate on the domestic final good,

$$y_{dis,t}\equiv\left(1-\frac{\tau_t}{100}\right)P_{AC,t}\,y_t, \quad \forall 0<\tau_t<1 \quad (3.19)$$

Where, τ_t is the net effective taxation rate which comprises the direct $\tau_{dir,t}$ and indirect $\tau_{indir,t}$ components as provided by (3.20).

$$\tau_t=\tau_{dir,t}+\tau_{indir,t} \quad (3.20)$$

To simplify the analysis, we assume that the COVID-19 pandemic labour supply shock and the COVID-19 pandemic global supply chain shock track each other closely that any of the two has sufficient information to predict the other. Thus,

$$CvD_t = CvD_{ls,t} = CvD_{sc,t} \qquad \forall 0 < CvD_t < 1 \tag{3.21}$$

For completeness of model specification,

$$A_t = a_0 + a_1 A_{t-1} + \epsilon_{A,t}, \qquad \forall \epsilon_{A,t} \sim N(\mu_A, \sigma_A^2), \ \sigma_A^2 \geq 0, \text{and } a_1 = 1 \tag{3.22}$$

$$CvD_t = v_2 + v_3 CvD_{t-1} + \epsilon_{CvD,t} \qquad \forall \epsilon_{CvD,t} \sim N(\mu_{CvD}, \sigma_{CvD}^2), \ \sigma_{CvD}^{2\,2} \geq 0, \text{and } 0 < v_3 < 1 \tag{3.23}$$

$$xpo_t = x_0 + x_1 xpo_{t-1} + \epsilon_{xpo,t}, \qquad \forall \epsilon_{xpo,t} \sim N(\mu_{xpo}, \sigma_{xpo}^2), \ \sigma_{xpo}^2 \geq 0, \text{and } 0 < x_1 < 1 \tag{3.24}$$

$$mpo_t = m_0 + m_1 mpo_{t-1} + \epsilon_{mpo,t} \qquad \forall \epsilon_{mpo,t} \sim N(\mu_{mpo}, \sigma_{mpo}^2), \sigma_{mpo}^2 \geq 0, \text{and } 0 < m_1 < 1 \tag{3.25}$$

$$\tau_{dir,t} = t_0 + t_1 \tau_{dir,t-1} + \epsilon_{dir,t} \qquad \forall \epsilon_{dir,t} \sim N(\mu_{dir}, \sigma_{dir}^2), \ \sigma_{dir}^2 \geq 0, \text{and } 0 < t_0, t_1 < 1 \tag{3.26}$$

$$\tau_{indir,t} = t_2 + t_3 \tau_{indir,t-1} + \epsilon_{indir,t} \qquad \forall \epsilon_{indir,t} \sim N(\mu_{\_indir}, \sigma_{indir}^2), \sigma_{indir}^2 \geq 0, \text{and } 0 < t_2, t_3 < 1 \tag{3.27}$$

3.2.2 Modelling development finance

We extend the McKinnon (1973) and Shaw (1973) financial repression model which suggests that savings are an increasing function of real saving interest rates and that, therefore, too low real saving interest rates hurt not only savings but also: development finance (which, within the context of this study, is bank credit), investment and economic growth.

Adapting Maturu (2021), we specify the following financial sector equations.

1. the domestic nominal currency outside banks equation;

$$cob_t = c_0 - c_1 rdeposr_t + c_2 y_{dis,t} + c_3 P_{AC,t} + \epsilon_{cob,t}$$
$$\forall \epsilon_{cob,t} \sim N(\mu_{cob}, \sigma^2_{cob}), \sigma^2_{cob} \geq 0, \text{ and } c_1, c_2, c_3 > 0 \qquad (3.28)$$

Where, from the Fisherian equation (Fisher,1977),

$$rdeposr_t = deposr_t - E_t\left(\frac{P_{AC,t+1}}{P_{AC,t}}\right) \qquad (3.29)$$

2. the nominal bank deposits equation;

$$depos_t = b_0 + b_1 rdeposr_t + b_2 y_{dis,t} + b_3 P_{AC,t} + \epsilon_{depos,t},$$
$$\forall \epsilon_{depos,t} \sim N(\mu_{depos}, \sigma^2_{depos}), \sigma^2_{depos} \geq 0, \text{and } b_1, b_2, b_3 > 0 \qquad (3.30)$$

3. the domestic private sector nominal bank credit equation;

$$creditp_t = r_0 + r_1 depos_t + r_2(lendp_t - deposr_t) - r_3\left(lendp_t - E_t\left(\frac{P_{AC,t+1}}{P_{AC,t}}\right)\right) - r_4 gnpls_t - r_5 prov_t + r_6 y_{dis,t} + r_7 P_{AC,t} + \epsilon_{creditp,t},$$

$$\forall \epsilon_{creditp,t} \sim N(\mu_{creditp}, \sigma^2_{creditp}), \sigma^2_{creditp} \geq 0, \text{ and } r_1, r_2, r_3, r_4, r_5, r_6, r_7 > 0 \qquad (3.31)$$

4. the domestic public sector nominal bank credit equation;

$$creditg_t = g_0 + g_1 depos_t + g_2(lendg_t - deposr_t) - g_3\left(lendg_t - E_t\left(\frac{P_{AC,t+1}}{P_{AC,t}}\right)\right) + g_4 gnpls_t + g_5 prov_t + g_6(G_t - \tau_t/100y_t) + g_7 P_{AC,t} + \epsilon_{creditg,t}$$

$$\forall \epsilon_{creditg,t} \sim N(\mu_{\_creditg,} \sigma^2_{creditgp}), \sigma^2_{creditgp} \geq 0, \text{and } g_1, g_2, g_3, g_4, g_5, g_6, g_7 > 0 \qquad (3.32)$$

5. the net nominal interest rate on bank deposits equation;

$$deposr_t = d_0 + d_2 (lendp_{t-1} - deposr_{t-1}) + d_3 cbr_t + \epsilon_{depor,t}$$
$$\forall \epsilon_{deposr,t} \sim N(\mu_{deposr}, \sigma^2_{deposr}), \sigma^2_{deposr} \geq 0, \text{ and } d_1, d_2, d_3 > 0 \qquad (3.33)$$

6. the net nominal interest rate on domestic private bank credit equation;

$$lendp_t = l_0 + l_1 lendg_t + l_2 cbr_t + \epsilon_{lendp,t}$$
$$\forall \epsilon_{lendp,t} \sim N(\mu_{lendp}, \sigma^2_{lendp}), \sigma^2_{lendp} \geq 0, \text{ and } l_1, l_2 > 0 \qquad (3.34)$$

7. the net nominal interest rate on domestic public bank credit equation;

$$lendg_t = e_0+e_2\ (G_t-\tau_t/100\ P_{AC,t}\ y_t)+e_2 cbr_t+\epsilon_{lendg,t},$$
$$\forall \epsilon_{lendg,t} \sim N(\mu_{lendg},\ \sigma^2_{lendg}), \sigma^2_{lendg} \geq 0, \text{and } e_1,e_2,e_3>0 \tag{3.35}$$

8. the gross non-performing loans equation;

$$gnpls_t = p_0+p_1\ gnpls_{t-1} - p_2 prov_{t+}\epsilon_{gnpls,t},$$
$$\forall \epsilon_{gnpls,t} \sim N(\mu_{gnpls},\ \sigma^2_{gnpls}),\ \sigma^2_{gnpls} \geq 0, \text{and } p_1,p_2>0 \tag{3.36}$$

9. the provisions for non-performing loans equation;

$$prov_t=v_0+v_1\ prov_{t-1}+v_2\ gnpls_t+\epsilon_{prov,t}$$
$$\forall \epsilon_{prov,t} \sim N(\mu_{\_prov},\ \sigma^2_{prov}),\ \sigma^2_{prov} \geq 0,\ 0<v_1<1 \text{ and } 0<v_2<\infty \tag{3.37}$$

10. the central bank rate equation;

$$cbr_t= \theta E_t\left(\frac{P_{CPI,t+1}}{P_{CPI,t}}\right)+(1-\theta)E_t\left(\frac{y_{t+1}}{y_t}\right)\epsilon_{cbr,t},$$
$$\forall \epsilon_{cbr,t} \sim N(\mu_{cbr},\ \sigma^2_{cbr}), \sigma^2_{cbr} \geq 0, \text{and } 0<\theta<1 \tag{3.38}$$

11. the real bank credit identity;

$$rcredit_t= \frac{(creditp_t+creditp_t)}{P_{AC,t}} \tag{3.39}$$

4.0 Empirical analysis

4.1 The estimated model

For the ease of cross-referencing between the estimable model and the model estimation results, we provide the estimable model in its code representation and by its economic growth, development finance, and fiscal operations and public debt modules. For the ease of reference among the model equations, we have provided the equation serial numbers.

Names of the parameters to be estimated are expressed in italics and the variables in terms of which the model is specified are in normal fonts. Lower- and upper-case model variable notations are simply variable names with no special consideration attaching to them.

Note that "*" is the multiplication operator, "^" is the operator for "raising a variable or an expression to the power of" and "{1}" is the first order lag operator on the variable to which its appended.

The economic growth module

```
yi = A*(K/omega)^alpha*((1-(deltaN+CvD))*N/omega)^(1-alpha)   (1)
y = yi*(P_yi/P_y)^(lambda/(lambda-1))   (2)
P_y = (1+tha_orgy)*P_yi   (3)
P_yi = lambda*(alpha)^(-alpha)*(1-alpha)^(-(1-alpha))*(P_K)^alpha*(1-(1-(deltaN+CvD))*W)^(1-alpha)   (4)
N = P_K/W*(alpha/(1-alpha))*K/*(((1-(deltaN+CvD))*)^2   (5)
P_K = (1+deltaK)*P_K{1}+(1+deltaI)*P_I   (6)
P_I = tha*P_AC   (7)
P_AC = (1+(indirtax/100))*P_yi   (8)
P_CPI = (1-tha)*P_AC   (9)
W = (1-alpha)*(alpha)^(alpha/(1-alpha))*A^(1/(1-alpha))*(P_K)^(alpha/(1-alpha))   (10)
K = (1-deltaK)*K{1}+(1-deltaI)*INVST   (11)
INVST = gha*rcredit   (12)
```

$$\text{y\_bar} = \text{P\_AC*y} \tag{13}$$

$$\text{C} = \text{(1-tha)*y\_bar} \tag{14}$$

$$\text{G} = \text{y\_bar-(y\_dis+(xpo-mpo))} \tag{15}$$

$$\text{y\_dis} = \text{(1-tax/100)*y\_bar} \tag{16}$$

$$\text{A} = \text{a0+a1*A\{1\}} \tag{17}$$

$$\text{xpo} = \text{x0+x1*xpo\{1\}} \tag{18}$$

$$\text{mpo} = \text{m0+m1*mpo\{1\}} \tag{19}$$

$$\text{tax} = \text{dirtax+indirtax} \tag{20}$$

$$\text{dirtax} = \text{t0+t1*tax\{1\}} \tag{21}$$

$$\text{indirtax} = \text{t2+t3*indirtax\{1\}} \tag{22}$$

$$\text{CvD} = \text{v2+v3*CvD\{1\}} \tag{23}$$

The financial development module

$$\text{cob} = \text{c0-c1*rdeposr+c2*y\_dis+c3*P\_AC} \tag{24}$$

$$\text{rdeposr} = \text{deposr-xpctinfp\_ac} \tag{25}$$

$$\text{depos} = \text{b0+b1*rdeposr+b2*P\_AC} \tag{26}$$

$$\text{creditp} = \text{r0+r1*depos+r2*spreadp-r3*rlendp -r4*prov+r5*y\_dis+r6*P\_AC} \tag{27}$$

$$\text{creditg} = \text{g0+g1*depos+g2*spreadg-g3*rlendg+g4*P\_AC} \tag{28}$$

$$\text{deposr} = \text{d0+d1*cbr} \tag{29}$$

$$\text{lendp} = \text{l0+l1*cbr} \tag{30}$$

$$\text{lendg} = \text{e0+e1*cbr} \tag{31}$$

$$\text{gnpls} = \text{p0-p1*gnpls\{1\}+p2*prov} \tag{32}$$

$$\text{prov} = \text{v0+v1*gnpls} \tag{33}$$

$$\text{cbr} = \text{z0+z1*cbr\{1\}} \tag{34}$$

Definitional identities

$$\text{rcredit} = \text{(creditp+creditg)/P\_AC} \tag{35}$$

$$\text{spreadp} = \text{lendp-deposr} \tag{36}$$

$$\text{spreadg} = \text{lendg-depos} \tag{37}$$

$$\text{rlendg} = \text{lendg-xpctinfp\_ac} \tag{38}$$

$$\text{rlendp} = \text{lendp-xpctinfp\_ac} \tag{39}$$

$$\text{xpctinfp\_ac} = \text{(P\_AC\{-1\}/P\_AC)\^{}12} \tag{40}$$

The model variables and parameters to be estimated are provided in **Table 3** and **Table 4**.

Table 3: Model variables

y_bar	domestic final output whose nominal value is the real gross domestic product at constant prices (KShs billion, February 2009=100)
y	domestic final output
yi	domestic intermediate output
P_y	domestic currency nominal price of y (Index, February 2009=100)
P_yi	domestic currency nominal price of yi (Index, February 2009=100)
N	employment level in the economy which is the unobserved number of employees
P_K	domestic currency price of physical capital stock K in the economy (Index, February 2009=100)
P_I	domestic currency price of investment goods INVST in the economy (Index, February 2009=100)
P_AC	domestic currency current market price of domestic final output y (Index, February 2009=100)

P_CPI	domestic currency current market price of domestic final consumption goods C (KShs billion, Index, February 2009=100)
W	domestic currency current market wage rate (Index, February 2009=100)
K	physical capital stock expressed in terms of domestic currency constant market prices (KShs billion, February 2009=100)
INVST	final investment goods expressed in terms of domestic currency constant market prices (KShs billion, February 2009=100)
C	final consumption goods expressed in terms of domestic currency constant market prices (KShs billion, February 2009=100)
y_dis	real disposable income expressed in terms of domestic currency constant market prices (KShs billion, February 2009=100)
A	unobserved state of aggregate production technology (a scale factor)
xpo	exported goods expressed in terms of domestic currency constant market prices (KShs billion, February 2009=100)
mpo	imported goods expressed in terms of domestic currency constant market prices (KShs billion, February 2009=100)
cob	currency (notes and coins) outside banks (KShs billion)
depos	nominal bank deposits (KShs billion)
creditp	nominal bank credit held by domestic private sector borrowers (KShs billion)
creditg	nominal bank credit held by domestic public sector borrowers (KShs billion)
deposr	bank deposit net nominal interest rate (% per annum)
lendp	net nominal interest rate on domestic private bank credit (% per annum)
lendg	net nominal interest rate on domestic public bank credit (% per annum)
gnpls	domestic banks nominal gross non-performing loans (KShs billion)
prov	domestic banks nominal provisions for non-performing loans (KShs billion)
cbr	net nominal central bank rate (% per annum)
Debt	nominal public debt (KShs billion)
G	nominal government expenditures (KShs billion)
Rev	nominal government revenues (KShs billion)
tax	net effective nominal government taxation rate (% per annum)
nontax	effective nominal government non-tax income rate (% per annum)
dirtax	net effective nominal government direct taxation rate (% per annum)
indirtax	domestic net effective nominal government indirect taxation rate (% per annum)
CVD	COVID-19 pandemic labour supply shock

Table 4: Model parameters

omega	number of the intermediate good producing firms in the economy which should ideally be equal to unity
alpha	physical capital share of domestic output
deltaN	human capital depreciation rate
lambda	gross price mark-up in the domestic goods market

tha_orgy	fraction of the domestic intermediate good price which is the representative good producing firm's organization cost of production
deltaK	physical capital depreciation rate
deltaI	physical capital stock adjustment cost rate
tha	scale factor of the gross domestic product deflator which is the price of domestic final investment final output
gha	scale factor of domestic bank credit which is development finance in the economy;
a0	stochastic trend in the law of motion of the state of aggregate production technology
x0	stochastic trend in the law of motion of exports
x1	persistence parameter in the law of motion of exports
m0	stochastic trend in the law of motion of imports
m1	persistence parameter in the law of motion of imports
t0	stochastic trend in the law of motion of net effective direct taxation rate
t1	persistence parameter in the law of motion of net effective direct taxation rate
t2	stochastic trend in the law of motion of net effective indirect taxation rate
t3	persistence parameter in the law of motion of net effective indirect taxation rate
t4	stochastic trend in the law of motion of the net effective non-tax income rate
t5	persistence parameter in the law of motion of the net effective non-tax income rate
c0	autonomous currency outside banks
c1	elasticity of currency outside banks to real net interest rate on bank deposits
c2	elasticity of currency outside banks to real disposable income
c3	elasticity of currency outside banks to output prices
b0	autonomous domestic nominal bank deposits
b1	elasticity of bank deposits to real net interest rate on bank deposits
b2	elasticity of bank deposits to output prices
r0	autonomous domestic private nominal bank credit
r1	elasticity of the domestic private nominal bank credit to nominal bank deposits
r2	elasticity of the domestic private nominal bank credit to the profitability of lending in the private sector where the profitability is proxied by domestic private bank lending-deposit interest rate differentials
r3	elasticity of the domestic private nominal bank credit to its real lending interest rate
r4	elasticity of the domestic private nominal bank credit to domestic credit risk which is proxied by the gross non-performing loans
r5	elasticity of the domestic private nominal bank credit to domestic banks provisioning for non-performing loans
r6	elasticity of the domestic private nominal bank credit to real disposable income
r7	elasticity of the domestic private nominal bank credit to domestic output prices
g0	autonomous domestic public nominal bank credit
g1	elasticity of the domestic public nominal bank credit to domestic nominal bank deposits
g2	elasticity of the domestic public nominal bank credit to profitability of lending in the public sector where the profitability is proxied by the domestic public bank lending-deposit interest rate differentials

g3	elasticity of the domestic public nominal bank credit to domestic public bank real lending interest rate
g4	elasticity of the domestic public nominal bank credit to domestic output prices;
g5	stochastic trend in the law of motion of domestic government nominal expenditures
g6	persistence parameter in the law of motion of domestic government nominal expenditures
d0	stochastic trend in the law of motion of the domestic net nominal interest rate on bank deposits
d1	persistence parameter is the law of motion of the domestic net nominal interest rate on bank deposits
l0	stochastic trend in the law of motion of the domestic private net nominal lending interest rate
l1	persistence parameter in the law of motion of the domestic private net nominal lending interest rate
e0	stochastic trend in the law of motion of the domestic public net nominal lending interest rate
e1	persistence parameter in the law of motion of the domestic public net nominal lending interest rate
p0	stochastic trend in the law of motion of domestic banks gross non-performing loans
p1	persistence parameter in the law of motion of domestic banks gross non-performing loans
p2	elasticity of the gross non-performing loans to bank provisions for non-performing loans
v0	stochastic trend in the law of motion of domestic bank provisions for non-performing loans
v1	persistence parameter in the law of motion of domestic bank provisions for non-performing loans
v2	elasticity of the bank provisions to gross non-performing loans
z0	stochastic trend in the law of motion of the central bank rate
z1	persistence parameter in the law of motion of the central bank rate
v2	stochastic trend in the law of motion of the COVID-19 pandemic labour supply shock
v3	persistence parameter in the law of motion of the COVID-19 pandemic labour supply shock
sd_cob	standard error of currency outside banks
sd_depos	standard error of bank deposits
sd_creditp	standard error of domestic private bank credit
sd_creditg	standard error of domestic public bank credit
sd_deposr	standard error of the domestic bank deposit interest rate
sd_lendp	standard error of the domestic private bank nominal lending interest rate
sd_lendg	standard error of the domestic public bank nominal lending interest rate
sd_cbr	standard error of the central bank interest rate
sd_xpo	standard error of exports
sd_mpo	standard error of imports
sd_dirtax	standard error of net direct taxation rate
sd_indirtax	standard error of net indirect taxation rate
sd_gnpls	standard error of gross non-performing loans
sd_prov	standard error of bank provisions
sd_nontax	standard error of non-tax income rate
sd_G	standard error of nominal government expenditures
sd_A	standard error of the state of aggregate production technology

4.2 Estimation

We estimate the model excluding the COVID-19 effects, where therefore CvD=0, using Bayesian econometric techniques and monthly time series data drawn from the period 2009:01-2017:02 for the following ten observable variables: y_bar and P_AC for the real sector; cob, depos, creditp, creditg, deposr, lendp, lendg and cbr for the financial sector. Note that the central bank rate cbr is a key monetary policy instrument. We follow Smets and Wouters (2003). Unlike Smets and Wouters, however, we apply the Regress Analysis of Time Series (RATs) software (Estima, 2018).

Bayesian model estimation techniques are appropriate because the estimable model is partly specified using rational expectation terms such as the expected domestic final output prices P_AC{-1} as well as unobserved variables such as the employment level N and physical capital stock K. The techniques are however prone to difficulties in deriving a non-linear model's steady states which is a requirement for solving the model into state-space representation for estimation using the linear Kalman filter. At te centre of the problem is choosing priors for the parameters to be estimated and there is no definite solution except appropriately employing one's intuition. Our estimable model is non-linear.

An indication of the appropriateness of the chosen priors is that Kalman filter iterative process takes a sufficiently large number of optimization iterations failure to which the process would have possibly stalled before deriving optimal parameter estimates. Although our estimation process did not converge under the very stringent default criterion, we consider the 128 Kalman filter optimization iterations achieved in our estimation to be adequate for obtaining reliable parameter estimates. We subject the estimates to identification using relevant theoretical predictions of qualitative effects and magnitudes of effect.

Considering the short span of data on COVID-19 pandemic case fatal rates, we use daily time series drawn from 2020:03:27-2021:03:10 to estimate the law of motion of the COVID-19 pandemic labour supply shock. We then compute the long run value of the shock from the estimated law of motion and scale it up to its monthly equivalent to obtain CvD=0.51.

Once the constraint CvD=0 is relaxed and we plug in CvD=0.51 into the estimable model, we obtain the estimated model as it applies within the context of the COVID-19 pandemic regime. The marginal analysis of the effect of COVID-19 pandemic labour supply shock involves computing the effect of an increase in the human capital depreciation rate by 51%.

Using monthly time series data to estimate the model is appropriate. This is because the estimated model can then be used as a tool for economic and policy analysis to provide timely economic advice to policy makers. Using monthly data does however present us with some challenge where observed data for the gross domestic product and the gross domestic product deflator are available on a quarterly basis.

We therefore interpolate the quarterly time series data for the gross domestic product and the gross domestic product deflator as discussed in Appendix 1. Suffice it to say that the interpolated data is adequate.

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5.0 The Model Estimation Results

5.1 Presentation

We provide the results in Table 5 where column 1 shows row numbers for the ease of reference to specific results. Column 1 lists the estimated model parameters using the initial values in column 3. The parameter estimates are provided in column 4 with corresponding standard errors, T-statistic values and the marginal statistical significance levels which are provided in columns 5, 6 and 7.

The coefficients' standard errors are very small and that shows that the parameter estimates are efficient. That is consistent with the rather unusually large T-statics values and very small marginal statical significance levels.

We have plotted graphs of actual and fitted data of selected variables in Figure 4 through Figure 20 to show that the model estimation results fit the data relatively well. In each case, the actual and fitted series, which cover the period 2009:01-2017:02, are confined to within the 95% upper and lower confidence intervals.

Table 5: Model estimation results

N0.	parameter	Coeff	Std rror	T-Stat	Signif
1	omega	0.923	0.000	29,562,150.34	0.000
2	alpha	0.486	0.000	77,252,203.93	0.000
3	deltaN	0.218	0.000	1,559,216.14	0.000
4	lambda	1.564	0.000	22,279,360.36	0.000
5	tha_orgy	0.103	0.000	3,617,555.31	0.000
6	deltaK	0.022	0.000	229,544.80	0.000
7	deltal	0.027	0.000	4,147,226.60	0.000
8	tha	0.084	0.000	3,304,555.11	0.000
9	gha	1.125	0.000	23,662,003.87	0.000
10	a0	-0.001	0.000	-43,635.99	0.000

N0.	parameter	Coeff	Std rror	T-Stat	Signif
11	x0	0.532	0.000	17,102,879.49	0.000
12	x1	0.825	0.000	28,334,946.72	0.000
13	t0	1.643	0.000	31,192,202.49	0.000
14	t1	0.435	0.000	12,922,725.45	0.000
15	t2	1.634	0.000	28,348,422.23	0.000
16	t3	0.661	0.000	3,064,236.55	0.000
17	t4	0.864	0.000	25,900,229.47	0.000
18	t5	0.436	0.000	13,068,295.09	0.000
19	c0	2.118	0.000	19,703,239.29	0.000
20	c1	-0.106	0.000	-3,405,646.01	0.000
21	c2	0.019	0.000	6,935,059.26	0.000
22	c3	1.293	0.000	24,321,553.32	0.000
23	b0	0.580	0.000	4,542,248.85	0.000
24	b1	-0.011	0.000	-643,097.51	0.000
25	b2	0.682	0.000	1,246,468.81	0.000
26	r0	-0.295	0.000	-2,822,600.00	0.000
27	r1	0.431	0.000	5,749,989.41	0.000
28	r2	0.319	0.000	5,393,363.49	0.000
29	r3	-0.409	0.000	-8,077,052.86	0.000
30	r4	-0.179	0.000	-4,010,232.47	0.000
31	r5	0.098	0.000	4,640,545.02	0.000
32	r6	0.011	0.000	307,750.22	0.000
33	r7	2.892	0.000	52,961,197.24	0.000
34	g0	-4.126	0.000	-4,774,026.45	0.000
35	g1	0.228	0.000	1,517,512.95	0.000
36	g2	0.015	0.000	1,429,053.48	0.000
37	g3	-0.173	0.000	-5,066,362.02	0.000
38	g4	2.854	0.000	22,243,100.83	0.000
39	g5	3.282	0.000	30,470,177.61	0.000
40	g6	0.440	0.000	8,693,494.51	0.000
41	d0	0.265	0.000	7,538,444.51	0.000

NO.	parameter	Coeff	Std rror	T-Stat	Signif
42	d1	0.687	0.000	21,359,737.81	0.000
43	l0	2.180	0.000	31,057,604.80	0.000
44	l1	0.311	0.000	9,991,029.81	0.000
45	e0	-0.857	0.000	-24,609,700.00	0.000
46	e1	1.359	0.000	35,915,670.51	0.000
47	p0	0.315	0.000	9,738,377.66	0.000
48	p1	0.897	0.000	16,951,558.16	0.000
49	p2	0.004	0.000	214,317.95	0.000
50	v0	0.469	0.000	15,341,410.84	0.000
51	v1	0.832	0.000	27,168,933.47	0.000
52	v2	0.004	0.000	109,113.09	0.000
53	z0	0.089	0.000	1,150,515.60	0.000
54	z1	0.707	0.000	16,489,390.32	0.000
55	sd_cob	6.770	0.000	1,135,910.62	0.000
56	sd_depos	3.030	0.000	1,050,204.44	0.000
57	sd_creditp	1.350	0.000	371,555.97	0.000
58	sd_creditg	1.623	0.000	1,090,550.01	0.000
59	sd_deposr	0.157	0.000	119,521.14	0.000
60	sd_lendp	0.837	0.000	281,600.71	0.000
61	sd_lendg	1.783	0.000	723,960.98	0.000
62	sd_cbr	0.099	0.000	1,313,926.28	0.000
63	sd_xpo	0.082	0.000	94,426.64	0.000
64	sd_mpo	0.132	0.000	121,996.72	0.000
65	sd_dirtax	0.896	0.000	557,167.85	0.000
66	sd_indirtax	0.657	0.000	1,294,831.27	0.000
67	sd_gnpls	0.046	0.000	80,026.44	0.000
68	sd_prov	0.044	0.000	n/a	0.000
69	sd_nontax	0.844	0.000	996,413.36	0.000
70	sd_G	0.798	0.000	646,075.18	0.000
71	sd_A	0.337	0.000	724,119.00	0.000

Note: n/a shows that no estimation result was obtained due to data limitations.

The model results do not fit fiscal operations and public debt data well. Aggregate demand for domestic final output and, in particular, the external economic sector which is captured by the trade account balance expressed as the excess of export over import is also not well defined.

Despite the poor empirical performance of the model regarding fiscal operations, public debt and the external sector, the results on the real and financial sector variables, which are directly relevant to the objectives of this study, are adequate. That is because the real sector variables including domestic final output and its prices are adequately determined on the production side and the key financial sector equations including those for the determination of bank credit and credit interest rates are specified within the context of the McKinnon-Shaw financial repression model where fiscal operations and public debt do not play a major role.

5.2 Real Sector Variables

Fig. 4: Actual and fitted domestic final output (y_bar)

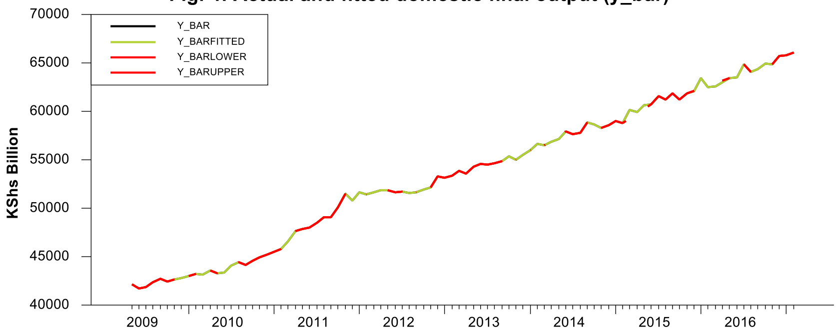


Fig. 5: Actual and fitted gdp deflator (p_ac)

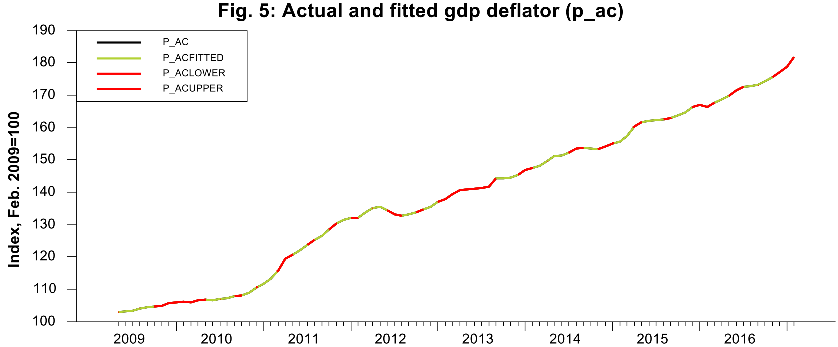


Fig. 6: Fitted consumer price index (p_cpi)

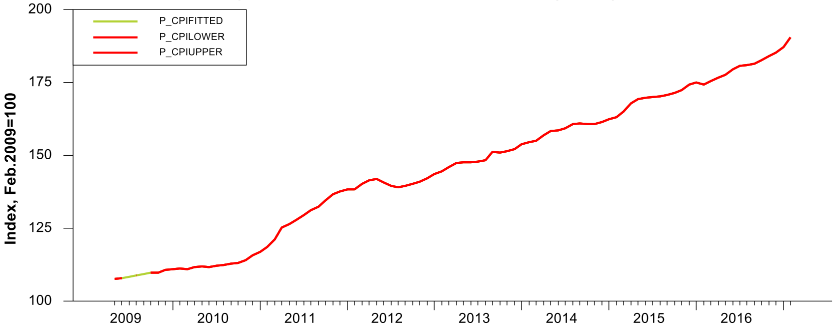
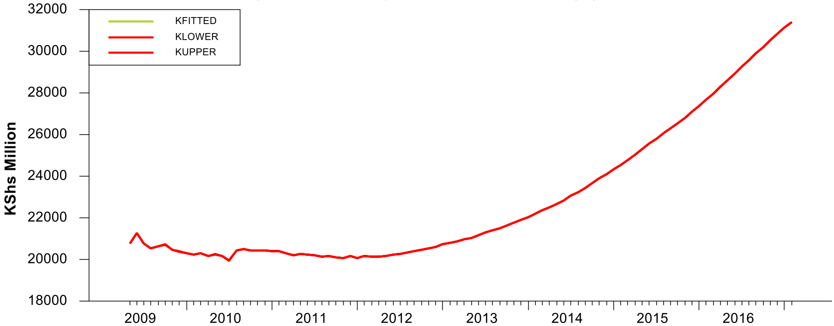


Fig. 7: Fitted physical capital stock (K)



*

Fig. 8: Fitted employment level (n)

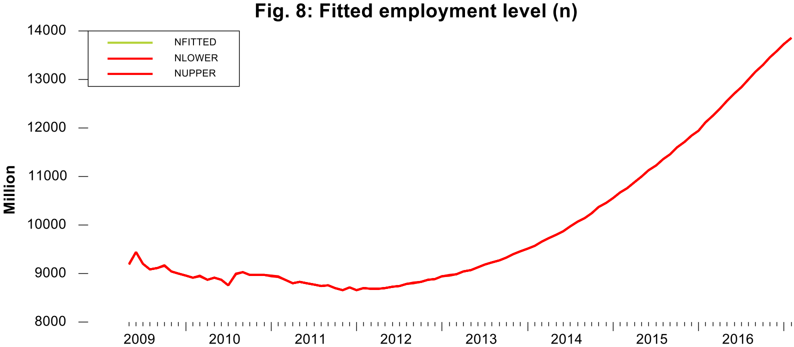


Fig. 9: Fitted wages (W)

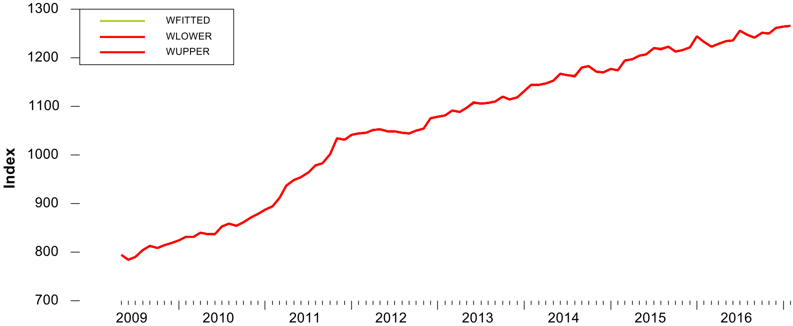


Fig. 10: Fitted ivestment (invst)

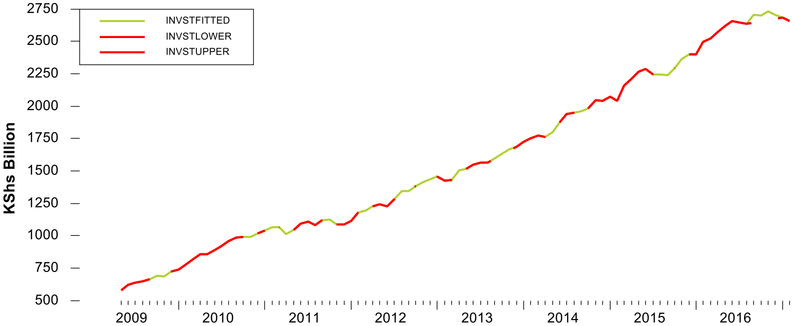


Fig. 11: Fitted private consumption (c)

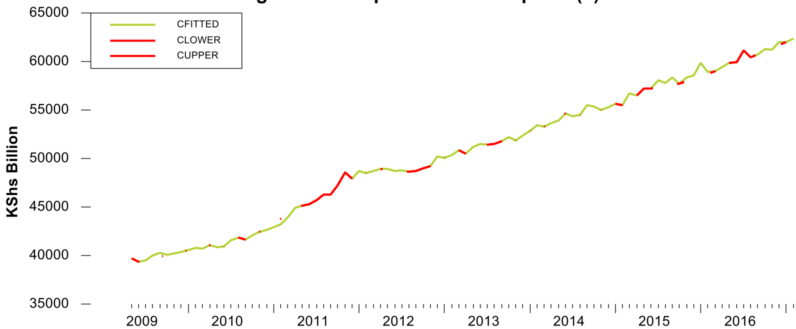
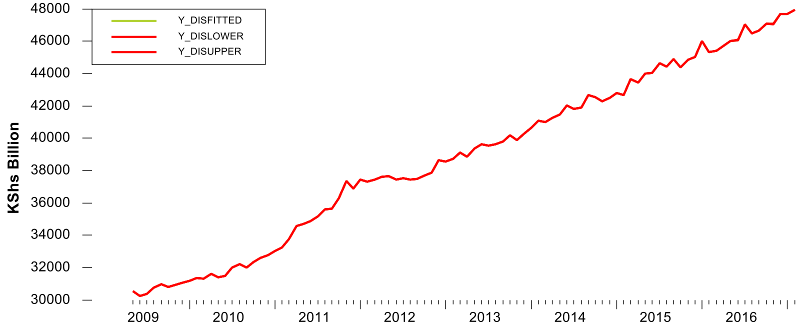


Fig. 12: Fitted real disposable income (y_dis)



5.3 Financial Sector Variables

Fig. 13: Actual and fitted currency outside banks (cob)

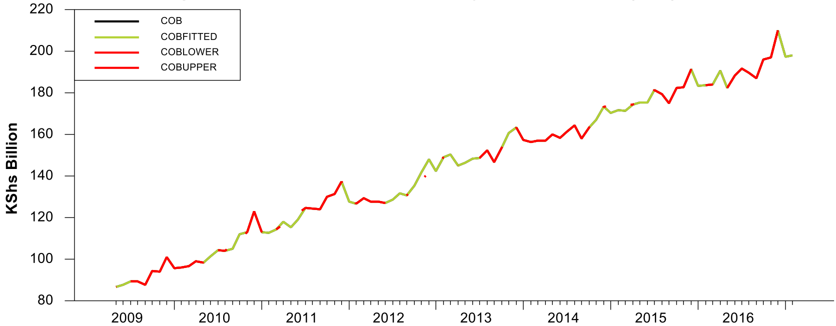


Fig. 14: Actual and fitted bank deposits (depos)

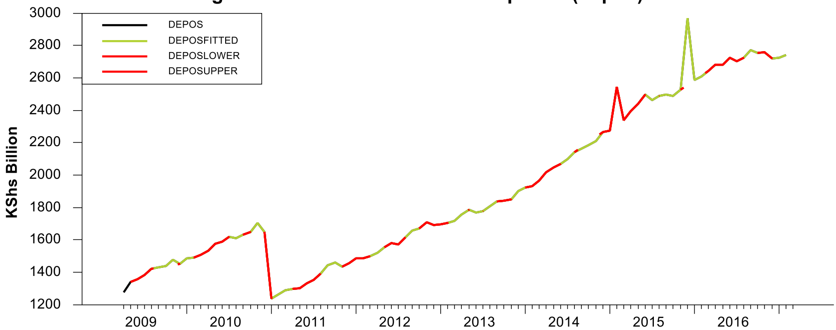


Fig. 15: Actual and fitted private bank credit (creditp)

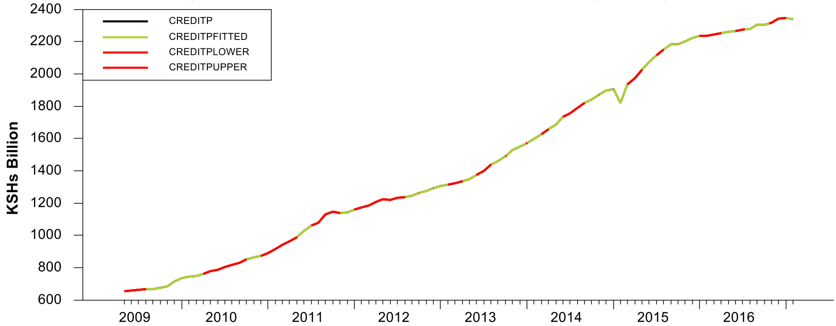


Fig. 16: Actual and fitted public bank credit (creditg)

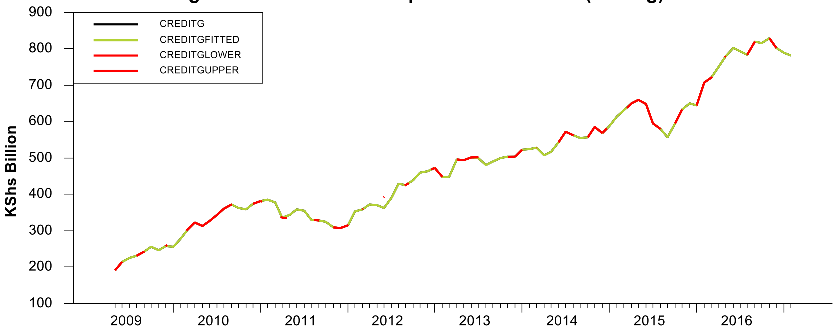


Fig. 17: Actual and fitted deposit interest rate (depor)

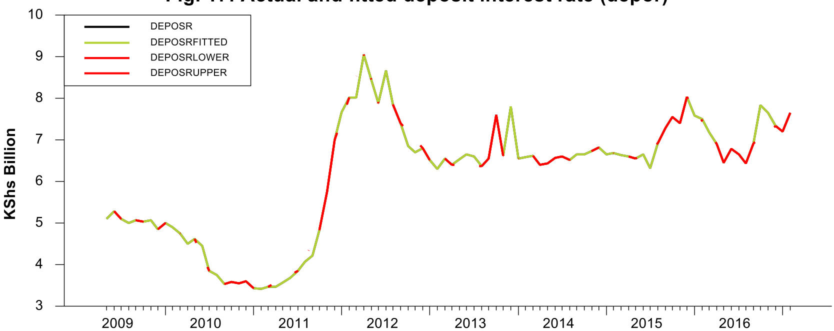


Fig. 18: Actual and fitted private lending interest rate (lendp)

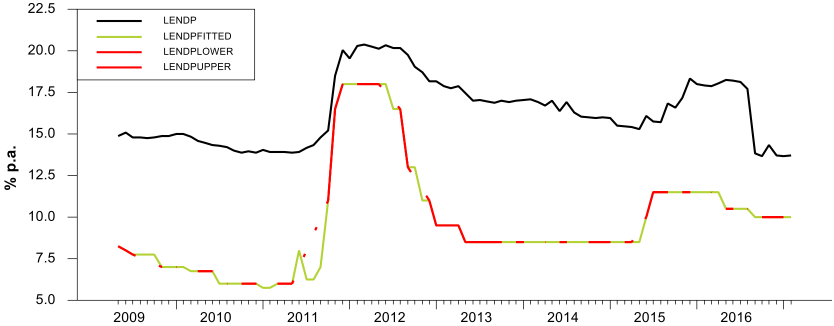


Fig. 19: Actual and fitted public lending interest rate (lendg)

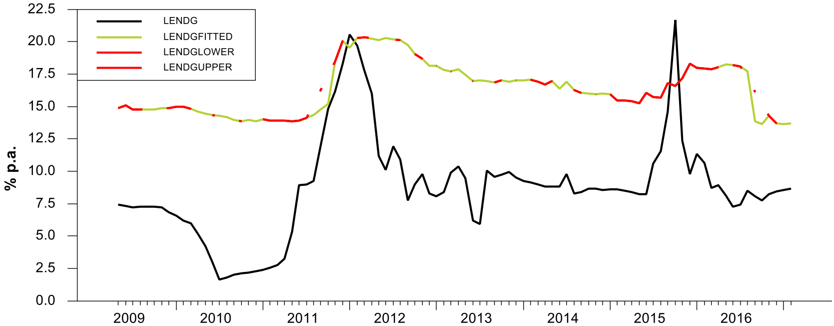
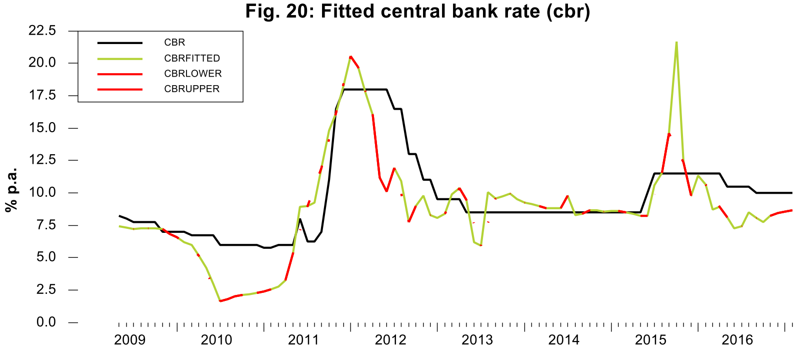


Fig. 20: Fitted central bank rate (cbr)



5.4 Discussion

We discuss the model estimation results by the specific objective of the study.

5.4.1 The finance-economic growth nexus

Development finance and growth are interdependent

The results show that bank credit, which represents development finance, and economic growth are interdependent and therefore mutually causative. Dependence of domestic final output y_bar and by extension economic growth on bank credit is captured in the model estimation results by gha in the domestic investment INVST equation (13) where, according to the results in **Table 5**, *gha=1.125*. Thus, domestic final output and economic growth increase with increasing real bank credit in the economy. An increase in real bank credit in the economy by 1 percentage point is expected to lead to an increase in domestic investment INVST by 1.125 percentage points.

Considering the capital adjustment cost rate of deltal=0.027 see **Table 5** row 7 under Coeff, 0.027 of the 1.125 percentage point increase in investment goods is lost during installation of the goods into new physical capital stock. The true effect of the initial corresponding increase in real bank credit on physical capital stock K through investment is therefore (10.027) *1.125 = 0.073 *1.125 = 1.095 percentage points.

Considering also that the elasticity of domestic intermediate output, and by extension domestic final output, with respect to domestic physical capital is equal to the capital share of the output, which is alpha=0.486 as provided in **Table 5** row 3, the elasticity of domestic final output and economic growth to real bank credit is therefore 0.486*1.095=0.532. An increase in real bank credit by 1 percentage point is therefore expected to lead to an increase in domestic final output, by extension economic growth, by 0.532 percentage points; which is a less than proportionate effect.

Conversely, the dependence of real bank credit on domestic final output and economic growth is captured by the direct effect of the real disposable income y_dis on domestic private bank credit creditp in equation (22) which is captured by r6=0.011 as provided in **Table 5** under row 24.

The historical record of real disposable incomes during the study period shows that domestic output and economic growth have been on a general persistent declining trend since October 2015. It is therefore reasonable to believe that disposable incomes must have been confined to the too low range. We therefore infer that the mutual causation between bank credit and economic growth is that of a vicious circle of development finance and economic growth where due to too slow economic growth, there is too slow real bank credit creation.

The McKinnon-Shaw financial repression exists

The downward spiral in bank credit and economic growth is exacerbated by the McKinnon-Shaw-like financial repression. See McKinnon (1973) and Shaw (1973). The model estimation results show that once *rdeposr* increases, *depos* and currency outside banks *cob* decrease.

The determination of bank deposits in the economy *depos* is provided by (21) where the elasticity of the deposits to real bank deposit interest rate *rdeposr*, which is computed within the context of the Fisherian equation (see Fisher, 1977) as $rdeposr=(deposr-(P_{AC}\{-1\}/P_{AC})^{12})$, is provided by $b1=-0.011$ in **Table 5** under *Coeff* at row 24.

Consistently, being the opportunity cost of currency (notes and coins) outside banks *cob*, the elasticity of *cob* to *rdeposr* is provided by $c1=-0.106$. See **Table 5** row 20. Intuitively, while an increase in the real bank deposit interest rate leads to a decrease *cob*, the reduction is not in favour of bank deposits whose real rate of return must be too small. The decrease in *cob* must therefore be in favour of other investment/saving vehicles whose real rate of return is considered to be relatively more remunerative than bank deposits.

We must add that consistent with theoretical expectations, the model estimation results show that once bank deposits *depos* increase, being an input into bank credit creation, induces an increase in domestic private bank credit *creditp* and public bank credit *creditg*. The elasticities of *creditp* and *creditg* to *depos*, which are positively signed, are $r1=0.432$ and $g1=0.228$ in equations (22) and (23) and in **Table 5** at row 27 and 35 under *Coeff*.

Sticky lending interest rates hurt bank lending

Consistent with expectations, the results show that an increase in banks' profit margin rate from financial intermediation *(lendp-deposr)* is positively related to domestic private bank credit *creditp*. The results are provided by, for instance, $r2=0.319$ at row 28 in **Table 5** under the *coeff* column. The results suggest that if the profit margin rate were suppressed as witnessed under the short-lived Banking (Amendment) Act 2016, private bank credit will decrease.

It has been argued that although the Act was repealed in November 2019, the profit margin rates have remained equally constrained as if the Act was operational. That is because banks cannot fully price the credit repayment default risk, which is expressed in terms of the gross non-performing loans, into the net nominal lending interest rate on domestic private credit as the Central Bank of Kenya takes too long to approve bank requests to change the lending rates. There is therefore residual financial repression effects arising from the Banking (Amendment) Act 2016 which hurts bank lending. To unleash banks' potential in core financial intermediation, which is deposit mobilization and credit creation, the bank lending and bank deposit interest rate determination regime should revert to the pre-Banking (Amendment) Act 2016 period where the rate were determined by the free market forces of demand for and supply of bank credit.

5.4.2 COVID-19 pandemic adversely affects the economy

COVID-19 pandemic, employment, and output

The model estimation results show that the pre-COVID-19 pandemic human capital depreciation rate is $deltaN=0.218$, which is provided in **Table 5** at row 3 and the *Coff* column. We estimate that the COVID-19 pandemic increases the depreciation rate by 0.51 units and therefore, certainly, reduces domestic final output and economic growth by reducing the employment level in the economy.

Considering that the capital share in domestic final output is *alpha*= 0.486, see row 2 and the *Coeff* column in **Table 5**, the labour share must be 51.4%. That suggests that the elasticity of domestic output to the employment level is 0.514 and that therefore an increase in the human capital depreciation rate by 0.51 due to COVID-19 pandemic labour supply shock, which represents a decrease in the employment level by as many percentage points, leads to a decrease in domestic final output and economic growth by 0.514*0.51=0.262 percentage points.

Suffice it to say that since COVID-19 labour supply shock hurts economic growth, it must also exacerbate the vicious circle of development finance (which is expressed as bank credit) and economic growth since March 2020.

COVID-19 pandemic and production technology

The model estimation results show that the capital share of output is *alpha*= 0.486 and therefore suggests that production technology was labour-intensive before COVID-19 pandemic arrived in March 2020. A decrease in the employment level due to the increase in human capital depreciation by 0.51 must have led to a shift to capital-intensive production technology as firms and banks enhanced physical capital stock as a substitute for lost human capital in a bid to sustain their respective output levels to the extent that demand allowed.

5.4.3 Fiscal and monetary policies are partly effective

Fiscal and monetary policies are effective if the policies' key transmission channels are operational and if implementing appropriate fiscal and monetary policies is devoid of binding constraints.

Policy transmission channels

Fiscal policy

There are 4 fiscal policy instruments incorporated into the analysis, namely, government expenditure *G*, the net effective taxation rate *dirtax*, the net effective indirect taxation rate *indirtax*, and the net effective non-taxation income rate *nontax*. Government expenditure *G* is *s* key component of aggregate demand for domestic final outp*ut y_bar=P_AC*y* which is provided by equation (15). Certainly, the taxation rates are inversely related to disposable incomes and provide the means of raising ordinary revenues for funding government expenditures.

Other factors held constant, an increase in *G* leads to a proportionate increase in domestic final output, economic growth and disposable incomes with potential positive spill-over effects to bank credit creation. In that sense, fiscal policy transmission through the government expenditure channel is operational.

We have demonstrated the effect of disposable income on bank credit. Suffice it therefore, to say that other factors remaining constant, an increase in government taxation implicitly leads to a decrease in disposable income and, under normal circumstances, a decrease in households' effective demand for bank credit. In that sense also, the effective direct and indirect taxation rate channels of fiscal policy transmission are operational.

Monetary policy

The central bank rate *cbr* drives the bank deposit interest rate *deposr*, the lending rate on private bank credit *lendp* and the lending interest rate on public bank credit *lendg* as provided in equations (24), (25) and (26) where, in turn, *deposr*, *lendp* and *lendg* are important determinants of bank deposits and bank credit as provided by (21), (22) and (23) with spill-over effects to domestic final output as provided by (13). Clearly, therefore, the interest rate channel of monetary policy transmission is operational. The results are consistent with those derived in Maturu (2007) and Maturu and Ndirangu (2018).

Binding constraints

Fiscal policy

Lack of adequate fiscal space is the binding constraint on fiscal policy and precisely for that reason, fiscal policy is ineffective. The constraint derives from firstly, prolonged dismal economic performance which constrains government ordinary revenues and secondly, strong expansion in fiscal operations funded by public debt. Consequently, the government has limited sources of funding. That limits the government's capacity to mount a sustained meaningful fiscal stimulus package to spur economic growth, disposable income and bank credit to break the vicious circle of development finance and economic growth into a virtuous circle.

Monetary policy

Lack of adequate effective supply of and demand for bank credit is the binding constraint which renders monetary policy ineffective. The shared cause of inadequate effective supply of and demand for bank credit is the credit repayment default risk. The risk reveals in the persistently large gross non-performing loans gnpls and bank provisions prov for the non-performing loans.

The elasticities of domestic private bank credit *creditp* to *gnpls* and *prov* are provided by $r4$=-0.179 and $r5$=0.098 at rows 30 and 31 in Table 5. Note that the effective elasticity of *creditp* to *gnpls* is 0.179. That is because the equation for *creditp* is specified with a negatively signed parameter attaching to *gnpls*.

Consistent to expectations, the result $r5=0.098$ shows that an increase in *prov* which makes up for eroded bank capital, leads to an increase in *creditp*. That is logical because the risk adjusted bank capital is one of the inputs into bank credit creation.

Fiscal and monetary policy interdependence

Intuitively, given a certain national income, an increase in appropriation of the public sector's share of the income through taxation and non-tax measures leads to a reduction in household's disposable income. While that could relax the binding constraint on fiscal policy, it worsens the binding constraints on monetary policy. Similarly, increased public bank lending induced by monetary policy easing, has potential to ease the fiscal policy constraint with potential boomerang effects on monetary policy.

There is therefore potential for enhanced effectiveness of fiscal and monetary policies through well-coordinated fiscal and monetary policy formulation and implementation. That is consistent with the findings in Kabanda, Muriu and Maturu (2018). See also Mishikin (1995) for elaboration of the monetary policy transmission mechanism.

5.4.4 Policy implications and recommendations

There are two critical policy questions arising from our discussion of the model estimation results. What would happen if the economy is left to its own devices and no policy action was taken to break the vicious circle of development finance (or bank credit) and economic growth? What should be done regarding economic policies to achieve a virtuous circle of development finance and economic growth?

The two questions answer to policy implications and policy recommendations which we address in turns as follows.

Policy implications

If the economy is left to its own devices, where economic problems are resolved through automatic economic adjustment, the vicious circle of bank credit and economic growth would continue indefinitely with profound dire consequences to citizens' wellbeing. The adverse effects will arise from low employment levels, wages and disposable incomes which limit citizens' access to consumption. To check the potential adverse human welfare effects, implementation of appropriate fiscal and monetary policies is indispensable.

Policy recommendations

To break the vicious circle of bank credit and economic growth, the government and the central bank of Kenya should formulate and implement coordinated fiscal and monetary policies to, first and foremost, enhance fiscal space as well as spurring bank credit through enhanced effective supply of and demand for bank credit. To enhance fiscal space, which has potential to enhance effective supply of and demand for bank credit through the fiscal and monetary policy interdependence,

1. the central and county governments should re-examine current fiscal year budgets and reset project priorities;

    a. non-strategic projects and those whose implementation has not gone too far and have relatively less risk of losses in cancellation and postponement costs should be cancelled or postponed to secure public savings;

    b. public procurement and expenditure efficiency should be enhanced through enforcement of the public procurement and asset disposal Act to conserve public resources by minimizing leakages through corruption;

    c. should seek for enhanced official project grants and improved terms of external loans including debt cancellation, debt rescheduling and reduced interest cost;

    d. formulate and implement an appropriate fiscal stimulus package using savings from the budget rationalization where leakages of the stimulus package to imports should be minimized if not eliminating it to ensure maximum economic impact; and

    e. intensify vaccination of residents against the COVID-19 virus.

2. The Central Bank of Kenya should,
    a. formulate and implement appropriate monetary policy to support the fiscal stimulus package;
    b. revert to market-based determination of bank lending and deposit interest rates so as to eliminate residual financial repression from the repealed Banking (Amendment) Act 2016 amid safeguards to check potential adverse monopsonistic effects on determination of bank deposit interest rates and monopolistic effects on determination of bank lending interest rates; and
    c. towards tightening micro- and macro-prudential policies to rid the banking system off gross non-performing loans, consultatively design a schedule of eliminating gross non-performing loans.

6.0 Conclusion

We sought to empirically analyse the finance-growth nexus within the context of COVID-19 pandemic. We also analyse the effectiveness of fiscal and monetary policies to pave way to providing policy recommendations.

Based on model estimation results, which fit the data relatively well, we find that: development finance and growth are interdependent where *too slow economic growth induces too slow real bank credit creation*. There is therefore a vicious circle of development finance (which is expressed in terms of bank credit) and economic growth.

As part of the characterization of the finance-economic growth nexus, we also find that the classical McKinnon-Shaw financial repression exists. That is because an increase in real bank deposit interest rate does not lead to an increase in bank deposits. That is in spite of the increase leading to a decrease in currency outside banks which must then end up being invested in other investment vehicles other than bank deposits.

The model estimation results show further that sticky lending interest rates hurt bank lending and that the COVID-19 pandemic adversely affects the economy through its initial effect on the human capital depreciation rate. That compounds the vicious circle of finance and growth.

Although fiscal and monetary policy transmission channels are operational, the policies are not fully effective because of binding constraints on their formulation and implementation. Fiscal policy is constrained by inadequate fiscal space, and monetary policy by inadequate effective supply of and demand for bank credit.

Since the vicious circle of bank credit and economic growth cannot resolve itself except by chance, it would continue indefinitely if not checked using appropriate socio-economic policies. The Central and local governments should therefore review their respective budgets to secure savings for use in mounting fiscal stimulus packages that could not only enhance the effectiveness of fiscal policy but also unleash the potential of monetary policy considering that fiscal and monetary policy are interdependent. The Central Bank should, in consultation with commercial banks, develop a plan to eliminate gross non-performing loans which are the main cause of inadequate effective supply of and demand for bank credit. Moreover, the Ministry of Health should intensify vaccination of residents against the COVID-19 virus so as to minimize the human capital depreciation rate and its adverse effects on economic growth and bank lending.

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Appendix 1:

Derivation of the monthly real gross domestic product series

1. Analytical model

The quantity theory of money, where the effective supply of money MV is equal to the gross domestic product (GDP) PY, applies. We assume that the GDP deflator P is directly proportional to the consumer price index (CPI) P^CPI. Thus, [Y1]

$$MV=PY \quad [Y1]$$

And,

$$P \propto P^{CPI} \quad [Y2]$$

Where,

M is the nominal broad money stock;

V is the income velocity of circulation of money; and

Y is the domestic final output.

Re-organizing [Y1] into an expression of **Y**,

$$Y=MV/P \quad [Y3]$$

Log-linearizing [Y3], where y=Log(Y), m=Log(M), v=Log(V) and p=Log(P),

$$y=m+v-p \quad [Y4]$$

Considering potential observation and measurement errors in data, we re-write the exact equation provided by [Y4] as a behavioural equation.

$$y_t=\beta_0+\beta_1 m_t+\beta_2 v_t-\beta_3 p_t+\epsilon_{y,t}, \quad \forall \epsilon_{y,t} \sim N(\mu_y,\sigma_y^2) \text{ and } 0<\beta_1,\beta_2,\beta_3<\infty \quad [Y5]$$

For the avoidance of contemporaneous correlation between v_t and m_t, considering that we use available data for **PY** and money **M** to compute **V**, we use v_{t-1} instead of v_t. Thus,

$$y_t=\beta_0+\beta_1\, m_t+\beta_2 v_{t-1}-\beta_3\, p_t+\epsilon_{y,t},\quad \forall\epsilon_{y,t}\sim N(\mu_y,\sigma_y^2)\ \text{ and } 0<\beta_1,\beta_2,\beta_3<\infty \qquad [Y6]$$

Considering that p comprises the consumer good prices p^c and investment good prices p^i, p^c must be a fraction of p. We therefore re-write [Y2] explicitly as provided by [Y7].

$$p=\pi_0\, p^c,\ \ \forall\pi_0>0 \qquad [Y7]$$

For analytical convenience, we assume that 〖 v〗_t is adequately explained by m_t and 〖 p〗_t as provided by [Y8] where the effect of Y is embedded in the autonomous term α_0.

$$v_t=\alpha_0+\alpha_1\, m_t+\alpha_2\, p_t+\epsilon_{v,t},\quad \forall\epsilon_{v,t}\sim N(\mu\_v,\sigma_v^2)\ \text{ and } 0<\alpha_1,\alpha_2<\infty \qquad [Y8]$$

2. Empirical model

Using [Y7] in [Y6] and [Y8], we obtain [Y9] and [Y10].

$$y_t=\beta_0+\beta_1\, m_t+\beta_2\, v_{t-1}-\tilde{\beta}_3\, p_t\text{^}c+\epsilon_{y,t},\quad \forall\epsilon_{y,t}\sim N(\mu_y,\sigma_y^2)\ \text{ and } 0<\beta_1,\beta_2,\tilde{\beta}_3<\infty \qquad [Y9]$$

Where,

$$\tilde{\beta}_3=\beta_3\,\pi_0 \qquad [Y10]$$

And,

$$v_t=\alpha_0+\alpha_1\, m_t+\tilde{\alpha}_2\, p_t\text{^}c+\epsilon_{v,t},\quad \forall\epsilon_{v,t}\sim N(\mu_v,\sigma_v^2)\ \text{ and } 0<\alpha_1,\tilde{\alpha}_2<\infty \qquad [Y11]$$

Where,

$$\tilde{\alpha}_2=\alpha_2\,\pi_0 \qquad [Y12]$$

We estimate [Y9] and [Y11] using official quarterly time series data 2009:02-2019:03. We obtain the data from the Central Bank of Kenya (CBK) on $M_{q,t}$ and the Kenya National Bureau of Statistics (KNBS) on $Y_{q,t}$, $P_{q,t}$ and $P^c_{q,t}$. The data measurement is provided as follows where subscript "q" denotes quarterly data.

$M_{q,t}$ is broad money $M2_t$ expressed in millions of Kenya shillings;

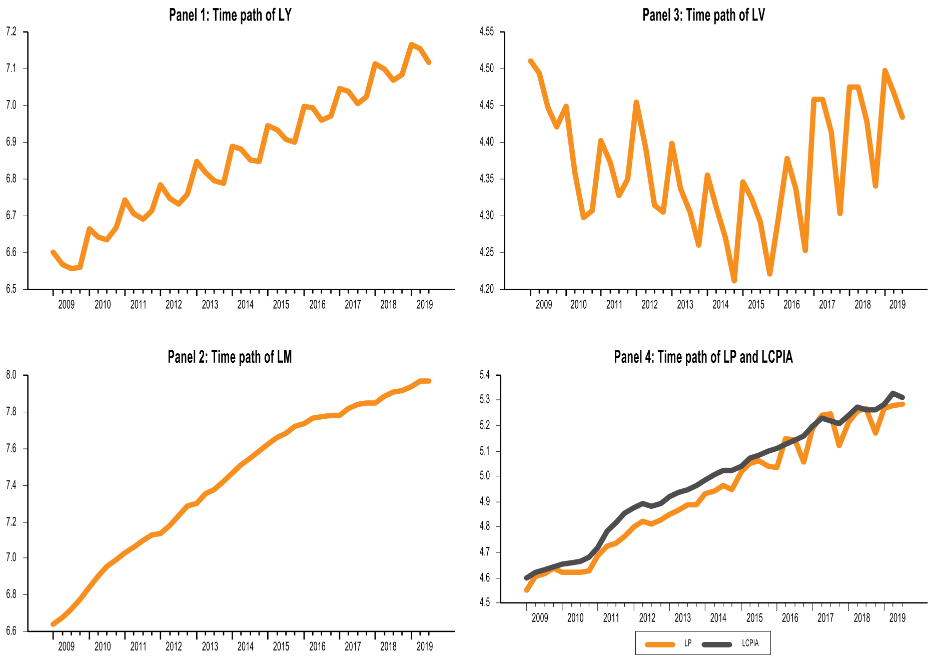
$Y_{q,t}$ is the real gross domestic product expressed in millions of Kenya shillings at constant market prices (February 2009=100);

$P_{q,t}$ is the gdp deflator (February 2009=100); and

$P^c_{q,t}$ is the consumer price index (February 2009=100).

To show the evolution of the data we have plotted **Figure 1**

Figure1: The time paths of model variables (logarithms)



3. Empirical results

3.1 Presentation

Upon estimating [Y11], [Y13] and [Y7], using ordinary least squares with robust error correction, we obtain the results in **Table 1**. For the ease of reference, we provide the results in equation form as provided by [Y13], [Y14] and [Y15].

It is notable that p_t that is directly proportional to p_t^c as provided by the restricted equation results $P_{q,r,t}$. That is because we fail to reject the null hypothesis that the constant value of in the equation of $P_{q,t}$ is not significantly different from zero under the t-test and F-test statics whose calculated values are $t(40)= -1.3$, and F(1,40)=1.6 with a marginal significance level of 0.209.

$$y_{q,t} = 1.5054+0.5974m_{q,t} + 0.5454v_{q,t-1} - 0.2946p^c_{q,t}\,, \quad \forall \mu_y=6.8672, and \sqrt{(\sigma_y^2)} = 0.0222 \qquad [Y13]$$

And,

$$v_{q,t}=2.9631-0.8946m_{q,t}+1.6159p^c_{q,t}\,, \quad \forall \mu_v=4.3651, and \sqrt{(\sigma_v^2\,)}=0.056 \qquad [Y14]$$

$$p_{q,t}=0.9913p^c_{q,t}\,, \quad \forall \mu_p=4.9494, and \sqrt{(\sigma_P^2)}=0.0334 \qquad [Y15]$$

It follows from [Y13] and [Y15] that $\beta_3\ \pi_0=-0.2946$ *where* $\pi_0=0.9913$ and that therefore,

$$0.9913\beta_3=-0.2946 \qquad [Y16a]$$

$$\beta_3=-0.2972 \qquad [Y16]$$

For information, we use [Y15] to express [Y13] in terms of $\mathrm{p_t}$ as provided by [Y17]

$$y_{q,t}=1.5054+0.5974m_{q,t}+0.5454v_{q,t-1}-0.2972p_{q,t}, \quad \forall \mu_y=6.8672, and \sqrt{(\sigma_y^2)} =0.0222 \qquad [Y17]$$

Table 1: Empirical results

Variable	$y_{q,t}$	$v_{q,t}$	$p_{q,t}$	$p_{q,r,t}$
Constant	1.5054	2.9631	-0.1529	
	(6.8)*	(10.2)*	(-1.3)	
$m_{q,t}$	0.5974	-0.8946		
	(7.4)*	(-6.1)*		
$v_{q,t}$	0.5455			
	(8.6)*			
$p^c_{q,t}$	-0.2946	1.6159	1.0219	0.9913
	(-2.0)**	(6.1)*	(42.6)*	(961.9)*
Diagnostic Test Statistics				
DW	1.6662	1.5818	1.6576	1.5975
SEE	0.0222	0.056	0.0331	0.0334
DF	38	38	40	41
Centred R^2	0.9847	0.4916	0.9784	

Notes: (.) the calculated t-statistic; * significant at 1% significance level; ** significant at 5% significance level; DW Durbin Watson, SEE Standard error of estimate/equation; and DF degrees of freedom.

3.2 Goodness of fit

We have plotted the logarithms of actual and fitted series of the real gross domestic product RGDP, income velocity of circulation of money V and the GDP deflator P in **Figure 2**, **Figure 3**, and **Figure 4** to show that the results adequately fit the data because both the actual and fitted series are confined to within the 95% confidence intervals throughout the study sample 2009:02-2019:03.

Figure 2:

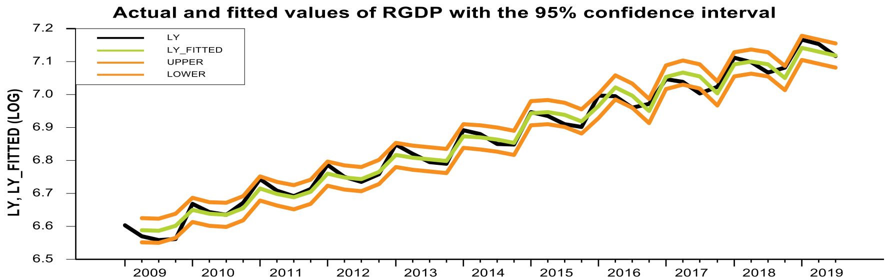


Figure 3:

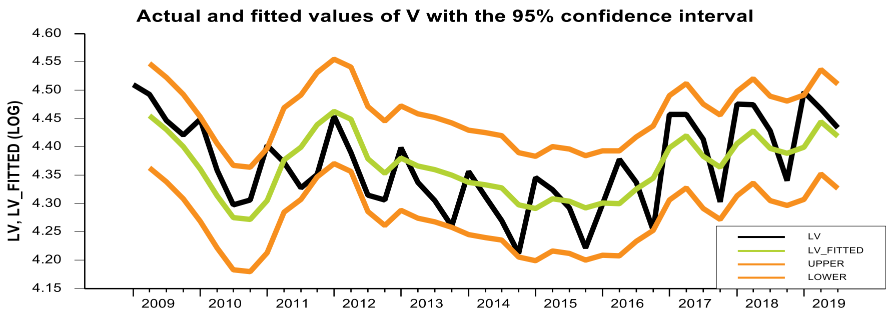
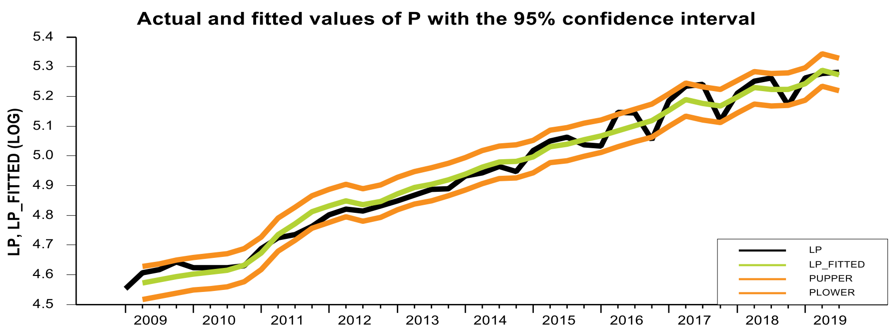


Figure 4:



Note: Based on the restricted regression results

3.3 Application

Derivation of monthly data

We assume that the quarterly data model results apply to monthly data and therefore the log monthly RGDP data is determined as provided by [Y18]

$$y_{m,t} = 1.5054 + 0.5974m_{m,t} + 0.5454v_{m,t-1} - 0.2946p^{c}_{m,t}, \quad \forall\sqrt{(\sigma^2_y)} = 0.0222 \qquad [Y18]$$

Where,

$$v_{m,t} = 2.9631 - 0.8946m_{m,t} + 1.6159p^{c}_{m,t}, \quad \forall\sqrt{(\sigma^2_v)}=0.056 \qquad [Y19]$$

We recover the RGDP data in original units $Y_{m,t}$ as provided by [Y20]

$$Y_{m,t} = 10\hat{}(y_{m,t}) \qquad [Y20]$$

Where,

$$V_{m,t} = 10\hat{}(v_{m,t}) \qquad [Y21]$$

We have plotted the derived monthly RGDP $Y_{m,t}$, the GDP deflator $P_{m,t}$ and the consumer price index $P^{c}_{m,t}$ in **Figure 5** and **Figure 6**.

Figure 5: Monthly RGDP, January 2009 – December 2019 (February 2009=100)

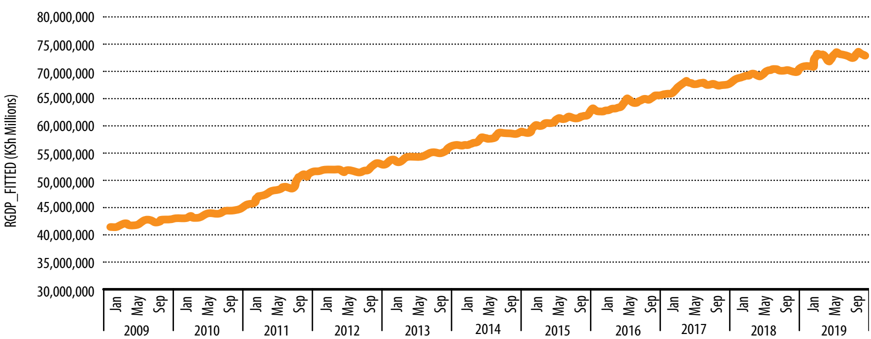
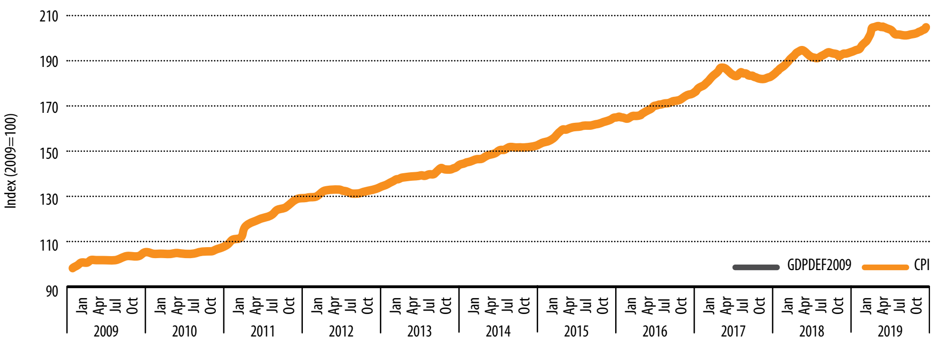


Figure 6: Monthly and data, January 2009 – December 2019 (February 2009=100)



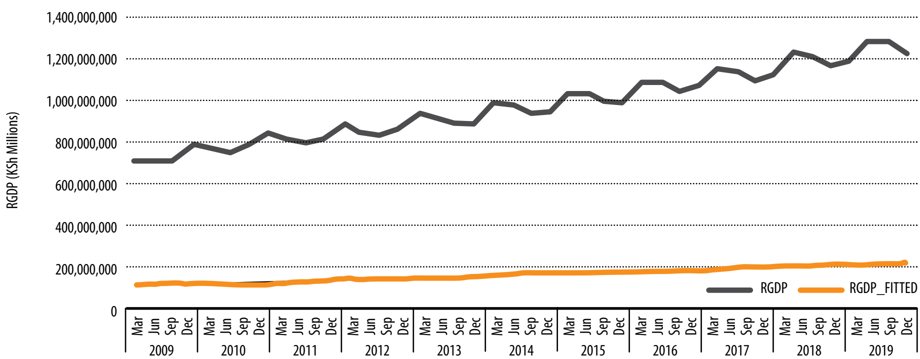
Evaluation of the plausibility of the monthly data

We compile the derived monthly RGDP data into quarterly data to obtain [Y22].

$$Y_{q,fitted,t} = \sum_{j=1}^{3} Y_{m,t-j}, \qquad \forall\sqrt{(\sigma_v^2)} = 0.0222 \qquad [Y22]$$

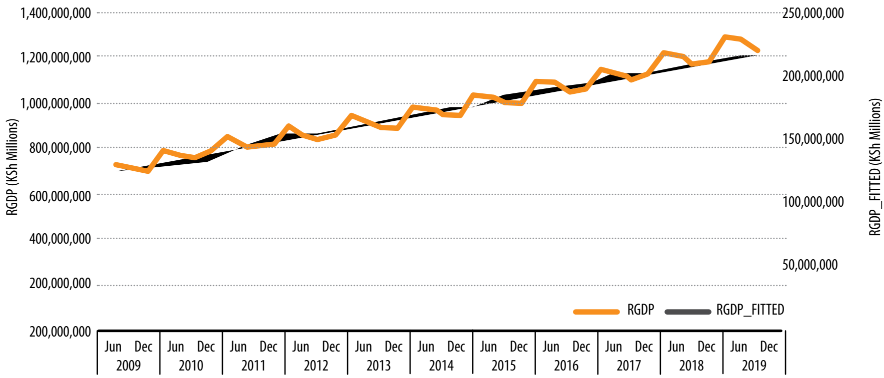
We have plotted the compiled quarterly RGDP, which is denoted by RGDP_FITTED, with actual RGDP in **Figure 7**.

Figure 7: Actual quarterly data RGDP and interpolated quarterly data RGDP_FITTED



\Despite the notable divergence between the actual quarterly data and the quarterly data compiled from the derived monthly data, the two are highly correlated; the correlation coefficient is **0.976**. That suggests that although the two series differ in terms of their levels at each data point, they are a linear transformation of each where therefore they are collinear. It can be shown that to a scale factor, the compiled quarterly data is the expected mean of the actual quarterly data. For instance, we demonstrate that point by plotting the two series in a compound graph where the series are read on primary and secondary vertical axes as shown in **Figure 8**.

Figure 8: Actual and compiled Quarterly RGDP, June 2009 – December 2019



To achieve reconciliation of the discrepancy in the levels of RGDP and RGDP_FITTED as shown in **Figure 8,** we must match the sample means of the two series as done in **Figure 8** by scaling up RGDP_FITTED. Intuitively, the scale factor is equal to the ratio of the sample average of the actual quarterly series $1/T\ (\sum_{i=1}^{T} TY_{q,t+i})$ to the sample average of RGDP_FITTED $1/T(\sum_{i=1}^{T} Y_{q,fitted,t+i})$ where $T=42$. Thus,

$$\frac{1/T\ \sum_{i=1}^{T} Y_{q,t+i}}{1/T\ \sum_{i=1}^{T} Y_{q,fitted,t+i}} = \frac{\sum_{i=1}^{T} Y_{q,t+i}}{\sum_{i=1}^{T} Y_{q,fitted,t+i}} = \frac{967,926,098}{172,339,465,} = 5.6164 \qquad [Y23]$$

Scaling up [Y22] by [Y23[, we obtain [Y24].

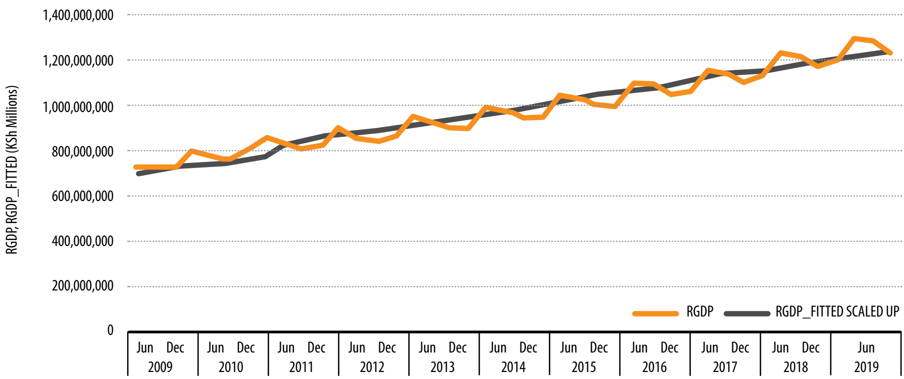
$$Y_{q,fitted,scaledup,t} = \frac{\sum_{i=1}^{T} Y_{q,t+i}}{\sum_{i=1}^{T} Y_{q,fitted,t+i}} \sum_{j=1}^{3} Y_{m,t-j}\ ,\ \forall\sqrt{(\sigma^2{}_v)}=0.0222 \qquad [Y24a]$$

Equivalently, where the scale factor is equal to 5.6164 ,

$$Y_{q,fitted,scaledup,t} = 5.6164 \sum_{j=1}^{3} Y_{m,t-j} , \qquad \forall\sqrt{(\sigma^2{}_v)}=0.0222 \qquad [Y24]$$

We have plotted the actual and scaled up interpolated quarterly data on one scale yields **Figure 9** the striking similarity of the compound graphs in **Figure 8** and **Figure 9**. We have therefore successfully reconciled the discrepancy between actual RGDP and RGDP_FITTED.

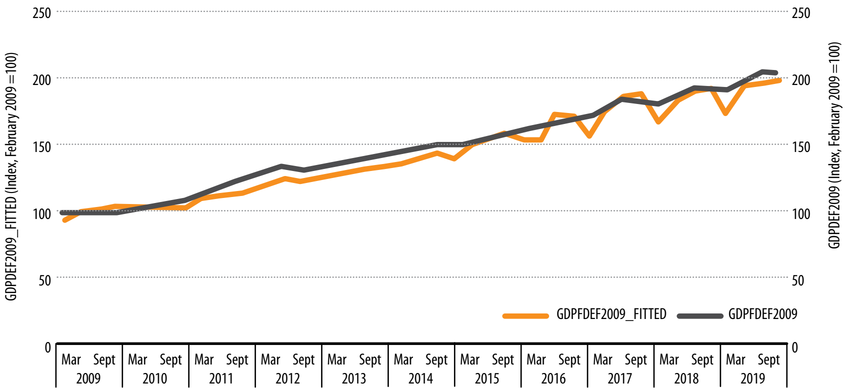
Figure 9: Actual and scaled up interpolated RGDP, June 2009 – June 2019



In scaling up the compiled quarterly RGDP to match the actual RGDP, we have implicitly assumed that the actual quarterly data is the true representation of the level of economic performance and that the complied RGDP_FITTED understates the performance. But, would it as well be that the actual quarterly data overstates the level of economic performance? For instance, the Central Bank of Kenya has recently raised concern about the RGDP projections and expressed the need to come up with an improved model fo forecasting domestic final output. If it be that actual quarterly data is incorrect, then there is an overstatement of RGDP by up to times.

Suffice it to say that following the steps leading us to the reconciled quarterly RGDP, we obtain the results presented in **Figure 10** for the GDP deflator where the actual quarterly series is denoted by GDPDEF2009 and the compiled deflator from derived monthly data is denoted by GDPDEF2009_FITTED. We have plotted **Figure 10** as a counterpart to **Figure 8**.

Figure 10: Actual and fitted quarterly series March 2009 – September 2019



Correcting the $P_{q,fittedt}$ by an overstatement by 5 units, we achieve the necessary data reconciliation for the quarterly GDP deflator.

Considering the compiled quarterly data evaluation results, we correct the derived monthly RGDP data for the presumed understatement by a scale factor of and GDP deflator for the presumed overstatement by a scale factor of 5. That is the final data which we apply in the empirical analysis.

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