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Full Length Research Paper

Stochastic simulation analysis of sustainable public debt in Zimbabwe

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This paper applies dynamic stochastic simulation methods to assess sustainable public debt management policies in Zimbabwe. The methodology applied involves estimating a fiscal reaction function and using it to simulate public debt path using a stochastic approach and historical information on drivers of public debt accumulation and their volatility. The results from the baseline scenario show that Zimbabwe's public debt would not deviate much from the desired regional indicative target in the SADC region of 60 percent in the medium to long-term. The policy implication is the need for policy makers to proactively respond to the changing macroeconomic environment and to implement countercyclical fiscal policies to limit the probability of debt from exploding.

Key words: Public debt dynamics, debt sustainability, stochastic simulation, fiscal reaction function.

INTRODUCTION

The sustainability of public debt cannot be determined with certainty. What matters is the risk caused by significant public debt accumulation, instead of the expected evolution of the public debt. A key determinant of the risk indicator is the quality of government policies in controlling public debt in the event of adverse shocks (Casper van Ewijk et al., 2013). Insight into the risk caused by significant rise in public debt and policy responses is critical as it informs decisions concerning the need for reform. As such the need for a dynamic, forward-looking framework to assess the stability of public debt under uncertainty is of critical importance.

Analysis of public debt under uncertainty is particularly crucial to Zimbabwe given the existence of a public debt overhang in an uncertain macroeconomic environment.

The country's susceptibility to exogenous shocks increased following the adoption of the multi-currency regime in 2009, where the United States dollar, the South African rand, Botswana pula, United Kingdom pound and the euro were accorded legal tender status for transaction purposes in the country. The adoption of the multiple-currency regime implies that Zimbabwe ceased to have a currency of its own. As a result, the dollarisation phenomenon curtailed the country's ability to generate seignorage revenue as well as its ability to influence policy through traditional demand management tools, such as the discount window and open market operations.

In the absence of seignorage revenue, the only policy instrument available to government to stimulate economic activity and to respond to macroeconomic shocks is

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external borrowing. Excessive reliance exacerbates the economy's vulnerability to external shocks. The current account deficit, which is a major driver of external debt dynamics has also been widening over the period 2000 to 2013, averaging more than 20 percent of GDP. The current account deficit has key being financed by debt creating flows, thus, worsening the already precarious debt overhang with adverse effects on debt sustainability.

Unlike, in the past where the country could retire domestic debt through seignorage revenue, under the multicurrency regime, Zimbabwe has to boost its revenue collections to be able to service both domestic and external debt. This paper is, therefore, motivated by the need to identify how the government has been responding to public debt developments with a view to determining sustainable public debt management policies in the medium to long-term. In doing so, the paper seeks to provide insights into the following key questions:

1. What should be the medium to long-term public debt path given the nature of shocks facing the country and its fiscal policy stance?
2. What should be the government's fiscal response to ensure medium to long term sustainability of public debt levels?

Answers to these questions will enable government to come up with public debt management policies that are consistent with maintaining public debt at sustainable levels. However, since future borrowing involves uncertainty, this requires stochastic simulation of public debt to obtain the distributions of public debt as well as the median public debt path and the probability of debt deviating from the optimal steady state.

Although the International Monetary Fund (IMF) regularly conducts debt sustainability analysis to assess the future path of public debt in Zimbabwe, the analysis has mainly been deterministic and does not take into consideration uncertainty in the public debt portfolio. The debt sustainability analysis, as typically carried out by the IMF has focused instead on debt dynamics. Under this approach, the government can be considered to be operating within its budget constraint as long as the expected fiscal policy stance keeps the debt-to-GDP ratio on a stable (or declining) path.

As pointed out by Celasun et al. (2006), there are serious shortcomings to this approach. First, the conditions under which the debt-to-GDP ratio behaves over time are not deterministic but stochastic. The government may have control over its policy setting, but the debt path also depends on macroeconomic conditions that are outside of its control, i.e. GDP growth, interest rates and the exchange rate. Second, even if debt is declining, a high level of debt and its rollover create a risk that liquidity (or other) shocks will unravel into a debt crisis. Without a handle on the probability distribution of shocks, it is impossible to assign a probability to this risk. This paper

derives fan charts to depict the probability distribution of the public debt to GDP ratio under a medium-term adjustment scenario, as a result of shocks to GDP growth and interest rates. The distribution of shocks is derived from the past shocks to these variables and the related variance covariance.

The high dependence of Zimbabwe on primary commodities and exposure to terms of trade shocks underscore the need for a stochastic analysis of the dynamics of government primary balance and its response to public debt. Since borrowing decisions are mainly determined by fiscal policy, an understanding of the determinants of fiscal performance is also critical to the formulation of sustainable public debt management policies. Insight into the sustainability of public debt is also essential to policymakers as it creates the need for speedy fiscal consolidation, the need for reform and the determination of the appropriate risk premium on public debt.

The analysis generates a distribution of simulated public debt paths, which shows the effect of fiscal responses and interest and growth rate volatility on public debt to GDP ratios. The results from the stochastic simulations would indicate the ability of government to control its finances in the medium to long-term, thereby allowing government to craft sustainable public debt management policies. If the simulated public debt is large, the government would be considered incapable of controlling its finances and the risk of medium to long-term default would be high. The projected median public debt levels from the simulation analysis, thus, offer a dynamic, forward-looking assessment of the sustainability of public debt.

The rest of the paper is structured as follows. Section two provides a review of Zimbabwe's public debt dynamics. Section three reviews the theoretical literature on stochastic public debt, fiscal response function and public debt dynamics. Section four describes in detail the methodology for stochastic public debt projections based on the estimated fiscal reaction function and debt dynamics. Section five provides analysis of results while section six concludes and provides policy implications and recommendations.

SECTION TWO: EVOLUTION OF ZIMBABWE'S PUBLIC DEBT

Historically, from 1980 until 2012, the public debt to GDP ratio for Zimbabwe averaged 80.1 percent reaching an all-time high of 105.9 percent in December 2008, and a record low of 16 percent in December 1980. The slowdown in the debt to GDP ratio from 2008 onwards reflects an improvement in capacity to repay, as measured by increases in GDP, exports and government revenue, as opposed to actual debt service payments. The country has not been servicing its debt which has culminated in accumulation of external payment arrears estimated at

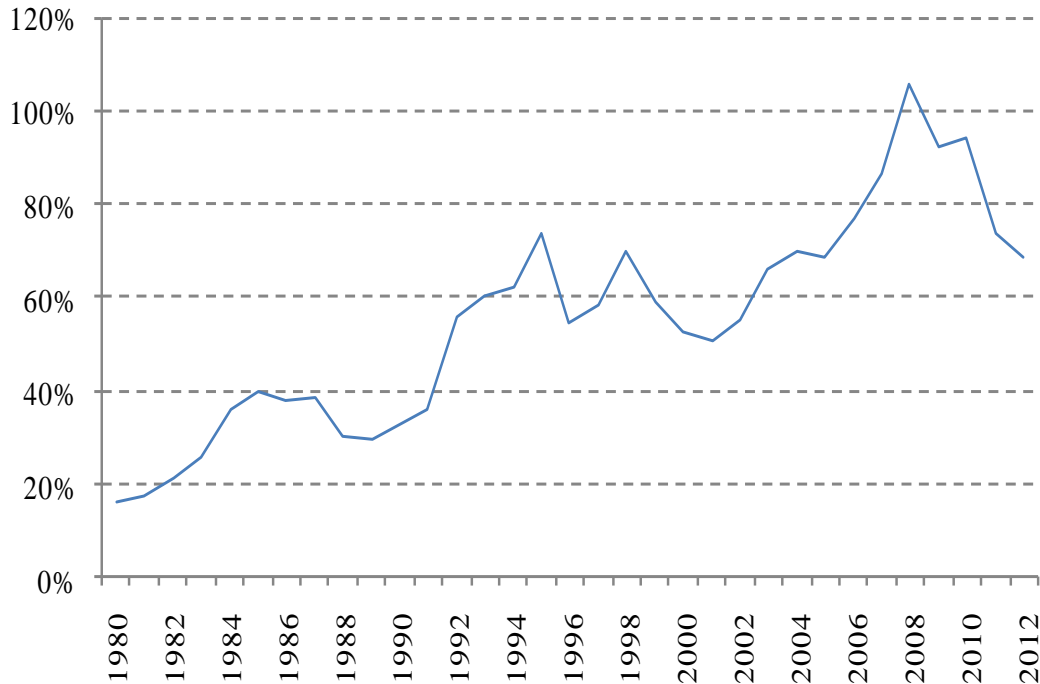


Figure 1. Trends in Zimbabwe's public debt to GDP ratio (1980-2012). Source: IMF World Economic Outlook 2012.

over 60 percent of GDP in 2012. Generally, public debt as a percentage of GDP is used by investors to measure a country's ability to make future payments on its debt, thus affecting the country's borrowing costs and government bond yields. As highlighted by Reinhart et al. (2010), the country's historical fiscal performance helps inform the assessment of what constitutes an optimal public debt policy. The arguments put forth by Reinhart et al. (2003) was based on the fact that a country's record at meeting its public debt obligations and managing its macro economy in the past, is relevant to simulating its ability to sustain moderate to high levels of indebtedness in the medium to long-term. Figure 1 shows the trend in Zimbabwe's public debt to GDP ratio.

From Figure 1, it can be shown that, Zimbabwe's public debt maintained an upward trajectory before stabilising somewhat between 1995 and 2000, when the economy was still recording fair growth rates. However, from 2000 onwards, the debt level spiraled due to more domestic borrowing in the absence of adequate external support. The growth in total debt was also a reflection of penalty charges for accumulating external payment arrears as well as new short-term loan facilities contracted by the central bank for Government in the absence of official development assistance.

At independence in 1980, Zimbabwe adopted a socialist ideology in which expenditure on human and social needs were given prominence. The new government was under immense pressure to finance post war reconstruction

projects as well as fulfilling the post-independence development agenda that included free education, health and higher wages. This culminated in increased expenditure which was not commensurate with the country's revenues. Consequently, the country began to experience high fiscal deficits and rising public debt.

The country's fiscal position was further exacerbated by the severe drought which hit the country between 1983 and 1985. The Government had to commit its limited resources towards drought mitigation programmes, thus, adding more pressure on the fiscal. As the country's public debt grew, the proportion of interest payments in total expenditure also increased significantly. On average, Government was spending 8.2% on interest payments in the 1980s. By 1990, interest payments accounted for about 16% of the Government's total budget, or an equivalence of 6% of GDP.

Government expenditure continued to rise in 1998 and 1999 due to Government's need to fulfill regional peace and security commitments in Democratic Republic of Congo (DRC). Consequently, the economy began to experience negative GDP growth rates of -0.8 and -2.1% in 1998 and 1999, respectively. Resultantly, the fiscal deficit as a percentage of GDP increased from 5.4% in 1997 to 24.6% in 1999. Shrinking tax revenue collection triggered by reduced economic activities, expenditure overruns from unbudgeted wage increases and huge domestic interest outlays all contributed to the weakening of the country's fiscal position. Figure 2 shows the trend in

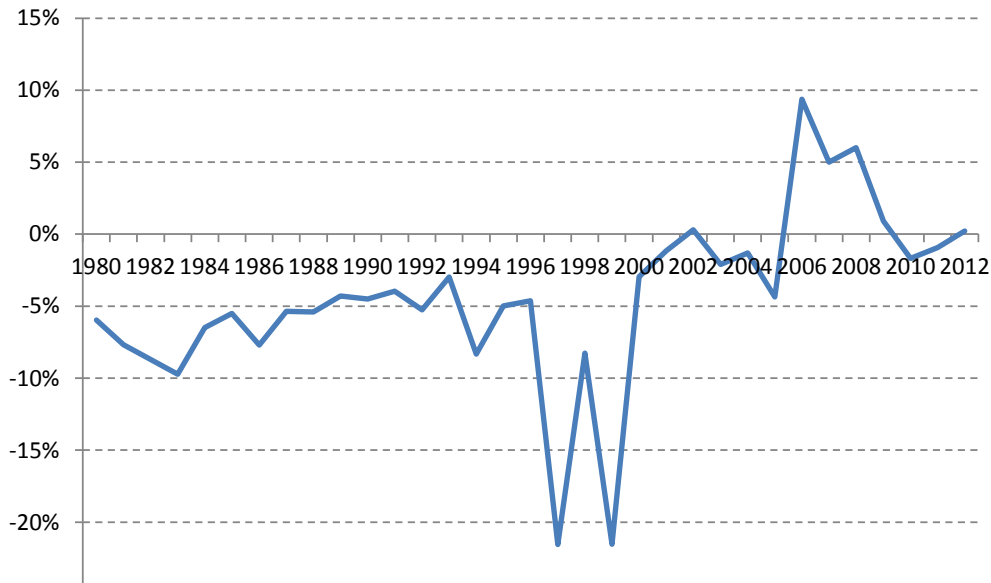


Figure 2. Trend in Government Primary Balance. Source: Government of Zimbabwe (2012).

the government primary balance from 1980 to 2012.

In 1999, the Government failed to honor its external payment obligations and was suspended from further accessing any financial support from the IMF, World Bank and other international lending institutions. Since then, the country has not been able to pay its external obligations for nearly a decade (2000- 2010) against the backdrop of progressive decline in export performance and the depletion of the foreign currency reserves, due to restrictive measures imposed on the country. The meager foreign currency resources available to the country have been allocated towards critical social needs such as education and health delivery systems.

Failure to service the loans and persistent breach of economic conditionality's caused the withdrawal or suspension of new credit by a number of international financial institutions (IFIs) including the IMF. This was, however, before the public debt level had soared to unsustainable levels. The US Government passed the Zimbabwe Democracy and Economic recovery Act (ZIDERA), which directed US representatives at major International Financial Institutions boards to block any extension of credit or cancellation of debt to Zimbabwe. This international isolation further constrained Zimbabwe's ability to access any future donor funding and meet its debt obligations and made it difficult to carry out investments in infrastructure. The public debt situation was aggravated further by a period of economic crisis and an unsustainable borrowing on the domestic front post 2000, negative economic growth, a disruptive political environment and macroeconomic fragilities.

The prevalence of high inflation rates which reached 231 million percent levels by July 2008 resulted in investors resisting long term Government paper in preference to

short term but high rewarding treasury bills, exposing Government to refinancing risk. By 2006, the portfolio was 99 percent short term and 1 percent long term, compared to 96 percent long term recorded in 1990.

The debt burden has been a stumbling block towards economic recovery initiatives of the country and has impacted negatively on the country's international credit rating, a development which has been a major deterrent to potential foreign investment and credit inflows. The accumulation of external payment arrears has to some instances, resulted in litigations against the Government of Zimbabwe by creditors as well as the placement of the country on lending restrictions by the international financial institutions. This resulted in difficulties in accessing financial support for key developmental projects, from the global financial markets. The country has, therefore, been relying mainly on domestic sources of finance for its operations. However, following the adoption of the multicurrency system in February 2009, with the US dollar as the principal currency, the Government has not been in a position to significantly borrow domestically due to attended liquidity challenges that have characterized Zimbabwe's multicurrency regime.

Composition of public debt

The composition of public debt has important implications on public debt dynamics. Analysis of the currency composition of the public debt and its maturity structure are relevant to assess the vulnerability of a country to a debt crisis (World Bank, 2005). This in turn determines the optimal public debt policy given the cost and risk trade characteristics of the public debt portfolio. Hence,

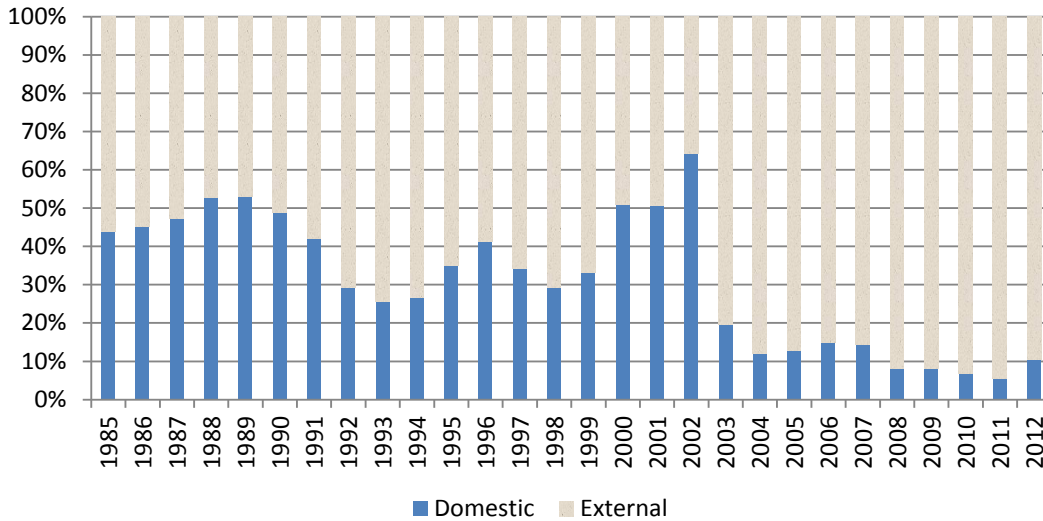


Figure 3. Composition of Zimbabwe's Public Debt (1985-2012). Source: Government of Zimbabwe (2012).

alongside the level of public debt ratio, analysis of the composition of public debt in terms is warranted.

Since the year 2000, there has been a general shift in the composition of public debt in Zimbabwe from external to domestic debt. This move was necessitated by the drying up of external sources of financing following the placement of Zimbabwe on restrictive measures by traditional creditors, notably the IMF and the World Bank. This trend has, however, been consistent with developments in other developing and emerging market economies where domestic debt is increasingly becoming more pronounced (Panizza, 2008). According to Panizza (2008), developing economies traditionally used the domestic debt market as a residual only when they did not have access to external resources or to sterilize aid flows. Recent developments have, however, seen an increasing number of countries switching from external to domestic debts, thus, posing the risk of trading a currency mismatch for a maturity mismatch since few of them are able to issue long-term domestic debts at reasonable interest rates (Panizza, 2008).

As at end of 2012, external debt constituted about 90 percent of Zimbabwe's public debt stock, while domestic debt accounted for the balance of 10 percent. The significant proportion of external debt implies a low cost public debt portfolio as most of the external debts were to a large extent contracted at concessional rates while the presence of captive investors, and practice of forced placements, has kept the cost of domestic debt below a true market rate. Furthermore, the IMF (2012) also noted the unidentified domestic contingent liabilities within some public entities as another source of potential debt. Figure 3 shows the trend in the composition of public debt since the year 1985 to 2012.

Figure 3 shows that the composition of domestic debt increased sharply in 2000 as the government tried to steer

the economy through more domestic borrowing against the imposition of economic sanctions on the country. The proportion of domestic debt in total public debt, however, declined progressively due to erosion of the value of the Zimbabwean dollar as a result of spiraling inflation.

REVIEW OF LITERATURE

An extensive literature that analyses and proposes different measures of public debt sustainability exists. Most of this literature, however, relies on unit root and co integration tests often in combination with the inter-temporal budget constraint to analyze the sustainability of public debt. Bohn (2007), however, shows that the consistency with the inter-temporal budget constraint is not a sufficient condition for public debt sustainability. According to Bohn, it is possible to satisfy the inter-temporal budget constraint, while simultaneously having a mildly explosive path of public debt to GDP ratios. The theoretical framework, motivated by Bohn (1998, 2008), also advocates for the existence of a fiscal reaction function, which implies that the primary balance is positively correlated with lagged public debt levels.

Ghosh et al. (2011), however, suggest that the size of primary balance response may vary with the level of the public debt ratio, reacting more strongly when the debt ratio exceeds a given threshold, but then the responsiveness eventually begins to weaken, and then actually decreases at very high public debt levels. Burger (2012) extended the model and calculated stable public debt positions based on the premise that a sustainable public debt policy is the one which stabilizes public debt at whatever level. Recent studies have also illustrated the existence of fiscal fatigue, whereby the government's ability to increase primary balances cannot keep pace with

rising public debt. As a result, the government faces an endogenous public debt limit beyond which public debt cannot be rolled over (Ghosh et al., 2013).

Bohn (2008) approach applied the inter-temporal budget constraint for government debt and a behavioral equation for the government's primary balance to analyze the behaviour of public debt. Bohn's approach equates fiscal sustainability with the stationarity of the public debt-to-GDP ratio and suggests that when the public debt-to-GDP ratio is stationary over time without a trend, one can consider public debt to be sustainable. The starting point of Bohn's analysis is, therefore, the inter-temporal budget constraint, which states that debt is a function of past debt and interest payments on previous debt outstanding. This is algebraically illustrated as follows:

$$D_t = (1 + i_t)D_{t-1} - PB_t + SF_t \quad (1)$$

Where D_t is the outstanding debt at time t , PB_t is the primary balance at time t , i_t is the nominal interest rate at time t , and SF_t is the stock-flow adjustment that ensures consistency between net indebtedness and variation in the observed public debt stock. The stock-flow adjustment includes a number of variables, such as the recognition of contingent liabilities, extra budgetary expenditures and other statistical discrepancies. Dividing equation 1 by nominal GDP gives the following:

$$\frac{D_t}{P_t Y_t} = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} * \frac{D_{t-1}}{P_{t-1} Y_{t-1}} - \frac{PB_t}{P_t Y_t} + \frac{SF}{P_t Y_t} \quad (2)$$

Where the nominal GDP is algebraically defined as: $P_t Y_t = (1 + \pi_t)(1 + r_t)P_{t-1} Y_{t-1}$, where Y_t is the nominal GDP at time t , P_t is the GDP deflator at time t , π_t is the inflation rate at time t , r_t is the real interest rate at time t and g_t is the real growth rate of the economy at time t . Assuming that $\pi_t = 0$ the equation can translate to:

$$d_t = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} d_{t-1} - pb_t = d_t = \frac{(1+r_t)}{(1+g_t)} d_{t-1} - pb_t \quad (3)$$

Where, the nominal interest rate is given by $i_t = (1 + r_t)(1 + \pi_t) - 1$. Defining equation 3 in lower cases results in the following equation:

$$d_t = \phi_t d_{t-1} - pb_t \quad (4)$$

Where $\phi_t = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} = \frac{(1+r_t)}{(1+g_t)}$, $d_t = \frac{D_t}{P_t Y_t}$ and $pb_t = \frac{PB_t}{P_t Y_t}$

The parameter in equation 4 is known as the automatic debt dynamics, and it can result in the accumulation of public debt without the government contracting any new debt. As shown in the equation, changes to automatic public debt dynamics are explained by the real interest rate and growth rate of the economy. The other determinants of the change in the public debt ratio as shown in equation 2 are the primary balance and the stock

flow adjustment, which is a residual. The primary balance is controlled by fiscal policy makers, while interest rates largely depend on actions of monetary authorities. The growth rate enters into this equation because a higher growth rate tends to reduce the public debt ratio, by raising the denominator of the public debt to GDP ratio.

The key reason for analyzing the public debt dynamics is to determine whether public debt is stable or explosive. Accordingly, from equation 4 it can be deduced that the ratio of the debt to GDP converges to a predetermined optimal level, or however, the public debt portfolio would explode from the predetermined optimal path. This condition has increasingly become known as the Aaron condition (Aaron, 1996). This implies that if the interest rate being paid on debt is greater than the growth rate of the economy, the interest burden on existing debt increases, while the debt to GDP ratio also increases. Subtracting from both sides of equation 3 results in the following equation:

$$\Delta d_t = (r_t - g_t)d_{t-1} - pb_t \quad (5)$$

Equation 5 shows that changes in the public debt ratio can be decomposed into three factors and their underlying processes that determine the evolution of public debt-to-GDP ratio. Equation 5 shows that for public debt to remain stable, the primary balance needs to at least cover the interest payments due. However, if past debts are very large or if interest rates are very high, the government would either be required to raise the primary balance or the public debt will increase every year in a snowballing effect because the portion of the payments that cannot be covered by the primary balance will be covered by issuing new loans, thereby increasing the debt stock.

The second part of Bohn's methodology involves estimating the fiscal reaction function, which indicates whether the government increases its primary balance in response to changes in the public debt-to-GDP ratio. Bohn's assumption is based on the fact that government budget is subject to changing circumstances and that governments usually react to increases in public debt instead of passively waiting to see their public debt evolving without putting some effort to control the debt level. This action is reflected in the policy response function, which has increasingly come to be known as the fiscal reaction function. A positive fiscal response means that the government takes action to reduce the deficit (or increase the surplus) when the public debt ratio rises. The fiscal reaction according to Bohn is specified as follows:

$$pb_t = \alpha + \rho d_{t-1} + z_t + \varepsilon_t \quad (6)$$

Where ρ is the fiscal reaction parameter and measures the response of the primary balance to the lagged public debt ratio, α is the constant variable, z_t is a set of other determinants of the primary balance and ε_t is an i.i.d. error term shock to the primary balance. This specification

shows how governments react to public debt accumulation given the structure of macroeconomic shocks facing the economy. Substituting equation (6) into (5) and assuming that the non-fiscal determinants are zero result in the following equation.

$$\Delta d_t = (r_t - g_t - \rho)d_{t-1} - \alpha \quad (7)$$

Equation (7) summarizes the determinants of public debt dynamics for the government, with the crucial factor being the sign of the term in front of the lagged public debt variable. If, implying that the interest rate exceeds the sum of the growth rate and the fiscal response coefficient, then public debt is intrinsically unstable. A rise in the public debt level leads to a further acceleration of the growth of public debt, which means that debt is on a potentially explosive path. However, if, implying that the interest rate does not exceed the sum of the growth rate and the fiscal response coefficient, then the time path of debt is intrinsically stable.

The condition for stability is referred to as the modified version of the Aaron condition, which is usually stated as the condition that the growth rate should exceed the interest rate, for government to have a sustainable public debt path. According to the modified Aaron condition, higher interest rates increase the growth of debt levels, whereas higher growth rates and a stronger responsiveness of the budgetary policy to debt tend to reduce debt growth.

Following Bohn's literature, several authors have investigated the potential relationship between the primary balance and the public debt ratio. For instance, Hamilton and Flavin (1986) analyzed the budget inter-temporal relation and No Ponzi game condition. This approach has been criticized by Bohn (2008) who proposed a sustainability test based on whether the primary balance to GDP ratio is a positive linear function of the debt to GDP ratio. Roubini (2001) showed that a stable debt to GDP in the medium to long term is considered as sustainable regardless of its level. According to him a debt to GDP ratio of 150% is as sustainable as a debt to GDP ratio of 50%. Ghosh et al. (2013) affirm that the sustainability indicator introduced by Bohn is too weak, and advocated for a new framework for assessing debt sustainability in the advanced economies by determining a debt limit beyond which fiscal solvency is in doubt. There is also a general empirical premise that governments usually behave responsibly, increasing primary surpluses in response to rising debt service so as to stabilize the public debt-to-GDP ratio at a reasonable level. This empirical finding is consistent with the findings of Bohn (2008) for the US, and Mendoza and Ostry (2008) for subsets of industrial and emerging economies. Despite the existence of this vast theoretical and empirical literature on public debt sustainability, literature is far from being settled. There is no consensus on the optimal (stable) debt limit and corresponding fiscal space, which provide early warning guide to exploding public debt levels. This paper,

thus applies the dynamic stochastic framework to simulate the public debt path for Zimbabwe given the nature of shocks facing the economy and its fiscal stance. This is particularly important to avoid the previous costly mistakes of accumulating public debt to unsustainable levels.

RESEARCH METHODOLOGY

The paper applies the methodological approach of Bohn (1998, 2008) to analyze Zimbabwe's debt sustainability using historical information. The methodology also draws from the method proposed by Celasun et al. (2006) which simulates interest rates and growth rates, taking account of the uncertain nature of these variables. The method combines the simulated interest rates and growth rates with the estimated fiscal response in order to determine the evolution in the public debt to GDP ratio. The analysis yields a distribution of possible time paths for future public debt to GDP ratios. This distribution can be characterized by the median for the public debt to GDP ratio and the confidence interval around this value.

First, the methodology consists of estimating the fiscal reaction function in line with Bohn's specification. Accordingly, the primary fiscal balance, which is considered the key operational target of the fiscal authorities, was estimated as follows:

$$pb_t = \alpha_0 + \rho d_{t-1} + \gamma ygap_t + X_t \beta + \varepsilon_t \quad (8)$$

where pb_t is the primary balance at time t , α_t is the intercept d_{t-1} is the public debt level at the end of the previous period, $ygap_t$ is the output gap, ε_t is an error term, and $X_t \beta$ is a vector of macroeconomic variables explaining changes in the primary balance unrelated to the solvency requirement.

With respect to the expected coefficients from the fiscal reaction function, a zero or negative coefficient of debt to GDP indicates that governments fail to respond effectively, or even have a perverse reaction of increasing the deficit when debt increases. This is referred to as fiscal fatigue by Ghosh et al. (2013). The specification includes a range of other explanatory variables suggested by Celasun et al. (2006), Mendoza and Ostry (2008), Burger et al. (2011) and Ghosh et al. (2013). These variables are the output gap to control cyclical fluctuations, and political and institutional variables. The output gap for Zimbabwe was computed using the Hodrick Prescott Filter (Hodrick, 1996) and the output gap results are depicted in Figure 4

The graph shows a negative output gap over the period 1999-2008, reflective of the downturn in economic performance during this period. During this period, the debt level was also on an increasing trajectory. The model specification is, however, not intended at predicting the fiscal behaviour but instead serve as a reference for simulating the public debt path for Zimbabwe in the medium to long term. It addresses the question of what would be the predicted public debt path if government balance were debt stabilizing and interest rates and output exhibit similar historical behaviour.

Estimation technique

The paper applies the method of ordinary least squares (OLS) to undertake the joint estimation of the primary fiscal reaction function and regression equations of other variables such as interest rates and economic growth that enter the law of motion of public debt dynamics. However, estimation of the fiscal reaction function raises some econometric issues stemming from the dependence of primary balance on past values of the debt to GDP ratio. A country able to generate higher primary balances on average would also tend to

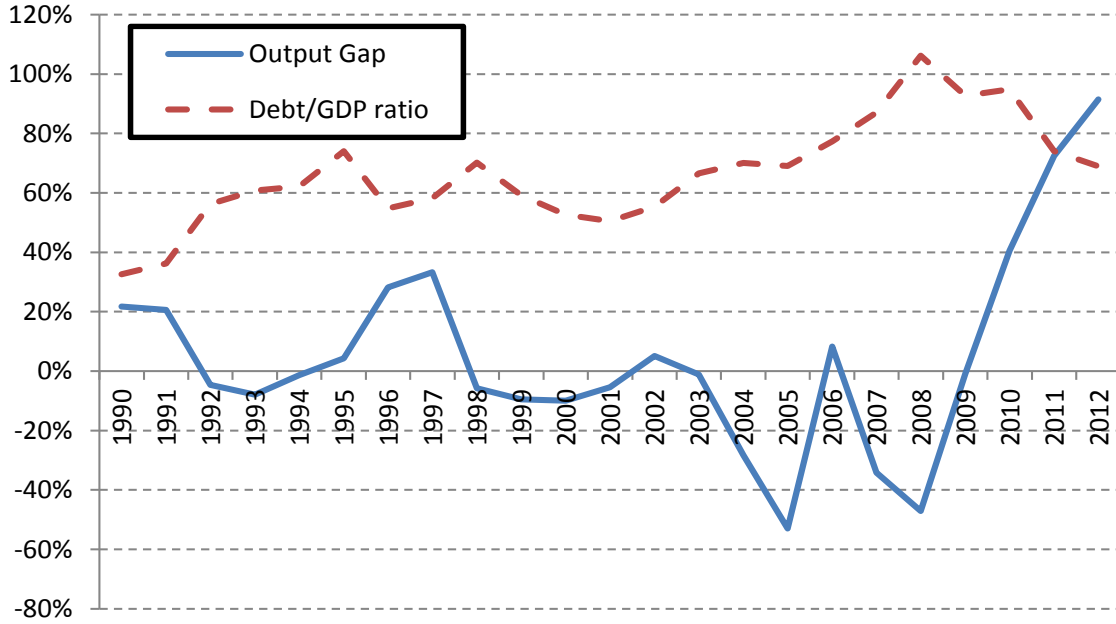


Figure 4. Trend in Public Debt to GDP and Output Gap for Zimbabwe. Source Researchers Own Computations.

have lower levels of public debt. This negative association between debt and time invariant country specific features, if not properly accounted for, could generate a downward bias in the estimated response of primary balance to lagged debt. As such, the Hausman endogeneity test was applied to test for potential endogeneity between the primary balance and the output gap.

For robustness check, the model was also estimated using panel data for Low Income Countries (LICs), given the structural breaks that Zimbabwe went through, which may affect the credibility of the estimated parameters. The estimated coefficients from the fiscal reaction function were then used to project the public debt path for Zimbabwe given its macroeconomic outlook as specified in the IMF World Economic Outlook (WEO), and the country's macroeconomic Framework (IMF, 2012).

Stochastic Simulation approach

The stochastic simulation was done in three stages, namely, estimating the fiscal reaction function, projecting the primary balance, using the variance of the residuals from the estimated fiscal reaction function and a standard normal distribution to generate the public debt path. The estimated fiscal reaction function from equation (8) above will be as follows:

$$\widehat{pb}_t = \widehat{\alpha}_t + \widehat{\rho}d_{t-1} + \widehat{\beta}_t gap_t \quad (9)$$

The error term is computed from the estimated fiscal response function in equation (9) as follows:

$$\varepsilon_t = pb_t - \widehat{\alpha}_t - \widehat{\rho} * d_{t-1} - \widehat{\beta}_t gap_t \quad (10)$$

The error term is then specified as follows:

$$\varepsilon_t = \varnothing \varepsilon_{t-1} + \mu_t \quad (11)$$

Where $\mu_t \sim N(0, \sqrt{(1 - \varnothing^2) * \sigma_\varepsilon})$ and σ_ε is the estimated standard

error of the regression. The effective interest on public debt was computed as a weighted average of domestic and foreign rates and exchange-rate movements as follows:

$$r_t = i_t^d d_{t-1}^d + i_t^f d_{t-1}^f \quad (12)$$

The weights of public debt denominated in foreign currency and domestic debt followed the historical pattern and varied to reflect the government's thrust to develop the domestic debt market in the medium to long-term. Projections of the underlying public debt dynamics are obtained through a fiscal reaction function and growth forecasts obtained from Zimbabwe's macroeconomic policy framework (IMF, 2012).

Baseline public debt to GDP simulation

The estimated fiscal response function was used to simulate the public debt path together with assumed growth rate of the economy and simulated interest rate structure from the macroeconomic framework. However, to account for the considerable share of public debt denominated in foreign currency, the simulation of the baseline public debt to GDP ratio was conducted using the debt dynamics equation illustrated below:

$$d_t = \left[\frac{(1+i_t^f)(1+\Delta\varepsilon_t)d_{t-1}^f + (1+i_t^d)d_{t-1}^d}{(1+\pi_t)(1+g_t)} \right] - pb_t \quad (13)$$

Where ε_t is the exchange rate. In the Zimbabwe case $\Delta\varepsilon_t$ is zero

since the country is dollarised and does not have an exchange rate of its own. Equation (13) can be summarized as:

$$d_t = \varnothing d_{t-1} - pb_t \quad (14)$$

$$\text{Where } \emptyset = \left[\frac{(1+i_t^f)d_{t-1}^f + (1+i_t^d)d_{t-1}^d}{(1+\pi_t)(1+g_t)} \right]$$

Replacing the primary balance with the estimated primary balance reaction function in equation (9) results in the following simulated public debt position:

$$d_t = \emptyset d_{t-1} - (\hat{\alpha}_t + \hat{\rho}d_{t-1} + \hat{\beta}_t \text{gap}_t) \quad (15)$$

This translates to the following equation after collecting the like tiers.

$$d_t = (\emptyset - \hat{\rho})d_{t-1} - (\hat{\alpha}_t + \hat{\beta}_t \text{gap}_t) \quad (16)$$

Equation (16) implies that the future public debt path is determined by automatic debt dynamics and the estimated fiscal response parameter and non-fiscal determinants of public debt policy which in this case is the output gap. The simulations are conducted under various scenarios on growth rate given the simulated interest rate path and the estimated fiscal policy response. As previously stated the simulated public debt path can only be sustainable if the modified Aaron condition is satisfied, implying that the effective interest rates on public debt do not exceed the sum of growth rate and the fiscal response on average. This implies that the public debt ratio will revert to an equilibrium steady state after a macroeconomic shock.

Bounds on the public debt limit

In order to derive the range of the sustainable public debt path, the upper and lower bounds of public debt dynamics were also established. These bounds provide an insight into the range within which the optimal public debt target would lie. As such, in line with the approach taken by Ghosh et al. (2013), the upper bound was computed as the largest root of the following equation:

$$\alpha + \rho(\bar{d}_2) + \bar{\varepsilon} = (r^* - g_t)\bar{d}_2 \quad (17)$$

The left-hand-side of equation 17 shows the best primary surplus that the government can achieve at a debt ratio under the best realization of macroeconomic shocks. The right-hand-side shows the lowest effective interest payment required by government to reduce or mitigate the risk of default. As public debt increases beyond, the primary surplus would increase at a slower rate. As a result, if the debt ratio exceeds, the primary balance would not suffice even under the best of circumstances to cover the interest payment, and debt dynamics would become explosive, thus, violating the modified Aaron condition and triggering default. Similarly, the lower bound was obtained as the largest root of the following equation:

$$\alpha + \rho(\bar{d}_1) - \bar{\varepsilon} = (r^* - g_t)\bar{d}_1 \quad (18)$$

The left side of equation 18 shows the smallest primary surplus required to cover the effective interest payment to ensure sustainability. In this case, since debt is non-increasing for all possible realizations of macroeconomic shocks, and there is no risk of default, the lower limit thus corresponds to the so called natural debt limit, defined in the macroeconomic literature on savings under incomplete markets as the largest debt that the government could take if it wants to ensure that it will never default in the next period or at any point in the future, even if the primary balance remains at its worst realization forever.

RESULTS AND ANALYSIS

This section provides the results of the fiscal reaction

function together with the simulated public debt to GDP ratio for Zimbabwe in the medium term. The results are then used to estimate the probability that public debt will exceed the desired target of 60% in the medium to long term. The analysis also facilitates the determination of the upper and lower limit of the public debt level, which are critical in establishing the natural public debt limit and the point at which public debt becomes highly unsustainable.

Estimated fiscal response

The results from the estimated fiscal reaction function are shown in Table 1. The regression only considered the fiscal determinants of public debt and omitted other variables that may affect fiscal policy such as institutional factors. These factors were omitted to avoid determining their out of sample trajectories required to simulate public debt paths until 2020. All the variables were integrated of order 1 and the signs of the main explanatory variables are as expected.

A strong response of the primary increases in public debt implies that the mean reversion of public debt is always sustainable. On the other hand, a weak response implies a public debt limit which explosive paths occur beyond a certain threshold, implying that public debt is unsustainable. A sufficiently strong response of the primary balance is essential to guarantee sustainability, whereas a weak response, although technically sufficient for solvency, cannot rule out explosive public debt paths.

The Hausman endogeneity test accepts the null hypothesis of weak instruments and as a result the OLS methodology was applied to estimate the fiscal reaction function for Zimbabwe. For the panel data for low income countries, the Hausman Specification test was used to select between the fixed effects and random effects model. The test chose the random effects as a perfect fit. As a result, the results of a random effects model which can jointly capture cross-country and within country determinants of primary balance was used.

The results in Table 1 show that the primary balances respond positively to increase in the public debt to GDP ratio, suggesting that the inter-temporal budget constraint exists. The output gap has a negative sign indicating that the primary balance response negatively to increases in the output gap. A positive response of the primary balance to lagged debt can be expected if buoyant public debt dynamics are corrected and a positive response to output gap imply that favourable economic developments would improve the budgetary position of a country via boom-induced revenue windfalls. This would indicate that the government follows counter-cyclical fiscal response. On the contrary, a negative coefficient would indicate a pro-cyclical fiscal policy, and an insignificant coefficient of output gap a cyclical fiscal response. The results show that if the primary balance-to-GDP ratio improves by 1% of GDP in year t , the primary balance would improve by 0.7% of GDP in year $t+1$. The negative and insignificant

Table 1. Primary balance reaction function.

	ZIM Model 1	LIC Panel: Model 2
Constant	-0.08*** (-0.00)	-0.04*** (0.01)
Lagged Debt/GDP Ratio	0.07*** (0.01)	0.06*** (0.01)
Output Gap	-0.08* (0.07)	-0.02** (0.05)
Diagnostic Test		
Adjusted R-Squared	0.41	0.48
Durbin-Watson Stat	1.62	2.37
Hausman Test	Prob<chi2=0.74	

Source: Researchers' Own Computations. Note: ***, significance at 1%, **, significance at 5%, *, significance at 10% and figures in parenthesis are p-values.

coefficient of the contemporaneous output gap indicates that the primary budget has a counter-cyclical effect in the year the business cycle position changes, probably due to a predominant impact of the built-in automatic stabilizers. The insignificant coefficient of the output gap in model 1 shows that Zimbabwe's fiscal policy stance has been cyclical during the past three decades, from 1980 to 2012. Nevertheless, the coefficient for the output gap for low income countries in LIC Panel Model 2 is negative and significant indicating pro-cyclical fiscal policy stance. This result is consistent with a large empirical literature that finds fiscal policy in low income countries to be pro-cyclical, in contrast to high-income countries where it is usually found to be countercyclical (Ilzetzki and Vegh, 2008). Burger et al. (2011) found a positive and statistically significant coefficient for South Africa indicating that the country follows a counter cyclical fiscal stance.

Implications of the estimated fiscal response for debt sustainability

Combining the information on interest rate and growth rate together with the estimated coefficients from the fiscal reaction function shows the following graph for testing Aaron condition (Figure 5).

A look at the evolution of interest rates and growth rates shows that Zimbabwe only satisfied the Aaron condition (< 0) from 2009 onwards, wherein the growth rates exceeded interest rates on average. This reflects the dominance of concessional external loans in the public debt portfolio, in the absence of significant domestic debt borrowing. Since the introduction of the multiple-currency system, Zimbabwe has not been able to borrow significant amounts from the domestic debt market due to attendant liquidity risk. During the crisis period, Zimbabwe experienced a significant

decline in real growth rates and a steady rise in real interest rates, on the external front, factors which resulted in explosion of public debt. The violation of the Aaron condition over the last 25 years, imply that solid fiscal responses was critical for government to ensure sustainable public debt. The introduction of the cash budgeting system by the Zimbabwean government in 2009 was, therefore, a positive response and partly helped in alleviating the public debt burden.

Simulated baseline of public debt dynamics

The stochastic simulations facilitated a derivation of a comprehensive indicator for assessment of a sustainable public debt policy. The simulations were undertaken by assessing the 'at risk' indicator, which measures the degree to which governments are in control of their public finances. The indicators were constructed as the median debt path in the simulation and the expected probable upper and lower bound for the debt level in the medium term. In the literature on stochastic public debt, the distribution of public debt is summarized using fan-charts (Medeiros, 2012). The fan chart provides a probabilistic view of the uncertainty around the baseline by showing a spectrum of possible outcomes. It also facilitates the computation of the stochastic properties of the data that incorporates the interaction between macroeconomic variables (Celasun et al., 2006). Accordingly, the results were summarized in a fan-chart type of analysis, which provided the frequency distribution of the calibrated public debt paths and served to illustrate the overall range of risks to the public debt dynamics. Fan-charts also provide a probabilistic view of the uncertainty around the baseline (IMF, 2013). The results are shown in Figure 6.

The results from the baseline stochastic simulation in

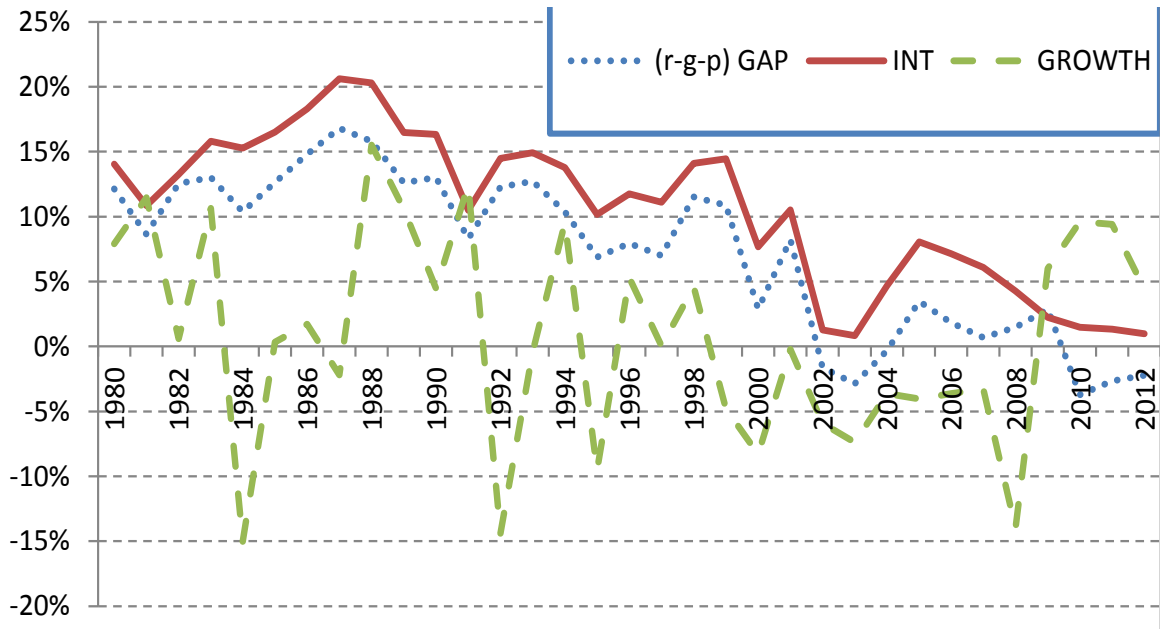


Figure 5. Graph historical movements in $(\phi - \rho^*)$ gap. Source Researchers' Own Computations.

Figure 6 show a general decline in public debt-to-GDP ratio for Zimbabwe in the medium to long-term. The results indicate that Zimbabwe's public debt would be slightly below the 60 per cent mark by 2020. The results, however, show a great deal of uncertainty in the projected debt-to-GDP ratio. The stochastic distribution shows the public debt-to-GDP ratio for Zimbabwe to be around 60 per cent for all the scenarios, with a lower bound of approximately 40 per cent of GDP. The lower bound can be regarded as the natural debt limit which is the debt level that the country can accommodate without fearing the risk of default, even under extreme macroeconomic shocks (Ghosh et al., 2013). Furthermore, the results show the 'at-risk' indicator of about 30 per cent of GDP. The at-risk indicator measures the deviation of the upward dispersion in the simulation. It is computed as the expected probable upper bound minus the expected debt level in the medium term projection. The median projections show that Zimbabwe's public debt would not get out of control until the end of the forecasting horizon. As a result, Zimbabwe's public debt can thus be regarded to be sustainable from an inter-temporal solvency condition over the period from 2013 to 2020.

Distribution of the simulated public debt-to-GDP ratio

The theoretical distributions shown in Figure 7 confirm that Zimbabwe's public debt follows a normal distribution. A skewed distribution would imply more risk to future debt sustainability. Hall (2013) shows that if the distribution of the simulated debt paths is properly defined in the

long-run, the debt-to-GDP ratio is stationary and follows a near unit root instead of a unit root process.

The distributions in Figure 7 capture interactions among the macroeconomic and fiscal variables being shocked, and informs about the plausible range of risks associated with the projected public debt paths. This in turn, prepares policy makers for a better-informed policy reaction should such risks materialize. The distributions are also informative of public debt sustainability. A narrower distribution indicates greater certainty on future debt dynamics and characterizes a country that is more in control of its finances. The distributions show that the debt level is skewed towards high debt ratios despite the shocks being normal. This implies that the snowball effect grows with the level of public debt. The distribution for the baseline scenario mean shows a slightly wider debt-to-GDP from as low as 40 to 160 per cent. The lower bound, however, shows a narrow distribution of up to 50 per cent. This implies that Zimbabwe would require a debt-to-GDP within this range to guarantee medium to long-term to ensure sustainability.

Robustness checks/ evaluating forecasting accuracy

The stochastic model's forecasting ability was also confirmed by the Q-Q plots shown in Figure 8 which confirms a normal distribution in the data.

The results from the normal Q-Q plots in Figure 8 strongly support the idea that the public debt distributions are normally distributed.

Overall, the results show that Zimbabwe public debt is

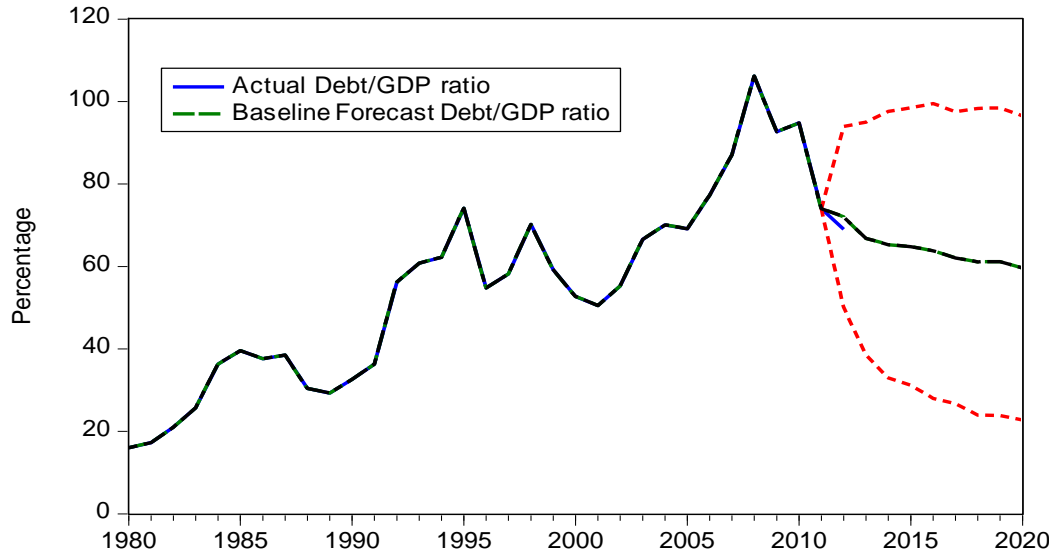


Figure 6. Stochastic Simulated Baseline public Debt Trajectory. Source: Researchers Own Computations.

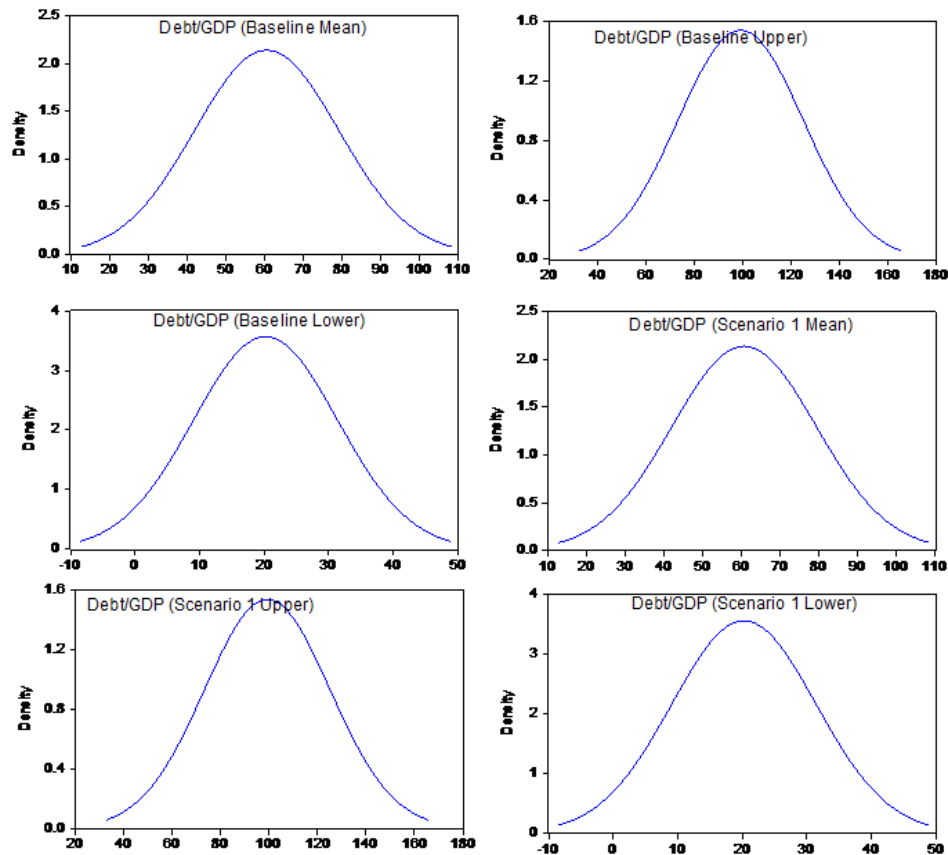


Figure 7. Distributions of the simulated public debt to GDP ratio path. Source: Researchers' own computations based on E-views.

sustainable from a solvency perspective and unsustainable from a liquidity perspective, given the

existence of external payment arrears in Zimbabwe's public debt stock. The country does not have resources to

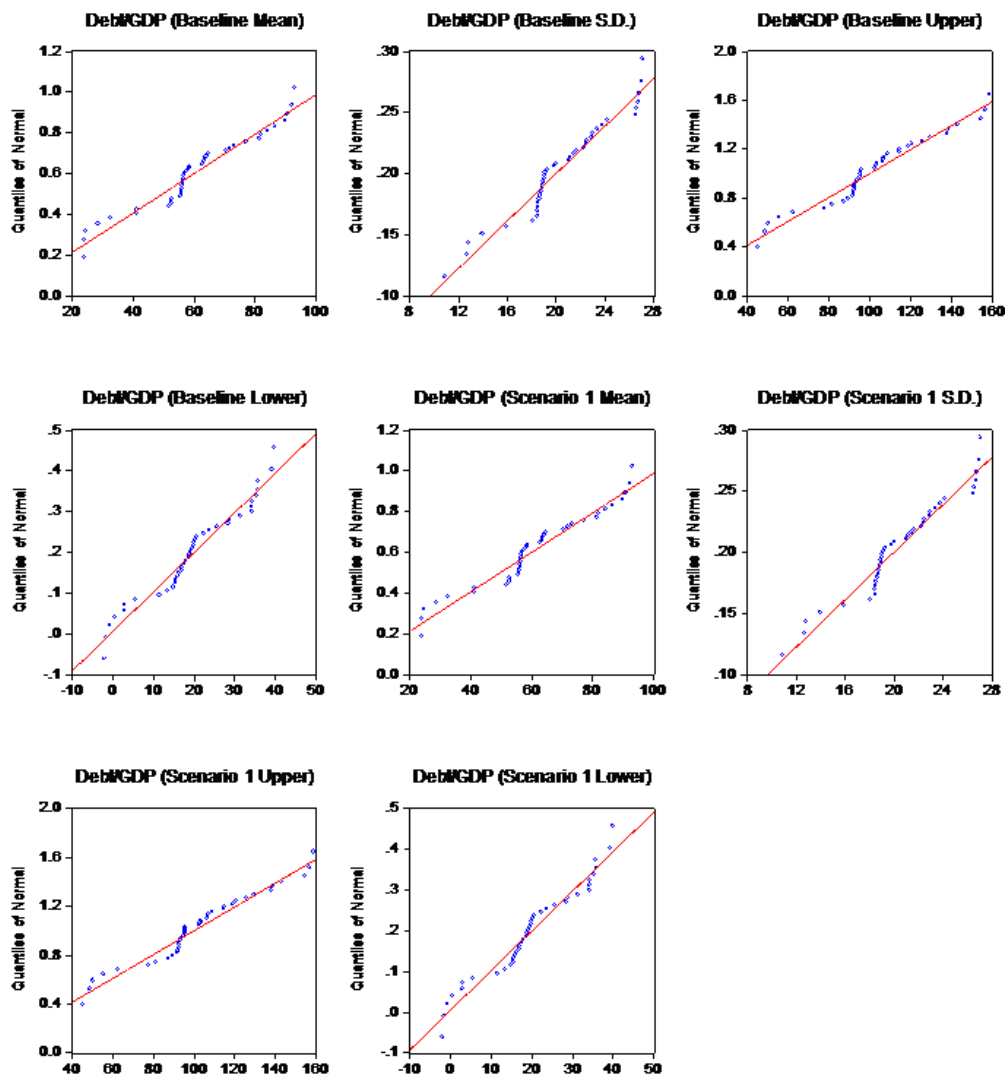


Figure 8. QQ Plots Baseline Scenario. Source: Researchers' Own Computations.

meets its maturing short term obligations which might require a debt resolution strategy. The simulations, however, suggest that Zimbabwe has the capacity to meet its obligations given the nature of shocks affecting the country, its fiscal stance and other macroeconomic fundamentals.

The results, therefore, underscore the need for prudent debt management to guard against the high risk of default as shown by large uncertainty within the projected public debt path. These results suggest that there is a higher chance that Zimbabwe would be able to reduce and maintain its public debt within sustainable limits in the medium to long term, given the macroeconomic shocks facing the economy and its current growth trajectory and fiscal stance.

From a policy perspective, the results from the stochastic simulation approach can be used to flag cases where fiscal consolidation may be urgently needed in

order to ensure that public debt remains on a sustainable path and that macroeconomic shocks do not derail public debt sustainability.

Conclusion

This paper applied the methodology of dynamic stochastic debt simulation to analyze the medium term public debt path for Zimbabwe. The paper followed the methodological approach of Bohn (2008) and distinguishes three channels that contribute to sustainable public debt. These channels are the economic growth, real interest rates and fiscal responses. The methodology combined the estimated fiscal response with a stochastic public debt simulation to project the median public debt path and the probability of public debt-to-GDP exceeding the desired SADC macroeconomic convergence threshold of 60 percent in

the medium to long-term.

Results from the fiscal reaction function show that Zimbabwe fiscal policy reacts positively to lagged public debt and negatively to the contemporaneous lagged output gap. The positive fiscal response to public debt suggests that the inter-temporal budget constraint exist and the negative response to output gap indicates that the fiscal policy stance has been pro-cyclical. The median public debt projections showed a declining path indicating that Zimbabwe's public debt would not get out of control until the end of the forecasting horizon and can, thus, be qualified to be sustainable over the medium to long term. The probabilistic sustainability indicator shows a moderate probability of 53 percent for a sustainable debt path in the medium term. Further the public debt simulations shows a lower bound distribution of between 20-50 percent which provide a reasonable range within which public debt sustainability would be guaranteed.

The stochastic simulation presented in this paper does not take into account liquidity or rollover risks or the possible realization of contingent liabilities. As such, the existence of arrears in Zimbabwe's public debt portfolio implies that the sustainability analysis presented in the paper mainly relates to government solvency which shows that the country has the capacity to service its public debt given its fiscal stance and the nature of shocks affecting it in the medium to long term. Nevertheless, exploring the implications of liquidity and rollover risk on the medium to long term debt sustainability presents possible avenues for future research.

From a policy perspective, the dynamic stochastic simulation provided in this paper can be used to flag cases where fiscal consolidation may be needed to ensure that public debt maintains a sustainable path. The implication from this analysis is the need for government to swiftly respond to increases in public debt to control the swings in public debt caused by macroeconomic shocks and to pursue counter-cyclical fiscal policies. Inappropriate response to increases in public debt in a timely and continuous fashion can quickly lead to a larger probability of the public debt paths getting out of control.

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily coincide with those of the Reserve Bank of Zimbabwe or Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.

Conflict of Interests

The author has not declared any conflict of interests.

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Full Length Research Paper

Human resource development as a correlate of performance of the banking industry in Ogun State, Nigeria

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The study examined human resource development as a correlate of performance of the banking industry in Ogun State. Primary and secondary data were used in the study. Primary data were collected from the sampled commercial banks' staff in Abeokuta metropolis while secondary data were sourced from published 2012 and 2013 Financial Statements of commercial banks. Data were analysed using Ordinary Least Squares and chi-square analyses. The study revealed significant positive relationship between expenditure on human development and each of the financial performance indicators. More than 50% of the total variation in each of the financial performance indicators except retained earnings (49%) was explained by human capital expenditure. The study also showed that training programmes have positive effect on the performance of commercial bank staff. The study posited that the new generation banks spent more on human resource development compared to old generation banks. The number of staff trainings and duration of trainings were low and most trainings were in-house. The need for management of commercial banks to encourage staff training in order to enhance their financial performance as well as the performance of employee is recommended. Old generation banks are advised to increase their annual budget on staff training.

Key words: Human capital, commercial bank, on-the-job training, Likert scale, retail banking.

INTRODUCTION

In recent times, world attention is being focused on the importance of human resources development as panacea

to problems associated with economic growth of nations. This is due to the fact that the growth of tangible capital

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JEL: J53, M53 and G21

stock of a nation depends to a considerable degree on human capital development. Without adequate investment in developing human capital which is the process of increasing knowledge, skills and the capacities of people in the country, the possibility of the growth of that nation might be minimal (Gyang, 2011). Human capital has been recognized as one of the key determinants of growth today (OECD, 2001). This applies especially to modern economies such as Switzerland, United States of America, China, and Japan among others as companies with a large share of skilled labour have moved to other countries of the world as a consequence of their comparative intellectual capital advantage (Polasek et al., 2011).

According to Muktar (2005), human resource is perhaps the most important component of an organisation. He reasoned that human resources are men and women who are working in an organization. They constitute the active agents that harness and combine other resources towards the accomplishment of organizations goals. Consequently, organizations must have competent employees who are able to carry out assigned tasks for the purpose of attaining organizational goals. It has long been recognized that employees' competence on a job is acquired not only by formal education but also through experience gained in the work environment and through the acquisition of specific skills and knowledge on the job through training and development.

The need for dynamism in the business environment and growing competition among business firms have forced companies to constantly evolve new ideas in order to succeed. To ensure sustainable relevance, firms must constantly be innovative by evolving new procedures and products in a competitive banking environment. This is achievable through efficient human resource (Sanchez and Soriano, 2011). Intellectual assets of any organization can differentiate it from others and can provide strong basis for its competitive position among competitors. Muktar (2005) identified manpower training and development as the critical variables in the performance function of organizations. This happens to be the vehicle through which the knowledge, skill, and attitudes requisite for the running of organizations are passed on to the people who make the organizations to achieve their goals. The realization of this fact has made organizations, especially those interested in attaining and maintaining excellent performance, to pay close attention to training and development. Failure to do so can, and indeed does, spell doom for such organization. Bank customers are increasingly demanding for high quality, low priced and immediate service delivery. They want additional improvement of value from their chosen banks (Olaniyi, 2004). Hence, the need for human resource development in banking sector to meet ever increasing demand for improved services from customers as well as the returns on investment by investors.

The unpredictability of economic environment coupled with various programmes and reforms often introduced by government have made it mandatory for commercial banks to make regular training of their staff very imperative in order to ensure their continuous existence in business. Introduction of Structural Adjustment Programme (SAP) in Nigeria in 1986 was an eye opener to the stakeholders in banking industry that it is only banks with dynamic workforce equipped with modern techniques that can survive the aftermath of the programme. Between 1999 and 2005, there was another round of financial reforms on two different occasions which saw banks increasing their capital base while banks (commercial and merchant) capital base was raised to a minimum of N25 billion in 2005 from N1 billion in 2001 (Soludo, 2007). The essence of these reforms was to control the volume of money in circulation, check inflation rate, make the financial sector more effective and relevant in meeting modern day demand for financial backup by investors and borrowers. It also aimed at increasing market competition and improves the asset quality. Banks that were unable to meet the stipulated N25 billion were given merger or acquisition option.

Studies on Human Capital Management Practices in the banking industry are few and those that have attempted to link human resource development to performance have given conflicting results (Bassanini and Scarpetta, 2001). One of such few studies by Muktar (2005) was based on the impact of human resource development on the performance of commercial banks in Nigeria. The present study is not only intended to replicate the study in subunit of Nigeria (Ogun state) but also to add to the existing literature on human resources development as a correlate to performance in banking industry in Nigeria. The importance of human resource development on the performance of banking industry cannot be overemphasized. Good performance motivates the investors and the intending investors in banking sector.

There are different parameters from which financial performance of commercial banks can be evaluated. Indicators such as total assets, total shareholder equity and profitability are commonly used (Faisal, 2012). Spathis and Doumpos (2002) identified risks and returns as measures of bank performance. Bank performance literature describes the objective of financial organizations as that of earning acceptable returns and minimizing the risk taken to earn this return (Hempel *et al.*, 1986). The concept of financial performance of the banks based on the financial ratio has been applied in many studies (Tarawneh, 2006; Sufian, 2009; Okpara, 2009; Onyeiwu and Aliemeke, 2013). Marimuthu *et al.* (2009) examined the extent to which human capitals have direct impact on firms' performance from various critical perspectives. Their literature-based analysis deduced that human

capital indicators enhanced the firm performance directly or indirectly. That firm performance can be viewed from two different perspectives; financial performance (productivity, market share and profitability) and non-financial performance (customer satisfaction, innovation, workflow improvement, and skills development. Profit after tax, customers deposit, total asset and share capital are used as measures of performance in this study. According to Ekwe (2013), before the year 2000, the three strong and popular banks in Nigeria were: the First bank of Nigeria (FBN), Union bank of Nigeria (UBN) and United Bank for Africa (UBA). Their volume of transactions as well as their assets and customer bases were not only very high but also very strong. With the emergence and introduction of modern technologies in banking, which depended heavily on intellectual capital, these trio were generally classified as old generation banks because they did not embrace the technology immediately; while banks that immediately embraced the modern technology, such as Zenith bank Plc, Eco bank Plc, Diamond bank Plc among others are classified as the new generation banks.

Studies (Gberevbie, 2012; Nzuve and Bundi, 2012; Yusuf, 2010; Gildado, et al., 2014) have focussed on human resource development as a correlate of performance in banking industry. Specifically, Yusuf (2010) revealed that investment on human capital has a significant positive impact on the book value per share on Nigerian banks. This means that, as more money is invested on the human capital of banks in Nigeria, the book value per share increases significantly. However, Nzuve and Bundi (2012) found a low positive correlation of 0.102 between turnover growth and recruitment excellence as a human capital management practice. Moreover, the contribution of human resource development to the performance of banking industry is a dynamic issue which should be assessed frequently due to ever changing in the requirements of the corporate world from their employee as the world is now a global village.

The study is aimed at determining the causal relationship between annual personnel expenses (proxy for expenditure on human capital development) and each of commercial bank's performance indicators (profit after tax, customers' deposits, total assets and share capital) as well as assessing the impact of human resource development on performance of commercial banks in the study area based on the opinion of the staff of the sampled banks. The study also profile the training programmes that commercial bank staff are exposed to. Unlike previous studies that relied on secondary data obtained from published annual financial statements (employer's data), this study also utilised data obtained from commercial bank staffs (employee's data) in order to come up with robust findings. The following research hypotheses are tested.

- (i) Ho₁: Annual profit after tax of commercial banks is not positively influenced by human resource development.
- (ii) Ho₂: Consumers' deposit is not positively influenced by human resource development.
- (iii) Ho₃: Training of staff do not influenced positively the performance of commercial banks.

Definition of terms

Terms here are conceptually and operationally defined for better understanding of the readers.

Human resource/human capital

Human capital is the knowledge, skills and abilities residing with and utilised by individuals (Schultz, 1961)

Commercial bank

Commercial bank is an institution where people or businesses keep their money and other valuable items (www.klaboyy.hubpages.com)

Human resources development

This is a systematic process of training and growth by which individuals gain and apply knowledge, skill, insights and attitude, manage work and personnel effectively (www.adekass.blogspot.com/2008/08/impact-of-motivation-on-employees.html).

Human Capital Investment

This consists of expenditures on education, training and medical care. Human capital will be measured by (staffing, training & development, incentives policy, and employee's loyalty) (www.econlib.org/library/Enc/HumanCapital.html)

Firms' performance

This encompasses specific areas of firm's outcomes: (a) financial (profits, return on assets, return on investments); (b) market performance (sales, market share); and (c) shareholder return (total shareholder return, economic value added), (Richard, et al. 2008).

On-the-job training

This is a type of training an employee that has acquired the prerequisite academic education undergoes; it includes learning how to perform the skill-driven tasks.

Returns on investment

This is the concept of an investment of some resource yielding a benefit to the investor. A high ROI means the investment gains compare favourably to investment cost (www.exodus.store.aptoide.com/app/...androidapps.../Financial%20Calculator)

Total credit

This represents the amount of loan given out by banks

Development

This is the process concerned with people's capacity in a defined and over a period to manage and involve positive change, and reduce or eliminate unwanted change (www.adekass.blogspot.com/2008/08/impact-of-motivation-on-employees.html)

Manpower

This includes unskilled, skilled supervisory and management staff of a company (www.adekass.blogspot.com/2008/08/impact-of-motivation-on-employees.html)

THEORETICAL FRAMEWORK AND LITERATURE REVIEW**Theoretical framework**

The classical economists propounded that land, capital and labour are the basic factors of production. Labour is usually associated with the human being and qualifies him as a resource, that is, "principal" source of wealth or income of a country or institution" (Chambers, 1996a). Labour occupies prime place in production because "land would remain uncultivated, and capital would lie idle and perhaps, would never even have been invented or accumulated, but by and for the utilization of labour" (Yesufu, 2000). Harbison (1973) has summarized the claims of this theory that human resources and not capital, income or material resources – constitute the ultimate basis for the wealth of nations. Capital and natural resources are passive factors of production; human beings are the active agents who accumulate capital, exploit natural resources, build social, economic and political organizations that carry forward national development (Harbison, 1973). Thus while not denying the importance of other resources in the productive process; the theory assumes that human beings are the most important assets of a nation or organization. Man as the source of labour potentially possesses limitless skill, knowledge and capabilities that can be developed, harnessed and managed to ensure national, sectoral or organizational survival and progress. Initial writing on human capital and performance of firms dates as back as 1960 with the works of economists such as Mincer (1962), and Becker (1976). They studied the relationship between education and economic growth, productivity and earnings growth which all have empirical support. They concluded that human capital is the basis in

explaining individual earning differences. They further state that employees who invest in education and training will raise their skill level and be more productive than those less skilled, and so can justify higher earnings as a result of their investment in their human capital.

Based on human capital theory, there are three basic views for the notion of human capital. The first is the investment view, which conceives human capital as the result of investment, and so the human capital value is the expenditure that is invested to enhance personal physical strength and intelligence, and acquire knowledge and skills (Schultz 1961). The second is the view of part outputs, which conceives that human capital is proprietary knowledge, and skill, experience and the relevant workplace competencies of managers and technical innovators (Weijie and Zhao, 2001). The third is the holistic output view, which conceives human capital as the total value of personal physical strength, intelligence, knowledge and skills for utilisation. The total output is the sum of labour abilities of a particular population (Wang et al., 2005). There exists a strong belief and support for the third view, namely, that human capital is the labour ability of any person. Thus, human capital is not limited only to managers or technical personnel. More specifically, human capital is the 'output' formed by the investment, the form is intangible, and its value is not what has been invested, but the worth of 'output'.

As noted by Stacey (2001), intellectual capital can be divided into two main categories, defined as human capital and invisible assets, or 'non-thinking' capital. These can be represented using apparently valid quantitative financial methods. For instance, human capital can be divided into three main areas: competence (e.g. average duration of employment, hours of training per employee, IT literacy), attitude (e.g. a leadership index, a motivation index) and intellectual ability (e.g. savings from employee suggestions, company diversification index).

According to Philips and Somboon (2006), the link between human capital and performance is based on two theoretical strands. The first is the resource-based view of the firm. The second is the expectancy theory of motivation as stated by Vroom (1964) composed of three elements: the valence or value attached to rewards; the instrumentality, or the belief that the employee will receive the reward upon reaching a certain level of performance; and the expectancy, the belief that the employee can actually achieve the performance level required.

Concept of performance in industry

According to Richard et al. (2008), firms' performance encompasses these specific areas of firm's outcomes: (a)

financial (profits, return on assets, return on investments); (b) market performance (sales, market share); and (c) shareholder return (total shareholder return, economic value added). Firms' performance is the ultimate dependent variable of interest for those concerned with just about any area of management: accounting is concerned with measuring performance; marketing with customer satisfaction and market share; operations management with productivity and cost of operations, organizational behaviour with employee satisfaction and structural efficiency; and finance with capital market response to all the above. March and Sutton (1997) found that roughly 28% of articles in the strategic management journal, the academy of management journal and administrative science quarterly included some measures of firm performance.

Performance is so common in organizational research that it is rarely explicitly considered or justified; instead it is treated as a seemingly unquestionable assumption (Devinney et al., 2008). The multi-dimensionality of performance covers the many ways in which organizations can be successful; the domain of which is arguably as large as the many ways in which organizations operate and interact with their environment.

Training and manpower development programmes

The expertise required by the industry can be divided into two sub-sets: (1) academic training, and (2) on-the-job skills. In terms of academic training, the required knowledge includes intermediate accounting, corporate finance, business law, economics, and strong written and oral skills (Carlson, 1994). The on-the-job training portion, which relies upon the assumption that an employee has acquired the prerequisite academic education, includes learning how to perform the following skill-driven tasks: credit analysis, credit investigations, and the professional conveyance of unpleasant information. Moreover, training also involves becoming familiar with banking laws and regulations, interviewing customers, and negotiating business deals using sales techniques (Carlson, 1997).

According to Adekass (2008), there are many types of training and manpower development programmes available. The particular method chosen by a company can be influenced by considering cost and time available, number of persons to be trained, depth of knowledge required, background of the trainee, etc. Manpower development is a systematic process of training and growth by which individuals gain and apply knowledge, skill, insights and attitude to manage work and personnel effectively. It involves the estimation of the demand for the supply of management staff for the organization in future. It is the involvement of efforts aimed at improving the quality as well as the number of management staff. Studies showed that many workers fail in organizational

expectations because the training needs were not identified and provided for. Development may help to build confidence in the workers and make them work more efficiently and effectively.

On-the-job training

This is a widely accepted method of developing workers used by most organizations. According to Obisi (1996), "old and experienced workmen perform much better in any organization when they undergo training and manpower development through on-the-job training programmes". The advantage of this method is that it creates good working relationship because employees get to know each other better as well as the working environment. On the other side, this method is disadvantageous in the sense that it could result to unorganized supervision, monotonous work and also using unqualified personnel for supervision when the qualified are undergoing the training. On the job training could take the following forms:

1. Training by experience workmen.
2. Apprenticeship, which is the oldest method of training.

Information presentation method

The aim is to impart the facts, theories, concepts, etc. without actual practice. Examples of information presentation method are:

Conference method: This could be in form of a seminar programme where a small group are drawn from different organizations.

Classroom method: It can be used to reach a large crowd and it is usually a two-way communication, where questions are asked and answers are given.

Programmed instruction: It includes teaching aides such as cassettes, films, etc. This method is different from conventional form of training in which the trainer guides the process because the materials to facilitate learning are resented in a way the student can control.

Lecture method: This is a student institutional method used in colleges, polytechnics and universities. It is cheaper and has the ability to accommodate more students.

Simulation approach: People are trained on real life experience, i.e. problem that present itself on real life. Simulation approach could take demonstration or role-playing method.

Role playing method: It is a technique in which some problems real or imaginary life situations are presented and acted out by trainee.

Professional training

This is used to help trainee acquire more skill usually in technical or commercial fields, where skills are acquired for performing a task. Vestibule training is a system of training used when a large number of people are to be trained on special machines or equipment's.

Literature review

In a study on human capital management practices and firms' performance: a survey of commercial banks in Kenya by Nzuve and Bundi (2012), using Ordinary Least Squares technique; they revealed that human capital management practices had a positive influence on turnover growth. They recommended the need for commercial banks in Kenya to enhance the human capital management practices. Wang et al. (2008) revealed the relationships between human capital and innovative capability. The study suggests that the larger the commercial banks' human capital, the stronger the innovative capability. The implication is that enterprises should cultivate high human capital rather than simply treating employees as costs.

In a study on the impact of human resource development on the performance of commercial banks in Nigeria by Muktar (2005), he revealed a strong and positive relationship between performance of commercial banks, and human resource development and training. The study found that as at December 1997, about 70% of the staff in commercial banks neither has degree or its equivalent nor do they have any professional qualification. With regards to the working experience 90% of the total staff in commercial banks has at least 3 or more years of working experience. And lastly, courses attended by commercial banks' staff in 1997 have short duration of less than 2 weeks.

Using simultaneous equation model, Nyong (1996) studied the performance of commercial banks in Nigeria. However, the study considered profitability as a measure of banks performance in spite of the high level of undercapitalization. The study sheds more light on the effects of managerial efficiency on the performance of commercial banks. The findings raised serious concern about the quality of human resource especially at managerial level, and the need for concerted efforts to promote staff development programme as a logical first step in preparing for dynamic banking.

Nigerian Institute Social and Economic Research (NISER) (2000) studied the performance profile of commercial banks in Nigeria in relation to the quality of human resource. In the study, banks' performance was proxied by profit before tax divided by Asset base ratio. It was discovered that the performance of commercial banks is associated, to a great extent with the

educational qualifications of its human resources. The study also found that there is a high percentage of staff in the industry with low qualifications. An encouraging development however is that, the percentage is declining as increasing number of staff who had no degrees are improving themselves by acquiring more certificates. The study recommended that, if staff with experience of 3 years or more could be complemented with those with higher qualifications, performance will undoubtedly improve. Muktar (2005) recommended the need to improve the quality of human resource in commercial banks through more rigorous training with longer duration and capacity utilization programmes.

Ismaila (2010) utilised ordinary least squares to test the impact of human capital investment on performance of Nigerian banks and Human Capital Efficiency Coefficient method to test the efficiency of human capital in Nigerian banks. The study found that there is significant relationship between Market Price per share (MPs) and human capital investment; there is a significant relationship between Book Value per share (BVs) and human capital. The study also found that human capital investment has positive impact on the efficiency of banks' employees.

Moreover, Benton (2004) studied human capital capabilities and processes that link human capital assets and approaches to overall business performance. The study utilized nineteen business organizations around the world. They found out that there is a strong link between the maturity of an organization's human capital processes and its overall financial performance. Their result further indicated that human capital processes drive important business capabilities like leadership, workforce performance and employee engagement. They submitted that these capabilities have a significant impact on key drivers of organizational performance. Bigsten and Paul-Collier (1998) studied the rates of return on physical and human capital in Africa's manufacturing sector in five African countries. Their findings revealed that the returns from both experience and training rise with the level of education. Private returns rise from 3% at the primary level to 10% at the secondary level and 35% for tertiary. Huselid (1995) study on the impact of human resource management practices on turnover, productivity, and corporate financial performance in the USA revealed that high performance work practices have a statistically significant impact on both intermediate employee outcomes (turnover and productivity) and short and long term measures of corporate financial performance.

METHODOLOGY

Data

Secondary and primary data were used in the study. Secondary data were sourced from the 2012 and 2013 Financial Statements of

four old and six new generation banks that were purposively selected. Data were collected on annual personnel expenses (proxy for expenditure on human capital development) and performance indicators (profit after tax, customers' deposits, total assets and share capital).

Primary data were collected using two-stage sampling technique. In the first stage, four old generation and six new generation banks were purposively selected. In the second stage, stratified random sample was adopted. Each bank was stratified into operations and marketing department. These are the two major departments in commercial banks. Six (6) staffs were selected randomly from each department; making twelve respondents per bank. A total of one hundred (120) respondents were considered. The choice of stratified random sampling was based on its ability to address the problem of one sidedness associated with simple random sampling technique. Also, stratified random sampling is practicable and gives efficient estimates. The study area Abeokuta is the capital of Ogun State in southwest, Nigeria. The choice of Abeokuta is based on its vibrant economic activities, the diverse population, location of public and private enterprises and branches of commercial banks. Primary data were used to expatiate on the results obtained from the secondary data and also to assess the effect of different staff training programmes undertaken on the performance of the commercial banks as well as the employees.

Structured questionnaire was used to collect data. The questionnaire contained more of close ended questions. Questions were asked on the socioeconomic characteristics of respondents, type and duration of training attended by staffs, number of training attended per year, the effect of such training on the performance of day-to-day work by staff. Part of the questionnaire that addressed the research hypotheses was designed using Likert format. A total of one hundred and twenty (120) questions were administered while one hundred and eight (108) were collected.

Methods of analysis

Data were analysed using descriptive, simple regression; and chi-square analyses to achieve the specific objectives of the study. Descriptive analysis included measure of central tendency (mean, median and mode), measure of dispersion (standard deviation and skewness), difference of means, graphs and charts. The chi-square test was used to assess the impact of the staff training on the performance of the bank as well as the staff.

The simple regression model used is shown below:

$$P_{Fi} = f(HCE).....(1)$$

$$PF = \phi_0 + \phi_1HCE + U_0.....(2)$$

Where:

PF represents the annual performance of the sampled commercial banks measured in terms of profit after tax, retained earnings, total asset, shared capital and customer's deposit. All the performance measurements are in naira.

HCE represents the annual human capital expenditure. The annual personnel expenditure was used as the proxy for human capital expenditure. The annual personnel expenditure as contained in the Financial Statements is made up of salaries, allowances and training expenditure.

ϕ_0 represents intercept

ϕ_1 represents regression coefficient

U_0 represents the random term.

The simple regression analysis involved regressing human capital expenditure on each of the performance measurements.

Chi-square analysis

Chi-square test was used in this study to show whether two sample characteristics (various measures of performance and the opinion of the respondents) are independent or not. Chi-square calculated value is obtained using the formula below:

$$\chi^2 = \sum \left(\frac{(O-E)^2}{E} \right).....(1)$$

Where:

O represents the observed frequency.

E represents the expected frequency.

Data would be obtained from contingency table (to be extracted from Likert scale table).

RESULTS AND DISCUSSION

Table 1 shows that the average annual human capital expenditure per bank was N7.19million. The positive skewness indicates that most banks spent less than the average human capital expenditure. The average annual profit after tax per commercial bank was N14.3million. Also, majority of the banks recorded less than the average annual profit after tax. Customers deposit ranges from N224, 718 to N1.2billion while the average total annual asset per was N459.39 million. Moreover, the study revealed a significant difference in the average annual human capital expenditure between the old and new generation banks ($p < 0.05$). Specifically, the new generation banks spent more on human capital development compared to the old generation banks (Table 2). Staffs of the new generation banks attended more training. This may not be unconnected with the better performance of the new generation banks in Nigeria. The study showed that the average profit after tax of the new generation bank is significantly greater than that of old generation banks ($p < 0.05$). This finding is in agreement with Ekwe (2014).

He revealed that most of the new generation banks post better and higher financial performance figures and better services than the old generation banks owing to the innovations introduced. However, the study posited higher inequality in terms of expenditure on human development among the new generation banks compared to old generation banks. Specifically, the Gini coefficients are 0.17 and 0.50 for old and new generation banks respectively.

The result of the simple linear regression shows that all the financial performance indicators have positive causal

Table 1. Descriptive analysis result for annual human capital expenditure (N) and the performance indicators (N).

Parameter	Personnel expenditure	Customers deposit	Total assets	Retained earnings	Share capital	Profit after tax
Mean	7191516.3	327750352.7	459392665.3	8784381.25	4278653.25	14302609.05
Standard Error	2547433.649	115933197.6	163928562.1	3411228.741	1268813.243	6044619.924
Median	52761.5	931474.5	1696938	116344	16094.5	32203.5
Mode	#N/A	#N/A	#N/A	17982	15698	#N/A
Std. Deviation	11392469.61	518469021.2	733110816.8	15255478.7	5674305.326	27032362.1
Sample Variance	1.29788E+14	2.6881E+17	5.37451E+17	2.3273E+14	3.21977E+13	7.30749E+14
Kurtosis	-0.842105766	-0.964885385	-0.733465434	4.052584273	-1.093613851	3.494879391
Skewness	1.053152694	1.021146285	1.081778112	2.080932813	0.784387897	2.055137031
Range	28402799	1261702317	1903785569	55198949	14713715	85540210
Minimum	9393	224718	580226	6193	1875	5300
Maximum	28412192	1261927035	1904365795	55205142	14715590	85545510
Sum	143830326	6555007054	9187853305	175687625	85573065	286052181
Count	20	20	20	20	20	20

Source: Field survey (2014).

Table 2. Equality test for annual human capital expenditure and profit after tax for old and new generation banks.

Parameter	Old Generation bank (9)		New generation banks (11)		Equalities
	Mean	sd	Mean	sd	p-value
Human capital Exp. (N)	47320.44	15686.3	130366767.5	12770199.7	0.0071***
Profit after tax	20843.9	16225.6	25987689.6	32475375.3	0.0242**

Note: *** means significant at 1% and ** means significant at 5%. Source: Field survey (2014).

relationship with expenditure on human development captured by personnel expenditure (Table 3). The coefficients of human capital expenditure for each of the five performance indicators are positive and statistically significant ($p < 0.05$). This means that as more money is invested in human capital development, the performance indicators increase (profit after tax, total asset, customers deposit, retained earnings, share capital), all

things being equal. Also, the result shows that more than 50% of the total variation in the performance indicators is explained by human capital expenditure except retained earnings (49%). This result is corroborated by the correlation coefficients between human capital expenditure and each of the performance indicators. All the coefficients are positively strong and significant ($p < 0.05$). Apart from strong

relationships, the result shows that as the human capital increases, the performance indicator increases (Table 4).

Assessment of human capital expenditure effect on bank performance by respondents

This section discussed the results obtained from

Table 3. Simple linear regression analysis result.

Variables	Coefficient estimate	Standard error	P-value
Dependent Variable: Profit after tax			
Intercept	1925365	0.51	0.71
HCE	1.72***	0.39	0.00
R ²	0.53		
Dependent Variable: Total assets			
Intercept	2.07E07	6.39E07	0.75
HCE	61.00***	4.83	0.00
R ²	0.90		
Dependent Variable: Customers deposit			
Intercept	1.05E07	3.49E07	0.77
HCE	44.11***	2.64	0.00
R ²	0.94		
Dependent Variable: Share capital			
Intercept	1551911	1007114	0.14
HCE	0.38***	0.08	0.00
R ²	0.58		
Dependent Variable: Retained earnings			
Intercept	2026148	2974597	0.50
HCE	0.94***	0.22	0.00
R ²	0.49		

Table 4. Correlates of performance indicators with human capital expenditure.

Variable	Human capital expenditure	p-value
Human capital expenditure	1	
Customer deposit	0.96925	0.000***
Total asset	0.94794	0.000***
Retained earnings	0.70179	0.001***
share capital	0.76125	0.000***
Profit after tax	0.72533	0.000***

Note: *** means significant at 1%.

the analysis of the primary data used in the study. The aim of this section is to assess the performance of the commercial banks based on the opinion of the respondents (staff) who attended various training programmes organised by their different commercial banks. The section also profiles the characteristics of the respondents (staff) which was lacking in the analysis obtained from secondary data.

Socioeconomic characteristics of respondents

The study showed that 67 % of the respondents were males while the other 33% are females. This indicates

that there were more male respondents (bank staffs) than female respondents in the study banks. Moreover, majority of the respondents (63.2%) are within the age bracket of 28- 37 years while 17% are within the age bracket of 18-27 years. Only 1.9% of the bank staffs that responded are 58years and above. The average age of respondents is 33.3year while the skewness is 1.2. This indicates that majority of the respondents (bank staffs) were less than 33.4 years old (average age). This is an indication that majority of bank staffs were youths. Also, the study revealed that 54.7% of the respondents are married while 42.9% are females and 44.4% of the male respondents are single.

Furthermore, the results showed that majority of the

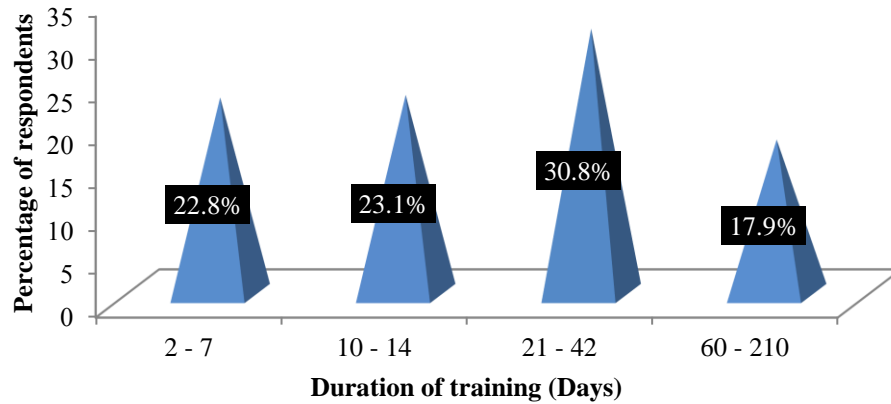


Figure 1. Basic training for the new staffs. Source: Field survey (2014).

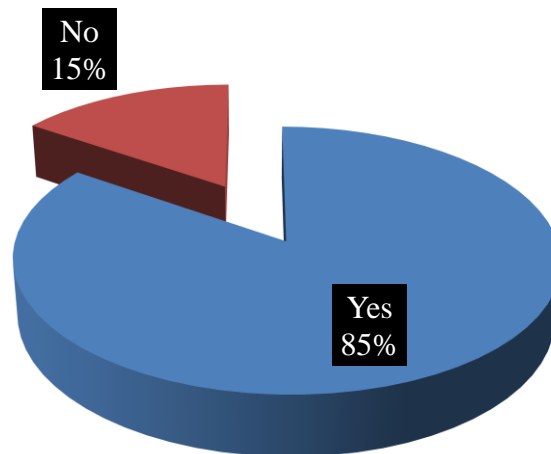


Figure 2. Duration of recent trainings attended by respondents.

respondents were well educated. Specifically, 3.8% of the respondents are PhD holders, 17% are MSc/MBA holders while 67% possess HND/BSc certificates. The least educated bank staffs (12.2%) possessed Ordinary National Diploma certificate. Also, 22.6% of the respondents possessed professional qualifications in addition academic qualifications. The professional bodies include Associate Chartered Accountant, Chartered Institute of Bankers, Nigeria, Chartered Institute of Public Administration, Nigerian Institute of Management and Institute of Chartered Secretary Association of Nigeria. The average work experience is 6.1 years with standard deviation of 7.6. The skewness of 1.4 indicates that majority of the respondents have work experience less 6.1years (average work experience).

Figure 1 shows that 83% of the respondents (bank staffs) had basic training on resumption of duty; while 15.1 % did not. Apart from the basic training on resumption, 72.6% of respondents claimed to have

received other trainings which spread across operations and marketing departments (Figures 2 and 3a).

The result posited that majority (33.0%) of the respondents attended two trainings per year, while 19.8% attended four trainings per year. Only 12.3% of the respondents attended a training per year, while less than one per cent (0.9%) attended eight trainings per year. The average number of training attended by respondents per year in the study area was 3.7 while the skewness is 2.1. The positive skewness indicates that majority of the respondents (bank staffs) did not attend up to 4 trainings (approximation of 3.7) in a year (Table 5). This means that the number of respondents that attended training programmes per year in the study area is low.

The study revealed further that there are respondents (junior staffs) that had many trainings; even up to 40 in a year but this was in form of in-house training that is given to junior staffs at least three times in a week before the normal banking operations commence in some banks.

Table 5. Distribution of number of trainings attended by respondents to date.

Training	No of respondents	Percentage (%)
1 - 3	19	18.8
4 - 6	34	33.6
7 - 9	15	14.8
10 - 12	10	10.0
More than 12	23	22.8

Source: Field survey (2014).

Table 6. Descriptive statistics for characteristics of trainings attended by respondents.

Parameter	No of training attended to date	Average No of training attended per year	Work experience (yr)	Age (yr)	Duration of training (days)
Mean	6.3	3.7	6.1	33.3	32.2
Standard Error	0.4	0.3	0.4	0.7	4.6
Median	5	3	2.5	32.5	14
Mode	5	2	2.5	32.5	14
Standard Deviation	3.6	3.3	4.5	7.6	40.9
Sample Variance	13.0	10.9	20.5	57.4	1670.6
Kurtosis	-0.4	4.4	1.9	3.3	5.7
Skewness	0.7	2.1	1.4	1.2	2.3
Range	12	17	18	40	210
Minimum	2	1	2.5	22.5	2
Maximum	14	17	20.5	62.5	210
Sum	536	385	640.5	3535	2544
Count	85	105	105	106	79

Source: Field survey (2014).

The trainers are senior bank staffs that have the organizations have been sent on training elsewhere. Such person is expected to pass the knowledge acquired through training to other members of staff regardless of whether he/she is competent to impact knowledge. This is a way of reducing cost incurred on human resources development. The breakdown of the trainings attended by the respondents show that 33.6% had 4-6 trainings to date while 18.8% had 1-3 training(s) to date. Moreover, 10.0% had between 10 – 12 trainings to date. The number of trainings attended to date means the number of training the respondent has attended since joining the particular commercial bank as staff (see table 5).

The result shows that the average number of training attended to date by respondents is 6.3 while the average work experience is 6.1years (Table 6). This is almost one training per year. This indicates that the number of training attended to date in the study area is low. Figure 2 shows the breakdown of the respondents' training durations. Specifically, majority (30.8%) of the respondents attended training that lasted for between 21

and 42days while 22.8% of the respondents had training that lasted 2 – 7days. Only 17.9% of the respondents attended training that lasted 60 - 210days. However, most of the trainings that lasted for 60 – 210 days are trainings within banks while few senior staffs are allowed to go for training that last for at most three months elsewhere including outside Nigeria. The skewness of duration of recent training attended is 2.3. This means that most of the respondents attended training that lasted less than the average training duration.

Training in different subsections of operation department

Figure 3 shows the percentages of respondents trained in different subsections of operations department. The figure reveals that majority (30%) of the respondents were trained in cash operations sub section; while 23 and 27% were trained in fund transfer and tellering respectively. Only 5% of the respondents were trained in

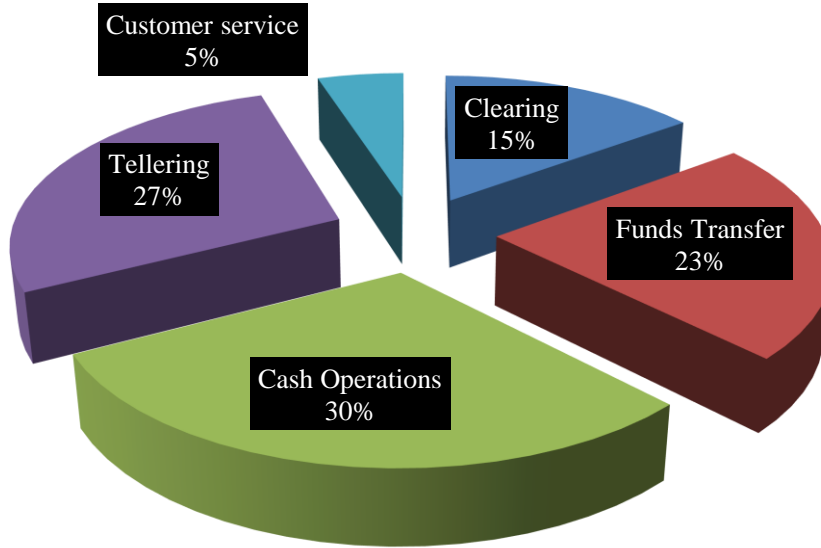


Figure 3. Respondents (%) trained in different subsections of operation department.



Figure 4. Respondents (%) trained in subsections of marketing department based on gender.

customer service subsection. Operations department is a major department in any commercial bank.

Further disaggregation shows that 68% of the respondents were trained in retail banking while 32% trained in public sector banking. This subsection is made up of the bank staffs that work on the field looking for new customers and maintaining relationship with old customers. Moreover, 27.5% of respondents trained in retail banking are females while 33.3% are females trained in public sector banking. Also 72.5 and 66.7% are

males trained in retail and public sectors banking respectively. All the female respondents trained in retail and public sector banking were single while 83.7 and 75.0% of male respondents trained in retail and public sector banking respectively are married (Figure 4).

The study also revealed the views of the respondents on the different trainings attended in the last on year based on course content, welfare and quality of lecture delivery. The result showed that 46.3% of the respondents strongly agreed that the content of last training attended

Table 7a. Contingency table on the impact of training on the performance of commercial bank.

		Opinion					Total	
		A	D	I	SA	SD		
Yardstick	A1	Count	58	1	5	57	2	123
		Expected Count	59.2	6.4	5.9	48.0	3.6	123.0
	A2	Count	46	2	5	59	1	113
		Expected Count	54.4	5.9	5.4	44.1	3.3	113.0
	A3	Count	58	9	5	38	3	113
		Expected Count	54.4	5.9	5.4	44.1	3.3	113.0
	A4	Count	55	7	7	47	2	118
		Expected Count	56.8	6.1	5.6	46.0	3.4	118.0
	A5	Count	61	7	4	38	3	113
		Expected Count	54.4	5.9	5.4	44.1	3.3	113.0
	A6	Count	55	10	7	31	9	112
		Expected Count	53.9	5.8	5.3	43.7	3.2	112.0
Total	Count	333	36	33	270	20	692	
	Expected Count	333.0	36.0	33.0	270.0	20.0	692.0	

Table 7b. Chi-square tests.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	41.194 ^a	20	.004
Likelihood Ratio	41.199	20	.004
N of Valid Cases	692		

6 cells (20.0%) have expected count less than 5. The minimum expected count is 3.24.

was detailed while 1.6% of respondents strongly disagreed, 52.2% of the respondents strongly agreed that the training attended is relevant to their daily office schedule. Only 7.3% of the respondents disagreed with the competence of the lecturers that anchor the training while 5.7% disagreed that the training environment was conducive for learning. The result also shows that 8.1 and 7.3% of respondents disagreed and strongly disagreed respectively with the fact that trainee's welfare was given desirable priority. From the foregoing, effectiveness of training hinges on ensuring the competence of the lecturer(s), conducive learning environment and the welfare of trainees.

Determination of whether training acquired by bank staff positively influenced the performance of their respective organisation or not

Chi-square test was used to achieve this specific objective. The yardstick use for measuring the commercial

banks' performance are increase in number of customers, reduced time per transaction or overall process time, increase in profit after tax and reduction in loan default among others. The contingency table based on Likert scale is shown in Table 7a and b.

Where:

A₁ represents increase in number of customers, A₂ represents reduced time per transaction or overall process time, A₃ represents increase in profit after tax, A₄ represents more customers are benefitting from loans, A₅ represents reduction in loan default, A₆ represents improved capital base, A represents agreed, D represents disagreed, I represent indifferent, SA represents strongly agreed and SD represents strongly disagreed.

From this result the null hypothesis is rejected while the alternative hypothesis that training (human resources development) has positive impact on the performance of commercial banks in the study area ($p < 0.05$). This means

Table 8a. Contingency table on the impact of training on the performance of bank staffs.

		Opinion					Total	
		A	D	I	SA	SD		
Yardstick	A1	Count	80	10	5	37	0	132
		Expected Count	66.4	4.7	6.1	52.4	2.5	132.0
	A2	Count	65	2	5	46	2	120
		Expected Count	60.4	4.3	5.5	47.6	2.3	120.0
	A3	Count	53	5	7	47	4	116
		Expected Count	58.4	4.1	5.3	46.0	2.2	116.0
	A4	Count	43	0	5	60	3	111
		Expected Count	55.8	3.9	5.1	44.0	2.1	111.0
	Total	Count	241	17	22	190	9	479
		Expected Count	241.0	17.0	22.0	190.0	9.0	479.0

Table 8b. Chi-square tests Chi-Square tests.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	33.504 ^a	12	.001
Likelihood Ratio	38.342	12	.000
N of Valid Cases	479		

8 cells (40.0%) have expected count less than 5. The minimum expected count is 2.09.

that through human resources development in form of in-service training, there is improvement in the performance of commercial banks in the study area in terms of increase customers, reduction in time per transaction (that is, reduction in time wasting), reduction in the number of loan beneficiaries that default and appreciable increase in profit after tax of banks. All these are ways through which investment in human resources development by banks is justified. These achievements are being recorded by commercial banks despite low in-service training among the bank staffs (Table 8a and b). It is expected that a better human resources development programme by commercial banks will bring about improvement in the performance indicators highlighted.

Determination of whether training acquired by bank staff positively influenced their performance or not

Where:

A₁ represents simplified work processes leading to reduced workload and paperwork and physical movements, **A₂** represents proper handling of adjustments and corrections, **A₃** represents increase in level of customer satisfaction; hence increase in satisfied

customer base, **A₄** represents I can relate better with customer, **A** represents agreed, **D** represents disagreed, **I** represent indifferent, **SA** represents strongly agreed and **SD** represents strongly disagreed

The result shows that the $\chi^2_{\text{calculated}}$ is greater than $\chi^2_{\text{tabulated}}$ ($p < 0.05$). Hence the null hypothesis is rejected while the alternative hypothesis that human resources development (in-service training) has a positive impact on the performance of commercial bank staffs.

CONCLUSION AND RECOMMENDATIONS

The study showed that expenditure human resources development (in-service training) has a positive causal relationship on the performance of commercial banks in the study area; most especially in terms of profit after tax, consumers' deposit, share capital and total assets. The positive effect of staff training on the performance of commercial bank was affirmed by the respondents (bank staffs). Also the respondents posited that training made their job easy. Moreover, the study revealed that the new generation banks expended more on staff training than the old generation banks; and within the new generation banks there was high inequality in the amount expended

on human resource development. Generally, the number of training attended by respondents in the study area was low.

While the adoption of cost saving method (in-house training) by banks enhances efficient utilization of resources, efforts should be made to ensure that training of the junior staff is not restricted to the offices alone but also be allowed to attend training outside. Since the study confirmed the high positive relationship between expenditure on human development and performance of commercial banks, management of commercial banks in the study area should ensure that human resource development is given high priority in order to ensure good returns on investment. Failure of banks to show the specific amount expended on human development in annual financial statement instead of lumping the amount under personnel expenses constituted a great challenge in this study.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

Optimizing the monthly crude oil price forecasting accuracy via bagging ensemble models

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The study investigates the accuracy of bagging ensemble models (i.e., bagged artificial neural networks (BANN) and bagged regression trees (BRT)) in monthly crude oil price forecasting. Two ensemble models are obtained by coupling bagging and two simple machine learning models (i.e., artificial neural networks (ANN) and classification and regression trees (CART)) and results are compared with those of the single ANN and CART models. Analytical results suggest that ANN based models (ANN & BANN) are superior to tree-based models (RT & BRT) and the bagging ensemble method could optimize the forecast accuracy of the both single ANN and CART models in monthly crude oil price forecasting.

Key words: Artificial neural networks, bagging (bootstrap aggregating), classification and regression trees, ensemble models, forecasting.

INTRODUCTION

Oil is an important component of the economic activity and the adverse effect of the crude oil prices on the level of the output is widely recognized in numerous empirical studies (Hamilton, 1983; Hamilton and Herrera, 2004; Huntington, 2005; Barsky and Kilian, 2004; Kilian, 2008). Therefore, forecasting crude oil prices is a very important topic, although it is an extremely hard one due to its intrinsic difficulty and practical applications. The supply and demand forces which are influenced by factors like

gross domestic product, stock market activities, foreign exchange rates, weather conditions and political events determine the crude oil prices (Bernabe et al., 2004; Yousefi and Wirjanto, 2004). These factors among others may cause the highly nonlinear and chaotic tendency of the crude oil prices (Yang et al., 2002).

In the past decades, traditional statistical and econometric techniques have been widely applied to crude oil price forecasting. Abramson and Finizza (1991)

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utilized a probabilistic model for predicting oil prices. Gulen (1998) attempted to predict the West Texas Intermediate (WTI) price using co-integration analysis. Morana (2001) offered a semiparametric statistical method based on the GARCH properties of crude oil price. Similarly, the GARCH model was used by Morana (2001) to forecast short-term oil prices. Ye et al. (2002, 2005, 2006) presented a single equation model to forecast short-run WTI crude oil prices, using OECD petroleum inventory levels, relative inventories, and high and low-inventory variables. Lanza et al. (2005) used error correction models to predict oil prices. Xie et al. (2006) employed a linear ARIMA model to forecast crude oil prices, argued that oil prices exhibit nonlinear behavior which cannot be captured by linear techniques.

As the traditional and econometric models have some limitations, some non-linear and emerging artificial intelligent models like artificial neural networks (ANN), support vector machines (SVM) and genetic programming (GP) can provide powerful solutions to nonlinear crude oil prediction. Abramson and Finizza (1991) attempted to predict crude oil prices using neural network models. Tang and Hammoudeh (2002) used a non-linear regression model to forecast OPEC basket price. Mirmirani and Li (2004) applied the VAR and ANN techniques to make ex-post forecast of U.S. oil price movements. Their analysis suggests that the BPN-GA model noticeably outperforms the VAR model. Xie et al. (2006) proposed a support vector machine model to forecast WTI prices. To evaluate the forecasting ability of SVM, authors compared its performance with those of ARIMA and BPNN. The experiment results showed that SVM outperforms the other two methods. Shambora and Rossiter (2007) and Yu et al. (2007) also used the ANN model to predict crude oil price. Gori et al. (2007) forecasted oil prices and consumption in the short term under three scenarios: parabolic, linear and chaotic behavior. Silva et al. (2010) used a wavelet decomposition to forecast oil price trends. Azadeh et al. (2010) applied an adaptive intelligent algorithm for forecasting gasoline demand based of artificial neural network (ANN), conventional regression and design of experiment (DOE).

In the recent years, there has been a growing interest in ensemble methods for integrating multiple predictions. To our knowledge there have been very few applications of ensemble models within energy economics. For example, Zhanga et al. (2008) used ensemble empirical mode decomposition (EEMD) for crude oil price analysis. Yu et al. (2008) proposed using an empirical mode decomposition (EMD) based neural network ensemble learning paradigm for crude oil forecasting. Authors found that across different forecasting models, for the two main crude oil prices – WTI crude oil spot price and Brent crude oil spot price – in terms of different criteria, the EMD-based neural network ensemble learning model

performs the best. The ensemble methods provide an enhancement of the forecasting accuracy of their individual constituent members such as artificial neural networks and classification and regression trees. The most popular and widely used method is bagging. Thus, we employ bagging in constructing ensemble models in the present study.

The organization of this paper is as follows. Section two is devoted to bagging, classification and regression trees and artificial neural networks. Section three describes the data, performance statistics, application details and empirical results. Finally, some discussions, conclusions and future study directions are given in section four.

METHODS AND DATA

Bagging

Bagging (short for bootstrap aggregating) was proposed by Breiman (1996). It works as follows (van-Wezel and Potharst 2007): A training set D consists of data $\{(X_i, Y_i), i = 1, 2, \dots, n\}$ where X_i is a realization of a multidimensional predictor variable and Y_i contains the label of the case i . For a regression problem, Y_i is a realization of a real valued variable. A replica dataset of size n is randomly drawn with replacement from the original dataset of the n patterns. A bootstrap sample D^* may contain some in D multiple times, whereas others are not included. When a bootstrapped sample is drawn, approximately 37% of the data is excluded from the sample and the remaining data is replicated to bring the data to full size. The excluded one third of the samples is known as the out of bag samples (OOB), while the replicated dataset is known as the in bag samples (Ismail and Mutanga, 2010). A more detailed version of bagging is described in Breiman (1996). Model structure of bagging ensemble developed in the present study is shown in Figure 1. Given a learning model h , bagging is defined for regression problems as follows (Pino-Mejias et al. 2008):

Definition 1. Bagging.

1 Input:

Training sample = $\{(X_i, Y_i), i = 1, 2, \dots, n\}$;

Base learning model h ;

2 Process:

I Construct a bootstrap sample $D^* = \{(X_i^*, Y_i^*), i = 1, 2, \dots, n\}$, according to the empirical distribution of the pairs $U_i, i = 1, 2, \dots, n$, in D .

II Fit h to D^* , obtaining the bootstrapped model h^* .

3 Output:

The bagged predictor is $h_b^*(x) = E[h^*(x) | D]$.

Classification and Regression Trees

Classification and regression trees (CART) was proposed by

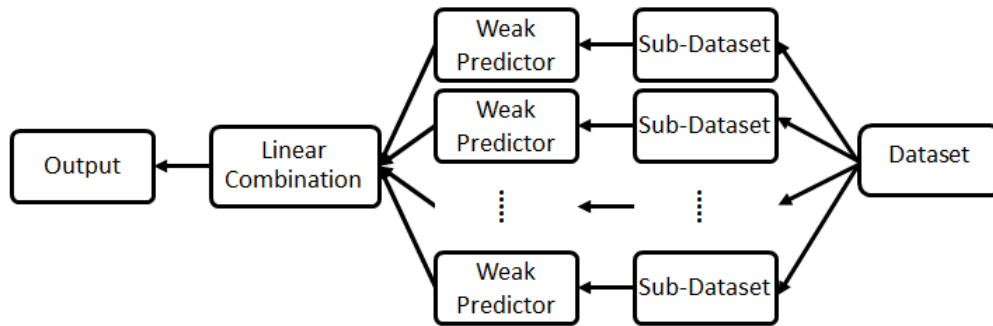


Figure 1. Bagging ensemble model structure.

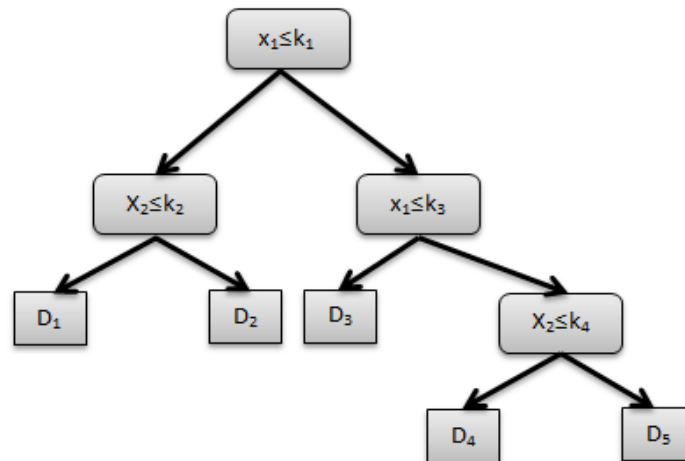


Figure 2. A CART structure.

Breiman et al. (1984) which is a nonlinear statistical technique (Cao et al., 2010).The CART method is based on binary recursive partitioning. A node, which is always partitioned into exactly two new nodes, is called a parent node. The new nodes are called child nodes. The method is recursive since the process can be repeated by treating each child node as a parent node (Grunwald et al., 2009). A terminal node is a node that has no child nodes. The main aim of CART is to estimate the response y by selecting some appropriate variables from a large dataset. It works as follows (Hancock et al., 2005): Each node within the tree has a partitioning rule. For regression problems, the partitioning rule is determined through minimization of the relative error statistic (RE):

$$RE(d) = \sum_{l=0}^L (y_l - \bar{y}_L)^2 + \sum_{r=0}^R (y_r - \bar{y}_R)^2 \quad (1)$$

Where y_l and y_r are the left and right branches with L and R observations of y in each, with respective means \bar{y}_L and \bar{y}_R .The decision rule d is a point in some predictor variable X that is used to determine the left and right branches. The partitioning rule that minimizes the RE is then used to construct a

node in the tree. In the last decade, CART has gained popularity in machine community. However, CART is very sensitive to small changes in the training dataset. More specifically, minor changes in the values of the training dataset can lead to significant changes in the selection of variables (Hastie et al. 2008; Ismail and Mutanga, 2010).Thus, CART is identified as unstable predictor that is prone to overfitting (Breiman, 1996). A CART structure is depicted in Figure 2.

Artificial Neural Networks

This study uses a multilayer perceptron (MLP) which is a conventional back-propagation artificial neural network. Back-propagation process is applied in two phases. The first phase is the forward phase; it involves feeding an input data to the input layer and propagating the signal as far as the output of the network to obtain the prediction. Next, the second phase is the backward phase; the error is employed to adjust the weights of the connections from the hidden to the output neurons. The error is also back propagated and used to adjust the weights of the connections from the input to the hidden neurons (Oliveira et al., 2010).The output signal for the l^{th} neuron in the n^{th} layer is given by,

$$y_l^n(t) = \varphi\left[\sum_{j=1}^p w_{lj}^n(t) y_j^{n-1}(t) + \Psi_l^n\right] \quad (2)$$

where $\varphi(\cdot)$ is the activation function, w_{lj}^n is the connection weight, t is the time index and $\Psi_l^n = w_{l0}^n(t)$ is the weighted. For an n -layer network, the synaptic weight $w_{ji}^n(t)$ is given by

$$w_{ji}^n(t+1) = w_{ji}^n(t) + \Delta w_{ji}^n(t) \quad (3)$$

subject to $l \leq n \leq N$ and it can be revised as given by

$$\Delta w_{ji}^n(t) = \eta \lambda_j^n(t) y_i^{n-1}(t) \quad (4)$$

subject to $0 < \eta < 1$

where η is the learning rate, and $\lambda_j^n(t) \equiv -\partial E_i / \partial u_j^n$ is the local error gradient. To improve the back-propagation algorithm, a momentum term α is added

$$\Delta w_{ji}^n(t) = \eta \lambda_j^n(t) y_i^{n-1}(t) + \alpha \Delta w_{ji}^n(t-1) \quad (5)$$

subject to $0 < \alpha < 1$

For the output layer, the local error gradient is given by

$$\lambda_j^N(t) = [d_j(t) - y_j^N(t)] \varphi[u_j^N(t)] \equiv e_j(t) \varphi[u_j^N(t)] \quad (6)$$

where $d_j(t)$ is the goal output signal, and $\varphi(\cdot)$ is the activation function.

2.4. Dataset and experimental settings

The data used in this analysis consist of the monthly West Texas Intermediate (WTI) spot price from January 1982 to November 2011 gathered from the Federal Reserve Bank of St. Louis Federal Reserve Economic Data (FRED). There are various data sets for oil price in the literature, but WTI data is most common due to having long period and providing data continuously from FRED. Bagging ensemble model was applied in forecasting prices in the monthly WTI. Prices are forecasted using time as inputs. In this study, the results are obtained by using a 10-fold cross-validation for each model. The 10-fold cross-validation procedure is applied as follows: First, the WTI dataset is randomized and then data are partitioned into three parts as training set (8 distinct folds), cross-validation set (1 fold) and testing set (1 fold). The training set is employed for the model training and the testing set is used to evaluate the accuracy of models. The cross-validation set is used to apply an early stopping process to avoid overfitting of the training data. Data mining toolkit WEKA (Waikato Environment for Knowledge Analysis) version 3.7.4 is used for experiment. WEKA is an open source toolkit, and it consists of a collection of machine learning algorithms for solving data mining problems (Witten and Frank, 2005).

In this study, the model-specific parameter values we use are as follows: the parameters for MLP are: the number of hidden layers is 5 and 10; the learning rate is 0.3, 0.4 and 0.5; the momentum factor

was 0.3, 0.4, and 0.5; and the training time is 300, 400 and 500. The experiments indicate that the best MLP parameters are as follows: the number of hidden layers is 5; the number of the learning rate is 0.3; the momentum factor is 0.4; and the training time is 500. The parameters for the CART are the following: number of folds; the minimum total weight; and number of seeds. In this case, the values for these parameters were 2, 2 and 1 for CART respectively. The bagging parameters are the size of each bag (as a percentage); the number of iterations; and the number of seeds. The best configuration parameters for the bagging are 100, 40, and 1 respectively. The base models (i.e., CART, ANN) parameters are identical to the case in which they are separately applied. In this study, we offer a better forecasting method for oil price, so we run the program for the each parameter values specified above and select giving the best value. We examined the effects of all the model parameters from the highest values to the least that can be applied in a proper way through the method algorithms. The parameter values that give the highest first three ones are selected for further examination and analyzed for the best values through which we can obtain the least prediction error. Prediction results for each parameter values are compared by using the root mean squared error, the mean absolute error, relative absolute error and root relative squared error accuracy measures.

APPLICATION AND EMPIRICAL RESULTS

The predictive models proposed in this study (i.e., ANN, RT, BRT and BANN) are evaluated by using the four accuracy measures (i.e., the root mean squared error RMSE, the mean absolute error MAE, relative absolute error RAE and root relative squared error RRSE) and also six numerical descriptors (maximum, minimum, mean, variance, maximum under-prediction MUP and maximum under-prediction MOP) are computed to investigate the statistical relation between original data and predicted data.

Mean absolute error:

$$MAE = \frac{1}{n} \sum_{i=1}^n |p_i - a_i| \quad (7)$$

Root mean squared error:

$$RMSE = \sqrt{\sum_{i=1}^n (p_i - a_i)^2 / n} \quad (8)$$

Relative absolute error:

$$RAE = \frac{\sum_{i=1}^n |p_i - a_i|}{\sum_{i=1}^n (\bar{a}_i - a_i)^2} \quad (9)$$

Root relative squared error:

$$RRSE = \sqrt{\frac{\sum_{i=1}^n (p_i - a_i)^2}{\sum_{i=1}^n (\bar{a}_i - a_i)^2}} \quad (10)$$

where a = actual target \bar{a} = average and p = predicted

Table 1. The comparison of performance statics for ANN and BANN models.

Model inputs	ANN				BANN			
	MAE	RMSE	RAE (%)	RRSE (%)	MAE	RMSE	RAE (%)	RRSE (%)
WTI _{t-1}	3,306	4,084	17,502	16,382	2,040	3,133	10,801	12,567
WTI _{t-1} , WTI _{t-2}	2,238	2,952	11,849	11,840	1,868	2,526	9,893	10,131
WTI _{t-1} , WTI _{t-2} , WTI _{t-3}	2,317	3,081	12,269	12,359	1,712	2,271	9,063	9,109

Table 2. Numerical descriptors for ANN models and actual data.

Model	Model inputs	min	max	mean	variance	MOP	MUP
Actual		12,850	125,390	34,371	1181,370		
ANN	WTI _{t-1}	15,839	110,017	36,641	1342,529	6,816	-15,373
	WTI _{t-1} , WTI _{t-2}	15,057	112,815	35,595	1266,988	5,281	-12,575
	WTI _{t-1} , WTI _{t-2} , WTI _{t-3}	15,023	113,344	35,700	1274,472	6,167	-12,046
BANN	WTI _{t-1}	12,849	109,208	33,735	1138,021	3,707	-16,182
	WTI _{t-1} , WTI _{t-2}	13,193	113,394	33,861	1146,567	3,426	-11,996
	WTI _{t-1} , WTI _{t-2} , WTI _{t-3}	13,439	116,530	34,267	1174,234	4,823	-8,860

target. Three input combinations based on preceding monthly crude oil prices are developed to forecast current monthly crude oil price. The input combinations evaluated in the study are; (1) WTI_{t-1}, (2) WTI_{t-1}, WTI_{t-2} and (3) WTI_{t-1}, WTI_{t-2}, WTI_{t-3}. In all cases, the output is the WTI_t for the current month. We purposely do not give the training performance statistics, because good testing accuracy gives no guarantee for a low test error. The performance statistics of ANN and BANN models in the test period are given in Table 1. The table indicates that the BANN model whose inputs are the prices of three previous months (input combination 3) has the best accuracy. It can be seen from Table 1 that the BANN model performs better than the single ANN model from the various performance criteria viewpoints. The table shows that the relative MAE, RMSE, RAE and RRSE differences between the BANN (input combination 3) and ANN (input combination 2) models are 23.514%, 23.065%, 2.786% and 2.731% in the test period, respectively. Table 2 summarizes the numerical descriptors (max, min, mean, variance, maximum over prediction and maximum under prediction) for the ANN and BANN models. The numerical descriptors estimated for the ANN and BANN models indicate that the BANN model yields more similar estimates and distributions when compared with the actual WTI data.

Table 3 indicates that the BRT model whose inputs are the prices of two previous months (input combination 2) has the smallest MAE, RMSE, RAE and RRSE in testing

period. And it is found that the RT model has the best accuracy for the input combination 3. Compared with the RT models, the BRT models yield better accuracy in monthly crude oil price forecasting. The relative MAE, RMSE, RAE and RRSE differences between the BRT (input combination 2) and RT (input combination 3) models are 14.581, 16.761, 2.403 and 3.918% in the test period, respectively. The numerical descriptors shown in Table 4 for the RT and BRT models show that the BRT model provides more similar estimates and distributions than RT. The BANN, ANN, BRT and RT residuals in test period are shown in Figure 3 for all input combinations respectively. It can be seen from the residuals that BANN approximates the actual values better than the others. The underestimations are obviously seen for the tree-based models.

The direct relationship between the MAE, RMSE, RAE and RRSE is very clear according to Tables 1 and 3. The best model for minimizing MAE (1.712) and RMSE (2.271) is BANN, the 2nd model is ANN (MAE=2.238, RMSE =2.952), the 3th model is BRT (MAE=2.659, RMSE =4.850) and finally the worst model is RT (MAE=3.112, RMSE =5.827). Tables 1 and 3 indicate BANN (RAE=9.063, RRSE=9.109) and ANN models (RAE=11.849, RRSE=11.840) are superior to the BRT (RAE=14.076, RRSE=19.457) and RT (RAE=16.479, RRSE=23.375) models for determining, RAE and RRSE statics. In general, note from Tables 1 to 3 that ensemble learning always provides a good improvement and

Table 3. The comparison of performance statics for RT and BRT models.

Model inputs	RT				BRT			
	MAE	RMSE	RAE (%)	RRSE (%)	MAE	RMSE	RAE (%)	RRSE (%)
WTI _{t-1}	3,295	5,855	17,449	23,486	2,755	4,989	14,588	20,014
WTI _{t-1} , WTI _{t-2}	3,259	5,924	17,254	23,763	2,659	4,850	14,076	19,457
WTI _{t-1} , WTI _{t-2} , WTI _{t-3}	3,112	5,827	16,479	23,375	2,826	5,078	14,964	20,368

Table 4. Numerical descriptors for RT models and actual data.

Model	Model inputs	min	max	mean	variance	MOP	MUP
Actual		12,850	125,390	34,371	1181,370		
RT	WTI _{t-1}	13,358	93,636	32,535	1058,512	6,691	-31,754
	WTI _{t-1} , WTI _{t-2}	14,143	93,636	32,544	1059,127	6,691	-31,754
	WTI _{t-1} , WTI _{t-2} , WTI _{t-3}	14,143	93,636	32,758	1073,063	6,691	-31,754
BRT	WTI _{t-1}	13,456	99,190	33,017	1090,136	7,517	-26,200
	WTI _{t-1} , WTI _{t-2}	13,619	99,130	33,102	1095,750	6,873	-26,260
	WTI _{t-1} , WTI _{t-2} , WTI _{t-3}	13,046	96,860	33,032	1091,116	7,830	-28,530

ensemble models (i.e., BANN, BRT) seems to be more adequate than the single ANN and RT models for forecasting monthly crude oil prices (Table 4).

The actual and predicted WTI distributions of the input combinations 1, 2 and 3 for testing period are depicted with boxplots presented in Figures 4, 5 and 6. The box height corresponds to the interquartile range, the whiskers depict the 5th and 95th percentiles and the horizontal line is the median. Dots indicate values outside the range and the horizontal line within each boxes indicate the median values. The performance of BANN model was better than the ANN, RT and BRT models when compared to the distribution of the actual WTI data. Moreover the distribution of WTI data predicted by the BANN model is similar to the distribution of actual data and the BANN model did the best job at the capturing the actual data for test phases.

DISCUSSION AND CONCLUSION

Ensemble learning is the supervised learning from the information generated by the base predictors. The main goal is to build an ensemble model that provides base predictor functionality and to increase the accuracy by combining the individual models (Chou et al., 2011). Integrating multiple instances of the same model type can reduce the variance and enhance prediction accuracy (Wang et al., 2009). In the present study, we have

investigated the potential use of bagging ensemble models for monthly crude oil price forecasting. The ensemble models (i.e., bagged artificial neural networks BANN, bagged regression trees BRT) are obtained by coupling bagging and two single unstable machine learning model (i.e., ANN, CART). We have also employed the base models ANN and CART as benchmark models and used tree input combination to test proposed predictive models. In general, the bagging method can be very effective procedure when applied to unstable learning algorithms, such as classification and regression trees and artificial neural networks (Mejias et al. 2010). Moreover, bagging ensembles can inherit almost all advantages of their base models while overcoming their primary problem, which is inaccuracy. Breiman (1996) pointed out that the bagged model variance is smaller than or equal to the variance of a simple model (i.e. CART, ANN), leading to increasing prediction accuracy (Louzada et al. 2011).

The obtained results from the study indicate that (i) bagging always provides a considerable enhancement. Bagged models (i.e., BANN, BRT) reduce the mean absolute errors, root mean squared errors, relative absolute errors and root relative squared errors with respect to the single ANN and CART models by 23.514-14.581%, 23.065-16.761%, 2.786-2.403% and 3.918-2.731%, respectively; (ii) ANN-based predictive models (i.e., BANN, ANN) are found better than tree-based predictive models (i.e., BRT, RT). (iii) BANN model is a

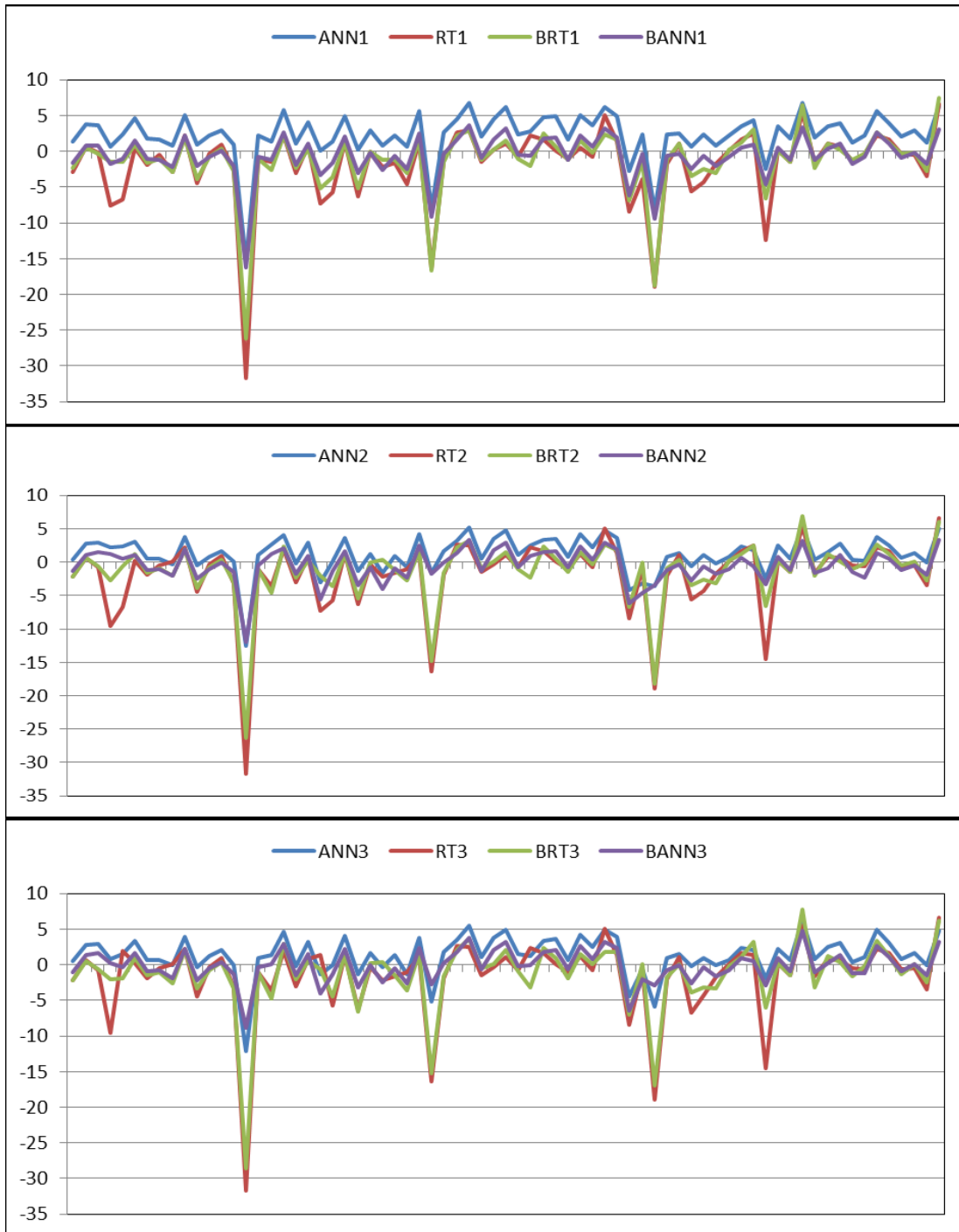


Figure 3. Residuals for the ANN, BANN, RT and BRT models.

promising approach for monthly crude oil price forecasting and finally (iv) the numerical descriptors (maximum, minimum, mean, variance, maximum under-prediction and maximum under-prediction) estimated for the proposed predictive models indicate that the BANN

model yields statically similar estimates and distributions when compared with the actual WTI data. In this study, bagging method is used in building ensemble models. The other ensemble models (e.g., boosting, random forest) could be used for construction of ensemble

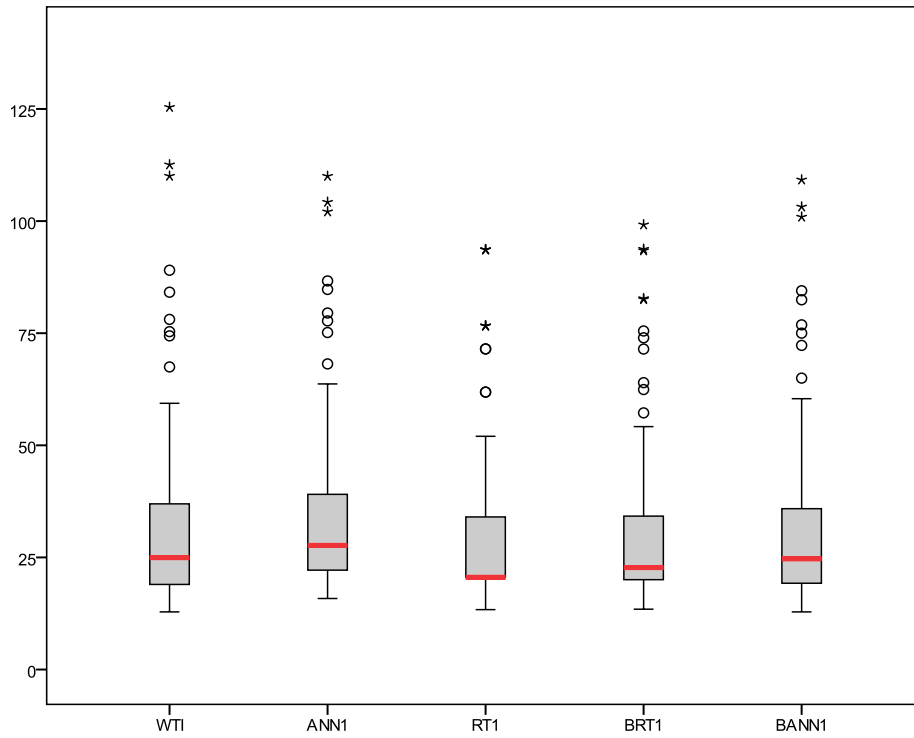


Figure 4. Box plots of actual and predicted WTI distributions for input combination 1.

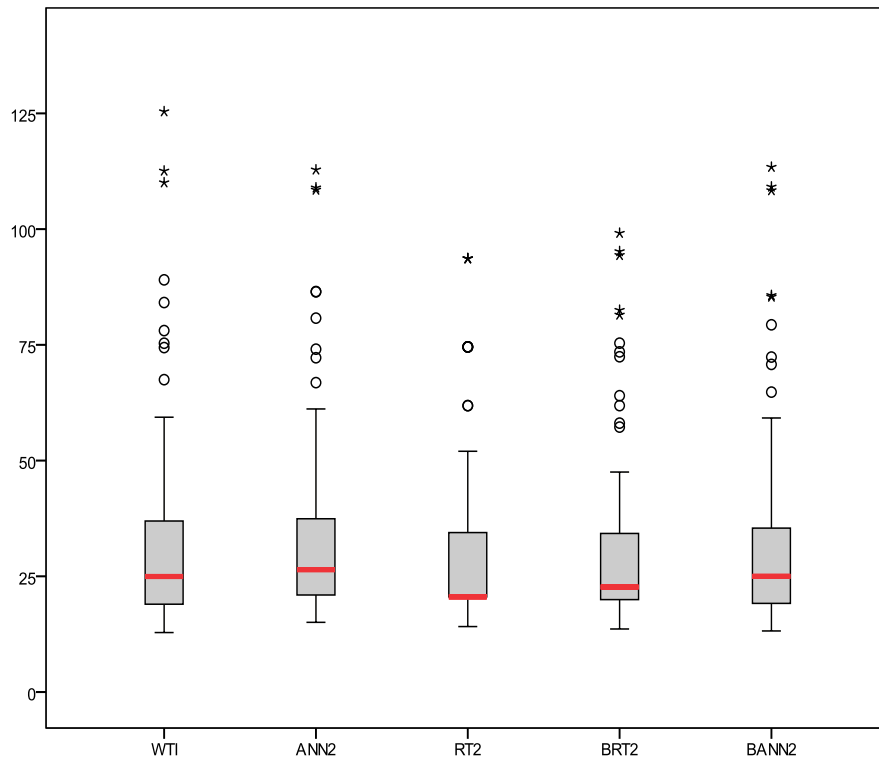


Figure 5. Box plots of actual and predicted WTI distributions for input combination 2.

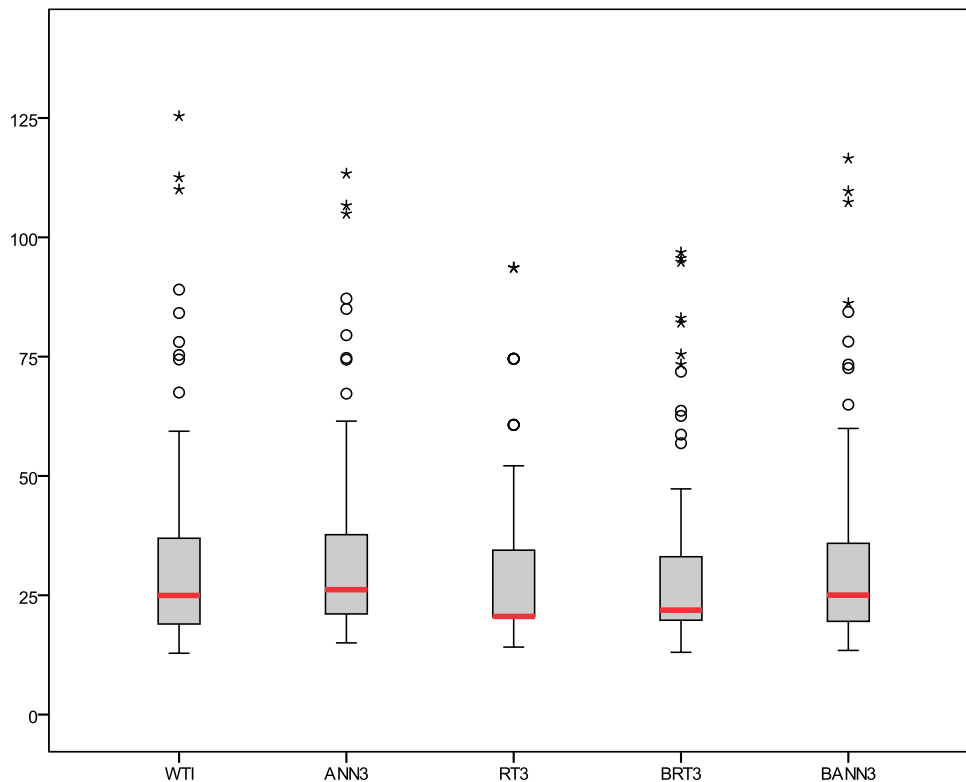


Figure 6. Box plots of actual and predicted WTI distributions for input combination 3.

models. We propose to investigate the usage of other ensemble models for future work.

Conflict of Interests

The authors have not declared any conflict of interests.

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