# JOURNAL OF APPLIED ECONOMICS AND BUSINESS

VOL. 6, ISSUE 3 – SEPTEMBER, 2018

Education and Novel Technology Research Association

# Journal of Applied Economics and Business

## VOL. 6, ISSUE 3 – SEPTEMBER, 2018

The Journal of Applied Economics and Business (JAEB – ISSN: 1857-8721) is an international peer-reviewed, open-access academic journal that publishes original research articles. It provides a forum for knowledge dissemination on broad spectrum of issues related to applied economics and business. The journal pays particular attention on contributions of high-quality and empirically oriented manuscripts supported by various quantitative and qualitative research methodologies. Among theoretical and applicative contributions, it favors those relevant to a broad international audience. Purely descriptive manuscripts, which do not contribute to journal's aims and objectives are not considered suitable.

JAEB provides a space for academics, researchers and professionals to share latest ideas. It fosters exchange of attitudes and approaches towards range of important economic and business topics. Articles published in the journal are clearly relevant to applied economics and business theory and practice and identify both a compelling practical issue and a strong theoretical framework for addressing it.

The journal provides immediate open-access to its content on the principle that makes research freely available to public thus supporting global exchange of knowledge.

JAEB is abstracted and indexed in: DOAJ, EZB, ZDB, Open J-Gate, Google Scholar, JournalITOCs, New Jour and UlrichsWeb.

# Publisher

**Education and Novel Technology Research Association**

Web: www.aebjournal.org

E-mail: editorial@aebjournal.org

support@aebjournal.org

publisher@aebjournal.org

# Editor-in-Chief


- **Noga Collins-Kreiner,** Department of Geography and Environmental Studies, Center for Tourism, Pilgrimage & Recreation Research, University of Haifa, ***Israel***


# Editorial board


- **Alexandr M. Karminsky,** Faculty of Economics, Higher School of Economics, ***Russia***
- **Anand Bethapudi,** National Institute of Tourism and Hospitality Management, ***India***
- **Bruno S. Sergi,** Department of Economics, Statistics and Geopolitical Analysis of Territories, University of Mesina, ***Italy***
- **Dimitar Eftimoski,** Department of Economics, Faculty of Administration and Information Systems Management, St. Kliment Ohridski University, ***Macedonia***
- **Evangelos Christou,** Department of Tourism Management, Alexander Technological Institute of Thessaloniki, ***Greece***
- **Irena Ateljevic,** Cultural Geography Landscape Center, Wageningen University, ***Netherlands***
- **Irena Nančovska Šerbec,** Department of mathematics and computing, Faculty of education, University of Ljubljana, ***Slovenia***
- **Iskra Christova-Balkanska,** Economic Research Institute, Bulgarian Academy of Sciences, ***Bulgaria***
- **Joanna Hernik,** Faculty of Economics, West Pomeranian University of Technology, Szczecin, ***Poland***
- **Ksenija Vodeb,** Department of Sustainable Tourism Destination, Faculty of Tourism Studies - TURISTICA, University of Primorska, ***Slovenia***
- **Kaye Chon,** School of Hotel and Tourism Management, the Hong Kong Polytechnic University, ***China***
- **Pèter Kovács,** Faculty of Economics and Business Administration, University of Szeged, ***Hungary***
- **Ramona Rupeika-Apoga,** Faculty of Economics and Management, University of Latvia, ***Latvia***
- **Renata Tomljenović,** Institute for Tourism, Zagreb, ***Croatia***
- **Valentin Munteanu,** Faculty of Economics and Business administration, West University of Timisoara, ***Romania***
- **Zoran Vaupot,** Faculty of Business Studies, Catholic Institute, ***Slovenia***

# Content

Journal of Applied Economics and Business

OPEN ACCESS ARTICLE

# INTERNATIONAL CAPITAL FLOWS AND EXCHANGE RATES, A DYNAMIC ANALYSIS: THE CASE OF TANZANIA

James Machemba[1], Hung Nguyen[2]

[1]Bank of Tanzania

[2]Fort Hays University

**Abstract**

This paper investigates the impact of international capital flows and other macroeconomic fundamentals on the real exchange rate for Tanzania. We employ a cointegrated vector autoregression (CVAR) and Vector Error Correction (VECM) framework of the Johansen (1988) and Juselius (1992) maximum likelihood estimation technique to assess the dynamic relationships among the real exchange rate and international capital flows such as foreign direct investment, foreign aid, and other macroeconomic fundamentals. For analysis of the short run structural VAR, we follow Sims (1986). Further, Cholesky identification restriction of the structural shocks (innovations) is employed to investigate the dynamic effects of international capital flows, foreign aid, and other macroeconomic fundamentals on the real exchange rate by analyzing the orthogonalized impulse response functions (OIRF) in the economy. The econometric results from the cointegration model revealed two long-run cointegration equations, suggesting that foreign direct investment and foreign aid have a statistically significant impact on the real exchange rate. Evidently, a 1% increase in foreign aid as a percent of GDP reduces the real effective exchange rate by 2.88%, while for foreign direct investment as a percent of GDP decreases real exchange rate by 5 % – hence both appreciating the value of the currency in the economy. By analyzing the Vector Error Correction Model, the speed of adjustments are significant and have an increasing impact on the real exchange rate toward the equilibrium which are 27.76% and 29.19%, this indicates a rapid response of the real exchange rate to deviations from its fundamentals; depreciating towards its initial equilibrium. The same results are supported by the forecast from the model, indicating that there is less appreciation of the currency in the future. Also, by analyzing the impulse response functions we found that shocks are permanent in the economy. This study also used the Structural VAR model to analyze sterilization of the Tanzanian economy. We recovered the structural coefficient and found a significant impact of sterilization of the international capital flows of about 94.2% showing an almost complete sterilization in the economy. Sterilization results were comprehended by the orthogonalized impulse response functions.

## INTRODUCTION

Identifying ways in which international capital flows and other fundamentals affect the real exchange rate is most important to less developed countries which face shortages of funds to meet their investment needs. International capital flows play an important role as a source of managerial expertise, capital, and technology for less developed economies. Appropriate management of the international capital flows have direct and indirect benefits such as enhancing investment and financing fiscal and current account deficits, these benefits are greater than mostly considered. In recent years, policy makers in less developed countries have been seeking efficient economic ways to attract external resources which provide low-cost financing and promote growth, and economic development (Dornbush, 1998).

As the world's economies become more interconnected, there has been an integration of less developed countries into the global economy, an event that has been associated with a surge in international capital flows. While these international capital flows permit higher investment, growth, and finance current account deficits as indicated above, large inflows have been associated with complex macroeconomic management problems on how to manage international capital flows to maximize the benefits to the economies (Aiyer et al., 2008).

Bakardzhieva et al. (2010) and Corden (1982) argue that one of the major determinants of loss of competitiveness in the economy is international capital flows. In other words, an increase in international capital flows might lead to an appreciation of the real exchange rate which can result in affecting the external competitiveness, widening the current account deficit, and may increase vulnerability to a financial crisis.

Combesetal (2012) illustrates that the effects of international capital flows may depend on the exchange rate regimes. For instance, with a fixed regime a rise in inflation will bring an appreciation of the exchange rate after money supply increases. However, with a flexible regime, real appreciation of the exchange rate will be due to an appreciation of the nominal exchange rate.

It is worthwhile to state that the impact of international capital flows depends on the types of expenditures each flow is spent on. When international capital flows are spent on poverty alleviation (social sector improvement), then this will likely generate increased spending on non-tradables, hence increasing the relative price of non-tradables which leads to appreciation of the real exchange rate. However, if the increase in international capital flows such as foreign direct investment (FDI) is spent on imported capital goods, then it may lead to a decrease in the price of tradables, and so less real exchange appreciation which might increase competitiveness (Barkardzhieva et al., 2010). This shows that in theory, international capital flows can cause real exchange rate

appreciation by increasing the amount of available non-tradable goods in the economy at the expense of tradable goods.

## Statement of the problem

Recently, a large body of theory and empirical research has been devoted to identifying the effects of international capital flows since its boom in the mid-1980s (Elbadawi & Soto, 1994). However, much less systematic research has been done to investigate the macroeconomic effects of international capital flows and exchange rate using dynamic models (structural VAR and VECM) in less developed countries, especially Tanzania. The contribution of this paper lies in comprehensively examining the effects of international capital inflows and other macroeconomic fundamentals on the real exchange rate in Tanzania using dynamic models of structural VAR and Vector Error Correction models (VECM).

## Purpose of the study

Empirical literature concerning the impact of international capital flows on the real exchange rates have been extensively done on the less developed and emerging economies of Latin America and to some extent on Asia. In Sub-Saharan Africa, most of studies have been on the foreign official transfers. These studies have been on groups of countries and some on single countries (Lartey, 2007). Different from the other studies, in this study we quantitatively investigate the strength of the relationships among international capital flows in the form of foreign aid, foreign direct investment, exchange rates, and other macroeconomic fundamentals such as terms of trade, government consumption, trade liberalization and productivity. Using Multivariate Dynamic models such as VAR and Cointegrated Vector Autoregression or VECM, we investigate whether the exchange rate is static or follows a dynamic path. This methodology of cointegration technique gives a clear picture of how the fundamentals determining the exchange rate may move permanently, and if it changes the equilibrium value.

## Research question

Using multivariate dynamic time series analysis, this study investigates the impacts of international capital flows on the real exchange rate. The major hypotheses that are tested are:

1) Are positive effects of foreign direct investment and foreign aid being offset by exchange rate appreciation and this offsetting reduces competitiveness of the economy?;

2) Do macroeconomic fundamentals lead to appreciation of the real exchange rate, which is harmful to the export sector and economic growth?; and
3) Is there a role for sterilization of international capital flows?

The study will use multivariate dynamic models, that is, structural VAR and Vector Error Correction Model to capture dynamics of the exchange rate, international capital flows and other macroeconomic fundamentals in the economy for the period of 1970 to 2009.

### Contribution of the study

This study contributes to the empirical literature in two respects. First, it adds to the empirical literature on the impact of international capital flows and other macroeconomic fundamentals on the exchange rate with more updated empirical evidences based on a longer period of data than the previous studies. The findings of the study help to provide more insights on macroeconomic management of increased international capital flows. Second, unlike any previous researches this study applies multivariate dynamic methodology of cointegrated vector autoregression and structural VAR to provide more robust results. Other studies applied traditional methodologies such as Engle-Granger two-step procedure and others adopted static analysis.

### Limitation of the study

This study focuses on the international capital flows and exchange rates for Tanzania. The study uses annual data and covers the 1970-2009 period. The choice of this period has been influenced by the availability of the latest published annual data and the duration of time for which data are available. The sample period is expected to provide a reasonable test of the relationships under the study when variables included in the model are restricted to be as few as can be justified.

### Structure of the study

Section two presents the background of the Tanzanian economy. Section three presents a review of the literature and trends of the selected determinants of exchange rate for Tanzania. Section four presents the methodology and models used in the study. Section five presents the empirical analysis of the econometric results and Section six presents the study's conclusion and discussion of the implications of the study.

## MACROECONOMIC BACKGROUND FOR TANZANIA

In this section, we outline major macroeconomic policies and the performance of the Tanzanian economy from independence to the present. Tanzania has gone through two outstanding macroeconomic phases: pre-adjustment and reforms. The pre-adjustment phase covers the period directly after independence, 1961, with a series of external shocks

starting in the 1970s. The recovery reform phase (1986- present) covers the period of economic reforms.

## Pre-adjustment

Right after independence, Tanzania's economic policies were characterized by market forces up to 1967. Import substitution was the main economic policy which aimed at bringing higher growth of income. As the country was not liberalized for trade, the only form of foreign inflows was in foreign aid mostly from the socialist countries and the country followed a fixed exchange rate regime. In 1967, the country adopted the Arusha Declaration which nationalized major industries such as textiles and large farms; it also expanded the public sector a process which led to a control regime in which all resource allocations were centralized. According to Rutasitara (2004) the control regime led to administrative allocation of credit and foreign exchange which led to interest rate and exchange rate becoming less relevant as policy tools and the private sector was severely crowded out. This was a result of putting several controls on the economic instruments, such as the annual Finance and Credit Plan (1971/72) and the Foreign exchange Plan.

The control regime had the negative impacts to the economy which were shown by the weakening of the economy toward the end of the 1970s. As the government financed social infrastructure and industries, this led to large internal and external imbalances specifically on the country's budget deficits and balance of payment crisis. Responding to a balance of payments crisis in 1986, the shilling was devalued by more than 50% (Rutasitara, 2004).

## Recovery reforms

In 1986, Tanzania started Economic Reforms. The first reform was through the National Economic Survival Program (NESP) followed by the Structural Adjustment Program (SAP). By the end of the 1980s, the recovery reforms were termed Economic Recovery Programs, ERP I and ERP II (Nyoni, 1998).

Being assisted by international organizations such as the International Monetary Fund (IMF) and the World Bank, Economic Recovery Programs (ERP I and ERP II) became most of the successful reforms. These reforms were based on devaluation of the local currency, removing price controls, government retrenchment and opening up the economy to the global economy (trade liberalization) with the aim of attracting international capital flows in the form of foreign direct investment. Economic Recovery Program also has the aim of reducing the role of the state in the domestic economy so as to reduce the government deficit and allow the private sector to expand. On the external

side, it aimed at liberalizing the current account and capital account so as to reduce the balance of payments deficit.

## International capital flows and Exchange rate management

Gulhati et al., (1985) argued that Tanzania, like many other Sub-Saharan countries, did not pursue a unified exchange rate policy until towards the beginning of the mid-1980s. In particular, it was not until the 1984 government budget speech that led to the devaluation of the Tanzanian shilling against the US dollar by 25.9% along with other measures to effect substantial trade liberalization in the country.

Lipumba (1991) found that the exchange rate policy that existed before 1986 had negative effects on the economy because it was overvalued. The policy discouraged exports, promoted inefficiency in resource allocation and utilization and increased profits of socially unproductive activities. It also encouraged international capital flight while exports continued to decline leading to a deficit in the trade account due to overvaluation of the shilling. This reduced the demand for Tanzania's exports as they became expensive to potential buyers.

Trade liberalization began in 1993 when further deregulation of the exchange rate and trade regime were put in place. Export licensing and price controls were removed while the Bank of Tanzania (BoT) delegated its powers of providing foreign exchange to commercial banks, customs department and Bureaus (BoT, 1994). In 1994, the Bank of Tanzania introduced the interbank foreign exchange market with the aim of ensuring efficiency and openness in foreign exchange allocation. With this arrangement the exchange rate became relatively freely determined by market forces.

Through the above explanations, it is clearly that the main link of the Tanzanian economy to the global economy is through the current and capital account rather than the financial market. The reason is that the financial market is not yet well developed in the country, the capital market and securities authority (CMSA) started in 1994 while the Dar es Salaam stock exchange (DSE) was introduced in 1996 and started working in 1998.The international capital flows have basically been used to finance the current account, which has been in deficit for the same period[1].

[1]Bank of Tanzania, Economic and operations report, 2010
http://www.bot-tz.org/Publications/EconomicAndOperationsAnnualReports/June_2010.pdf

## SURVEY OF THE THEORETICAL LITERATURE

This section explains the relationship between the exchange rate and international capital flows. International capital flows are a significant component of foreign private flows that provide much of the finance needed to increase the use of existing capacity in order to stimulate new investments in less developed countries (UNDP, 2011). According to the Tanzania investment report (2009) the major components of international capital flows are foreign portfolio equity, foreign direct investment, and other investments. In this recent Tanzania investment report (2009) it has shown that international capital flows in the form of foreign direct investment accounts for more than 90% of total foreign private investment in Tanzania. The remaining percentage consists of foreign portfolio equity and other investment. Foreign portfolio equity investment has been negligible due to the restrictions on the capital account as well as the underdevelopment of the capital and securities markets in the country. There are several factors which influence international capital flows: inflation, exchange rate, uncertainty, credibility, government expenditures (budget deficits), macroeconomic stability as well as institutional and political factors (Ahlquist, 2006).

In this study, we refer to international capital flows as foreign direct investment (FDI) together with it we also use foreign aid (AID) since there are few private financial inflows such as private portfolio in Tanzania. We argue that well used foreign direct investment and foreign aid will make a major contribution to the development of the economy.

### Theoretical framework of exchange rates

One of the most important determinants of a country's relative level of economic health is the exchange rate. The exchange rate plays a vital role in a country's level of trade, which is critical and important to most free market economies in the world. The basic objective of exchange rate policy is to ensure both external and internal balance as well as overall macroeconomic stability through maintenance of favorable external reserves, preservation of the value of the domestic currency, and price stability (Adeleke, 2006). In addition, the exchange rate level has implications for the balance of payments viability and the level of external debt. This stresses the importance of letting the exchange rate find its equilibrium level because it is only when the equilibrium exchange rate prevails then there is viability in the balance of payments position of the country (Opoku-Afari et al., 2004; Elbadawi & Soto, 1994).

According to Pilbeam (2006) real exchange rates can be categorized under two main groups which are based on purchasing power parity and a distinction between tradable and non-tradable goods. We present the theoretical framework below.

***Purchasing Power Parity***

According to Pilbeam (2006) the underlying assumption of many models incorporating exchange rates is the purchasing power parity (PPP).The PPP theory is built on the application of the law of one price which is based on perfect goods arbitrage. In other words, this argument of the law of one price states that assuming no transportation costs and other government imposed barriers of trade, identical goods will sell for the same price in two separate markets (Pilbeam, 2006). The important thing here is that there will be equalization of goods prices internationally which is brought by arbitrage once the prices of goods are measured in the same currency.

Following Pilbeam (2006) Purchasing Power Parity comes in two versions which are the absolute and relative PPP. According to the argument of the law of one price, the formal structure of the absolute Purchasing Power Parity (PPP) states that in any two countries the nominal exchange rate between the currencies is the price ratio of the two countries (Martinez-Hernandez, 2010):

$$e_t = \frac{p_t}{p_t^*} \tag{1}$$

where $e$ is the nominal exchange rate, $p_t$ is the price of a bundle of goods expressed in the domestic currency, and $p_t^*$ is the price of an identical bundle of goods in the foreign country expressed in terms of foreign currency. Depreciation in equation (1) occurs when the domestic price rises relative to the foreign price. With the existence of transportation costs, imperfect information and the distorting effects of tariff and non-tariff barriers to trade the absolute PPP is unlikely to hold precisely. The relative (or weak) version of PPP states that the exchange rate will change by the amount of the inflation differential between two countries (Pilbeam, 2006: 127) which is expressed as:

$$\%\Delta e_t = \%\Delta p_t - \%\Delta p_t^* \tag{2}$$

where,$\%\Delta e_t$is the percentage change in the exchange rate, $\%\Delta p_t$ is the percentage change in domestic inflation rate and $\%\Delta p_t^*$ is the percentage change in foreign inflation rate.

To obtain the real exchange rate in the long-run, nominal exchange rate is adjusted by the ratio of the foreign price level ($p_t^*$) to the domestic price level ($p_t$) and expressed as:

$$r_t = e_t \frac{p_t^*}{p_t} \tag{3}$$

This equation shows that when there is a decline in $r_t$ this implies that the real exchange rate has appreciated in value.

McNown and Wallace (1989) tested PPP theory for Argentina, Brazil, Chile and Israel for the 1970s and 1980s and found support for the PPP. However, even though the theory of PPP has been found to be useful, it has several limitations and failures in its operations. Pibleam (2006) outlined some of the failures which make PPP not to hold which are, transportation costs and impediments, imperfect competitions, productivity differentials, differences between capital and goods markets, and statistical problems.

***Tradable and Non-tradable Goods***

The second category of exchange rate is based on the distinction between tradable and non-tradable goods (Pilbeam, 2006). This category shows the indicator of a country's competitiveness level in the foreign trade through relative price of tradables and non-tradables. Internal and external equilibrium will be attained with the relative price of tradables and non-tradables assuming that economies of these countries are closely related in their relative structures of their cost differentials. Internal equilibrium presupposes that the market for non-tradables clears in the current period while the external equilibrium implies that the current account balances are compatible with long run sustainable international capital flows (Elbadawi & Soto, 1994).

According to Ahn (2009) and Pilbeam (2006) using tradable and non-tradables, real exchange rate changes can be decomposed into price changes of tradables and non-tradables. From equation (3), home and foreign consumer price indexes are geometric averages of tradables $(p_t^T, p_t^{T*})$ and non-tradable $(p_t^N, p_t^{N*})$ prices with weights $1-\tau$ and $\tau$, and $1-\varphi$ and $\varphi$ respectively:

$$p_t = (p_t^T)^{1-\tau}(p_t^N)^{\tau} \tag{4}$$

$$p_t^* = (p_t^{T*})^{1-\varphi}(p_t^{N*})^{\varphi} \tag{5}$$

Transforming and log-differencing equations (3), (4), and (5) from the levels of nominal exchange rates and consumer price indexes in terms of the rate of change to obtain

$$\hat{r}_t = \hat{e}_t + \hat{p}_t^* - \hat{p}_t \tag{6}$$

$$\hat{p}_t = (1-\tau)\hat{p}_t^T + \tau\hat{p}_t^N \tag{7}$$

$$\hat{p}_t^* = (1-\varphi)\hat{p}_t^{T*} + \varphi\hat{p}_t^{N*} \tag{8}$$

where$\hat{r}_t$ is the rate of change in the real exchange rate. The real exchange rate change as the sum of non-tradabes and tradables price changes between countries is obtained by substituting equation (7) and (8) into equation (6) as

$$\hat{r}_t = \hat{e}_t + (1-\varphi)\hat{p}_t^{T*} + \varphi\hat{p}_t^{N*} - (1-\tau)\hat{p}_t^{T} + \tau\hat{p}_t^{N} = \hat{e}_t + [\widehat{p}_t^{T*} - \hat{p}_t^{T}] + [\varphi(\hat{p}_t^{N*} - \hat{p}_t^{T*}) - \tau(\hat{p}_t^{N} - \hat{p}_t^{T})] = \hat{g}_t + \hat{z}_t \quad (9)$$

where

$$\hat{g}_t = \hat{e}_t + [\hat{p}_t^{T*} - \hat{p}_t^{T}] \quad (10)$$

$$\hat{z}_t = [\varphi(\hat{p}_t^{N*} - \hat{p}_t^{T*}) - \tau(\hat{p}_t^{N} - \hat{p}_t^{T})] \quad (11)$$

Equations (10) and (11) give two important components concerning the real exchange changes from tradables and non-tradable goods. The difference between countries' tradables price changes and the sum of the spot exchange rate change is given by $\hat{g}_t$ while the component which reflects both the relative prices of non-tradables to tradables caused by sectoral productivity differentials between countries and the differences in the tastes for tradables and non-tradables is given by $\hat{z}_t$ (Ahn, 2009).

***The Mundell-Fleming Model***

Pilbeam (2006) showed how the Mundell-Fleming model can be used to explain changes in the exchange rate. According to the Mundell-Fleming model the exchange rate may change when fiscal and monetary policy attains internal and external balance. The two policies have different effects under different exchange rate regimes and capital mobility conditions for instance depending on the slope of the Balance of Payment schedule (BP). In the Mundell-Fleming model, an increase in income leads to an increase in imports, which is a leakage in the economy. The increase in imports will increase the current account deficit, which may lead to changes in the exchange rate depending on the exchange rate regime. For instance, with low capital mobility and a flexible exchange rate, an expansionary fiscal policy will lead to deterioration of the current account while the increase in the interest rate will improve the capital account. As the country has low capital mobility, the current account deficit will outweigh the improvement of the capital account so that the balance of payments will move into a deficit. With a floating exchange rate, the increase in income will lead to a depreciation of the exchange rate.

The Mundell-Fleming model shows a clear implication to the Tanzanian economy as the country has low capital mobility and is currently following a flexible exchange rate regime; therefore, an expansionary fiscal policy will increase in income which will lead to a deficit in the balance of payments and hence a depreciation of the exchange rate.

***Real exchange rate indices***

Interpreting real exchange rates depends on the calculations which are used to obtain the indices. The criterion used to obtain the indices is by choosing the base year which meets both internal and external equilibrium in that specific year. In this case interpretations of real exchange movements may be different if they are based on different base years. We

use real effective exchange rates defined by the PPP (measured by nominal effective exchange rate multiplied by the ratio of foreign consumer prices to domestic consumer prices (Li & Rowe, 2007) as one of the variables to determine the dynamic forces that affect the short-run disequilibrium which lead to disequilibrium in the long-run relationship.

## Survey of the Empirical Literature

There are different methodologies which have been employed in studying the effects of international capital flows on the real exchange rate. According to the empirical literature, the link between international capital flows and the real exchange rate has been studied with sometimes conflicting results. In this section, we outline most of the empirical literature concerning the impact of international capital flows and other macroeconomic fundamentals on the real exchange rate. We first start with the studies specifically done for Tanzania, and then outline studies which have been done outside the Tanzanian economy.

Nyoni (1998) employed an Engle-Granger error correction model to examine the impact of foreign aid inflows on the real exchange rate in Tanzania, especially regarding the Dutch disease. He pointed out that a recipient country may experience undesirable consequences due to an influx of foreign aid. These undesirable effects may include appreciation of the real exchange rate which can lead to a decline in exports and manufacturing production. In his long-run model, he specified the following variables which are: foreign aid inflows, government expenditures, exchange controls and trade liberalization while in the short-run model in addition to the above, he also included nominal devaluation. Contrary to the theoretical predictions such as the Mundell-Fleming model, he found that foreign aid generates depreciation of the real exchange rate in Tanzania. That is an increase of foreign aid by 10% led to 5% depreciation in the real exchange rate. This showed absence of the Dutch disease phenomenon in the country. While this conclusion by Nyoni is contrary to the theoretical proposition that foreign aid causes real appreciation of the real exchange rate, one of the reasons given by Nyoni was that the foreign exchange market was not freely functioning, and when it will be freely functioning then foreign inflow will cause appreciation of the real exchange rate. Another argument from Nyoni (1998) and Mwachukwu (2008) was that depreciation of the real exchange rate was partly a reflection of the fact that much of the assistance was tied to imports from donors which made conditions on structural and budgetary reforms.

Using Ordinary Least Squares (OLS) estimations, Falck (1992) examined the impact of international capital flows on the real exchange rate appreciation in Tanzania. In his

study, he specified the model with the following variables: foreign aid, macroeconomic policy proxied by growth of domestic credit (measured as the rate of growth of domestic credit minus lagged rate of growth of real GDP), terms of trade, rate of the nominal exchange rate and real exchange rate lagged one period. He applied OLS on the twelve different real exchange indexes for Tanzania, and applied a three-stage selection procedure to each one of them (Lartey, 2007). In his study he found that foreign aid was mostly spent on the service sector which increased upward pressure on domestic prices hence leading to real exchange appreciation.

Sackey (2001) developed an empirical model of real exchange rate with special focus on foreign aid for Ghana linking it with export performance so as to examine the impact of aid on exports. Using cointegration techniques he found that foreign aid led to depreciation of the real exchange rate though aid dependence was quite high hence there was no Dutch disease effect for the period of 1962-1996. However, Opoku-Afari et al., (2004) used Vector Autoregressive techniques and found that in the short-run foreign aid had no impact on the real exchange rate, but in the long-run all categories of international capital flows cause real exchange rate appreciation for the period of 1996-2000. However, when terms of trade were used in the model together with foreign aid, the real exchange rate depreciated. Opoku-Afari et al., (2004) gave a possible explanation for this difference in the impact of terms of trade: they argue that it may be that foreign aid inflows support production rather than consumption so that the substitution effect outweighs the income effect causing depreciation. These studies used different econometric techniques; the first used the Error Correction Model (ECM) while the second employed the Vector Autoregressive (VAR) model.

A study by Aremu (1997) and Osinubi and Amaghionyeodiwe (2010) in Nigeria showed that foreign direct investment in the form of private investment can speed up the pace of economic development of the less developed countries (LDCs). This pace can lead to satisfactory rate of growth on self-sustaining. That is, raising the standard of living of its people will enable them to move from economic stagnation to self-sustaining economic growth. In their studies, they came up with the conclusion that to reach a viable level of income in LDCs it is therefore imperative to continue attracting foreign direct investment (FDI) to LDCs.

Elbadawi and Soto (1994) employed cointegration techniques by estimating the cointegrated long-run equilibrium path between the capital flows and real exchange rate for the case of Chile. In their study, they found that foreign direct investment and long-term capital flows are cointegrated with long-term effective real exchange rate. Another interesting result was from the estimated elasticity of the volume of trade (degree of openness); this demonstrated that trade liberalization led to more depreciation of the

effective real exchange rate. The main conclusion of their study was that sustainable long-term international capital flows and foreign direct investment caused the real exchange rate over-valuation, whereas there was no impact on the short-term flows and portfolio investment. Thus, an important part of the actual appreciation of the Chilean Peso would not require counter balancing exchange rate or macroeconomic policy.

The link between foreign aid and the real exchange rate in the Francophone Countries – CFA zone was investigated in the short-run by Outtara and Strobl (2007) using 12 countries. From their study in which they used panel data techniques, they found that there was no Dutch disease. That is, an increase in foreign aid by 10% was associated with only an increase of 1% in the real exchange rate indicating that foreign aid led to depreciation of the franc. Outtara and Strobl (2007) gave an argument for this that nominal devaluation of the Francophone Countries (CFA franc) in 1994 and openness of the economy contributed to the depreciation of the real exchange rate. They recommended that due to the absence of Dutch disease these countries can continue to receive foreign aid as there will be no negative effects on the real exchange rate due to the absence of the Dutch disease.

Several studies included variables such as terms of trade, trade policy and productivity shocks to evaluate the impact of international capital flows on the real exchange rate. For instance, Edwards (1994) and Baffes et al., (1999) included policy variables. In addition to that, they included macroeconomic developments, such as devaluation hence allowing for nominal devaluation in their equilibrium equation. Other studies which provide support for the hypothesis that international capital flows lead to the real exchange rate appreciation are from Van Wijnbergen and Edwards (1989), White and Wignarja (1999) who used general to specific modeling procedure for Sri Lanka to investigate the behavior of the real exchange rate.

Foreign aid has macroeconomic potential impact to a country in terms of the real exchange rate, exports, and competitiveness. Aiyer et al., (2008) investigated the macroeconomic challenges created by surges in aid inflows for five African countries. In their study they put forward possible policy responses to increased aid in terms of absorption, which widening of the current account deficit excluding aid and spending of aid; that is widening of the fiscal deficit excluding aid. Thus, they underlined that the main issues concerning macroeconomics of aid depend on the fiscal sphere and the monetary and exchange rate sphere. Aiyer et al., (2008) and Martins (2006) gave the distinction between the two by pointing out that the central bank controls the absorption through monetary policy and sale of foreign exchange – optimal level of sterilization and

effective exchange rate, and the Government as fiscal authority controls spending – policy decisions such as how much foreign aid the government should spend, and how much it should save some of the aid resources[2]. To conclude their study, they proposed the viable policy option that countries should spend and absorb foreign aid when received in the country, in this way more of the negative impacts associated with an influx of foreign inflows can be avoided.

Several gaps in the analysis of the impact of different types of international capital flows and macroeconomic fundamentals are revealed by the literature review concerning real exchange rate competitiveness. The empirical evidence discussed in the literature above suggests that an increase in international capital flows most often leads to real exchange rate appreciation. Furthermore, there are ambiguous and contradictory results regarding the effect of international capital flows especially in Sub-Saharan Africa. The studies do not allow for easy comparison due to the fact that single-country studies employed different definitions of the real exchange rate and different international capital flow variables. Moreover, most of the studies focused on official transfers as the main type of international capital flows. Changes in composition of the international capital flows suggest the need to incorporate measures of other international capital flows such as foreign direct investment (FDI) as an independent variable in studying the real exchange rate in Tanzania. Thus, in this study we contribute to the existing literature by investigating the impact of international capital flows to the exchange rate using structural Vector Autoregressive and a multivariate cointegration framework incorporating foreign direct investment, foreign aid together with other policy variables such as government expenditure, and productivity as independent variables. Significant variables which lead to exchange rate competitiveness will make a strong case for implementing policies which attracts international capital inflows. The policy variables are essentially fiscal and monetary policy and foreign market interventions.

## Selected determinants of the real exchange rate in Tanzania

This section outlines several selected determinants of the real exchange rate in Tanzania. We put forward the theoretical effects of the selected determinants. Theoretical a priori will guide in the signs of the estimated coefficients which shows a proper impact on the exchange rate. The selected determinants to be discussed are foreign aid, foreign direct investment, terms of trade, government consumption and productivity in which we use real GDP per capita.

[2]Table *(a)* in Appendix A narrates different combinations in response to scaling up aid

***International capital flows***

Corden and Neary (1982) study the impact of international capital inflows on the real exchange rate appreciation. In their study, the real exchange rate appreciation depends on the degree of reversibility of the capital flow. In this study, we mainly use international capital flows as foreign direct investment (FDI) as it is the one which mostly dominates the private inflows for Tanzania, and is less likely to be reversible, together with it we use foreign aid inflows (AID).This is useful to show how different measures of international capital flows impact the real exchange rate for policy analysis.

***Foreign aid (AID)***

Foreign aid inflows are claimed to augment domestic resources, this scenario tends to advocate that the process leaves the economy as a whole, better off. It is on this argument that foreign aid becomes an important source of resources to LDCs. However, another argument is that, the macroeconomic impact of foreign aid will depend on how the country spends the resources which largely depends on the policy responses of the fiscal and monetary authorities on how to manage the real exchange rate (Powell et al., 2005). The concern of many countries has been the impact of aid on the real exchange rate, and hence on the competitiveness of the export goods. Foreign aid will increase aggregate demand when used to finance government deficit, which increases prices and income the process which may lead to real exchange appreciation. This concern of increase inflation has raised several questions on how to manage the foreign inflows. Powell et al., (2005) have put forward two concepts on how to manage foreign aid inflows in LDCs which are absorption and spending of the foreign aid inflows to increase the aggregate demand. In this case, coordination between absorption and spending is necessary; for instance when the country receives foreign aid inflows the government should decide how much to spend domestically using local currency and the central bank should decide how much of the foreign aid related foreign exchange rate to sell on the market (Tareq, 2007).

The analysis of the foreign aid effect centers on two parts, the first is on expanding non-tradable services and the second is on the tradable services. Non-tradable services involve spending on health care, construction, and education. Government spending on the non-tradable sector will generate excess demand which will increase wages in the non-traded sector, this case will lead to a movement of labor from the traded sector assuming that supply side of skilled labor is fixed. An increase in wages will raise the price of non-traded goods relative to traded goods the process which hurts the tradable sector and reduces competitiveness of traded goods in the economy (Corden & Neary, 1982).

The second effect is when foreign aid is used on the tradable sector such as used to import capital goods, and foreign consultants etc. in addition to that when supply side factors are not limited for instance unskilled labor. The use of foreign aid on the traded sector will lead to a less likely of wages and prices to increase which means less likely the real exchange rate will appreciate (Berg et al., 2005).

In this study, foreign aid (AID) comprises aid grants and loans. Figure 2 illustrates the evolution of foreign aid in log values from 1970-2009. Figure 1below shows a declining trend of foreign aid starting in 1990 up to 2000 and thereafter the international donor community increased foreign aid. The declining trend was partly due to the economic recession that affected several donors in the early 1990s and concerns about the effectiveness of aid in achieving the desired outcome, such as policy reform, economic growth and poverty reduction. While the increasing of foreign aid was partly due to the United Nations Millennium Declaration which made different countries increase promises of financing developing countries (Powell et al., 2005; Martins, 2006).

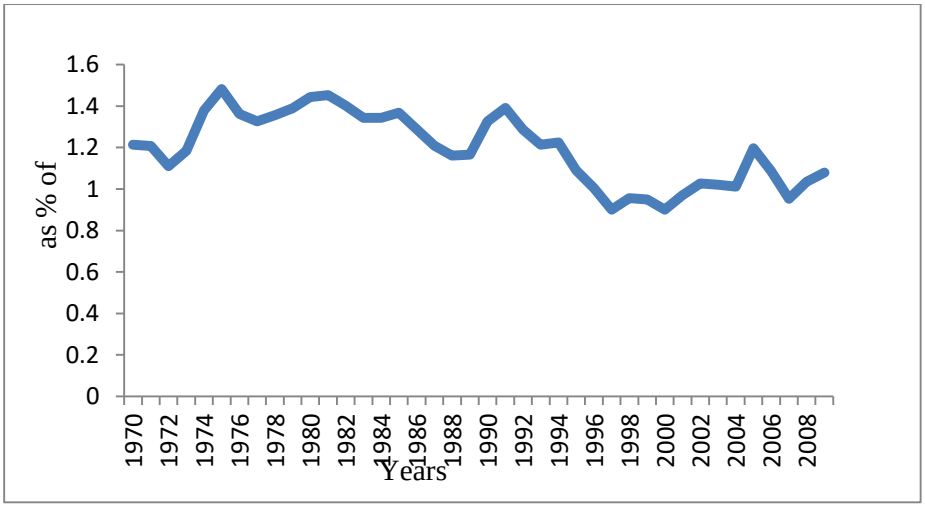



FIGURE 1. FOREIGN AID (AID) IN LOG VALUES

*Source*: IMF World Bank Outlook and Global Development Finance

### *Foreign direct investment*

Lartey (2007) using panel data of 16 Sub-Saharan African countries found that foreign direct investment (FDI) causes the real exchange rate to appreciate but to a lesser extent compared with foreign aid inflows. Thus, FDI termed to be more stable flow when is not immediately reversible.

The less effect of foreign direct investment on the real exchange rate is that foreign direct investment is intermediated through the local banking system and hence might lead to less credit and money expansion (Tanzania Investment Report, 2009). Another important factor is that in less developed countries, FDI is mostly related to investment in imported

machinery and equipment. The imports of machinery and equipment do not suffer from constraints in local supply capacity and hence have almost no effect on the real exchange appreciation. Furthermore, the spillover effects of FDI may improve local productive capacity through an increase in physical capital formation, transfer of technology, higher competitive efficiency and managerial know-how (Aremu, 1997). Figure 2 illustrates the evolution of foreign direct investment as a percent of GDP from 1970-2009. The figure shows that there has been increase and decline of foreign direct investment, the highest increase started in 2001 after the government put good measures to the economy to attract external resources, however the recent financial crisis had led to a decline in the foreign direct investment to some extent.

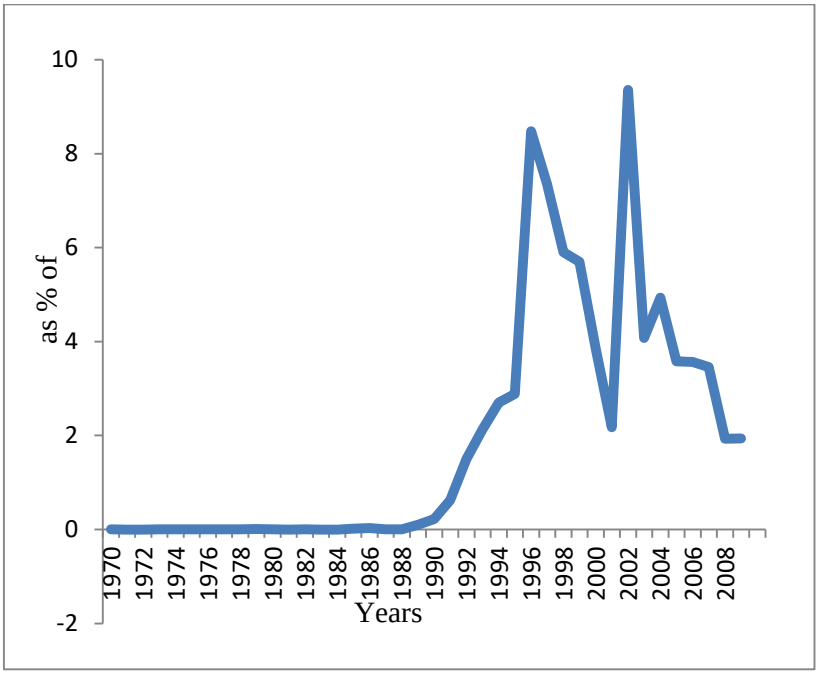



FIGURE 2. FOREIGN DIRECT INVESTMENT (FDI)

*Source*: IMF World Bank Outlook and Global Development Finance

### *Terms of Trade*

Tanzania's exports are largely dominated by primary agricultural products whose demand in the world market has fallen overtime. Terms of trade captures the influence of external demand and supply factors in the traded sector. Terms of trade are the price of exports in terms of imports. An increase in the relative price of exports relative to imports induces contraction of the non-traded goods sector and encourages labor flows to the export sector (Opoku-Afari et al., 2004). This process of an increase in income leads to more spending on all products, which increase prices of non-tradables – the effect

known as the income effect. The income effect will lead to the real exchange appreciation, but will not happen only if there is a substitution effect from domestic goods to foreign goods in which the real exchange rate may depreciate (Li & Rowe, 2007). Therefore, shock to the external terms of trade may elicit the real exchange movements. Figure 3 illustrates the evolution of terms of trade from 1987-2009 which shows that terms of trade have been declining since 1987 and thereafter started to increase in 2005.

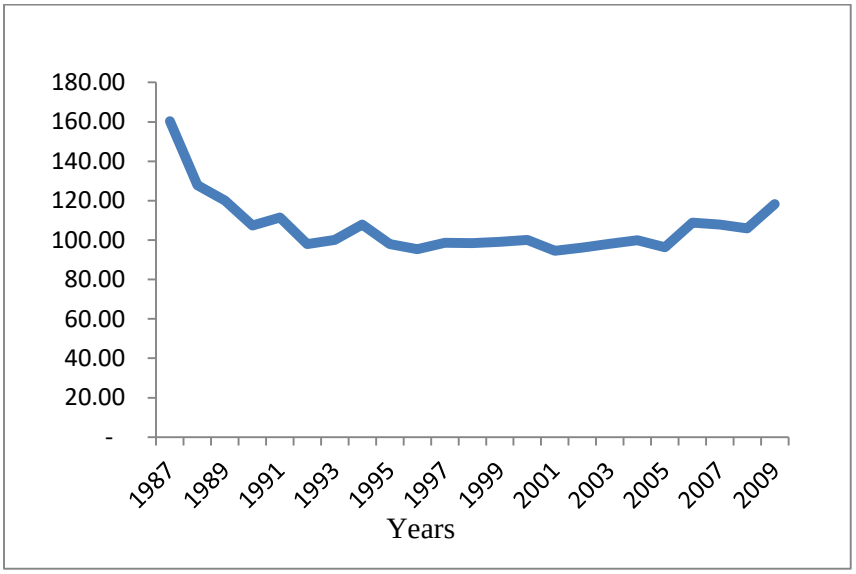



FIGURE 3. TERMS OF TRADE (IN LOG VALUES)

*Source*: Global Development Finance

***Government consumption (expenditure)***

The effect of Government expenditure on the real exchange rate depends much on how the inflows are spent. When the Government increases spending on the non-tradable goods this will increase the relative prices of the non-tradable goods. As the non-tradable component of the consumer price is large, an increase in non-tradable goods will increase inflation which will likely lead to the real exchange rate appreciation and hence a reduction in competitiveness of traded goods in the economy (Bakardzhieva et al., 2010). However, if the inflows are spent on the traded sector, this will lead to an increase of demand for imports – a process which leads to current account deficit. In order to maintain the external equilibrium in the balance of payments the real exchange rate will depreciate – a process which leads to competitiveness of traded goods in the economy. Comparing the two effects, most of studies have shown that inflows used to increase Government expenditure are biased toward the non-tradable sector in which it is mostly likely to observe an appreciation of the real exchange rate (Bakardzhieva et al., 2010). Figure 4 illustrates the evolution of government expenditure as a percent of GDP from

1970-2009. The Tanzanian government expenditure has been increasing since 1986 which was a period of structural adjustment recovery of reforms.

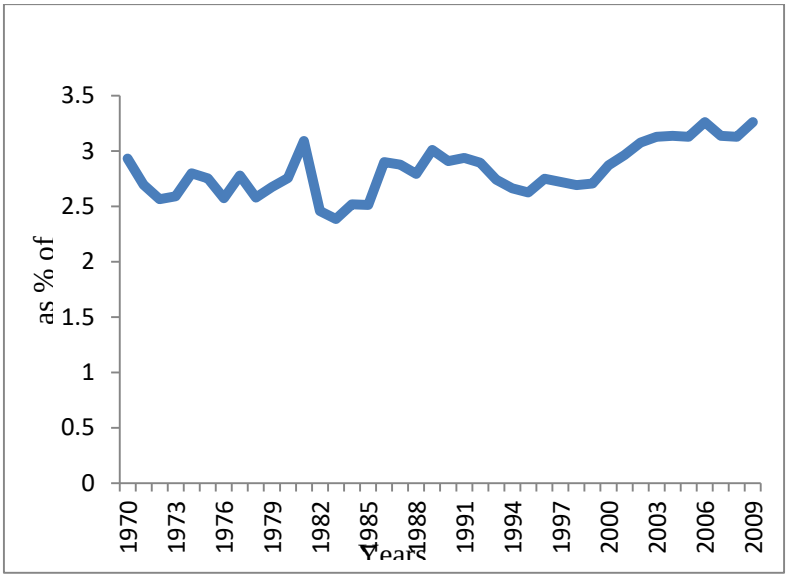



FIGURE 4. GOVERNMENT POLICY (IN LOG VALUES)

*Source*: Bureau of Statistics, and Ministry of Finance—Treasury

### *Productivity*

Differences in technological progress can affect the real exchange rate. Furthermore, technological progress is more likely to take place in the traded relative to the non-traded sector of the economy. This effect is explained by the Balassa-Samuelson effect which is the most known explanation for the real exchange rate changes. The Balassa-Samuelson effect assumes that productivity gains in the tradable goods sector are greater than productivity gains in the non-tradable sectors. This assumption postulates that when productivity in the traded sector goods increases then it will lead to an increase in wages in both the tradable and non-tradable sectors within a country (Li & Rowe, 2007). Since prices in tradable sectors are internationally determined and homogeneous across countries, then considering the Balassa-Samuelson effect, higher productivity will lead to an appreciation of the Tanzanian shilling (Li & Rowe, 2007). In this study, we follow Bakardzhieva et al., (2010) and use real GDP per capita as a proxy for the productivity effect. Bakardzhieva et al., (2010) argued that using the GDP per capita as a proxy for productivity, aims at using the methodology which postulates that countries which experience a real appreciation in their currencies have higher per capita incomes. Figure 5 illustrates the evolution of real GDP per capita from 1970-2009 which shows that since 1994 the real GDP per capita has been increasing.

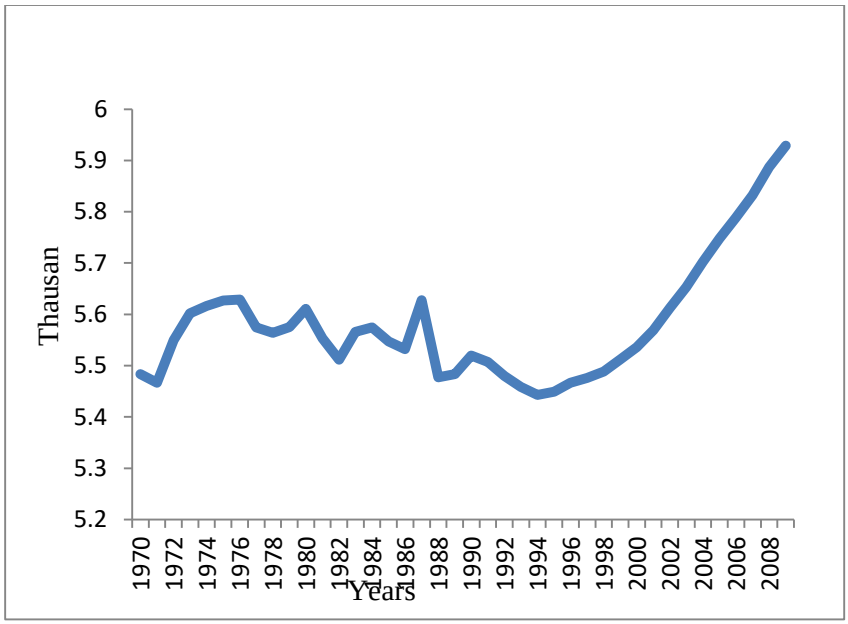



FIGURE 5. REAL GDP PER CAPITA (IN LOG VALUES)

*Source*: Bureau of Statistics, and Ministry of Finance—Treasury

### *Real Exchange Rate*

Edwards (1989) found that the real exchange rate is determined by real variables in the long-run. Those changes in the real exchange rate may be due to changes in the fundamentals such as international capital flows, terms of trade, trade liberalization (openness), government consumption, and productivity. In this study, the real exchange rate RER is defined as nominal effective exchange rate (NEER) multiplied by the ratio of foreign price (consumer price index of Tanzania's trading partners) and domestic price (consumer price index for Tanzania). This implies that an increase in the real exchange rate is depreciation, and a fall is appreciation of the value of the currency. Therefore, appreciations and depreciations of the real exchange rate relative to the equilibrium value signals a loss or gain in competitiveness.

$$RER = NEER * \left[\frac{CPI_f}{CPI_d}\right] \quad (12)$$

where, $CPI_f$ is Consumer price index of Tanzania's trading partners and $CPI_d$ is Tanzania's consumer price index. This definition is made in line with purchasing power parity[3].Figure 6 illustrates the evolution of real effective exchange rate from 1970-2009. Since the structural adjustment in 1986, the exchange rate has been showing competitiveness in the economy, which is depreciating.

[3]The REER is based on nominal exchange rates and consumer prices (CPI). Lack of data prevents supplementing the indices as the ratio between non-tradables and tradable prices.

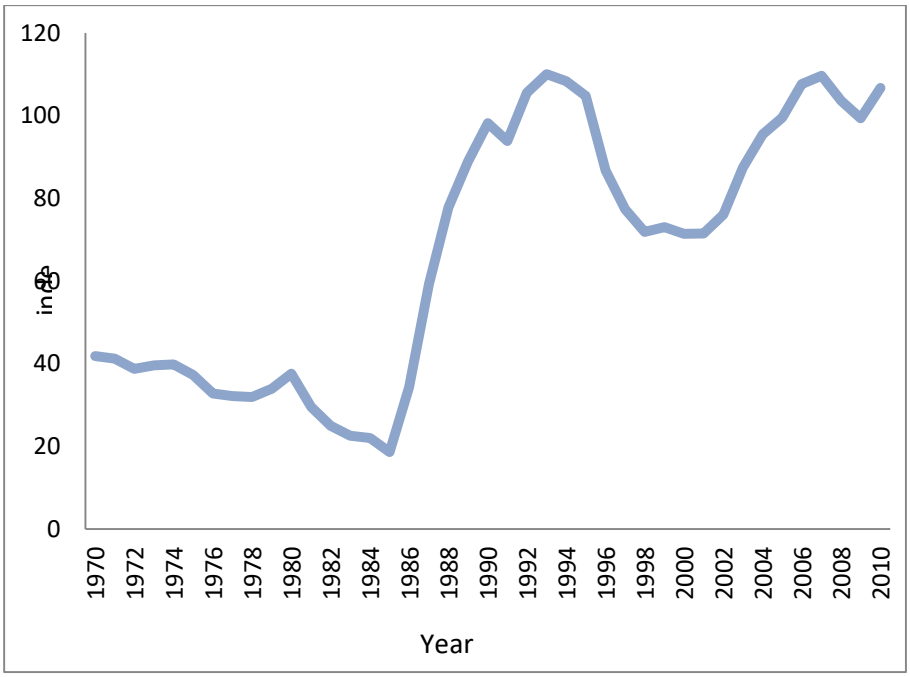



FIGURE 6. REAL EFFECTIVE EXCHANGE RATE (2005=100) IN LOG VALUES

*Source*: Authors' calculations based on BoT various reports

## Summary of the Section

This section has shown that there are different theories and empirical studies which explain international capital flows. From the empirical findings, these findings these studies arrive at different conclusions, due partly to the information sets included and partly to some methodological differences. From the above findings, the studies showed that most of the studies dealt with few variables as the main determinant of exchange rate. This study contributes to the existing knowledge, adding to the empirical literature the impact of international capital flows and other macroeconomic fundamentals on the exchange rate with more updated empirical evidences based on a longer period of data than the previous studies. The findings of the study help to provide more insights on macroeconomic management of increased international capital flows. Second, different from other studies, this study applies multivariate dynamic methodology of cointegrated VAR and structural VAR to provide more robust results. Other studies applied traditional methodologies in which they adopted Engle-Granger methodology and some static analysis. Using multivariate dynamic system of cointegration we will see clearly if the country should continue to attract more external resources whether the economy goes back to the equilibrium depending on the speed of adjustment coefficients. Speeds of

adjustments are very important because they show if the economy is taken away or goes back to the equilibrium after several shocks.

# METHODOLOGY

## Data

This study uses annual data from 1970 to 2009 as monthly and quarterly data for most of the variables used. We first investigate the data for several descriptive statistics and stationarity to see whether the data are likely to be integrated of order one, which is I (1) process. A VAR model is used when we find no cointegration among the variables, otherwise Cointegrated Vector Autoregressive (CVAR) model or Vector Error Correction Model (VECM) is used. We formulate a VAR model in 5 endogenous variables: real effective exchange rate (reer), real GDP per capita (rgdpcap) as a percent of GDP, foreign aid (aid) as a percent of real GDP, foreign direct investment (fdi) as a percent of real GDP, government consumption (gcons) as a percent of real GDP and we follow Hendry and Juselius (2001) to introduce a dummy for exogenous variable (dum) for the 1986 structural adjustment programs. All variables are in logarithms, except for dummy variable and foreign direct investment which has negative values.

Data were obtained from several institutions which are: International Financial Statistics (IFS), International Monetary Fund (IMF), World Bank, World Development Indicators (WDI), Ministry of Finance, Bureau of Statistics (BoS) and Bank of Tanzania (BoT). One challenge we faced in conducting this study is the availability and length of the time series data for the region. This restricts this study to a parsimonious model of only a few variables.

## Measurement of interdependence

There are different methodologies which have been given through the literature on how to measure various aspects of interdependence. As Less Developed Countries (LDCs) become more connected to the global economy, there has been a substantial interest in issues of financial and economic interdependence, especially regarding the flow of international capital. International capital flows link financial and economic development in one country to other countries. Greater economic integration or globalization through international capital flows will lead to greater international transmission of developments in one country and hence generate greater economic interdependence (Willett et al., 2011). In this part, we present a summary of descriptive statistics and simple correlation statistics of the relationship between the determinants of the exchange rate. In the other following sections we present the multiple variable analyses, specifically the VECM and VAR models.

### *Summary of Descriptive statistics*

TABLE I. SUMMARY OF DESCRIPTIVE STATISTICS FOR RER MODEL (Sample: 1970-2009)

| | FDI | L_AID | L_GCONS | L_REER | L_RGDPCAP |
|---|---|---|---|---|---|
| Mean | 1.913 | 1.195 | 2.824 | 4.055 | 5.580 |
| Median | 0.162 | 1.208 | 2.787 | 4.272 | 5.558 |
| Maximum | 9.356 | 1.482 | 3.261 | 4.701 | 5.928 |
| Std. dev. | 2.595 | 0.171 | 0.227 | 0.551 | 0.117 |
| Skewness | 1.318 | -0.129 | 0.178 | -0.402 | 1.357 |
| Kurtosis | 3.869 | 1.778 | 2.153 | 1.749 | 4.381 |
| | | | | | |
| Jarque-Bera | 12.849 | 2.596 | 1.406 | 3.686 | 15.465 |
| Probability | 0.001 | 0.272 | 0.495 | 0.158 | 0.0004 |
| Observations | 40 | 40 | 40 | 40 | 40 |

Where,

L_REER is the log of real effective exchange rate, L_GCONS is the log of Government Consumption, FDI is Foreign Direct Investment, L_RGDPCAP is the log of productivity, and L_AID is log of Foreign aid.

### *Correlations*

TABLE II. SUMMARY OF CORRELATIONS AMONG THE VARIABLES

| | L_AID | L_REER | L_RGDPCAP | L_GCONS | FDI |
|---|---|---|---|---|---|
| L_AID | 1 | | | | |
| L_REER | -0.631 | 1 | | | |
| L_RGDPCAP | -0.162 | 0.180 | 1 | | |
| L_GCONS | -0.369 | 0.629 | 0.593 | 1 | |
| FDI | -0.753 | 0.557 | 0.047 | 0.301 | 1 |

In summary, the initial inspection of the variables suggests that data has small correlations as there is no perfect correlation or higher correlations than one. These correlations show how the series co-move with each other, which provides an intuitive overview and for more complicated analysis, it also serves as a good benchmark in analyzing correlations.

## Analysis of Stationarity and Cointegration Relationships

In time series analysis, when the means and variances of a series remain constant over time then a series is said to be stationary. A stationary series tends to constantly return to its mean value, hence the effects of shocks is only transient (Enders, 2010). Thus following (Enders 2010) a series $y_t$ is (covariance) stationary of the process if it has

a) a constant mean, $E(y_t) = E(y_{t-s}) = \mu$

b) a constant, finite variance, $var(y_t) = var(y_{t-s}) = \sigma_y^2$ and

c) a finite covariance, $cov(y_t, y_{t-s}) = cov(y_{t-j}, y_{t-j-s}) = \gamma_s$

Time series data that do not satisfy the above criteria are said to be non-stationary. The difference between stationary and non-stationary series can be explained by using a simple AR(1) model of the form:

$$y_t = \alpha + \rho y_t + u_t \quad (13)$$

Obtaining $|\rho| < 1$ shows that the series is stationary while non-stationary series is the one in which we have $|\rho| \geq 1$ (Adam, 1992)[4]. If a series can be differenced $d$ timesthen is termed to be integrated of order $d$, this implies that it is stationary after differencing it $d$ times and is denoted as$x_t = I(d)$. Applying the above analysis when one obtains I(0) from the series this means that the series is stationary. However, in general most non-stationary series are I(1) or I(2) (Adam, 1992).

***Testing for unit roots and causality***

Unit root theory is the cornerstone to the methodology used for testing the stationarity or non-stationary of a time series. The Box-Jenkins (1976) strategy for analyzing non-stationary process requires differencing of the series so as to transform the process into a stationary series. The strategy has three stages, identification, estimation and diagnostic checking and hence forecasting (Enders, 2010). One of the major drawbacks of the Box-Jenkins methodology is that all series must be stationary to obtain meaningful results. The method is still used, however, the development of unit root theory and testing by Dickey and Fuller (1988) and subsequent theory of co-integration by Johansen and Juselius (1988, 1992) has meant a non-stationary series can be analyzed in a co-integrated framework. The co-integration frameworks address the major drawback of Box-Jenkins methodology.

To avoid spurious relationship, investigating the order of stationarity should be the first step in the test for co-integration in time series analysis. Following section 4.3 above, to avoid spurious regression results, a unit root analysis will first be used to test for stationarity of the time series data used in this study. With that respect, this study uses Augmented-Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests to test for stationarity of the data.

## Specification of the Models

The models we use in this study are the multivariate dynamic time series models which are the cointegration vector autoregression (CVAR) and the VAR models. The empirical

[4] If $\rho$=1 then the series is pure random walk variable.

models that are informed by the literature as well as data availability are of the following functional regression model:

RER = (international capital flows i.e. foreign aid and foreign direct investment, Terms of Trade, Productivity, Trade Openness, Government consumption).

Theoretically each of the variables in the above empirical model specification has pronounced impact on the real exchange rate. However, *a priori* it is not certain to know the expected theoretical sign of the explanatory variables. But most of the empirical studies we outlined in this study showed that international capital flows leads to appreciation of the real exchange rate. Thus, an increase in aid is expected to lead to a less depreciation of the real exchange rate, an increase in foreign direct investment will lead to less depreciation of the real exchange rate, while the effect of government expenditure depends much on the consumption of the non-tradable and tradable goods, with a negative sign indicating that the government is consuming more of non-tradable goods against the tradable goods – an appreciation of the real exchange rate while a positive sign is an indication of consuming more of traded goods compared to the non-traded goods – a less appreciation of the real exchange rate. Productivity (real GDP per capita) is expected to cause appreciation of the real exchange rate due to the fact that high wages (income) will lead to an increase in prices, i.e. income effect outweighs substitution effect (Li & Rowe, 2007; Opoku-Afari et al., 2004).

***Cointegrated Vector Autoregression Model CVAR (or VECM)***

Economic theory does not provide much guidance on the lag order of the system. In this case, before estimating a CVAR model with associated cointegrating vector we will select optimal lag length using an unrestricted VAR model. Engle and Granger (1987) provided the original definition of cointegration as a single equation. The procedure has several disadvantages such as the choice of independent variables in the two-step procedure and how to detect the number of cointegration equations when a model has more than two variables (Enders, 2010). This approach has subsequently been surpassed by the system of equations advocated by Johansen and Juselius (1988, 1992).

To address the Engle and Granger (1987) problem, we use the Johansen (1988) and Juselius (1992) maximum likelihood estimation techniques for a multivariate approach to cointegration to estimate the long-term determinants of real exchange rate. Maximum likelihood estimation framework is the most appropriate because it allows for feedback effects to take place among the variables in the model. It is achieved using the Vector Autoregressive (VAR) system of dynamic equations which uses minimal assumptions to that examine the inter-relationships between economic variables about the underlying

structure of the economy. Therefore, the cointegration technique gives a clear picture of how the fundamentals determining the real exchange rate may move permanently, thus altering equilibrium value.

In its general form, the Johansen(1988) and Juselius (1992) methodology takes its starting point from the unrestricted vector autoregression (VAR) of order $p$ given by

$$x_t = \mu + A_1 x_{t-1} + \cdots + A_p x_{t-p} + \varepsilon_t \tag{14}$$

where$x_t$ is an $n$ x 1 matrix of variables that are integrated of order one, I(1) and $\varepsilon_t$is an $n$ x 1 vector of innovations, $\mu$ is the matrix of deterministic terms and $p$ is the lag length. A VAR(2) model in matrix form is given as (Enders, 2010: 385)

$$x_t = \mu + A_1 x_{t-1} + A_2 x_{t-2} + \varepsilon_t \tag{15}$$

$$\begin{bmatrix} x_{1t} \\ \vdots \\ x_{kt} \end{bmatrix} = \begin{bmatrix} a_{1,11} & \cdots & a_{1,1k} \\ \vdots & \ddots & \vdots \\ a_{1,k1} & \cdots & a_{1,kk} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} + \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \begin{bmatrix} x_{1t-2} \\ \vdots \\ x_{kt-2} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \vdots \\ \mu_{kt} \end{bmatrix} \text{ where}$$

$$A_1 = \begin{bmatrix} a_{1,11} & \cdots & a_{1,1k} \\ \vdots & \ddots & \vdots \\ a_{1,k1} & \cdots & a_{1,kk} \end{bmatrix} \text{and} A_2 = \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix}$$

This VAR(2) can be reparameterized to form the vector error correction model, VECM (CVAR) specification by adding and subtracting the following on the right hand side (RH)

$$\begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix}$$

$$\begin{bmatrix} x_{1t} \\ \vdots \\ x_{kt} \end{bmatrix} = \begin{bmatrix} a_{1,11} & \cdots & a_{1,1k} \\ \vdots & \ddots & \vdots \\ a_{1,k1} & \cdots & a_{1,kk} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} + \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \begin{bmatrix} x_{1t-2} \\ \vdots \\ x_{kt-2} \end{bmatrix} + \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} -$$

$$\begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \vdots \\ \mu_{kt} \end{bmatrix} \text{ and rearranging we have}$$

$$\begin{bmatrix} x_{1t} \\ \vdots \\ x_{kt} \end{bmatrix} = \left( \begin{bmatrix} a_{1,11} & \cdots & a_{1,1k} \\ \vdots & \ddots & \vdots \\ a_{1,k1} & \cdots & a_{1,kk} \end{bmatrix} + \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \right) \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} - \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \left( \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} - \begin{bmatrix} x_{1t-2} \\ \vdots \\ x_{kt-2} \end{bmatrix} \right) + \begin{bmatrix} \mu_{1t} \\ \vdots \\ \mu_{kt} \end{bmatrix}$$

and subtracting $\begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix}$ on each side and rearranging we have

$$\begin{bmatrix} \Delta x_{1t} \\ \vdots \\ \Delta x_{kt} \end{bmatrix} = - \left( \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} - \begin{bmatrix} a_{1,11} & \cdots & a_{1,1k} \\ \vdots & \ddots & \vdots \\ a_{1,k1} & \cdots & a_{1,kk} \end{bmatrix} - \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} \right) \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} - \begin{bmatrix} a_{2,11} & \cdots & a_{2,1k} \\ \vdots & \ddots & \vdots \\ a_{2,k1} & \cdots & a_{2,kk} \end{bmatrix} \left( \begin{bmatrix} x_{1t-1} \\ \vdots \\ x_{kt-1} \end{bmatrix} - \begin{bmatrix} x_{1t-2} \\ \vdots \\ x_{kt-2} \end{bmatrix} \right) + \begin{bmatrix} \mu_{1t} \\ \vdots \\ \mu_{kt} \end{bmatrix}$$

Simplifying and writing in matrix notation we have

$$\Delta x_t = -(1 - A_1 - A_2) x_{t-1} - A_2 \Delta x_{t-1} + \mu_t \tag{16}$$

where $\mathbf{\Pi} = (1 - A_1 - A_2)$

This VAR (16) can be reparameterized to form the vector error correction model (VECM) specification as follows

$$\Delta x_t = -\Pi x_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} + D_t + \mu_t \quad (17)$$

where

$$\Gamma_i = -\sum_{j=i+1}^{p} A_j$$

and$\Pi = \left(1 - A_1 - A_2 - \cdots - A_p\right)$while a negative and significance coefficient of the error correction term, ECT indicates that any short-term fluctuations between the independent variables and the dependent variable will give rise to stable long-run relationship between the variables (Rousseau & Wachtel, 1998) $x_t$is a nx1 vector of endogenous variables, which is $x_t = [l\_reer\ l\_gcons\ l\_aid\ l\_rgdcap\ l\_tot\ fdi]'$ and the existence of $r$ cointegrating relationships is given by the following hypothesis

$$H(r): \mathbf{\Pi} = \alpha\beta' \quad (18)$$

where Πis an n x n matrix, $\alpha$ is an n x r matrix of the speed of adjustment to equilibrium, values of $\alpha$ close to zero imply slow convergence and $\beta$ is also an n x r matrix of long-run coefficients which determines the cointegration relationships among the variables. The differenced variables in the form of Δ are I(0) and stationary and are used to capture short-run dynamics while the inclusion of $D_t$ assists in capturing deterministic components, such as constant, trend, and dummies. Specifying the model as in equation (17) implies that the system contains information on both long-run and short-run adjustment to changes in $x_t$ through the estimates of $\Gamma_i$ and Π respectively (Harris, 1995).

If the rank (**Π**) has full rank *k*, then all the variables in the system are stationary, estimating with the VECM, the Level VAR, and unrestricted OLS will give identical results. If the rank (**Π**) is 0, there are no cointegrating variables, all rows are linearly dependent, and the system is non-stationary. In this case all the variables need to be differenced so as to remove non-stationarity in the series then standard inferences can be applied. Existence of cointegration in the system is obtained when the rank (r) of the matrix **Π** has been detected. This means that if **Π** has the reduced rank *0<r<n*, then statistically it is said that there exists n x r matrices $\alpha$ and $\beta$ each with rank *r* such that $\mathbf{\Pi} = \alpha\beta'$ and $\beta' x_t$ is I(0).

If cointegration has been detected between the series then it is known that there exists a long-term equilibrium between them so I will apply a VECM or CVAR model in order to evaluate the short run properties of the cointegrated series. That is in theory the model will have Granger representation because when X and Y series are cointegrated then there must exist Granger causality in at least one direction, which is either X must Granger cause Y or Y must Granger cause X (or both) (Sims et al., 1990). In case of no cointegration a VECM is no longer required and we will directly proceed to Granger causality tests to establish causal links between the variables and use the structural vector autoregression (SVAR) model in differenced form of the variables.

***Structural Vector Autoregression (SVAR) model***

Disagreements by economists on the true structure of the economy have led to an increase in popularity of the structural VAR models in recent years (Keating, 1992). To obtain the coefficients of the structural VAR, a reduced VAR model is used which uses an Ordinary least square methodology. Coefficients from the reduced VAR are used to recover coefficients of the structural VAR model so as to analyze the true economy. Following the methodology, the VAR model captures dynamic relationships among variables of interest and has comparatively higher predictive power than single equation specifications. This model is employed to investigate sterilization in the Tanzanian economy.

We follow the structural VAR approach by Bernanke (1986), Blanchard and Watson (1986), Sims (1986), Enders (2010) and Keating (1992) for a contemporaneous structural VAR model. We use orthogonal restriction (Cholesky) to analyze the dynamic impact of structural innovations.

***Contemporaneous structural VAR model***

Specification of the structural VAR model follows Keating (1992), Bernanke (1986), Blanchard and Watson (1986), Sims (1986), and Enders (2010) in matrix form as

$$\begin{bmatrix} 1 & \theta_{12} \\ \theta_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ w_t \end{bmatrix} = \begin{bmatrix} \theta_{10} \\ \theta_{20} \end{bmatrix} + \begin{bmatrix} \varphi_{11} & \varphi_{12} \\ \varphi_{21} & \varphi_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ w_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{yt} \\ \mu_{wt} \end{bmatrix} \quad (19)$$

$$\text{Or} Z x_t = \tau_0 + \tau_1 x_{t-1} + \varepsilon_t \quad (20)$$

where $y_t$ and $w_t$ are endogenous variables such that $y_t$ has contemporaneous effect on $w_t$ at the same time $w_t$ has contemporaneous effect on $y_t$. $\theta_{12}$ and $\theta_{21}$ are the structural parameters on the contemporaneous endogenous variables which are to be recovered from the reduced model, (the sterilization coefficients). $y_{t-1}$and$w_{t-1}$ are the exogenous variables in the model while $\mu_{yt}$ and $\mu_{wt}$ are the structural innovations.

To obtain the reduced form from the structural VAR one should pre-multiply equation (20) by $Z^{-1}$on the structural VAR as;

$$x_t = Z^{-1}\tau_0 + Z^{-1}\tau_1 x_{t-1} + Z^{-1}\varepsilon_t \quad (21)$$

Such that $x_t = K_0 + K_1 x_{t-1} + e_t$ (22)

To estimate the reduced VAR model, Sims (1980) proposed a way to identify the structural VAR model – the recursive system (orthogonal and Cholesky restriction) which imposes a restriction on the primitive system (the SVAR). Using the recursive system, estimated reduced form residuals are linked to structural innovations through the relationship $Ze_t = \varepsilon_t$, where $e_t$ and $\varepsilon_t$ corresponds to the reduced form and structural innovations respectively. Here zero restrictions on $Z$ are investigated to obtain an identified structural VAR. SVAR models concern themselves only with modeling the unexpected changes in $x_t$ (Keating, 1992).

## EMPIRICAL ANALYSIS

This Section presents results from the different models estimated using methodologies in Section 4, and theoretical and empirical findings from Section 3. It also gives an analysis of the results in depth.

### Unit root tests

We now present unit root tests using the Augmented Dickey-Fuller and Phillips-Perron tests to show the order of integration of the variables, this are presented in Table III below.

Table III. AUGMENTED DICKEY-FULLER (ADF) AND PHILLIPS-PERRON (PP) STATISTICS

| Level | ADF | | PP | | |
|---|---|---|---|---|---|
| | t-values | | t-values | | |
| Variables | without trend | trend | without trend | trend | lags |
| fdi | -1.5547 | -3.1228 | -2.1634 | -3.1623 | 3 |
| l_gcons | -2.1526 | -3.7163** | -2.0725 | -3.7271** | 3 |
| l_aid | -1.4693 | -3.0985 | -1.4707 | -2.3423 | 2 |
| l_reer | -1.6054 | -2.7108 | -1.1746 | -2.0913 | 2 |
| l_rgdpcap | 0.7379 | 0.1446 | 0.7863 | 0.2992 | 2 |
| l_tot | -0.627 | -0.957 | -4.981** | -3.900** | 3 |
| nfa | -0.156 | -0.074 | 7.545 | 4.345 | 3 |
| nda | -0.084 | -3.314 | -1.263 | -3.325 | 1 |
| 1st Difference | | | | | |
| d(fdi) | -9.4517** | -9.3605** | -9.8081** | -9.7278 | 2 |
| d(l_gcons) | -7.5558** | -7.5281** | -8.8123** | -11.1357** | 3 |
| d(l_aid) | -5.9724** | -6.0539** | -5.1596** | -5.1169** | 2 |
| d(l_reer) | -3.4208** | -3.6387 | -3.4711** | -3.4217 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| d(l_rgdpcap) | -5.9551** | -6.2631** | -6.0686** | -6.2624** | 3 |
| d(l_tot) | -3.637** | -2.418 | -5.385** | -8.235 | 3 |
| d(nfa) | -9.911** | -5.395** | -3.391** | -5.871** | 1 |
| d(nda) | -9.364** | -9.598** | -9.447** | -9.747** | 1 |

The null hypothesis is rejected at 5% level (**)

The results of ADF and PP tests show that we cannot reject the null hypothesis that the series of interest have a unit root at a level of significance of 5%. However, according to the Phillips-Perron test log of terms of trade (l_tot) is stationary in levels while log of government consumption is stationary at levels using ADF and PP with trend. Testing unit roots of all variables at first difference shows that all variables are stationary which means that the variables are integrated of order one i.e. I(1) process. We can conclude that the standard regression model is not appropriate in examining the relationship between the real exchange rate and the fundamentals. Instead, we will use cointegration techniques to uncover the relationships.

## Choice of lag length

Testing for cointegration vectors using the Johansen (1988) and Juselius (1992) test statistics implies that the values of the vector of the parameters are sensitive to the choice of the lag length (*p*).Therefore, to estimate the VEC model for inferential and interpretive purposes it requires the selection of the most appropriate number of lags in the model. In this study we specified the optimal lag length according to different information criteria using initial VAR model in levels that takes into account the sensitivity of lag length. This process is a statistical test and determines the number of variables to be included in the model; in addition economic theory in using VAR model was employed. Below is Table IV which gives results of order selection criteria.

TABLE IV. VAR LAG ORDER SELECTION CRITERIAS

| Lag | Likelihood Ratio | Final Prediction Error | AIC | Hannan-Quinn | SBIC |
|---|---|---|---|---|---|
| | | | Information criteria | | |
| 0 | NA | 8.9e+32 | 90.0546 | 90.1314 | 90.2723 |
| 1 | 349.95 | 2.7e+29 | 81.9478 | 82.4082 | 83.2539* |
| 2 | 73.158 | 1.6e+29 | 81.3219 | 82.1661 | 83.7165 |
| 3 | 677.781* | 1.2e+29* | 80.8413* | 82.0692* | 84.3244 |

An asterisk indicates lag order selected by the criterion.

As can be seen from the result presented in table IV, the lag length which is suggested by the criteria is the lag length of *p*=3 from the VAR model, this is according to the likelihood ratio (LR), final prediction error (FP), Akaike information criteria (AIC) and Hanna-Quinn (HQIC). Lag one is only chosen by Schwartz information criteria (SBIC). The disagreement between the criteria reflects the different ways in which they punish the extra lag. The lag length of *p*=3is used to determine rank (r) of cointegrated vectors in the cointegration test, while *p*-1 lags are used in estimating the Cointegrated VAR or VEC

model. However, it should be noted that tests used for lag length are only valid under assumptions of correctly specified model, because adding too many lags can be harmful, that is over parameterization of the model. Other misspecification tests are often needed until a satisfactory model specification is achieved.

### 5.3 Johansen Cointegration test results

Given the specified lag length, we use the Johansen (1988) and Juselius (1992) – JJ procedure o test for cointegration among the variables in the model. The JJ method is preferred mainly because it is able to detect more than one cointegration relationship as opposed to the Engle-Granger approach. Furthermore, since the JJ method relies on the relationship between the rank of the matrix and its characteristic roots it is more suited for a multivariate system (Verbeek, 1997). In the trace statistic test, the null hypothesis is that the number of cointegration vectors is less or equal to $r = 0$ to $n$. The maximum eigenvalue statistic tests that the number of distinct cointegration vectors is $m$ against the alternative of $m+1$cointegrating vectors. In the event trace and maximum eigenvalue statistics yield different results, then the result of trace test should be preferred (Alexander 2001). The existence of cointegration implies that Granger causality must exist in at least one direction between the real effective exchange rate and fundamentals. Table V presents the Johansen and Juselius (JJ) cointegration tests.

Table V. JOHANSENS COINTEGRATION TESTS

| Unrestricted intercepts and no trends, order of the VAR = 3 | | | | |
|---|---|---|---|---|
| Hypothesized No. of Cointegration equations | | | | |
| Null | Alternative | Trace Statistic | 5% critical value | Prob.** |
| r = 0 | r = 1 | 90.12198* | 69.81889 | 0.0005 |
| r≤ 1 | r = 2 | 50.06231* | 47.85613 | 0.0306 |
| r ≤ 2 | r = 3 | 24.68937 | 29.79707 | 0.1728 |
| r ≤ 3 | r = 4 | 5.465251 | 15.49471 | 0.7576 |
| Null | Alternative | Max-Eigen Statistic | 5% critical value | Prob.** |
| r = 0 | r = 1 | 40.05967* | 33.87687 | 0.0081 |
| r ≤ 1 | r = 2 | 25.37294 | 27.58434 | 0.0935 |
| r ≤ 2 | r = 3 | 19.22412 | 21.13162 | 0.0905 |
| r ≤ 3 | r = 4 | 5.287329 | 14.26460 | 0.7052 |

Note: * denotes rejection of the null at the 5% level of significance.
**MacKinon-Haug-Michelis (1999) p-values

Typically, finding the rank of **Π** in the system is taken as evidence of cointegration. Presence of cointegration between the variables suggests a long term relationship among the variables. Both the trace and the maximum eigenvalue tests of the Johansen and Juselius procedure detected the presence of cointegration. From Table V, the trace statistic indicates two cointegrating vectors while the maximum-eigen statistic indicates one cointegrating vector. Given the conflicting results from the two statistics, we follow the trace statistic which indicates two cointegrating vectors among the variables (Alexander, 2001).

Obtaining cointegration at the 5% level in five-variables indicates that there is a persistent co-movement among the aggregate variables, the long-run relation between the real effective exchange rate and the fundamentals which are foreign aid, foreign direct investment, government consumption and productivity proxied by real GDP per capita. Therefore, the estimated VECM(1) system of the real effective exchange rate with two cointegration vectors is given in matrix form as (Skrabic & Tomic-Plazibat, 2009):

$$\begin{bmatrix} \Delta l\_reet_t \\ \Delta l\_gcons_t \\ \Delta fdi_t \\ \Delta l\_rgdpca_t \\ \Delta l\_aid_t \end{bmatrix} = \begin{bmatrix} -0.277 & -0.291 \\ -0.187 & -0.267 \\ 1.707 & -1.174 \\ -0.030 & 0.123 \\ -0.005 & 0.181 \end{bmatrix} \begin{bmatrix} 1.00 & 0.00 & 0.047 & -2.463 & 2.887 & 6.123 \\ 0.00 & 1.00 & -0.044 & -0.378 & -1.856 & 1.611 \end{bmatrix} \begin{bmatrix} l\_reet_{t-1} \\ l\_gcons_{t-1} \\ fdi_{t-1} \\ l\_rgdpca_{t-1} \\ l\_aid_{t-1} \\ 1 \end{bmatrix} +$$

$$\begin{bmatrix} 0.415 & 0.044 & 0.012 & -1.138 & 0.454 \\ 0.212 & -0.415 & 0.004 & 0.265 & 0.540 \\ -1.479 & 2.105 & -0.767 & 5.013 & -4.764 \\ 0.088 & -0.111 & 0.006 & -0.461 & 0.236 \\ 0.052 & -0.043 & 0.00007 & 0.023 & 0.254 \end{bmatrix} \begin{bmatrix} \Delta l\_reet_{t-1} \\ \Delta l\_gcons_{t-1} \\ \Delta fdi_{t-1} \\ \Delta l\_rgdpca_{t-1} \\ \Delta l\_aid_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} 0.098 & -0.118 & -0.009 & -0.963 & -0.491 \\ 0.032 & -0.339 & 0.004 & 0.580 & 0.031 \\ -0.696 & 1.327 & -0.356 & 0.725 & -4.161 \\ -0.165 & -0.093 & 0.002 & -0.269 & 0.137 \\ 0.017 & -0.027 & -0.004 & -0.284 & -0.357 \end{bmatrix} \begin{bmatrix} \Delta l\_reet_{t-2} \\ \Delta l\_gcons_{t-2} \\ \Delta fdi_{t-2} \\ \Delta l\_rgdpca_{t-2} \\ \Delta l\_aid_{t-2} \end{bmatrix} + \begin{bmatrix} 0.375 \\ 0.277 \\ -0.015 \\ -0.08 \\ -0.135 \end{bmatrix} + \begin{bmatrix} -0.205 \\ -0.167 \\ 0.043 \\ 0.029 \\ 0.087 \end{bmatrix} \quad (23)$$

The estimated real effective exchange rate has the following form given the VECM(1) system equation (23) (Skrabic & Tomic-Plazibat, 2009)

$$\begin{aligned} \Delta l\_reer_t = & -0.2776 * (l\_reer_{t-1} + 0.047 * fdi_{t-1} - 2.462 * l\_rgdpcap_{t-1} + 2.887 * l\_aid_{t-1} + 6.122) \\ & - 0.291 * (l\_gcons_{t-1} - 0.044 * fdi_{t-1} - 0.378 * l\_rgdpcap_{t-1} - 1.856 * l\_aid_{t-1} + 1.610) \\ & + 0.415 * \Delta l\_reer_{t-1} + 0.044 * \Delta l\_gcons_{t-1} + 0.011 * \Delta fdi_{t-1} - 1.138 * \Delta l\_rgdpcap_{t-1} \\ & + 0.454 * \Delta aid_{t-1} + 0.098 * \Delta l\_reer_{t-2} - 0.118 * \Delta l\_gcons_{t-2} + 0.009 * \Delta fdi_{t-2} - 0.963 \\ & * \Delta l\_rgpcap_{t-2} + 0.049 * \Delta aid_{t-2} + 0.375 * dum - 0.205 \end{aligned}$$

Table VI presents t-statistics of estimated long-run static cointegrated model coefficients while Table VII presents the tests of cointegration residuals.

Table VI. LONG-RUN COINTEGRATION VECTOR COEFFICIENTS

| Cointegration Equation 1 | | | |
|---|---|---|---|
| Variables | Coefficients | Standard error | t-value |
| $l\_reer_{t-1}$ | 1 | | |
| $l\_gcons_{t-1}$ | 0.0000 | | |
| $fdi_{t-1}$ | 0.0479 | 0.0497 | 0.9654 |
| $rgdpcap_{t-1}$ | -2.4628 | 0.6085 | -4.0477** |
| $l\_aid_{t-1}$ | 2.8874 | 0.7653 | 3.7727** |
| c | 6.1229 | | |
| Cointegration Equation 2 | | | |
| $l\_reer_{t-1}$ | 0.0000 | | |
| $l\_gcons_{t-1}$ | 1 | | |
| $fdi_{t-1}$ | -0.0444 | 0.0261 | -1.7007 |
| $rgdpcap_{t-1}$ | -0.3785 | 0.3200 | -1.1829 |
| $l\_aid_{t-1}$ | -1.8561 | 0.4025 | -4.6112** |
| c | 1.6108 | | |

The null hypothesis is rejected at 5% level (**), cointegration equations 1 and 2 are normalized equations.

TABLE VII: STATIC MODEL: COINTEGRATION RESIDUALS TESTES BETWEEN REER AND EXPLANATORY VARIABLES

| | t-value | Prob. |
|---|---|---|
| Augmented Dickey-Fuller (ADF) tests on residuals | -5.3068** | 0.0001 |
| Phillips-Perron (PP) tests on residuals | -7.1230** | 0.0000 |

The null hypothesis is rejected at 5% level (**).

From Table VII, results of ADF and PP show that the residuals from the cointegrated real exchange rate equation are stationary implying long-run relationship among the variables. Investigating the computed Augmented Dickey-Fuller results with a p-value of 0.0001 at the 5% significant levels and the Phillips-Perrontest results with the p-value of 0.000 at the 5% significant levels tends to support cointegration between the real exchange rate and its fundamentals. Figure 7 plots the residuals from the cointegrated equation.

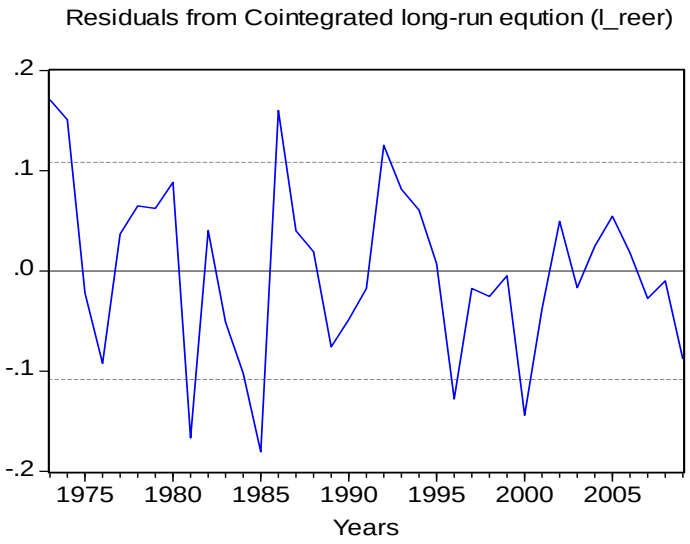



FIGURE 7. RESIDUALS FROM THE CONITEGRATED REAL EXCHANGE RATE MODEL

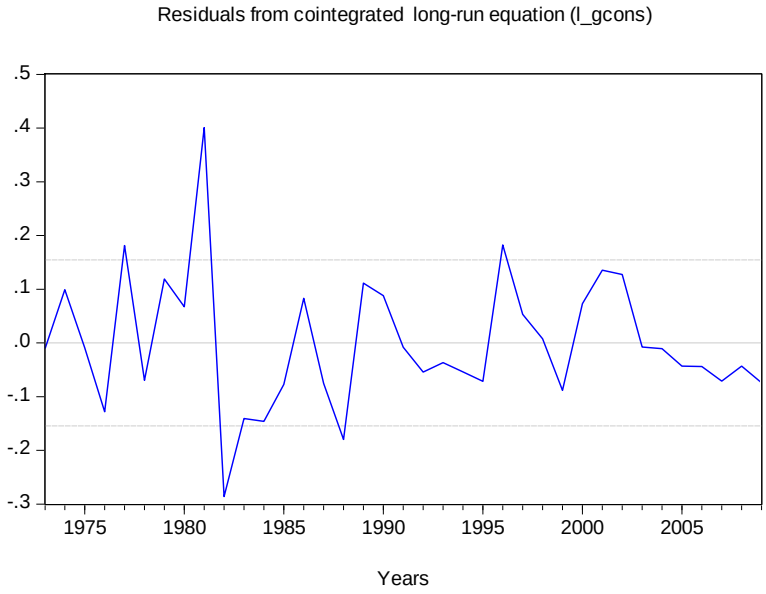



FIGURE 8. RESIDUALS FROM THE COINTEGRATED GOVERNMENT CONSUMPTION MODEL

From Figures 7 and 8, the residuals from the cointegration equation are shown to be stationary as the residuals tend to constantly return to their mean values; this evidence reveals cointegration among the variables given by the long run equation. Figure 9 presents the graph of cointegration relation for the real exchange rate relationship to its fundamentals.

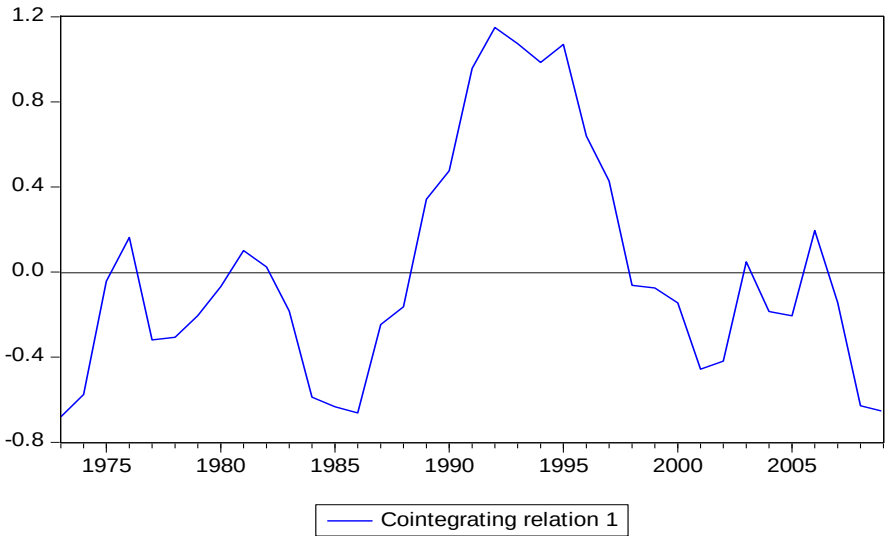



FIGURE 9: COINTEGRATION RELATION (REAL EXCHANGE RATE RELATIONSHIP)

The cointegration relation graph shows that there is no visual evidence of trends in these series and therefore it allows analyzing cointegration Equation 1.

Of importance to this study is the cointegration Equation 1 which conforms to theoretical predictions. In this equation, the dependent variable is the real effective exchange rate in which the impact is analyzed on. According to the long-run cointegration Equation 1, it is expected that a 1% increase in aid as a percent of GDP will reduce the real effective exchange rate i.e. appreciate the currency by 2.88%. The same effect occurs with foreign direct investment, that one unit increase in foreign direct investment (fdi) decreases the real effective exchange rate by 5%, though this result is not significant. This result supports the standard Dutch disease economics that international capital flows lead to appreciation of the real exchange rate. Productivity, rgdpcap (real GDP per capita) has a depreciating effect as expected that a 1% increase in productivity leads to 2.46%increase in the real effective exchange rate, this results is supported when substitution effect outweighs income effect. Tables VIII and IX present the VECM(1) and VECM(2) system of coefficients.

TABLE VIII. VECM(1) SYSTEM COEFFICIENTS

| Variables | Coefficients | Standard error | t-value |
|---|---|---|---|
| $\alpha_1$ | -0.2776 | 0.0539 | -5.1445** |
| $\alpha_2$ | -0.2919 | 0.0959 | -3.0411** |
| $D(l\_reer_{t-1})$ | 0.4153 | 0.1414 | 2.9364** |
| $D(l\_aid_{t-1})$ | 0.4509 | 0.2642 | 1.7186 |
| $D(l\_rgdpcap_{t-1})$ | -1.1382 | 0.5086 | -2.2378** |
| $D(l\_gcons_{t-1})$ | 0.0441 | 0.1363 | 0.3234 |
| $D(fdi_{t-1})$ | 0.0119 | 0.0130 | 0.9127 |

| | | | |
|---|---|---|---|
| D(l_reer$_{t-2}$) | 0.0982 | 0.1415 | 0.6936 |
| D(l_aid$_{t-2}$) | -0.4906 | 0.2492 | -1.9685* |
| D(l_rgdpcap$_{t-2}$) | -0.9633 | 0.4903 | -1.9645* |
| D(l_gcons$_{t-2}$) | -0.228 | 0.289 | -0.788 |
| D(fdi$_{t-2}$) | -0.0093 | 0.0122 | 0.7614 |
| C | -0.2048 | 0.0489 | -4.1818** |
| Dum | 0.3756 | 0.0692 | 5.4312** |

The null hypothesis is rejected at 5% level (**) or at 10% level (*)

TABLE IX: VECM(2) SYSTEM COEFFICIENTS

| Variables | Coefficients | Standard error | t-value |
|---|---|---|---|
| $\alpha_1$ | -0.1875 | 0.0770 | -2.4348** |
| $\alpha_2$ | -0.2671 | 0.137 | -1.9495** |
| D(l_reer$_{t-1}$) | 0.2122 | 0.2018 | 1.0508 |
| D(l_aid$_{t-1}$) | 0.5401 | 0.3772 | 1.4318 |
| D(l_rgdpcap$_{t-1}$) | 0.2647 | 0.7261 | 0.3645 |
| D(l_gcons$_{t-1}$) | -0.4145 | 0.1946 | -2.1295** |
| D(fdi$_{t-1}$) | 0.0041 | 0.0186 | 0.2212 |
| D(l_reer$_{t-2}$) | 0.0317 | 0.2021 | 0.1573 |
| D(l_aid$_{t-2}$) | 0.0314 | 0.3558 | 0.0885 |
| D(l_rgdpcap$_{t-2}$) | -0.5803 | 0.7000 | 0.8291 |
| D(l_gcons$_{t-2}$) | -0.3396 | 0.1763 | -1.9261** |
| D(fdi$_{t-2}$) | -0.0039 | 0.0174 | 0.2248 |
| C | -0.1669 | 0.0699 | -2.3862** |
| Dum | 0.2775 | 0.0987 | 2.8105** |

The null hypothesis is rejected at 5% level (**) or at 10% level (*)

Table VIII presents estimates for the real effective exchange rate error correction terms ($\alpha_1$ and $\alpha_2$) and short-run estimates in the VECM(1). For the purpose of this study, the major interest is on the impact of international capital flows (foreign aid and foreign direct investment) on the real exchange rate. From the empirical results in cointegration Equation 1 both foreign aid and foreign direct investment have the correct expected sign, which a tendency to increase the value of the currency. The parameter $\alpha$ has the expected sign which determines the speed of adjustment towards equilibrium. The negative and significant coefficient on the error correction terms ($\alpha$) in the real effective exchange rate of the VECM(1) indicates a rapid response of the real effective exchange rate to deviations from its fundamentals during a year, this is about 27.76% and 29.19% adjustment towards the equilibrium. For instance, starting from an initial condition of real appreciation (that is the error correction terms are negative) then the self-correcting mechanism calls for a depreciation of real exchange rate. In particular, negative deviations from the stationary relationship are corrected by an increase in the real effective exchange rate which is a depreciation of the currency which may take up to three years to return back to its initial equilibrium. Thus, the positive effect of the foreign direct investment and foreign aid

which were offset by the exchange rate appreciation do not reduce competitiveness of the economy as the economy goes back to its initial (above) equilibrium exchange rate.

As expected, productivity is significant and bear a negative sign, meaning it tend to appreciate the real exchange rate in the short-run. This implies that the demand-side effect outweighs the supply-side effect of improved technology leading to an increase in the price of non-tradables which might bring about appreciation of the domestic currency. Using Granger causality shown by the significance of the lagged coefficient of the productivity, it implies that productivity Granger cause real effective exchange rate with the direction of causality running from productivity to the real exchange rate. The constant term is significant which is consistent with the fact that the variables display linear trends. The significance of the shift dummy variables show that the effects of the 1986 structural adjustment programs (SAP) were significant with strong and positive impact in the economy, that is they led to real exchange rate depreciation.

Using the model of interest, VECM(1) we did dynamic forecasts for 5 years out of sample. The forecast shows that there is an increase of the real exchange rate which should increase the competitiveness of the economy. Figure 10 presents the graph of the forecast.

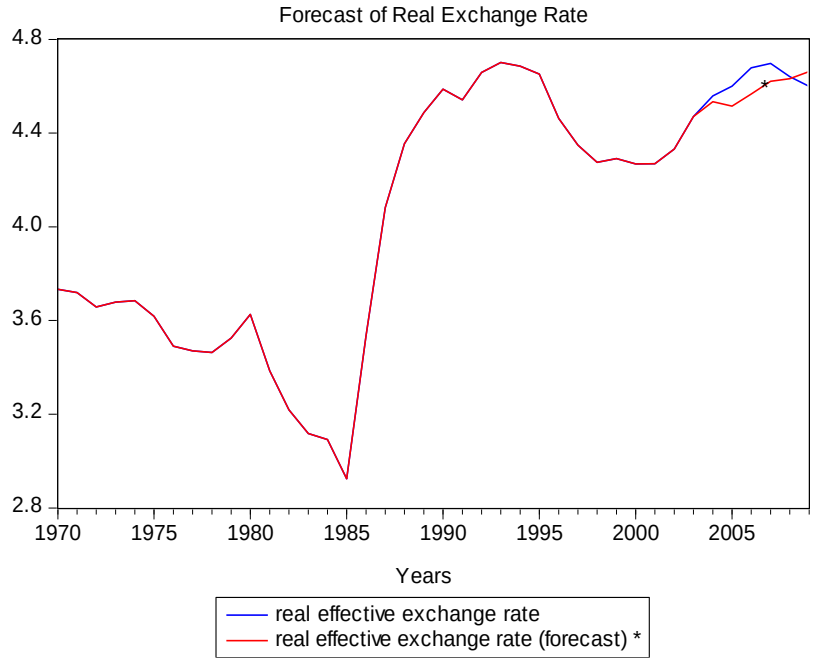



FIGURE 10. DYNAMIC FORECAST OF THE REAL EXCHANGE RATE

## Diagnostic tests

To investigate the model for robustness and stability, we checked for serial correlation, normality and heteroscedasticity. We used the Lagrange Multiplier (LM) test for serial

correlation, heteroscedasticity white test for heteroscedasticity and the Jargue-Bera (JB) test for multivariate normality of residuals. The results are robust to the inclusion of the dummy variable.

Given the diagnostic tests we found that the Lagrange Multiplier (LM) test showed no serial correlation between residuals up to four lags. Standard stability tests showed that the model was stable given that all characteristic roots fell within the unit circle. The model showed no heteroscekasticity, as the null hypothesis was not rejected at the 5% level. However, based on the Jarque-Bera (JB) test, multivariate normality of residuals was rejected at p-value less than 5%. Table X presents the diagnostic tests.

TABLE X. DIAGNOSTIC TESTS OF THE VEC(1) MODEL

| ARCH(4) LM test: | lag | LM-test | Prob. |
|---|---|---|---|
| | 1 | 23.00835 | 0.5771 |
| | 2 | 25.11383 | 0.4560 |
| | 3 | 26.49634 | 0.3815 |
| | 4 | 32.23007 | 0.1515 |
| Normality (joint)test: | | Jarque-Bera | Prob. |
| | | 27.62776 | 0.0021** |
| Residual Heteroskedasticity (Joint)test | | Chi-Square | Prob. |
| | | 379.5294 | 0.425 |

$H_0$: no autocorrelation at lag order

Another type of robustness check which we used in this study is to drop one of the variables and see if there are much effect or change of the signs on the estimates of the other variables. Dropping one of the variables implies we have to test for cointegration with the remaining variables. The first model is the one without foreign aid (l_aid). In this model we found one long run cointegration equation based on the trace and maximum-eigenvalue tests. The long run cointegration equation shows that in the long run it is expected that a one unit increase in foreign direct investment (fdi) will reduce the real effective exchange rate by 8%, an appreciation of the value of the currency as expected. The Vector Error Correction for this model VECM(3) shows a statistically significant speed of adjustment toward the equilibrium which is 24% a year. This means that negative deviations from the stationary relationship are corrected by an increase in real effective exchange rate – a depreciation of the real exchange rate. Table XI and XII presents the long run cointegration equation and the Vector Error Correction coefficients respectively.

TABLE XI. (WITHOUT FOREIGN AID), LONG-RUN COINTEGRATION VECTOR COEFFICIENTS

| Cointegration Equation | | | |
|---|---|---|---|
| Variables | Coefficients | Standard error | t-value |
| $l\_reer_{t-1}$ | 1 | | |
| $l\_gcons_{t-1}$ | -5.1852 | 0.9725 | -5.3313** |
| $fdi_{t-1}$ | 0.0870 | 0.0373 | 2.3296** |
| $rgdpcap_{t-1}$ | -0.4112 | 0.9568 | -0.4298 |
| c | -3.4336 | | |

The null hypothesis is rejected at 5% level (**)

TABLE XII. (WITHOUT FOREIGN AID),VECM(3) SYSTEM COEFFICIENTS

| Variables | Coefficients | Standard error | t-value |
|---|---|---|---|
| $\alpha_1$ | -0.2496 | 0.0438 | -5.6882** |
| $D(l\_reer_{t-1})$ | 0.2896 | 0.1385 | 2.0913** |
| $D(l\_rgdpcap_{t-1})$ | 0.1794 | 0.4293 | 0.4178 |
| $D(l\_gcons_{t-1})$ | 0.0666 | 0.1150 | 0.5795 |
| $D(fdi_{t-1})$ | 0.0123 | 0.0111 | 1.1167 |
| $D(l\_reer_{t-2})$ | -0.0638 | 0.1311 | -0.4871 |
| $D(l\_rgdpcap_{t-2})$ | 0.1706 | 0.4357 | 0.3915 |
| $D(l\_gcons_{t-2})$ | -0.1415 | 0.1102 | -0.1283 |
| $D(fdi_{t-2})$ | 0.0026 | 0.0109 | 0.2418 |
| C | -0.2610 | 0.0506 | -5.1566** |
| Dum | 0.4250 | 0.0709 | 5.9885** |

The null hypothesis is rejected at 5% level (**)

The second model is the one without foreign direct investment (fdi); testing for cointegration we found that there are two cointegration equations using the trace and maximum-eigenvalue tests. In this case the long run equation showed that a 1% increase in aid leads to an appreciation of the value of the currency by 1.2%. The Vector Error Correction VECM(4) for this model has significant and right signs of the speed of adjustments (error correction terms, ECT). It shows that a negative deviation from the stationary relationship is corrected by an increase in the real effective exchange rate with the speed of adjustment of 30% and 16.9%. Therefore, inspecting these equations it is clear that most of coefficient signs do not change much, this shows that the models estimates of the VECM(1) and VECM(2) models are robust and stable. Table XIII and XIV presents the long run cointegration equations and Vector Error Correction coefficients respectively.

TABLE XIII. (WITHOUT FDI), LONG-RUN COINTEGRATION VECTOR COEFFICIENTS

| Cointegration Equation 1 | | | |
|---|---|---|---|
| Variables | Coefficients | Standard error | t-value |
| $l\_reer_{t-1}$ | 1 | | |
| $l\_gcons_{t-1}$ | 0.0000 | | |
| $rgdpcap_{t-1}$ | -1.3695 | 0.6118 | -2.2383** |
| $l\_aid_{t-1}$ | 1.2182 | 0.5340 | 2.2812** |
| c | 2.1215 | | |
| Cointegration Equation 2 | | | |
| $l\_reer_{t-1}$ | 0.0000 | | |
| $l\_gcons_{t-1}$ | 1 | | |
| $rgdpcap_{t-1}$ | -0.3881 | 0.3188 | -1.2170 |
| $l\_aid_{t-1}$ | -1.3139 | 0.2782 | -4.7216** |
| c | 0.9249 | | |

The null hypothesis is rejected at 5% level (**) or at 10% level (*)

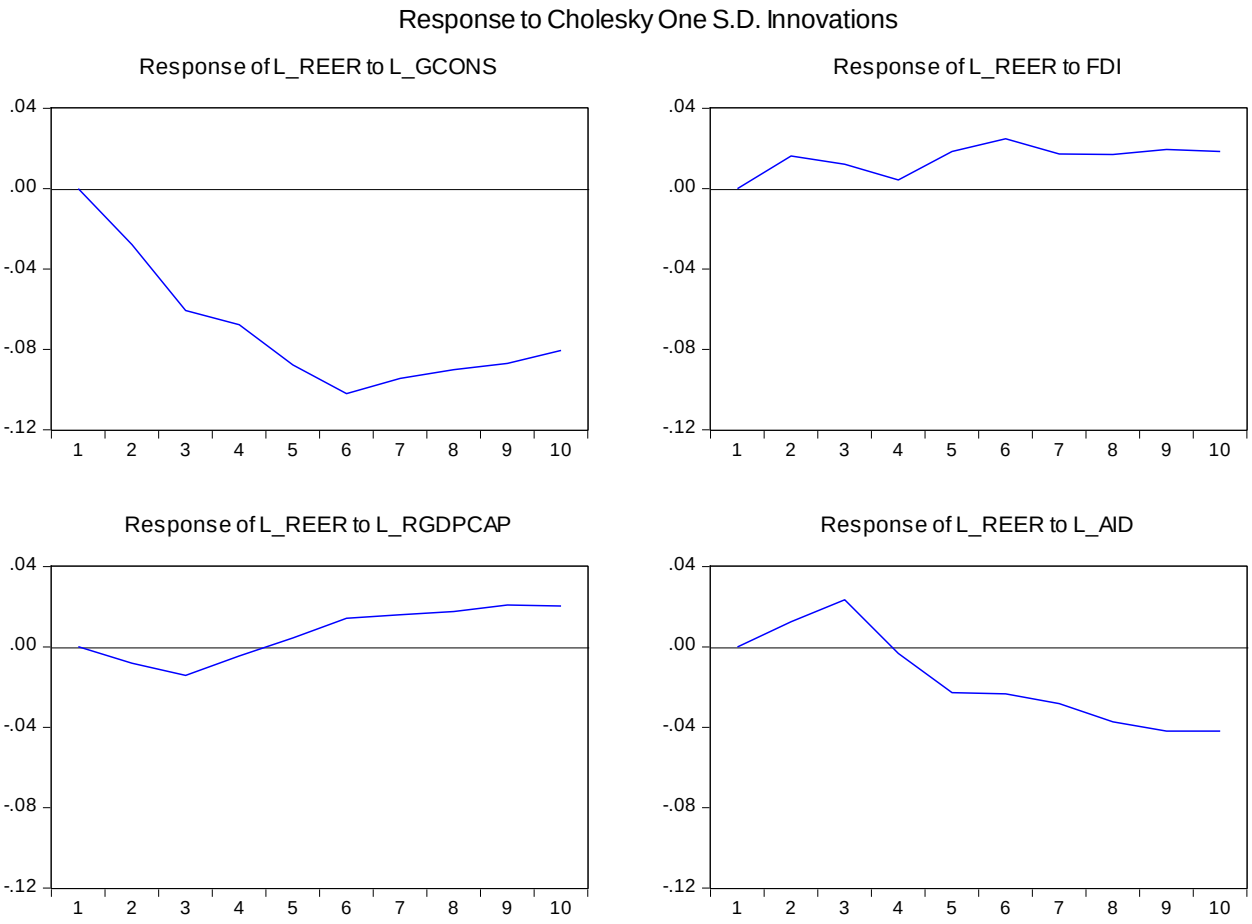
TABLE XIV. (WITHOUT FDI), VECM(4) SYSTEM COEFFICIENTS

| Variables | Coefficients | Standard error | t-value |
|---|---|---|---|
| $\alpha_1$ | -0.3093 | 0.0561 | -5.5081** |
| $\alpha_2$ | -0.1691 | 0.0913 | -1.8525** |
| $D(l\_reer_{t-1})$ | 0.3836 | 0.1312 | 2.9237** |
| $D(l\_aid_{t-1})$ | 0.3453 | 0.2271 | 1.5204* |
| $D(l\_rgdpcap_{t-1})$ | -0.7282 | 0.4531 | -1.6071* |
| $D(l\_gcons_{t-1})$ | 0.0082 | 0.1284 | -0.0645 |
| $D(l\_reer_{t-2})$ | 0.0836 | 0.1301 | 0.6428 |
| $D(l\_aid_{t-2})$ | 0.3911 | 0.2185 | -1.7892* |
| $D(l\_rgdpcap_{t-2})$ | -0.6701 | 0.4483 | -1.5001* |
| $D(l\_gcons_{t-2})$ | -0.1348 | 0.1164 | -1.1585 |
| C | -0.2254 | 0.0471 | -4.7808** |
| Dum | 0.3992 | 0.0663 | 6.0141** |

The null hypothesis is rejected at 5% level (**) or at 10% level (*)

## Impulse responses

Since shocks to a particular variable can generate variations to itself and other variables, we traced the magnitudes of transmission of shocks from the fundamentals and the real exchange rate by performing the Cholesky decomposition employing the orthorgonalized methodology of Sims (1980) to determine the impulse responses. Sims (1980) approach is possible to trace out the time path of the various shocks on the variables. Figure 11 presents the impulse response functions, based on the orthogonalized function.




where,

L_REER is the log of real effective exchange rate, L_GCONS is the log of Government Consumption, FDI is Foreign Direct Investment, L_RGDPCAP is the productivity and L_AID is log of Foreign aid

FIGURE 11. IMPULSE RESPONSE FUNCTION OF THE REAL EXCHANGE RATE FROM THE ESTIMATED VECM MODEL

Impulse response analysis indicates that the series are responsive to various shocks. In particular according to this model, Figure 11 shows that unexpected shocks to foreign direct investment (fdi), aid, government consumption (gcons) and real gross domestic product per capita (rgdpcap) will have a permanent effect on the real effective exchange rate for the period of 10 years.

The initial response of the real effective exchange rate to a unit shock in foreign direct investment (fdi) leads toan increase of the real exchange rate by 0.42% a positive and

significant result for four years and after the shock it continues to be positive, that is increasing the real effective exchange rate.

A one unit shock on aid, leads to an increase in the real effective exchange rate by 2.3% of GDP up to the 3rd year and continues to have a permanent fall for the whole period in the model, which is decreasing of the real effective exchange rate.

The initial response of the real effective exchange rate to a one unit shock in government consumption is negative and significant for one year after the shock it becomes negative and continues for the period specified.

A shock on real gross domestic product per capita leads to decrease in real effective exchange rate for three years by 0.4% and thereafter, the real effective exchange rate starts to increase slowly for the remaining period, which is a permanent effect. The graphs above indicates that an orthogonalized shock to the government consumption, aid, gross domestic product per capita both as a percent of GDP and the foreign direct investment have permanent effect on the real effective exchange rate. The permanent effect is due to the fact that the I(1) variables modeled in a cointegrating VECM are not mean reverting, that the unit moduli in the companion matrix imply that the effect of a shock will not die out over time. Table XVII and XVIII in Appendix B show the shock of the fundamentals to the real exchange rate and forecast error variance decomposition respectively.

## Reserve Accumulation and Sterilization

In any country with an independent central bank, when a central bank purchases foreign assets, it must decide whether to fund it increasing reserve money which is inflationary or to reduce net domestic asset which is sterilization on the domestic reserve money. Sterilization refers to central banks offsetting international reserve to follow independent monetary policy, that is monetary authorities ensure that foreign exchange interventions do not affect the domestic monetary base. Therefore, when a central bank accumulates reserves then this accumulation has monetary implications in the future.

To offset the effects of reserve accumulation on the monetary base, traditionally there has been a number of ways to do this including selling instruments. Central banks can use open market operations (OMO) or foreign exchange operation (FXO). OMO includes selling of market instruments such as central bank bills, government bonds or using swaps or repurchases operations[5] (Aizenman & Glick, 2008). FXO involves the central

[5]Foreign exchange swaps, the central bank typically agrees to buy foreign exchange forward, while repurchase operations (repos) the central bank sells securities with an agreement to buy them back in the future.

bank purchasing foreign currency assets (money or foreign treasury bonds) held by private agents by the central bank.

We measure sterilization, assuming that changes in reserves are exogenously determined and estimate sterilization coefficients by running a simple OLS on monetary reaction function using a SVAR model (Willett et al., 2007). Obtaining the estimated sterilization coefficient will answer the hypothesis put forward in the research question 1.3(c): "is there a role for sterilization of international capital flows?" The model is specified as:

$$\Delta NDA_t = c_0 + c_1 \Delta NFA_t + X'\beta + \varepsilon_t \quad (24)$$

where $\Delta NDA_t$ and $\Delta NFA_t$ are change in net domestic assets and net foreign assets (a proxy for international capital flows (reserves)), respectively. $X$ represents other explanatory variables that might influence monetary policy's reaction and when $c_1 = -1$ the economy has full monetary sterilization while when $c_1 = 0$ means there is no sterilization. Thus sterilization intervention is ultimately an exchange of domestic bonds for foreign bonds.

Using the econometric framework of Willett et al (2006), Bernanke (1986), Blanchard and Watson (1986), Sims (1986), Keating (1992), and Enders (2010) and using differenced variables as they are I(1) in levels (nonstationary) the structural VAR model in matrix form is specified as

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} \Delta nda_t \\ \Delta nfa_t \end{bmatrix} = \begin{bmatrix} \theta_{10} \\ \theta_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} \Delta nda_{t-1} \\ \Delta nfa_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{ndat} \\ \varepsilon_{nfat} \end{bmatrix} \quad (25)$$

To identify the structural system we use the recursive system proposed by Sims (1980), that is exactly identification. We impose a restriction such that the coefficient $b_{21}$ is equal to zero(0) on the primitive system (25). This means that $nda_t$ has no contemporaneous effect on$nfa_t$ (Enders, 2010).This restriction gives a reduced VAR which can be estimated by Ordinary Least Squares (OLS). Given the restriction the reduced VAR model is

$$\begin{bmatrix} \Delta nda_t \\ \Delta nfa_t \end{bmatrix} = \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \theta_{10} \\ \theta_{20} \end{bmatrix} + \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} \Delta nda_{t-1} \\ \Delta nfa_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{ndat} \\ \varepsilon_{nfat} \end{bmatrix} \quad (26)$$

The reduced model is estimated and the primitive parameters $b$ and $\gamma$ are recovered. Estimating the reduced VAR I recovered the coefficient of $b$ as 94.2% which clearly shows that there is almost complete sterilization in the economy as it is negative. This is due to substantial treasury bill sterilization with high interest rates due to an increase in fiscal spending with no widening of the current account – absorption, such as increasing net imports (Aiyer et al., 2008).

### *Diagnostic tests of the structural VAR*

To check for model robustness and stability, we checked for normality using a Lagrange-multiplier test, and for stability of the model we checked if the eigenvalues lie inside of the unit circle. We found that the model satisfies normality conditions and that it was stable, all eigenvalues lied inside the unit circle meaning the VAR satisfied the stability condition. The Lagrange-multiplier and stability tests are presented as in Tables XV and XVI, respectively.

TABLE XV. LAGRANGE-MULTIPLIER TEST

| Lag | chi2 | df | prob>chi2 |
|---|---|---|---|
| 1 | 5.512 | 4 | 0.238 |
| 2 | 1.923 | 4 | 0.749 |

$H_0$: no autocorrelation at lag order

The tests show that we do not have more evidence to reject the Null hypothesis, $p$ >0.05; therefore, the model satisfies normality conditions.

TABLE XVI: EIGEN VALUES STABILITY CONDITION

| Eigenvalue | Modulus |
|---|---|
| 0.5447173 | 0.544717 |
| -0.4441132 | 0.444113 |

All eigenvalues lie inside the unit circle, VAR satisfies stability conditions

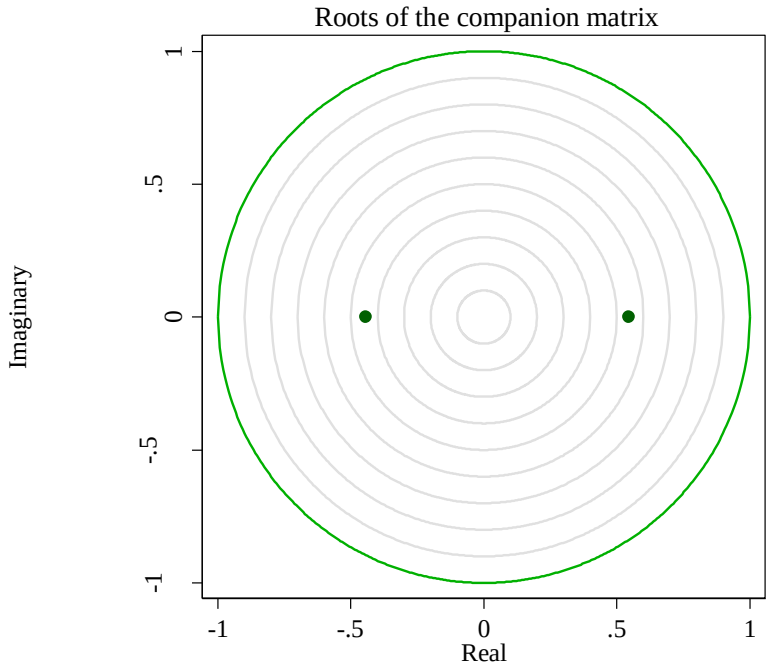



FIGURE 12. VAR STABILITY

The graph above shows that the eigenvalue lies inside the unit circle, which means the model is stable.

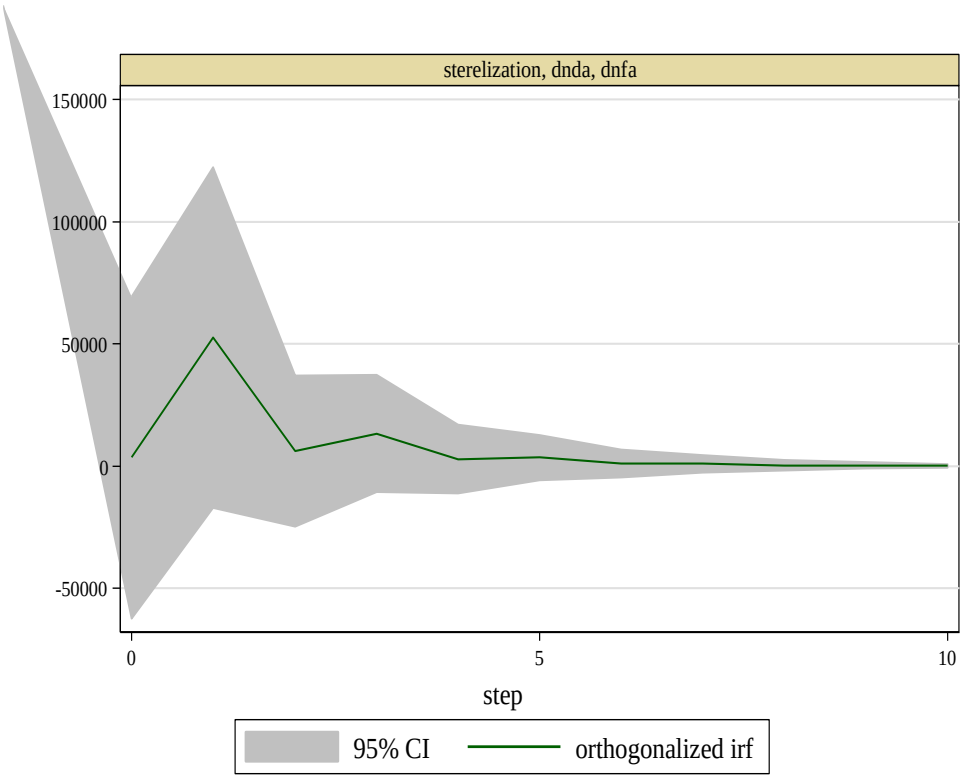



FIGURE 13. IMPULSE RESPONSE FUNCTION OF NDA FROM THE SVAR MODEL

From Figure 13, the unexpected (orthogonalized) shock to the net foreign assets has temporary effect on the net domestic assets. The shock leads to an increase in net domestic assets up the 2nd year and then starts to decrease and eventually dies out. This is due to the fact that the structural VAR model has a time invariant mean and finite and time-invariant variance that is why the effect of a shock to net domestic asset must die out so that the variable can revert to its mean which means that, shock of sterilization is temporary to the economy.

## CONCLUSION AND POLICY IMPLICATIONS

This study investigated the impact of international capital flows and other macroeconomic fundamentals on the real exchange rate in Tanzania. Different from other studies, this study used cointegrated VAR and structural VAR for testing the hypotheses specified in the study. The econometric results suggested the presence of long run equilibrium relationships among the variables in the model. The Vector Error Correction model is useful as it showed both the interaction of the short run and long run effects of the variables used in the model especially when looking for the effects of the determinant

of real exchange rate. In general, the study rejected the hypothesis of positive effects of foreign direct investment and foreign aid being offset by exchange rate appreciation. It showed that even though the positive effects are being at least partially offset by appreciation in the short term the error correction terms brings them back to their initial equilibrium by depreciating the real exchange rate back toward its original level.

The study described several determinants of real exchange rate. These are terms of trade, government consumption, foreign direct investment, productivity and foreign aid. These determinants of the exchange rate have different mechanisms for how they affect the exchange rate. Therefore, it is very important for policy makers in LDCs to know the direction of the exchange rate changes given the determinants.

The empirical analysis of this study provided evidence that the variables are integrated of order one as various forms of the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests indicated. On this basis, the Johansen and Juselius (1988, 1992) cointegration test was employed, and results from the trace and maximum eigenvalue tests rejected the null hypothesis of no cointegration. This implies that the variables used in the model have long run equilibrium relationships from which they may deviate in the short run, but will be returned to in the long run. The empirical results for the magnitude of coefficients from the long run cointegration equation indicated that a 1% increase in foreign aid appreciates the currency by 2.88%; while a 1 unit increase in foreign direct investment appreciates the currency by 4.7%. On the other hand, the error correction terms as speed of adjustment were 27.76% and 29.19% which have the right sign and are significant this implies that it may take up to three years to return back to its initial equilibrium, that is return to the long run equilibrium relationship. The negative signs of the speed of adjustment imply that in the long run, the value of the currency depreciate after the initial appreciations. The model forecast using a dynamic forecast with five year steps out of sample showed that the currency value depreciates back to its initial level.

Investigating whether the Central Bank could maintain monetary independence the study provided empirical evidence of sterilization in the economy under the sample period, 1970-2009. Empirical estimation of the structural VAR showed almost a complete sterilization in the economy. Recovering the coefficient of the net foreign assets we found that the coefficient of the net foreign assets was 94.2% implying an almost complete sterilization of the foreign assets. The high sterilization showed the ability of countering the effect of the money supply caused by the balance of payment changes, for instance to hold the domestic money supply unchanged due to the inflows of the foreign direct investment and foreign aid. The process involved domestic asset transactions that restored the monetary base to its original size.

One of the policy implications is that given the current economic integration or globalization, international capital flow is very important in supplementing resources to less developed countries. The models used in the study clearly showed that in the short-run the exchange rate appreciates; however, with the rapid speed of adjustment, there is a tendency for the exchange rate to depreciate, returning to its initial long-run equilibrium. This implies that international capital flow when appropriately managed may not hurt the economy, hence bringing development and growth to the economy. In this respect, less developed countries should not disengage themselves from globalization for the need of external resources. Therefore, they should continue to search for international (external) resources with low cost financing in order to reduce the resource gap by augmenting their domestic resources.

While this study used time series analysis, a possible future study is that researchers should attempt to use panel data which gives a large sample to investigate the impact of international capital flows especially foreign aid and foreign direct investment for the East African Community.

## REFERENCES

Adam, C. (1992). Recent Developments in Econometrics Methods: An Application to the Demand for Money in Kenya. AERC special paper 15 (September).

Adeleke, S. (2006). Impact of Exchange Rate on Foreign Private Investment in Nigeria. http://bai2006.atisr.org/CD/Papers/2006bai6406.doc (April 10, 2012).

Ahn, G. (2009). Looking for the Balassa-Samuelson Effect in Real Exchange Rate Changes. Journal of Economic Research, 14, 219-237.

Ahlquist, S. J. (2006). Economic Policy, Institutions, and Capital Flows: Portfolio and Direct Investment Flows in Developing Countries. International Studies Quarterly, 50, 681-704.

Aiyar, S. Berg, A. & Hussain, M. (2008). The Macroeconomic Management of Increased Aid: Policy Lessons from Recent Experience. World Institute for Development Economic Research (UNU-WIDER) Working Papers RP2008/79.

Aizenman, J. & Glick, R. (2008). Sterilization, Monetary Policy, and Global Financial Integration. Mimeo, In: University of California, Santa Cruz.

Alexander, C. (2001). Market Models: A Guide to Financial Data Analysis. John Wiley & Sons Ltd.

Aremu, J. A. (1997). Foreign Private Investment: Determinants, Performance and Promotion. CBN Bulletin, 108-112.

Baffes, J., Elbadawi, I. & O'Connel, S. (1999). Single Equation Estimation of the Equilibrium Real Exchange Rate. In: Exchange Rate Misalignment, Concepts and Measurements for Developing Countries, eds. Hinkle, L and Montiel, P, J. A World Bank Research Publication: Oxford University Press.

Barkardzhieva, D., Naceur, S. & Kamr, B. (2010). The Impact of Capital and Foreign Exchange Flows on the Competitiveness of Developing Countries. IMF working Paper 154.

Bernanke, B. S. (1986). Alternative Explanation of the Money-Income Correlation, Carnegie-Rochester Conference Series on Public Policy Autumn, 49-100.

Blanchard, O. J. & Watson, M. W. (1986). Are Business Cycles All Alike? In: The American Business Cycle, eds. Robert J. Gordon. University of Chicago Press.

Blanchard, O. J. & Quah, D. (1989). The Dynamic Effects of Aggregate Demand and Supply Disturbances. American Economic Review, 655-673.

Buffie, E., Adam, C., O'Connell, S. & Pattillo, C. (2004). Exchange Rate Policy and the Management of Official and Private Capital Flows in Africa. IMF Staff Papers, 51, Special Issue, 126-160.

BOT. (1994). Inflation in Tanzania. Paper presented in the 8th conference of Financial Institutions Arusha, 5th-7th December.

Box, G. & Jenkins, G. (1976). Time Series Analysis, Forecasting, and Control.San Francisco, California: Holden Day.

Combes, J-L., Kinda, T. & Plane, P. (2012). Capital Flows, Exchange Rate Flexibility, and the Real Exchange Rate. Journal of Macroeconomics, 34, 1034-1043.

Corden, W. M. & Neary, P. (1982). Booming Sector and De-Industrialization in Small Open Economy. Economic Journal, 92, 825-848.

Cushman, D. & Zha, T. (1997). Identifying Monetary Policy in a Small Open Economy under Flexible Exchange rates. Journal of Monetary Economics, 39, 433-448.

Dickey, D. & Fuller, W. (1981). Likelihood Ratio Statistics of Autoregressive Time Series with Unit Root Test. Econometrica, 49, 1057-1072.

Dornbush, R. (1998). Capital Controls: An Idea Whose Time Is Past. Should the IMF Pursue Capital-Account Convertibility?. Essays in International Finance, Ed. by Stanley Fischer et al., 207.

Edwards, S. (1994). Real and Monetary Determinants of the Real Exchange Rate Behavior: Theory and Evidence from Developing Countries. In: Estimating Equilibrium Exchange Rates, (Eds.) Williamson, J. Institute for International Economics.

Elbadawi, I. & Soto, R. (1994). Capital Flows and Long-Term Equilibrium Real Exchange Rates in Chile. The World Bank 1306.

Enders, W. (2010). Applied Econometric Time series. Hobeken, NJ: John Wiley.

Falck, H. (1992). Foreign Aid and Dutch Disease: The case of Tanzania. Minor Field Study series 23: Economics Department, University of Lund.

Engle, R. F. & Granger, C. W. J. (1987). Cointegration and Error Correction: Representation, Estimation and Testing. Econometrica, 55, 251-276.

Gulhati, R., Swadesh, B. & Vimal, A. (1985). Exchange Rate Policies in Eastern and Southern Africa. World Bank staff working paper 720.

Gupta, S., Powell, R. & Yang, Y. (2006). Macroeconomic Challenges of Scaling up Aid to Africa: A Checklist for Practitioners. International Monetary Fund, Washington D.C.

Harris, D. (1995). Using Co-integration Analysis in Econometric Modeling. Prentice Hall.

Hendry, D. & Juselius, K. (2001). Explaining Cointegration Analysis: Part II. The Energy Journal, 22, 75-120.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. Journal of Economic Dynamics and Control, 12, 231-254.

Johansen, S. & Juselius, K. (1992). Testing Structural Hypothesis in a Multivariate Co-integration Analysis of the PPP and UIP for the UK. Journal of Econometrics, 53, 211-244.

Keating, W. J. (1992). Structural Approaches to Vector Autoregression. Federal Reserve Bank of St. Louis Review, September, 37-57.

Lartey, E. (2007). Capital Inflows and the Real Exchange Rate: An Empirical Study of Sub-Saharan Africa. The Journal of International Trade & Economic Development, 16, 337-357.

Li, Y. & Rowe, F. (2007). Aid Inflows and the Real Effective Exchange Rate in Tanzania. The World Bank (December).

Lipumba, I. (1991). Reflections on Economic Development: The Tanzanian Experience. Uchumi, 2 (January).

Martinez-Hernandez, F. (2010). An Alternative theory of Real Exchange Rate Determination: Theory and Empirical Evidence for the Mexican Economy, 1970-2004. Inv. Economics, 69, 55-84.

Martins, P. (2006). Aid Absorption and Spending in Africa: A Panel Cointegration Approach. University of Nottingham, CREDIT, WP No. 10/06.

McNorm, R. & Wallace, M. S. (1989). International Price Levels, Purchasing Power Parity and Co-integration: A Tests of 4 High-inflation Economies. Journal of International Money and Finance, 8, 533-545.

Mwachakwu, J. (2008). Foreign Aid Inflows and the Real Exchange Rate in Sub-Saharan Africa. Quantitative and Qualitative Analysis in Social Science, 2, 95-106.

Nyoni, T. (1998). Foreign Aid and Economic Performance in Tanzania. World Development, 26, 1235-1240.

Opoku-Afari, M., Morrissey, O. & Lloyd, T. (2004). Real Exchange Rate Response to Capital Inflows: A Dynamic Analysis for Ghana. University of Nottingham, CREDIT, WP No 04/12.

Osinubi, T. & Amaghionyeodiwe., L (2010). Foreign private investment and Economic Growth in Nigeria. Review of Economic and Business Studies, 3, 105-127.

Ouattara, B. & Strobl, E. (2004). Foreign Aid Inflows and the Real Exchange Rate in the CFA Franc Zone. University of Nottingham, CREDIT, WP No. 04/07.

Pilbeam, K. (2006). International Finance. New York. New York, NY: Palgrave Macmillan.

Powell, R., Gupta, S. & Yang, Y. (2005). The Macroeconomic Challenges of Scalling Up Aid to Africa. IMF Working Paper, WP/05/179l.

Rousseau, P. L. & Wachtel, P. (1998). Financial Intermediation and Economic Performance: Historical Evidence from Five Industrialized Countries. Jouranl of Money, Credit and Banking, 30, 657-678.

Rutasitara, L. (2004). Exchange Rate Regimes and Inflation in Tanzania. The African Economic Research Consortium.

Sackey, H. (2001). External Aid Inflows and the Real Exchange Rate in Ghana. The African Economic Research Consortium.

Sims, C. A. (1986). Are Forecasting Models Usable for Policy Analysis?. Federal Reserve Bank of Minneapolis Quarterly Review, (Win), 2-16.

Sims, C. A, Stock, J. H. & Watson, M. W. (1990). Inference in Time Series Models with Some Unit Roots. Econometrica, 58, 113-144.

Skrabic, B. & Tomic-Plazibat, N. (2009). Evidence of the Long-run Equilibrium between Money Demand and Determinants in Crotia. International Journal of Human and Social Sciences, 4(16), 1177-1181.

Tanzania Investment Report. (2009). Report on Foreign Private Investment in Tanzania.

Tareq, S. (2007). Managing Scaled-up Aid. http://www.imf.org/external/pubs/ft/survey/so/2007/POL0720B.htm (October, 2012).

United Nations Development Programme, UNDP. (2011). Towards Human Resilience: Sustaining MDG Progress in an Age of Economic Uncertainty. http://www.undp.org/content/dam/undp/library/Poverty%20Reduction/Towards_SustainingMDG_Web1005.pdf (February 5, 2013).

Van Wijnbergen, S, & Edwards, S. (1989). Disequilbirium and Structural Adjustment . In: Handbook of Development Economics, 2, 1481-1533 (Eds.) Chenery, H and Srinivasan, T. N.

Verbeek, M. (1997). A Guide to Modern Econometrics. New York: John Wiley & Sons.

White, H. & Wignaraja, G. (1992). Exchange Rates, Trade Liberalization and Aid: The Sri Lankan Experience. World Development, 20, 1471-1480.

Willett, D. T., Ouyang, A. & Rajan, R. (2007). China as a Reserve Sink: The Evidence from Offset and Sterilization Coefficients. Hong Kong Institute of Monetary Research, 10.

Willett, D. T., Li, L. & Zhang, N. (2011). A survey of measurement of interdependence. Claremont Institute for Economic Policy Studies.

# APPENDICES

## Appendix A

TABLE *(A)*. DIFFERENT COMBINATIONS IN RESPONSE TO SCALING UP FOREIGN AID

| | **Absorbed** | **Not absorbed** |
|---|---|---|
| **Spent** | Government spends aid<br>Central bank sells foreign exchange<br>Current account widens | Fiscal deficit widens<br>Central bank does not sell foreign exchange<br>International reserves are built up<br>Inflation increases |
| **Not spent** | | |
| | Government expenditure are not increased<br>Central Bank sells foreign exchange<br>Monetary growth is slowed, nominal exchange Rates appreciate, inflation is lowered | Government expenditure are not increased<br>Taxes are not lowered<br>international reserves are built up |

*Source*: Gupta et al., (2006) and Martins (2006).

**Different forms of data transformation**

$$TOT = \frac{P_x}{P_m} \quad \text{(A.1)}$$

where$P_x$ is the foreign price of exports and $P_m$ is the foreign price of imports

$$GCON_t = \frac{GC_t}{GDP_t} \quad \text{(A.2)}$$

given that *GC* is total government expenditure and *GDP* is gross domestic product.

## Appendix B

TABLE XVII. RESPONSE OF THE REAL EXCHANGE RATE TO SHOCKS

| Period | L_GCONS | FDI | L_RGDPCAP | L_AID |
|---|---|---|---|---|
| 1 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | -0.0278 | 0.0161 | -0.0080 | 0.0124 |
| 3 | -0.0606 | 0.0122 | -0.0142 | 0.0233 |
| 4 | -0.0677 | 0.0042 | -0.0044 | -0.003 |
| 5 | -0.0877 | 0.0184 | 0.0043 | -0.022 |
| 6 | -0.1021 | 0.0248 | 0.0142 | -0.023 |
| 7 | -0.0945 | 0.0172 | 0.0159 | -0.028 |
| 8 | -0.0901 | 0.0169 | 0.0176 | -0.037 |
| 9 | -0.0870 | 0.0194 | 0.0208 | -0.041 |
| 10 | -0.0805 | 0.0184 | 0.0202 | -0.041 |

Cholesky ordering: L_REER, L_GCONS, FDI L_RGDPCAP, L_AID

TABLE XVIII. FORECAST ERROR VARIANCE DECOMPOSITION

| Period | S.E. | L_REER | L_GCONS | FDI | L_RGDPCAP | L_AID |
|---|---|---|---|---|---|---|
| 1 | 0.108 | 100.00 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 0.173 | 95.84 | 2.566 | 0.863 | 0.217 | 0.513 |
| 3 | 0.221 | 88.074 | 9.103 | 0.836 | 0.549 | 1.435 |
| 4 | 0.247 | 82.934 | 14.73 | 0.696 | 0.470 | 1.162 |
| 5 | 0.273 | 74.611 | 22.31 | 1.022 | 0.410 | 1.645 |
| 6 | 0.298 | 65.495 | 30.39 | 1.546 | 0.570 | 1.993 |
| 7 | 0.317 | 59.111 | 35.89 | 1.668 | 0.759 | 2.566 |
| 8 | 0.333 | 53.819 | 39.85 | 1.771 | 0.968 | 3.581 |
| 9 | 0.348 | 49.393 | 42.70 | 1.932 | 1.243 | 4.726 |
| 10 | 0.361 | 46.08 | 44.64 | 2.056 | 1.470 | 5.740 |

Cholesky ordering: L_REER, L_GCONS, FDI L_RGDPCAP, L_AID

Journal of Applied Economics and Business

OPEN ACCESS ARTICLE

# GREEN SOLUTION FOR CLEAN ENVIRONMENT: THE CASE OF SKOPJE, MACEDONIA

*Biljana Petrevska*[1*], *Vlatko Cingoski*[2]

[1]Faculty of Tourism and Business Logistics, University Goce Delcev - Stip, Macedonia

[2]Faculty of Electrical Engineering, University Goce Delcev - Stip, Macedonia

*biljana.petrevska@ugd.edu.mk

***Abstract***

*Many countries face environmental problems along with traffic jams, over-crowded traffic and poor public transportation system. The paper elaborates a project idea of introducing a new sustainable city transport in the capital of Macedonia, based on light and electricity driven monorail system. Yet, the research does not attempt to provide a detailed map applicable to solve pollution problems of Skopje, but rather to suggest framework for serious consideration for answering profound issues, like the nature of urban air pollution, pollution sources, and available resources. Moreover, the study posts some valuable recommendations for developing monorail as probably the only permanent solution that may improve environmental footprint of Skopje. By following many positive world-wide examples, the paper proposes a scheme in which local and central policy makers may approach in selection and implementation of internationally based experiences. It places a special emphasis on how to coordinate policies across many sectors that are closely linked to the mitigation of air pollution from city urban transport, in the first line environment, transport, and energy. Greater use of public transport offers a single most effective strategy currently available for achieving significant energy savings and environmental gains, without creating new government programs or imposing new rules on the private sector. Consequently, Skopje may have fast, reliable, modern, ecologically friendly and long-term sustainable city transport.*

***Key words:***

*Energy; Clean environment; Monorail.*

## INTRODUCTION

Monorail (MR) is a modern, economical and environmentally friendly, fast and widely-used way for urban transport, particularly applicable for large city environments. Many countries worldwide apply this way of urban transport due to many advantages that it

has. Today, such systems are widely used in almost all major world cities in the United States, Japan, Germany, Australia, France, Sweden, South Korea, Taiwan, Canada, China, etc.

Up-to-date, various models of new city transportation system have already been discussed, such as the gasification of the buses and/or procurement of new electric buses, up to introducing trolleybuses or even trams. However, so far, no model has been introduced or even deeper investigated. Some are just make-up solutions (gasification), others are not suitable due to existing overcrowded city structure and its geographical characteristics (trams), or their implementation needs totally new and expensive infrastructure that leads to additional traffic congestions (trolleybus and tram). Introduction of a subway was quickly rejected due to extremely high investment cost and lack of feasible number of passengers (needs > 20,000 passengers/hour) to justify such high investment costs, make it cost-effective and evaluate properly the possible alternatives (Azar et al., 2003; Kato, et al., 2004; Tzeng & Shiau, 1987).

By introducing an intelligent energy system for efficient energy processes and mitigation technologies for the reduction of environmental pollutants, many positive environmental, social and economic impacts arise (Barrero et al., 2008; Ozzie, 2012; Yann, 2015). The most targeted measures to reduce pollution should be aimed at transportation emissions since the energy use and greenhouse gas (GHG) emissions are closely related when considering public transport as a major element of urban development (Norman et al., 2006; Schipper et al., 1992). Furthermore, there is an inevitable link between transport, energy and urban form as part to create sustainable cities (Banister et al., 1997; Næss et al., 1996; Shapiro et al., 2002; Thackeray et al., 2012).

This paper elaborates a project idea of introducing a new sustainable city transportation model based on light and electricity driven MR system for the city of Skopje, Macedonia. As a city which has been consecutively ranked as one of the most polluted in the world, Skopje is faced with rapid life quality reduction, along with aggravated potentials for public transportation and commuting within the city.

## BACKGROUND MATERIAL

From a technological viewpoint, the MR may be considered as long electricity driven bus that moves along a single rail above the ground. MR tracks are usually not more than half the width of the vehicle, which means for safety reasons, a monorail vehicle has to be internally stabilized to prevent its lateral overturning. Thus, due to its narrow rails, these systems provoke less negative economic and environmental impacts compared to light or heavy rail systems. Commercially, there are three major MR types: (i) Monorails that envelope/straddle a track (Figure 1); (ii) Monorails that run on top of a track or a slab at

the surface (Figure 2); and (iii) Suspended monorails under a track which is above the vehicle and the propulsion motors and bogies are on the top of the vehicles (Figure 3).

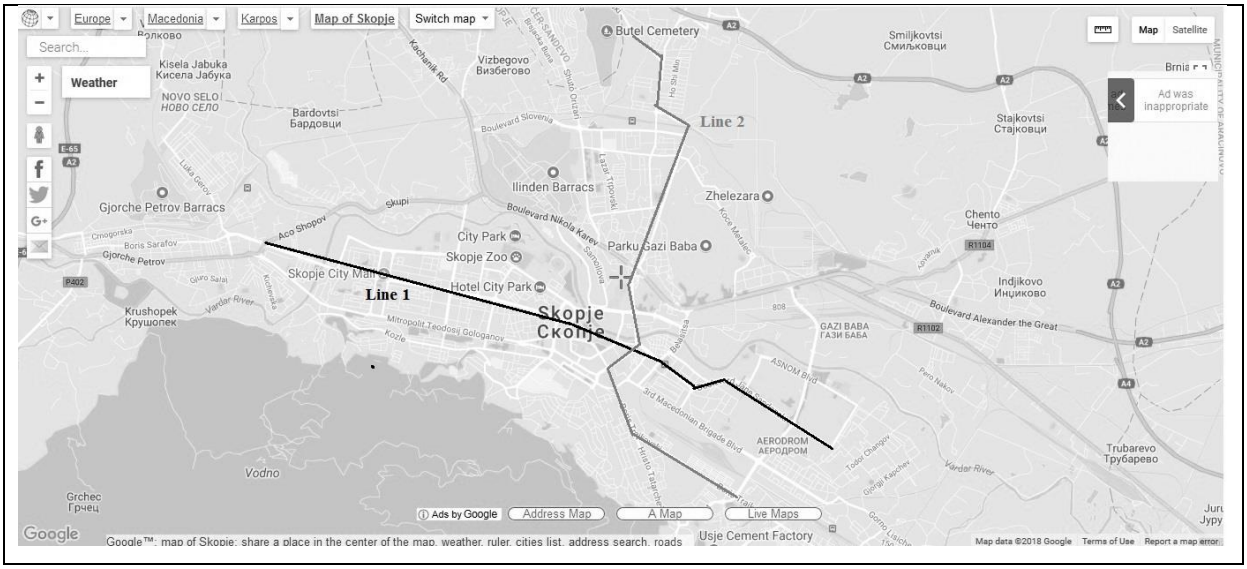
FIGURE 1. STRADDLE TYPE OF MR STRUCTURE

FIGURE 2. URBANAUT TYPE OF MR STRUCTURE

FIGURE 3. SUSPENDED TYPE OF MR STRUCTURE

## PROJECT IDEA FOR MONORAIL IN SKOPJE

Based on desk research and taking into consideration the location of Skopje, the average number of potential passengers, as well as the location of various strategic urban units, the research revealed possibility of proposing construction of two perpendicularly positioned MR lines.




Legend:
____ Line 1 (Gjorce Petrov to Novo Lisice)
------ Line 2 (11 October to central Cemetery)

FIGURE 4. PROPOSED MR LINES FOR SKOPJE
*Source*: Adopted according to (Cingoski & Petrevska, 2018: 426).

Figure 4 presents two MR lines, whereas:

- Line 1 may start from the municipality of Gjorce Petrov to Novo Lisice, with future potential line extensions to the municipality of Saraj and the recreation center Matka on one side, and the Skopje International Airport on the other side; and
- Line 2 may start from the suburbs of October 11, through Kisela Voda and the Koco Racin Boulevard towards the municipality of Chair and Butel, ending in the vicinity of the Skopje central Cemetery.

By constructing such MR transport system, Skopje may cover almost 70% of its city public transportation needs, with just two MR lines. In a case of a construction with a total length of approximately 16 km, some initial projection of financing may be calculated. So, for a single line, the cost may be around 120 mil. EUR, while for a dual line 220 mil. EUR.

These lines will be the backbone of the whole future MR public transportation system for the capital city. This study recommends to be constructed as dual lines allowing passengers commuting in both directions, as well as enabling further extension of the system with other single MR lines to other areas. In the first phase, all stations of the MR system may be well connected with other city suburb areas that already have active bus lines. This will support utility and increase number of passengers for the MR system at least for additional 50%, thus achieving usage rate of more than 10,000 passengers/hour.

By achieving this, the project feasibility might be undoubtedly improved. Hence, the projections for expected number of passengers may expand to approximately 65 million/year, allowing the average price of at least 1 EUR per single use.

However, more detailed feasibility analysis is required, leading to financial justification, whereas, everything that may result in investments return rate under 12 years, is strongly acceptable. Due to general fact that construction costs for MR is heavily depended on many issues (like: total length of the system, terrain topography, location and current utilities, passengers' requirements, speed, number of stopping stations, etc.), it is necessary for the case of Skopje to make more in-depth feasibility analysis.

## BENEFITS OF MR FOR SKOPJE

By constructing elevated MR transportation structure, Skopje may benefit in multiple ways since it provides many advantages, such as:

- It occupies less space, provides better traffic safety, and it is faster and more secure;
- It is relatively cheap, easy operational and straightforward for maintenance, and since it uses concrete or metal tracks, provides fast and simple driving;
- Since it is electrical, it is almost noiseless, environmentally highly acceptable and recommended for very densely populated central city core;
- It is fully "green" thus saving lot of pollutant's emissions and being fully applicable for Skopje;
- It may be easily accommodated within the current public transport; and
- It allows to keep green areas under the tracks which will give additionally environmentally friendly footprint to Skopje.

## CONCLUDING REMARKS

The study does not attempt to provide a detailed map applicable to solve pollution problems of Skopje, but rather to suggest framework for serious consideration for answering profound issues, like the nature of urban air pollution, pollution sources, and available resources. Moreover, it intends to propose some scheme in which local and central policy makers may approach to identify a solution based upon international experience. The research findings revealed that greater use of public transportation offers single most effective strategy currently available for achieving significant energy savings and environmental gains, without creating new government programs or imposing new rules on the private sector.

By proposing a monorail powered vehicles as efficient public transportation system, Skopje may significantly reduce emissions and achieve pollution reduction. Although being defined as an expensive alternative, MR massively declines the lifecycle GHG emissions. Only with two suitably designed MR lines of about 16 km, almost 70% of all city public transportation needs might be accommodated. Since it will be positioned above the ground level, Skopje may gain more green areas, parks, bicycle tracks and parking spots thus enabling environmental improvement. Yet, the proposed project requires considerable economic policy dimension that is heavily dependent on cost-benefit analysis. Hence, the capital city of Skopje must design and adopt air pollution strategy appropriate to its own circumstances. Namely, environmental and ecological impacts are important, but are only one aspect of urban transport policy, vis-à-vis economic, financial, social and distributional concerns which also come into play.

## REFERENCES

Azar, C., Lindgren, K. & Andersson, B. A. (2003). Global energy scenarios meeting stringent $CO_2$constraints-cost-effective fuel choices in the transportation sector. Energy Policy, 31(10), 961-976.

Banister, D., Watson, S. & Wood, C. (1997). Sustainable cities: transport, energy, and urban form. Environment and Planning B: Planning and Design, 24, 125-143.

Barrero, R., Van Mierlo, J. & Tackoen, X. (2008). Energy savings in public transport. IEEE Vehicular Technology Magazine, 3(3), 26-36.

Cingoski, V. & Petrevska, B. (2018). A new long-term sustainable public transportation system for the city of Skopje, Proceedings from the 26th International Conference Ecological Truth & Environmental Research, Bor, Serbia, 12-15 June, 2018, 422-428.

Kato, M. et al. (2004). Straddle-type Monorail Systems with Driverless Train Operation System. Hitachi Review, 53(1), 25-29.

Norman, J., MacLean, H. & Kennedy, C. (2006). Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions. Journal of Urban Planning and Development, 132, 10-21.

Næss, P., Sandberg, S. & Røe, P. G. (1996). Energy use for transportation in 22 Nordic towns. Scandinavian Housing and Planning Research, 13(2), 79-97.

Ozzie, Z. (2012). Green illusions: the dirty secrets of clean energy and the future of environmentalism, University of Nebraska Press, Lincoln and London.

Shapiro, R., Hassett, K. & Arnold, F. (2002). Conserving energy and preserving the environment: the role of public transport, Report for the American Public Transport Association.

Schipper, L., Steiner, R., Duerr, P., An, F. & Strøm, S. (1992). Energy use in passenger transport in OECD countries: Changes since 1970. Transportation, 19(1), 25-42.

Tzeng, G-H. & Shiau, T-A. (1987). Energy conservation strategies in urban transportation. Energy Systems and Policy, 11, 1-19.

Thackeray, M., Wolvertonb, C. & Isaacs, E. (2012). Electrical energy storage for transportation-approaching the limits of, and going beyond, lithium-ion batteries. Energy & Environmental Science 5(7), 7854-7863.

Yann, J. (2015). Handbook on clean energy systems. John Willey & Sons.

Journal of Applied Economics and Business

OPEN ACCESS ARTICLE

# Stock Movement Prediction Based on Social Media Sentiment Analysis

Aleksandar Dodevski, Natasa Koceska, Saso Koceski

Faculty of Computer Science, University Goce Delchev, Stip, Macedonia

aleksandar.dodevski@hotmail.com, {natasa.koceska, saso.koceski}@ugd.edu.mk

***Abstract***

Stock prediction is attracting a lot of attention, mainly due the financial gains that may be obtained. However, this is very difficult task and it is very challenging problem that intrigues multiple scientific disciplines such as finance, computer sciences as well as engineering and mathematics. There are many approaches and theories regarding stock movement prediction. In the era of social network and big data, as well as huge speed of news spreading, probably the most interesting are those theories based on social media sentiment analysis. This approach is taking as input non quantifiable data such as financial news articles, social networks posts, or tweeter messages, about a company and predicting its future stock trend with news sentiment classification. Sentiment classification is performed using artificial intelligence algorithms. Main aim of this paper is to give a comprehensive review of current state of the art related to stock movement prediction based on social media sentiment analysis with an emphasis on a Twitter platform.

***Keywords***

*Stock prediction; Social media; Tweeter; Sentiment analysis, Artificial intelligence.*

## INTRODUCTION

The stock market usually refers to the collection of markets and exchanges where the issuing and trading of equities or stocks of publicly held companies, bonds, and other classes of securities take place. This trade is either through formal exchanges or over-the-counter (OTC) marketplaces.

Also known as the equity market, the stock market is one of the most vital components of a free-market economy. It provides companies with access to capital in exchange for giving investors a slice of ownership.

The stock market is a playground where investors can make profit or loss. During time investors have formed various strategies with the intention to beat the market. The outcomes and final results of these strategies differ widely, yet overall profits should correspond to the outcome of zero-sum game, i.e. that the total sum of winnings and losses of various market players is always equal to zero. There is no way to create a perfect deterministic mathematical

model that will help in finding the best time to buy or sell the stocks, because there are too many independent variables and other numerous factors influencing stock prices, that simply can't be taken into account.

Stock prediction has remained a very difficult task and it is still very challenging problem that intrigues multiple scientific disciplines such as finance, computer sciences as well as engineering and mathematics. Due to its financial gain, it has attracted much attention both from academic and business community. They analyze the market movements and plan their trading strategies on top of it. Considering the fact that the stock market delivers huge amount of data on a daily basis, it is becoming almost impossible task for an individual to consider all the current and past information in order to forecast future behavior of a stock. In the literature, two different approaches for market trends prediction, are published up to date. The first one is named "technical analysis" and other one "fundamental analysis". In order to predict the future trends technical analysis takes into account past price and volume data. In contrary, fundamental analysis is performing detailed analysis of the business itself including its financial data in order to get some insights. There is a theory and hypothesis that argues about the results obtained by both types of analysis, and this hypothesis is called efficient-market hypothesis (EMH). Following this hypothesis, securities markets are extremely efficient in reflecting information about individual stocks and about the stock market as a whole (Marwala and Hurwitz, 2017). The main idea upon which this hypothesis is based, starts from the fact that when information arises, the news travels quickly and it influencing the prices of stocks and securities almost without any delay. Therefore, neither technical analysis, nor even fundamental analysis, would enable an investor to achieve returns greater than those that could be obtained by holding a randomly selected portfolio of individual stocks, at least not with comparable risk (Marwala and Hurwitz, 2017). The EMH is following the so called "random walk" patterns, which as a word is used in the economy and finance sector to describe economic data series where all subsequent data variations represent random departures from previous. The logic of the random walk idea is that if the flow of information is unimpeded and information is immediately reflected in stock prices, then tomorrow's price change will reflect only tomorrow's news and will be independent of the price changes today (Marwala and Hurwitz, 2017). But, news as a concept and their pathways of spreading is by definition are unpredictable, and, therefore, consequent price changes should also be unpredictable and random. Due to this, market prices should completely reflect all known information, and even uninformed investors buying a diversified portfolio at the tableau of prices given by the market will obtain a rate of return as generous as that achieved by the experts (Marwala and Hurwitz, 2017).

However, some research has successfully challenged the efficient market hypothesis by investigating stock markets in some countries, e.g. (Butler and Malaikah, 1992) and attempted to extract patterns in the way stock markets behave and respond to external stimuli.

In the year 2008, the last and the most violent stock market crash took place in United States. On September 20, 2008, the bank bailout bill (Emergency Economic Stabilization Act of 2008) to Congress. The DJIA fell 777.68 in intra-day trading. That was the largest point drop in any single day in history. The month started with the news of Lehman Brothers being declared bankrupt, which took place on September 15, 2008. The Dow dropped 504.48 points.

The Dow hit its pre-recession high on October 9, 2007, closing at 14164.43. Less than 18 months later, it had dropped more than 50 percent to 6594.44 on March 5, 2009 (Temin, 2010).

There had been a lot of speculation and predictions about this great recession by the economists. Apart from the economists, people can now discuss about these issues over the internet and share ideas and feelings. Behavioral economics suggests that the decision-making process of individual mostly depends on his/her emotional or sentimental state.

Information has always been important playing a role building market perception and market investment. In digital era of information and social networks, we can access all sorts of information from any sources easily. Today one of the big information sources is social media that include Twitter.

Twitter, which also features the tag "microblogging site", is such a social networking site in action since 2006. 100 million active Twitter users update nearly 500 million tweets every day. Users express their opinion, decisions, feeling etc. through these tweets. As time passed, Twitter is being used as a tool to share important information rather than casual tweets. Twitter as a social media has a huge implication with rapid and sensitive reaction to political, social, and economic issues. Sharing tweeter messages is involving huge number of people that are tweeting stock related messages that contain information about stocks market and news about updates. As a consequence, Twitter as one of popular social media, can be a valuable source of information in predicting stock market trends based on people's sentiment.

Main aim of this paper is to give a comprehensive review of current state of the art related to stock movement prediction based on social media sentiment analysis with an emphasis on a Twitter platform.

## SOURCES OF DATA

As stated by (Blume, Easley and O'hara, 1994) technical analysts believe that future price movements can be predicted by analyzing price and volume data. (Pring, 1991) details the use and the role of technical analysis in his work. However, the accuracy of this technique is discussed controversially by economists and is considered to be less successful by (Gidófalvi and Elkan, 2001).

Financial news articles are considered as the major source of market information for investors. (Cecchini et. al., 2010) found that financial news can have the power to predict financial events (i.e. bankruptcy and fraud). Thus, many researchers have tried to figure out if one can transfer this predictive power to the stock markets. (Wüthrich et. al., 1998) managed to achieve an accuracy of 45% on predicting the direction of the Dow Jones Industrial Average using online

financial news. They created a system that uses a three class prediction (up, down or steady) based on old financial news texts combined with previous stock values as a training set.

(Schumaker and Chen, 2009) achieved a predictive power of 58% on values of the S&P 500 stock index using a similar training set as described by Wüthrich et. al. to train Support Vector Machines. They found that extracting nouns from news texts leads to a more accurate result compared to a bag-of-words representation. (Ammann, Frey and Verhofen, 2014) examined the Handelsblatt, a leading German financial newspaper, and stated that newspaper content in general do have the power to predict future price movements. They used the DAX as a target for their predictions. Although, all these researchers stated that news most certainly have influence to the stock market, we must not underrate the effect of public mood stages and sentiment.

Psychological researchers like (Dolan, 2002) state that emotion biases decision making, particularly in making decisions under risk. Naturally, this also affects investors, traders and other financial decision-makers as pointed out by (Nofsinger, 2005). From his investigations, he concluded that the stock market itself is a measure of social mood, whereupon a high (low) stock market level indicates a high (low) social mood. Since the appearance of social media platforms like Twitter it has never been easier to analyze public mood. Nowadays, almost everybody can share his opinion online and researchers are then able to use this data.

(Bollen and Mao, 2011) were able to bring the mood of people posting on Twitter in relation with the behavior of the stock market. They used different tools to classify about ten million collected Twitter messages by approximately 2.7 million users into six stages of mood, namely calm, alert, kind, vital, sure and happy. Then they used the classified Twitter messages combined with the corresponding stock market values (Dow Jones Industrial Average) as training set for a neural network. Their model achieved an accuracy of 86.7%.

## DATA VARIABLES

### *Dependent variables*

Stock data have several interesting values to investigate. In most cases, several dependent variables are observed such as stock's closing price or adjusted closing price, which is the closing price amended to include dividends and other distributions that occurred before. Some authors tried to use different market levels, considering either individual companies or sectors (Liu, Mao, Wang & Wei, 2012).

The adjusted price is the former price, deducted of the aforementioned dividends and distributions. Among others, Sandner, Sprenger, Tumasjan and Welpe (2010) also have a look at traded volumes, which are more likely to grow with the number of tweets mentioning the stock. Then, some authors try to predict returns and volatility.

Returns are actually natural logarithm returns R of stock prices S(t) over a time interval of one day. This additional operation has several advantages such as normalization of the variations:

$$R_t = \ln(S_{(t)}) - \ln(S_{(t-1)}) \quad (1)$$

Volatility is then calculated on a defined period of time, usually ranging from 10 to 50 days. It takes the standard deviation (sd) of the last n days, pondered by the square root of the total number of days N in the time series. For each data point $X_t$ and the average $\overline{X}$ the standard deviation is computed as follows:

$$sd = \sqrt{\frac{\sum_{t=1}^{n}(X_t - \overline{X})^2}{n-1}} \quad (2)$$

Then naturally, volatility at time t is obtained as below for the whole time series at the disposition.

$$Volatility_t = sd * \sqrt{N} \quad (3)$$

The meaning behind volatility is the uncertainty or risk about the scale of change in a stock's value. A high volatility refers to the likelihood for this stock to change significantly in a short period of time in either direction.

Incidentally, the binary variable representing the movements of the stock are rarely compared with twitter data in articles. Earlier studies strictly focused on establishing a relationship between different time series but prediction models are harder to set for non-binary variables as they can take a very wide range of values. Krauss, Nann and Schoder (2013) address these issues by describing returns on investment based on transactions predicted by several sources. However, they mention several limitations which prove that the application to prediction is still experimental in this field.

### *Independent variables*

If the predominance of Twitter can be explained by its research-friendly attributes, some authors still mention other web sources as their text data (Kraus & Nann, 2013; Bollen, Counts & Mao, 2011). Many authors find it reasonable to consider a delay of one day between twitter and stock data but Sandner, Sprenger, Tumasjan and Welpe (2014) also tried a longer delay of two days.

With concern for a methodological approach, studies involving Twitter data usually begin by omitting classification through opinion or sentiment and only count the number of tweets. Liu, Mao, Wang and Wei (2012) investigated the daily number of tweets related to the S&P500 stocks. The advantage of such choice is the simplification of operations by removing a machine learning or manual annotation step of the different tweets at hand. Message volume is obtained

after taking the natural logarithm of the number of tweets. A slight variant of the message volume is the number of users that tweeted and is used notably by Castillo, Gionis, Hristidis, Jaimes and Ruiz (2012).

Nevertheless, such variables are a bit too simple and are not expected to yield robust results in the case of stock movements prediction. Moreover, they are not suited for instigating a relation with bullish or bearish market as they do not provide any opinionated information. Therefore, authors tend to implement specific public mood state in their correlation analysis. The approach can differ in diverse ways but the basic principle remains the same. The point is to use an indicator which depicts the reality with a certain precision.

The most classical time series in this regard is the overall sentiment of tweets. It consists of point data of two or three classes in which tweets are assigned. For instance, a tweet can be positive, negative or eventually neutral regarding the stock studied. Bollen, Mao and Zeng (2011) even enrich this simple reduction of human mood structure by adding other mood dimensions2. Another article by Bollen, Mao and Pepe (2011) tries with other mood states3. But deriving bullishness or bearishness from overall sentiment might be too simplistic for some authors.

Actually, while positive or negative sentiment is linked with past or present transactions, bullishness and bearishness represent belief about the future (Bar-Haim, Dinur, Feldman, Fresko & Goldstein, 2011). This characteristic is far more elusive to determine because the level of significance of tweets relating to the future can change tremendously but if tweets can correctly be assigned, this method is a more realistic view of the relevant variables. Rao and Srivastava (2012) define bullishness B at time t with this equation which comes from the continuation of a previous work from Antweiler and Frank (2004). Where, $M_t^{Positive}$ is the number of positive tweets on day t and $M_t^{Negative}$ the number of negative tweets.

$$B_t = \ln\left(\frac{1+M_t^{Positive}}{1+M_t^{Negative}}\right) \tag{4}$$

Another interesting indicator, which they consider, is the level of agreement A among positive and negative tweets. It takes the value 1 when the tweets are either all bullish or bearish for a time unit measure t and is computed as follows.

$$A_t = 1 - \sqrt{1 - \frac{M_t^{Negative} - M_t^{Positive}}{M_t^{Negative} + M_t^{Negative}}} \tag{5}$$

Finally, Bar-Haim, Dinur, Feldman, Fresko and Goldstein (2011) also speak of the influence of the user's expertise. They assume that similar information does not have the same weight depending on the emitter's expertise in the financial field.

## AI METHODOLOGIES

The growing popularity of the Artificial Intelligence (AI) and its application in various fields (Loshkovska and Koceski, 2015), starting from tourism (Koceski and Petrevska, 2012), through medicine (Trajkovik et al., 2014), (Stojanov and Koceski, 2014), (Koceski and Koceska, 2016), biology (Stojanov et al., 2012), education (Koceski and Koceska, 2013), robotics (Koceski et al., 2012), (Koceski et al., 2014), (Serafimov et al., 2012), (Koceska et al., 2013), and also in economy (Koceski and Koceska, 2014), is mainly due to the apparatus i.e. the models and techniques used to mimic the human reasoning, learn and improve during time.

Although there are highly accurate methods to analyze and extract relevant knowledge from structured data such as tables or databases, the task of extracting useful information from unstructured data like social media data still remains a major challenge (Montoyo et al., 2012). Sentiment analysis, also known as opinion mining, involves the use of natural language processing, text analysis and computational linguistics to identify and extract subjective messages. Generally speaking, sentiment analysis aims to determine the attitude of a speaker or a writer with respect to a known topic or the overall contextual polarity of being a positive or negative contexts of a document.

According to (Vohra and Teraiya, 2013) there are three main categories of sentiment classification approaches:

1. Supervised classification, used for predicting the polarity of sentiments based on a training set. Among the machine learning techniques, classifiers based on Naïve Bayes (NB), maximum entropy (ME), and support vector machines (SVM) usually exhibit the best performance [Vohra and Teraiya, 2013, Kim and Hwang, 2014).

2. Lexicon-based approach. This does not need any prior training in order to mine the data. It uses a predefined list of words, where each word is associated with a specific sentiment.

3. Hybrid approach which combines both machine learning and lexicon based approaches. Mudinas et. al. combined the lexicon based and the machine learning based approaches.

### *Forecasting performance evaluation*

To evaluate the performance of their prediction tools, authors choose to compute different metrics. Deng et al. (2013) plainly compare accuracies of prediction of stock movements from their different VAR models. Many authors also opt for a simple accuracy measure (Krauss, Nann & Schoder, 2013; Liu, Mao, Wang & Wei, 2012; Rao & Srivastava, 2012). While other authors use it in combination with the mean absolute percentage error (MAPE) (Bollen, Counts & Mao, 2011):

$$MAPE \frac{\sum_i^n \left| \frac{a_i - \hat{a}_i}{a_i} \right|}{n} \times 100 \quad (6)$$

where $\hat{a}_i$ is the predicted value of the stock and $a_i$ is the actual one.

## CONCLUSION

The sector of exploiting microblogging for stock predictions is still quite recent and experimental. As a result, we identified some weaknesses among the various articles treating the subject.

To start, all of the studies reviewed are focused on American stock markets. These stocks are highly volatile in nature and it is easier to crawl relevant tweets for them as they can be affected by many actors across the world. This might not hold true for stocks from another origin and especially since there are far more U.S. users than from the rest of the world. American users are expected to be more active as well. In other words, representation of the public mood might be way less accurate for other geographical areas such as Europe.

Another limitation of some articles is the short time span. The longest period considered is 9 months, but most authors limit their analysis to not more than 3 months of data. However, some results of a Granger causality analysis with individual companies' stocks are indeed better with a longer time span.

This could indicate that results with shorter periods are actually pessimistic. Then, the next limitation is about the selection of the time span. The correlation between stock data and Twitter data is clearer when the stocks are submitted to strong variations. It is then tedious to use predictions when the market is not subject to changes. To use tweets relatively safely as an input for stock movements prediction, the investor must be sure that the stocks will move dramatically enough. This raises the question of significance of such predictions.

Finally, there is no systematic testing of correlation between variables and the accuracy measures can be too simplistic. The subject is very experimental in nature and authors usually just check the accuracy of their models without validating formally their assumptions on data. Plain accuracy can be misleading as a bad model can still provide good results in some cases. As a matter of fact, this can lead to biased predictions. Moreover, a model applied to a particular set might give good results but be inefficient in other conditions as the variables such as public mood or stock movements are derived from very complex phenomena difficult to translate into mathematical models.

## REFERENCES

[1] Ammann, Manuel, Roman Frey, and Michael Verhofen. "Do newspaper articles predict aggregate stock returns?." Journal of behavioral finance 15, no. 3 (2014): 195-213.

[2] Blume, Lawrence, David Easley, and Maureen O'hara. "Market statistics and technical analysis: The role of volume." The Journal of Finance 49, no. 1 (1994): 153-181.

[3] Bollen, J., Counts, S. & Mao, H. (2011). Predicting financial markets: Comparing survey, news, twitter and search engine data. arXiv preprint arXiv:1112.1051.
[4] Butler, Kirt C., and S. Jamal Malaikah. "Efficiency and inefficiency in thinly traded stock markets: Kuwait and Saudi Arabia." Journal of Banking & Finance 16, no. 1 (1992): 197-210.
[5] Cecchini, Mark, Haldun Aytug, Gary J. Koehler, and Praveen Pathak. "Making words work: Using financial text as a predictor of financial events." Decision Support Systems 50, no. 1 (2010): 164-175.
[6] Deng, X., Li, H., Li, Q., Liu, B., Mukherjee, A. & Si, J. (2013). Exploiting Topic based Twitter Sentiment for Stock Prediction. ACL (2), 2013, 24-29.
[7] Dolan, Raymond J. "Emotion, cognition, and behavior." science 298, no. 5596 (2002): 1191-1194.
[8] Gidofalvi, Gyozo, and Charles Elkan. "Using news articles to predict stock price movements." Department of Computer Science and Engineering, University of California, San Diego (2001).
[9] Kim, Sukjoong, and Byung-Yeon Hwang. "Propensity analysis of political attitude of twitter users by extracting sentiment from timeline." Journal of Korea Multimedia Society 17, no. 1 (2014): 43-51.
[10] Koceska, Natasa, Saso Koceski, Francesco Durante, Pierluigi Beomonte Zobel, and Terenziano Raparelli. "Control architecture of a 10 DOF lower limbs exoskeleton for gait rehabilitation." International Journal of Advanced Robotic Systems 10, no. 1 (2013): 68.
[11] Koceska, Natasa, and Saso Koceski. "Financial-Economic Time Series Modeling and Prediction Techniques–Review." Journal of Applied Economics and Business 2, no. 4 (2014): 28-33.
[12] Koceski, Saso, and Biljana Petrevska. "Empirical evidence of contribution to e-tourism by application of personalized tourism recommendation system." Annals of the Alexandru Ioan Cuza University-Economics 59, no. 1 (2012): 363-374.
[13] Koceski, Saso, and Natasa Koceska. "Evaluation of an assistive telepresence robot for elderly healthcare." Journal of medical systems 40, no. 5 (2016): 121.
[14] Koceski, Saso, and Natasa Koceska. "Challenges of videoconferencing distance education-a student perspective." International Journal of Information, Business and Management 5, no. 2 (2013): 274.
[15] Koceski, Saso, Natasa Koceska, and Ivica Kocev. "Design and evaluation of cell phone pointing interface for robot control." International Journal of Advanced Robotic Systems 9, no. 4 (2012): 135.
[16] Koceski, Saso, Stojanche Panov, Natasa Koceska, Pierluigi Beomonte Zobel, and Francesco Durante. "A novel quad harmony search algorithm for grid-based path finding." International Journal of Advanced Robotic Systems 11, no. 9 (2014): 144.
[17] Krauss, J., Nann, S. & Schoder, D. (2013). Predictive Analytics On Public Data-The Case Of Stock Markets. In ECIS (p. 102).
[18] Liu, B., Mao, Y., Wang, B. & Wei, W. (2012). Correlating S&P 500 stocks with Twitter data. In Proceedings of the first ACM international workshop on hot topics on interdisciplinary social networks research (pp. 69-72). ACM.

[19] Loshkovska, Suzana, and Saso Koceski, eds. ICT innovations 2015: Emerging technologies for better living. Vol. 399. Springer, 2015.

[20] Marwala, Tshilidzi, and Evan Hurwitz. "Efficient Market Hypothesis." In Artificial Intelligence and Economic Theory: Skynet in the Market, pp. 101-110. Springer, Cham, 2017.

[21] Montoyo, Andrés, Patricio MartíNez-Barco, and Alexandra Balahur. "Subjectivity and sentiment analysis: An overview of the current state of the area and envisaged developments." (2012): 675-679.

[22] Mudinas, Andrius, Dell Zhang, and Mark Levene. "Combining lexicon and learning based approaches for concept-level sentiment analysis." In Proceedings of the first international workshop on issues of sentiment discovery and opinion mining, p. 5. ACM, 2012.

[23] Nofsinger, John R. "Social mood and financial economics." The Journal of Behavioral Finance 6, no. 3 (2005): 144-160.

[24] Pring Martin, J. "Technical Analysis, Explained 'The Successful Investors' Guide to Spotting Investment Trends and Turning Points." (1991).

[25] Rao, T., & Srivastava, S. (2012). Twitter sentiment analysis: How to hedge your bets in the stock markets. In State of the Art Applications of Social Network Analysis (pp. 227-247). Springer International Publishing.

[26] Schumaker, Robert P., and Hsinchun Chen. "Textual analysis of stock market prediction using breaking financial news: The AZFin text system." ACM Transactions on Information Systems (TOIS) 27, no. 2 (2009): 12.

[27] Serafimov, Kire, Dimitrija Angelkov, Natasa Koceska, and Saso Koceski. "Using mobile-phone accelerometer for gestural control of soccer robots." In Embedded Computing (MECO), 2012 Mediterranean Conference on, Bar, Montenegro, pp. 140-143. 2012.

[28] Stojanov, Done, and Saso Koceski. "Topological MRI prostate segmentation method." In Computer Science and Information Systems (FedCSIS), 2014 Federated Conference on, pp. 219-225. IEEE, 2014.

[29] Stojanov, Done, Aleksandra Mileva, and Sašo Koceski. "A new, space-efficient local pairwise alignment methodology." Advanced Studies in Biology 4, no. 2 (2012): 85-93.

[30] Temin, Peter. "The great recession & the great depression." Daedalus 139, no. 4 (2010): 115-124.

[31] Trajkovik, Vladimir, Elena Vlahu-Gjorgievska, Saso Koceski, and Igor Kulev. "General assisted living system architecture model." In International Conference on Mobile Networks and Management, pp. 329-343. Springer, Cham, 2014.

[32] Wüthrich, Beat, D. Permunetilleke, Steven Leung, W. Lam, Vincent Cho, and J. Zhang. "Daily prediction of major stock indices from textual www data." Hkie transactions 5, no. 3 (1998): 151-156.

[33] Vohra, S. M., and J. B. Teraiya. "A comparative study of sentiment analysis techniques." Journal JIKRCE 2, no. 2 (2013): 313-317.