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# EXCHANGE RATE VOLATILITY AS A FUNCTION OF BENEFICIATION

Kabelo Baloyi (Student Number 0606234M)

Supervisor: Professor Christopher Malikane

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## Declaration

I Kabelo Baloyi (student number 0606234M) declare that this research is my original work, it has not been presented for a degree in any other University or any other award. I have acknowledged ideas from published and unpublished work of other persons.

Signature of Candidate : 

Date : September 15, 2021

## Abstract

There have been several studies by scholars and governments alike to determine how to stabilise financial markets following a surge in economic crises that have devastated the financial markets, and paralysed banking systems, leaving economies to default on their obligations. Previous research in this field focused on the role of fiscal, monetary, and exchange rate policy in macroeconomic stability, however, did not capture the effects of other contributors such as manufacturing growth and export growth on the financial markets. This study examines the relationship between mineral beneficiation and the foreign exchange market, with a focus on the exchange rate volatility and foreign reserves accumulation. Using panel regression, we empirically examine whether a percentage of mineral beneficiation does affect the foreign exchange market performance and overall economic progress in a country. The study compares the beneficiation measure of 40 countries, broken down into high-income, upper middle-income, and low-income economies relative to the United States (US). A panel regression analysis is also conducted on these countries to assess empirically the statistical significance of beneficiation on both exchange rate and foreign reserves. Based on panel regression results for exchange rate, we find a significantly negative relationship between exchange rate and beneficiation - this means that as the beneficiation measure increases, local currencies strengthen relative to the US dollar. We also found that the regression relationship between beneficiation and foreign reserves is significantly positive, which means that those countries that add value to their natural resources tend to accumulate more foreign reserves. As a result, it can be concluded that, beneficiation of mining output and trading in value-added goods would help reduce currency volatility and increase foreign reserves earned, which in turn would help stabilize the foreign exchange market and reduce the exchange market pressure.

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# 1. Introduction

## 1.1. Purpose of Study

The objective of this study is to empirically examine the relationship between mineral beneficiation and the foreign exchange market, with a specific focus on the exchange rate volatility and foreign reserves accumulation. It is our purpose to study this relationship to examine whether mineral beneficiation can influence exchange rates, and if so, whether countries that trade products with high value-added tend to accumulate more foreign exchange. The study is motivated by recent financial events like the 2007-2009 economic recession which Crotty (2009) described as “the worst financial crises since the great depression”. The global severity of these events on financial markets has stimulated interest amongst scholars and governments to investigate mechanisms to stabilise the financial market and minimise their vulnerability to future shocks (Crotty, 2009). Easterly and Fischer (1990) stated that maintaining a sound macroeconomic framework can minimise the vulnerability of economies to external shocks, which in turn increases prospects for sustained economic growth.

This study will test these theories by introducing mineral beneficiation as a new measure and a determinant in the foreign exchange market. Beneficiation in mining literature is defined as a process of separating desirable economic minerals from undesired and noneconomic minerals (Craig and Vaughan, 1994), however in the context of this paper we defined beneficiation as “the proportion of the value derived from asset exploitation which stays 'in country' and benefits local communities” (Gumede, 2012). We calculate beneficiation as annual gross mining output (in million US\$) less gross annual mining export (in million US\$), represented as a percentage of annual gross mining output. Given an understanding of the recent global financial crises and their effect to both advanced and advancing economies, it is imperative to further pursue any model with the potential to stabilise one or more financial markets.

To understand the relationship between mineral beneficiation and the foreign exchange market, we found it necessary to test the theory that high mineral endowment should lead to economic development, since countries with abundant mineral resources would export their products to other countries and theoretically earn more foreign reserves and stabilize their exchange rates. However as stated by Korinek and Ramdoo (2017), mineral abundance does not automatically result in sustained economic development, in fact they further state that mining brings little in terms of direct employment in the region of primary operation. Considering these circumstances, governments should look for other ways to derive more value from their mineral wealth. In this study, we investigate the possible effects of using domestic resources in the further processing of mining output on the foreign exchange market.

## 1.2. Financial Market Stability

Financial Market stability is defined as “a condition where the financial system can withstand shocks which impair the allocation of savings and investments opportunities and the processing of payments in the economy” (Padoa-Schioppa, 2003). According to (Fischer and Easterly, 1990) and (Montiel and Servén, 2005), requirements for a stable financial market system can be summed up by macroeconomic stability, which captures fiscal, monetary and exchange rate policies. These are further emphasised by Lane (2012) as he analysed the causes of the European Sovereign Debt Crisis between 2007 and 2010. Lane (2012) found that a large current account deficit and the failure to tighten fiscal policy led to the financial instability of the Eurozone.

The literature on stabilising financial markets is skewed towards the role of fiscal, monetary and exchange rate policy in macroeconomic stability, however, does not capture the effects of other contributors such as manufacturing growth and export growth on the financial markets. The literature on industrialisation is also skewed to one side, focusing on poverty alleviation, creating employment, improving health care, and changing the macroeconomic policies to suit industrial development (Fukunishi, et al. 2006) (Collier, 2007) (Pacheco-López and Thirwall, 2013) (Acemoglu and Robinson, 2012), but does not make any reference to the stability of financial markets as a prerequisite for sustained and inclusive growth.

Kaldor (1967) examined the relationship between manufacturing output and growth of GDP and based on empirical results which showed a positive causal relationship, which he concluded that the manufacturing sector is the main engine for fast economic growth. This came to be known as Kaldor's first law of growth (Pacheco-Lópezb and Thirwall, 2013). Pacheco-Lópezb and Thirwall, (2013) added on Kaldor's first law by investigating the relationships between manufacturing growth and export growth, in their findings they reported that countries producing manufactured goods with a high-income elasticity of demand tend to have a higher growth of exports and a higher growth of GDP, therefore stable financial markets. Maizels (2000) explained how most developing economies depend on production and export of primary commodities for their socioeconomic welfare. He concludes by saying that most of these economies tend to export primary commodities which leads to their economic development and currencies being tied to the volatility of the commodity market. By comparing exchange rate volatility for countries that trade in primary commodities to those that trade in finished goods, we will be able to determine the effects of beneficiation to the foreign exchange market.

### 1.3. Problem Statement

This study seeks to address the problem where most countries with mineral abundance tend to be classified as developing nations, they are not benefiting from their mineral endowment and seem to have their currency tied to the commodity market. We address this problem by comparing countries that trade in primary commodities to those that trade in finished goods. The observation has been that countries that are classified as developed tend to have stable financial markets, and have developed industrial sector and trade in finished goods as compared to developing countries, therefore our problem statement is:

How does the percentage of mineral beneficiation affect the foreign exchange market?

In addressing the above problem statement, the study will seek to answer the following research questions:

#### 1.3.1. Research Questions

- Does mineral beneficiation affect exchange rates in a statistically significant way?
- Does mineral beneficiation affect foreign exchange reserves in a statistically significant way?
- How do economies with a higher beneficiation measure compare to those with a lower beneficiation measure?
- Can beneficiation contribute to the stability of financial markets?

### 1.4. Contribution

The study compares the beneficiation measure of 40 countries, broken down into high-income, upper middle-income, and low-income economies relative to the United State. A panel regression analysis will also be conducted on these countries to empirically assess the statistical significance of beneficiation on both exchange rate and foreign reserves. Following Meese and Rose (1991) on their exchange rate determinants, we will modify the original equation by introducing beneficiation as one of the independent variables. The first contribution will be to show how countries with different income classes compare in terms of mineral beneficiation and secondly to test if there is correlation between income and mineral beneficiation. In addition, panel regression will demonstrate whether mineral beneficiation is a significant factor that affects foreign reserves and exchange rate, and therefore making it a new measure.

Furthermore, we will introduce the concept of Exchange Market Pressure (EMP) after Aizenman, and Binici (2015) as a measure of "weighted sum of exchange rate depreciation and international reserve loss (including interest rate differentials in some cases)". Using EMP we will determine the relationship between foreign reserves and exchange rate, and therefore quantify the effects of beneficiation to the foreign exchange market. Beneficiation ensues from industrialisation; therefore, this study also contributes to the effects of industrialisation on the financial markets, focusing on the foreign exchange market, where there is a void in research.

### 1.5. Hypothesis

Two hypotheses are tested, which are outlined by Maizels (2000), who states that countries that trade in primary commodities have their currencies linked to the commodities market volatility, which impacts on foreign reserves needed to finance the import of capital goods.

**Hypothesis 1:** Countries that trade in value-added mineral resources tend to have stronger currencies relative to the US Dollar.

**Hypothesis 2:** Countries that trade in value-added mineral resources tend to accumulate more foreign exchange reserves.

## 2. Literature Review

Maizels (2000) outlines how most developing economies depend on production and export of primary commodities for their socioeconomic welfare. He further explains how the commodities sector can promote economic development by either producing more raw material to support domestic industrialisation or by exporting commodities to earn foreign exchange, which can be used to subsidise imports of capital goods. He concludes by saying that most economies tend to export primary commodities which leads to their economic development being dependent on the commodities market and their currencies tied to the volatility of the commodity market. In this section we will review the following topics in literature to illustrate the how skewed is the current literature and the gap which this study seeks to address:

- The relationship between manufacturing, GDP growth and exports
- The effects of manufacturing to the exchange market
- The effects of manufacturing to the foreign reserves
- The combined effects of exchange rate and foreign reserves to the financial market (exchange market pressure)

### 2.1. Manufacturing and GDP Growth

There is a wealth of literature on the causal relationship between the growth of manufacturing output and GDP growth.

Kaldor (1967) examined the relationship between manufacturing output and growth of GDP in his quest to understand why growth rates differ between countries. In his study Kaldor's empirical results showed a positive causal relationship between manufacturing output and GDP growth. Based on these results Kaldor (1967) concluded that the manufacturing sector is the main engine for fast economic growth. Fagerberg and Verspagen (1999) further investigates the relationship by comparing manufacturing with GDP for developing and developed countries. They found that manufacturing as an engine of growth depends on the development of the country. For economically and technologically developed countries, manufacturing doesn't seem to be an engine of growth as suggested by Kaldor.

Pacheco-Lópezb and Thirwall (2013) Expanded on Kaldor's findings by stating that the reason manufacturing is the main engine for fast economic growth was because manufacturing itself is subject to increasing returns, both static and dynamic, while land-based activities and services are subject to diminishing returns (Pacheco-Lópezb and Thirwall, 2013). This came to be known as Kaldor's first law of growth (Pacheco-Lópezb and Thirwall, 2013). Pacheco-Lópezb and Thirwall, (2013) found that Kaldor's first law does not explain what constitutes manufacturing growth, and where the demand for this would be coming from because his model focused on a closed economy which does not include foreign trade, balance of payments and foreign exchange constraints. In an attempted to answer these questions Pacheco-Lópezb and Thirwall, (2013) suggested an empirical test that would illustrate that in an open economy, GDP growth is controlled by export growth, and due to their higher income elasticity of demand as compared to other commodities (primary and tertiary) manufactured good are a positive function of output growth. Linking an earlier study by Hausmann et. al. (2007) on 'what you export matters', Pacheco-Lópezb and Thirwall,

(2013) concluded that countries producing manufactured goods with a high-income elasticity of demand will have a higher growth of exports and a higher growth of GDP.

Attiah (2019) brings another argument in literature on the effectiveness of manufacturing to foster economic development, by comparing India's investment in the services and industry and the failure of industrialisation in Africa and Latin America. This study uses 40 developing countries and 10 developed countries to determine the effect of manufacturing as an engine of growth. The findings are in line with the hypothesis that manufacturing is the engine of growth, but this effect is more pronounced in 'poorer countries', as developed countries are more focused on the services sector. These studies make it clear that manufacturing is an engine for faster economic growth, what we need to understand is sectoral contribution within manufacturing.

## 2.2. Manufacturing growth and the exchange rate

Building on these foundations, our interest is determining the effects of manufacturing (mining-based products) in stabilising financial markets. Financial Market stability is defined as a "condition where the financial system can withstand shocks which impair the allocation of savings and investments opportunities and the processing of payments in the economy" (Padoa-Schioppa, 2003). Interest amongst scholars and governments on this topic was sparked by the USA economic downturn of 2007, which drifted focus from what causes global financial crisis to how their impacts can be minimised by stabilising the financial markets (Papanikos, 2015) and (Crotty, 2009). In the literature of (Fischer and Easterly, 1990), (Montiel and Servén, 2005) and (Lane, 2012), requirements for a stable financial market system can be summed up by macroeconomic stability, which captures fiscal, monetary and exchange rate policies, leaving a gap on how manufacturing and trading of manufactured goods can contribute to stabilisation of the financial markets.

With a focus on the exchange market, one of the long-standing puzzles in international economics as described by Engel and West (2005) is the difficulty of tying floating/volatile exchange rate to the microeconomic fundamentals. In theory exchange rate is determined by such fundamental variable like money supply, outputs and interest rate, however floating exchange rate between countries with similar inflation are well approximated as random walks. In their study Engel and West (2005) found that though there was granger causality between exchange rate and money, income, price and interest rate, the empirical results were not uniformly strong, and therefore macroeconomic fundamentals might not best explain exchange rate. Anderson et al. (2003) introduced some innovation in explaining the determinants of exchange rate by introducing the effects of news about fundamentals on the exchange rate, and even though their conclusion was for a short term, they found that news about fundamentals did drive the exchange rate in the FOREX market.

## 2.3. Manufacturing growth and foreign reserves

Fischer and Easterly (1990) describe foreign reserves as the second means of financing a government deficit after money printing, thus explain the importance of foreign reserves accumulation. Steiner (2013) further explains that central banks accumulate reserves to buffer against capital flight and secondly to protect the economy from effects of sudden stops in capital flow and flow reversals. Calvo et al (2008) suggested that holding of foreign reserve could both prevent the effects of reduction in capital inflows by mitigating exchange rate depreciation and act as a buffer in the event of such reductions. Given the observed growth of foreign reserves accumulation by central banks (Steiner, 2013) and (Arslan and Cantu, 2019), it is important to further investigate how manufacturing (beneficiation) can affect foreign exchange reserves accumulation.

## 2.4. Exchange Market Pressure

Aizenman, and Binici (2015) studied the ways domestic and external global factors (such as risk appetite, global liquidity, U.S. monetary policy, and commodity prices) affected the exchange market before and after the global financial crisis. Park and Mercado Jr. (2014) build on studies of Eichengreen, Rose, and Wyplosz (1999) and used in Balakrishnan et al. (2011) by introducing financial stress as episodes when the financial system is under strain and its ability to intermediate is impaired. They further introduce an index that can capture this financial stress as the Exchange Market Pressure Index (EMPI) which captures the depreciation



of the local currency with respect of US dollar and the reduction in foreign exchange reserves. The literature gives room for further research on how manufacturing/industrialisation through beneficiation can influence the financial markets. This research paper addresses this gap by investigating the effects of beneficiation on the foreign exchange market.

### 3. Methodology

#### 3.1. Data

The data used in this research is annual data from 40 developing and developed economies over a 20-year period from 1996 to 2015. The data was gathered from the OECD input/output tables which we used to calculate the beneficiation measure and foreign reserves. Countries used in the study were chosen to show diversity in terms of geographical spread, economic development, and income disparity according to data available in OECD input/output. The period of study was also motivated by data availability for the selected countries. International Monetary Fund, International Financial Statistics and data files, World Bank and OECD data site provided data for the following variables which are included in the model, real GDP, broad money supplies and annual nominal interest rate. Foreign direct investment data was sourced from UNCTADstat, Human Development Index was sourced from UNDP. Data was transformed in the following manner: the output gap was generated for GDP using the Hodrick-Prescott Filter on seasonally adjusted GDP. Quasi-differentials between the foreign country (U.S.A) and the domestic countries were also calculated as indicated in equations 7, 8 and 11 below. The data was log normalised and differenced according to the panel stationarity tests.

**Table 1:** *Countries (40) of interest used in the study, over a period of 20 years (1996 to 2015).*

| Country        | Country      | Period      |
|----------------|--------------|-------------|
| Australia      | Brazil       | 1996 - 2015 |
| Austria        | Chile        | 1996 - 2015 |
| Belgium        | China        | 1996 - 2015 |
| Canada         | Colombia     | 1996 - 2015 |
| Czech Republic | Estonia      | 1996 - 2015 |
| Denmark        | India        | 1996 - 2015 |
| Finland        | Indonesia    | 1996 - 2015 |
| France         | Israel       | 1996 - 2015 |
| Germany        | Korea        | 1996 - 2015 |
| Hungary        | Latvia       | 1996 - 2015 |
| Ireland        | Malaysia     | 1996 - 2015 |
| Italy          | Mexico       | 1996 - 2015 |
| Japan          | Peru         | 1996 - 2015 |
| Netherlands    | Philippines  | 1996 - 2015 |
| New Zealand    | Russian Fed. | 1996 - 2015 |
| Portugal       | South Africa | 1996 - 2015 |
| Slovakia       | Thailand     | 1996 - 2015 |
| Spain          | Tunisia      | 1996 - 2015 |

|        |         |             |
|--------|---------|-------------|
| Sweden | Turkey  | 1996 - 2015 |
| UK     | Vietnam | 1996 - 2015 |

### 3.2. Empirical method

#### 3.2.1. Exchange rate

Following Engels (2014) we define exchange rate of a country as the “price of the foreign currency in units of the domestic currency, so an increase in the exchange rate is depreciation in the home currency”. Engels and West (2005) relate exchange rate to economic fundamentals and the future expectation of exchange rate, giving the following relationship:

$$S_t = (1-b)(f_{1t} - z_{1t}) + b(f_{2t} - z_{2t}) + bE_t S_{t+1} \quad (1)$$

Where:  $S_t$  is the log of exchange rate. Engels and West (2005) defined  $f_{it}$  to represent economic fundamentals that ultimately drive the exchange rate, such as money supplies, money demand shocks, productivity shocks, etc. which are observable fundamentals and  $z_{it}$  as a measure of errors and unobserved shocks. The fundamentals used by Engels and West (2005) follow those tested by Meese and Rogoff (1984) see also Meese and Rose (1991) Devereux and Angel (2002) and Engels (2014), therefore we formulate change in exchange rate as follows:

$$\Delta S_t = f(m_t, \pi_t, i_t, y_t, p_t) + \varepsilon_t \quad (2)$$

Where:  $\Delta S_t$  is the change in bilateral spot exchange rate;  $m_t$  is the log of relative nominal money supply;  $y_t$  is the log of relative domestic output;  $i_t$  denote the domestic nominal interest rate;  $p_t$  is the log of home price level and  $\varepsilon_t$  is the error term. The variables for foreign country will be the same but denoted by  $m_t^*, p_t^*, i_t^*, y_t^*$ . The adopted equation for this study is given by:

$$\Delta S_{it} = \beta_0 + \beta_1(i_{it} - i_{it}^*) + \beta_2(m_{it} - m_{it}^*) + \beta_3(y_{it} - y_{it}^*) + \varepsilon_{it} \quad (3)$$

Where:  $(i_{it} - i_{it}^*)$  is the interest differential between domestic and foreign country,  $(m_{it} - m_{it}^*)$  is the nominal money supply differential,  $(y_{it} - y_{it}^*)$  output gap differential, and  $\varepsilon_{it}$  is the error term.

In this study we expand on equation 3 above by introducing beneficiation variable to the economic fundamentals which determine change in exchange rate. Using the OECD input-output table we calculated the beneficiation variable using the following equation:

$$B_t = \frac{M_t - EM_t}{M_t} \quad (4)$$

Where:  $B_t$  is the beneficiation variable at year t,  $M_t$  is the gross mining output and  $EM_t$  is the total mining export. Substituting equation 4 into equation 2 we get

$$S_t = f(X_t, B_t) + \varepsilon_t \quad (5)$$

Where:  $X_t = (m, i, y)$  after Engels and West (2005) and  $B_t$  is beneficiation. The regression equation will be given by:

$$\Delta S_{it} = \alpha_t + \beta_x X_t + \gamma_b B_t + \varepsilon_t \quad (6)$$

$$\Delta S_{it} = \beta_0 + \beta_1(i_{it} - i_{it}^*) + \beta_2(m_{it} - m_{it}^*) + \beta_3(y_{it} - y_{it}^*) + \gamma_1 B_{it} + \varepsilon_{it} \quad (7)$$

Where  $B_{it}$  is beneficiation of country  $i$  at year  $t$ , where  $t=1996-2015$  and  $\gamma$  is the coefficient of beneficiation. IF  $\gamma_1 > 0$  that will mean there is a negative relationship between beneficiation and exchange rate.

### 3.2.2. Foreign Reserves

Fischer and Easterly (1990) describe foreign reserves as the second means of financing a government deficit after money printing, thus explain the important of foreign reserves accumulation. To further understand the influence of beneficiation to the foreign exchange market, we will examine the fundamentals which also relate to changes in foreign reserves. According to Steiner (2013) Central banks accumulate reserves to protect the economy from detrimental effects of sudden stops in capital flow and flow reversals. Following Vacaflores and Kishan (2014) we have derived the formulation of change in foreign reserves using control variables from literature, and the beneficiation variable as derived above, the estimation equation can be represented as:

$$\Delta fr_t = \varphi_f(i_t - i_r^*) + \varphi_y y_{t-1}^* - \varphi_y y_{t-1} + \varphi_s s_{t-1} + \varphi_B B_t + \varepsilon_{it} \quad (8)$$

Where  $\Delta fr_t$  is the change in foreign reserves,  $(i_t - i_r^*)$  is the short-term interest rate differential of domestic to foreign countries respectively,  $y_{t-1}^*$  is the lag of foreign output,  $y_{t-1}$  is the lag of domestic output,  $s_t$  is the nominal spot exchange rate (domestic per foreign currency) and  $B_t$  is the beneficiation variable. If  $\varphi_B > 0$  that means, there is a positive relationship between beneficiation and foreign reserves volatility.

### 3.2.3. Exchange Market Pressure

We then use the data derived from above to measure the Exchange Market Pressure Index (EMPI) for economies in the study to quantify the effect of beneficiation in stabilising the foreign exchange market. EMPI captures the depreciation of the local currency relative to foreign (in this case the US dollar) and the reduction of foreign exchange reserves (Park and Mercado Jr., 2014). Following IMF (2009) chapter four and Park and Mercado Jr. (2014) EMPI is defined as follows:

$$\Phi_t = \frac{\Delta s_t - \mu_t^s}{\sigma_s} - \frac{\Delta fr_t - \mu_t^f}{\sigma_f} \quad (9)$$

Where  $\Phi_t$  is the EMPI,  $\Delta s_t$  is percent change in exchange rate,  $\Delta fr_t$  is change in foreign reserves,  $\mu_t^s$  and  $\mu_t^f$  are time varying means of the changes in exchange rate and foreign reserves respectively,  $\sigma_s$  and  $\sigma_f$  are standard deviations. In deriving the EMP equation we substitute equation 7 and 8 above to equation 9

$$\Phi_t = \frac{\beta_0}{\sigma_s} + \frac{\beta_i}{\sigma_s}(i_{it} - i_{it}^*) + \frac{\beta_m}{\sigma_s}(m_{it} - m_{it}^*) + \frac{\beta_{yg}}{\sigma_s}(y_{it} - y_{it}^*) + \frac{\gamma_B}{\sigma_s} B_{it} + \mu_{it}^s + \frac{1}{\sigma_s} \varepsilon_{it} - \frac{\varphi_f}{\sigma_f}(i_{it} - i_{it}^*) - \frac{\varphi_y}{\sigma_f} y_{it}^* + \frac{\varphi_y}{\sigma_f} y_{it} - \frac{\varphi_s}{\sigma_f} s_{it} - \frac{\varphi_B}{\sigma_f} B_{it} + \frac{1}{\sigma_f} \varepsilon_{it} \quad (10)$$

Which can be simplified to give:

$$\Phi_t = \zeta_0 + \zeta_i(i_{it} - i_{it}^*) + \zeta_m(m_{it} - m_{it}^*) + \zeta_{yg}(y_{it} - y_{it}^*) + \zeta_B B_{it} - \zeta_y^* y_{it}^* + \zeta_y y_{it} - \zeta_s s_{it} + \eta_t \quad (11)$$

Where:

$$\begin{aligned} \zeta_0 &= \frac{\beta_0}{\sigma_s}, \zeta_i = \frac{\beta_i}{\sigma_s} - \frac{\varphi_f}{\sigma_f}, \zeta_m = \frac{\beta_m}{\sigma_s}, \zeta_{yg} = \frac{\beta_{yg}}{\sigma_s}, \zeta_\pi = \frac{\beta_\pi}{\sigma_s}, \zeta_B = \frac{\gamma_B}{\sigma_s} - \frac{\varphi_B}{\sigma_f}, \zeta_y^* = \frac{\varphi_y^*}{\sigma_f}, \zeta_y = \frac{\varphi_y}{\sigma_f}, \zeta_s \\ &= \frac{\varphi_s}{\sigma_f}, \eta_t = \frac{1}{\sigma_s} \varepsilon_{it} + \frac{1}{\sigma_f} \varepsilon_{it} - \frac{1}{\sigma_f} \mu_t^f - \frac{1}{\sigma_s} \mu_t^s \end{aligned}$$

### 3.3. Econometric technique

We will estimate the following equations: equation (7) which explores the relationship between exchange rate and beneficiation, equation (8) which explores the relationship between foreign exchange reserves and beneficiation, and from the results of eq. (7) and (8) we will conclude how eq. (11) which explores the relationship that exchange rate and foreign reserves have with EMP, will be affected. We expect a negative relationship between Exchange rate and beneficiation. This will be consistent with hypothesis 1 of this study which states that Countries that add more value to their natural resources tend to have stronger currencies relative to the US Dollar. We expect a positive relationship between change in foreign reserves and beneficiation, confirming that economies that trade in finished good accumulates larger sums of foreign reserves and therefore stabilising the financial market. This will be consistent with hypothesis 2 of this study which states that Countries that add more value to their natural resources tend to accumulate more foreign exchange reserves. We also expect the relationship between EMP and foreign exchange reserves to be negative, this will mean that high foreign reserves lead to low financial stress in the foreign exchange market during financial crisis.

## 4. Empirical Evidence

### 4.1. Descriptives

When we plot the natural log of beneficiation against the log of nominal exchange rate (figure1A), we observe a negative slope which indicates that a higher beneficiation measure can result in appreciation of the local currency against the foreign currency which in this case is the US dollar. For our nominal exchange rate we used the price of foreign currency in local currency, meaning a decrease in the exchange rate indicated strengthening of the local currency against the US dollar. This observation is inline with our first hypothesis that countries that add more value to their mining output tend to have stable currencies against the US dollar.

Figure1B is a plot of the natural log of beneficiation against the log of foreign reserves. In figure 1B we see a positive slope between the two measures, indicating that countries that add more value to their mining outputs tend to accumulate more foreign reserves. This is inline with our second hypothesis and can be backed up by the literature of Arslan and Cantú (2019), whom in their study to determine the drivers behind reserve accumulation, found that countries with higher foreign exchange reserves suffer less from major financial shocks, and this has been a driver for many emerging countries to accumulate more foreign exchange reserves as a precaution against these financial shocks. Our results thus far indicate that one way of accumulating high reserves is by trading in finished good and strengthening the manufacturing sector.

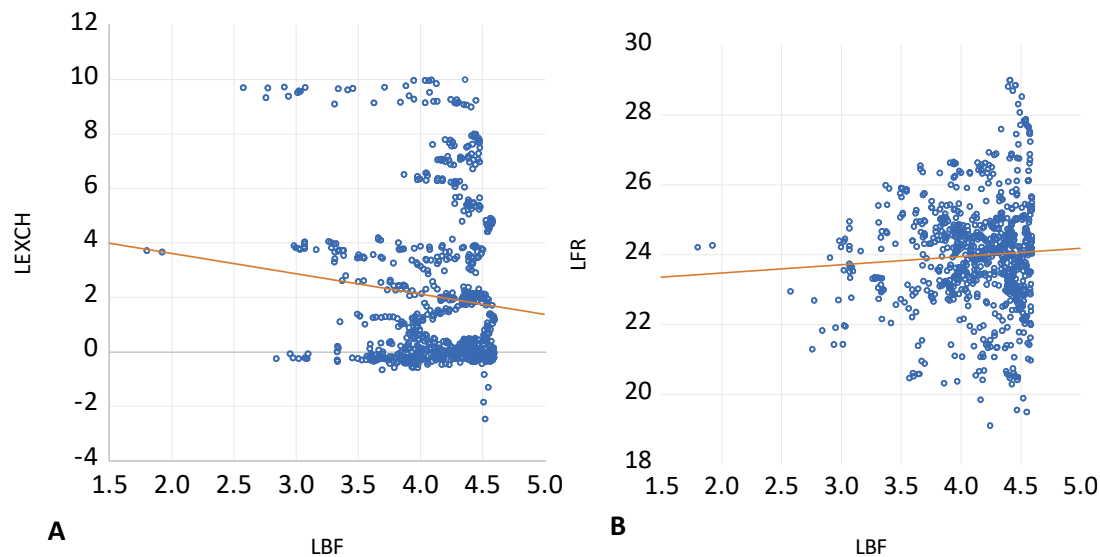


Figure 1: Scatter plot indicating the relationship between the beneficitation measure against exchange rate and foreign reserves. A. is the log of beneficitation against the log of nominal exchange rate and B. shows the log of beneficitation against the log of foreign reserves. The data comes from 40 countries spread across all regions and different income categories from 1996 to 2015.

The observations from figure1 above can be confirmed by Table2 below, where we selected a sample which includes high, upper-middle, and lower-middle income countries as classified by the world bank. We observe how high-income countries tend to have a higher average beneficitation measure of 81.2% compared to upper middle income at 67.3% and lower middle income at 51.9%. For instance, New Zealand increased their beneficitation measure by 5% between 1996 and 2015, this was then accompanied by a 59% increase in reserves and a 21% appreciation of their currency against the US dollar (USD). There are other factors that affect the exchange rate as well as foreign reserve accumulation, for instance Vietnam increased their beneficitation by 62.8% between 1996 and 2015, this is also associated with an increase of 93.9% in foreign reserves, however their currency was significantly depreciated. The depreciation of Vietnam's currency can be attributed several issues, one to note could be the fact that they are still an emerging industrial sector, therefore most of the accumulated reserved are used to import machinery required to grow the manufacturing industry. The loss in accumulated reserves increase inflation and therefore depreciates currency.

As stated above that there are other factors affecting the foreign exchange market, one worth mentioning is the control of the monetary authorities on the currency value. If we take Japan for instance, it has a high beneficitation measure averaging 94% over a 20-year period, however, there has been a beneficitation decrease of 3.1% in that period (1996 – 2015). This decrease is accompanied by an 82% increase in foreign reserves and a 12% depreciation of their currency. This is aligned with what we have observed in figure 1A that a decrease in the beneficitation measure leads to a depreciation of the local currency, however the percentage changes here suggests that there might have been a currency devaluation. Most East Asian countries devalue their currency making their exports cheaper to the foreign markets and, therefore increasing their exports and strengthen domestic manufacturing by making imports expensive.

Table 2: Percentage Change in beneficitation, Foreign reserves, and Exchange rate over 20 years (1996 to 2015) for a selected sample of countries classified in to high, upper middles and lower middle-income according to the World Bank (source: <https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2020-2021>)

| <b>High Income</b>         |               |              |                       |                      |                       |                      |                         |
|----------------------------|---------------|--------------|-----------------------|----------------------|-----------------------|----------------------|-------------------------|
| <b>Country</b>             | <b>Period</b> | <b>BF</b>    | <b>BF%<br/>Change</b> | <b>FR<br/>(MUSD)</b> | <b>FR%<br/>Change</b> | <b>EXCH<br/>Rate</b> | <b>EXCH%<br/>Change</b> |
| Canada                     | 1996          | 0.766        | 0.002                 | 20422.424            | 0.744                 | 1.364                | -0.085                  |
| Canada                     | 2015          | 0.768        |                       | 79695.446            |                       | 1.279                |                         |
| Finland                    | 1996          | 0.927        | -0.041                | 6916.261             | 0.171                 | 0.773                | 0.129                   |
| Finland                    | 2015          | 0.885        |                       | 8341.476             |                       | 0.901                |                         |
| Germany                    | 1996          | 0.625        | -0.254                | 83177.914            | -0.422                | 0.769                | 0.132                   |
| Germany                    | 2015          | 0.370        |                       | 58506.811            |                       | 0.901                |                         |
| Japan                      | 1996          | 0.960        | -0.031                | 216648.012           | 0.821                 | 108.779              | 12.265                  |
| Japan                      | 2015          | 0.929        |                       | 1207019.204          |                       | 121.044              |                         |
| New Zealand                | 1996          | 0.920        | 0.050                 | 5953.469             | 0.595                 | 1.455                | -0.021                  |
| New Zealand                | 2015          | 0.970        |                       | 14699.798            |                       | 1.434                |                         |
| <b>Average</b>             |               | <b>0.812</b> |                       |                      |                       |                      | <b>2.484</b>            |
| <b>Upper Middle Income</b> |               |              |                       |                      |                       |                      |                         |
| Brazil                     | 1996          | 0.578        | -0.002                | 58789.944            | 0.834                 | 1.005                | 2.322                   |
| Brazil                     | 2015          | 0.513        |                       | 354174.893           |                       | 3.327                |                         |
| China                      | 1996          | 0.867        | -0.501                | 107039.425           | 0.968                 | 8.314                | -2.087                  |
| China                      | 2015          | 0.866        |                       | 3345193.764          |                       | 6.227                |                         |
| Russian                    | 1996          | 0.577        | -0.060                | 11276.435            | 0.965                 | 5.121                | 55.817                  |
| Russian                    | 2015          | 0.709        |                       | 319835.210           |                       | 60.938               |                         |
| South Africa               | 1996          | 0.666        | -0.666                | 941.557              | 0.977                 | 4.299                | 8.460                   |
| South Africa               | 2015          | 0.605        |                       | 41619.506            |                       | 12.759               |                         |
| <b>Average</b>             |               | <b>0.673</b> |                       |                      |                       |                      | <b>18.646</b>           |
| <b>Lower Middle Income</b> |               |              |                       |                      |                       |                      |                         |
| India                      | 1996          | 0.892        | -0.501                | 20170.157            | 0.940                 | 35.433               | 28.719                  |
| India                      | 2015          | 0.391        |                       | 334310.993           |                       | 64.152               |                         |
| Philippines                | 1996          | 0.274        | 0.190                 | 10058.229            | 0.864                 | 26.216               | 15.146                  |
| Philippines                | 2015          | 0.464        |                       | 73963.945            |                       | 41.362               |                         |
| Tunisia                    | 1996          | 0.611        | -0.034                | 1897.641             | 0.741                 | 0.973                | 0.792                   |
| Tunisia                    | 2015          | 0.577        |                       | 7328.122             |                       | 1.766                |                         |
| Vietnam                    | 1996          | 0.158        | 0.628                 | 1735.898             | 0.939                 | 11032.583            | 10359.972               |
| Vietnam                    | 2015          | 0.786        |                       | 28250.255            |                       | 21392.556            |                         |
| <b>Average</b>             |               | <b>0.519</b> |                       |                      |                       |                      | <b>2601.157</b>         |

Figure 2 below, shows a time series plot of beneficitation, exchange rate, and foreign reserves for our sample countries grouped by income level during the study period (1996 -2015). In this plot, you can see how these variables trend together over the last 20 years. As we can see from figure 2A, there is a clear relationship between these three variables among high-income countries. Beneficitation and foreign reserves seem to be very well correlated during the period of this study; starting from 2001, they became well defined, and that correlation continued through the 2007-2009 financial crisis, where they both plunged, and start to recover from 2010. On the other hand, the exchange rate is seen to be decreasing, which indicates that the local currency is strengthening. This relationship is well defined post the financial crisis (from 2010 - 2015). We can conclude from these observations that as beneficitation increases, foreign reserves increase, and local currency strengthens for high income countries.

It is not apparent in countries of lower-middle and upper-middle income that beneficitation and foreign reserves are related (see figure 2B and C), likely because beneficitation levels are not as high and manufacturing and industrial sectors are not as developed as those in high-income countries. However, there is a pronounced correlation between exchange rate and reserves. This relationship is amplified after

the financial crisis (2010 - 2015), where we see an increase in exchange rates and a decrease in reserves for the same period. As a result, we can conclude that, even though the beneficitation trend is not well pronounced for upper-middle and lower-middle income countries, the relationship between exchange rate and foreign reserves still stands.

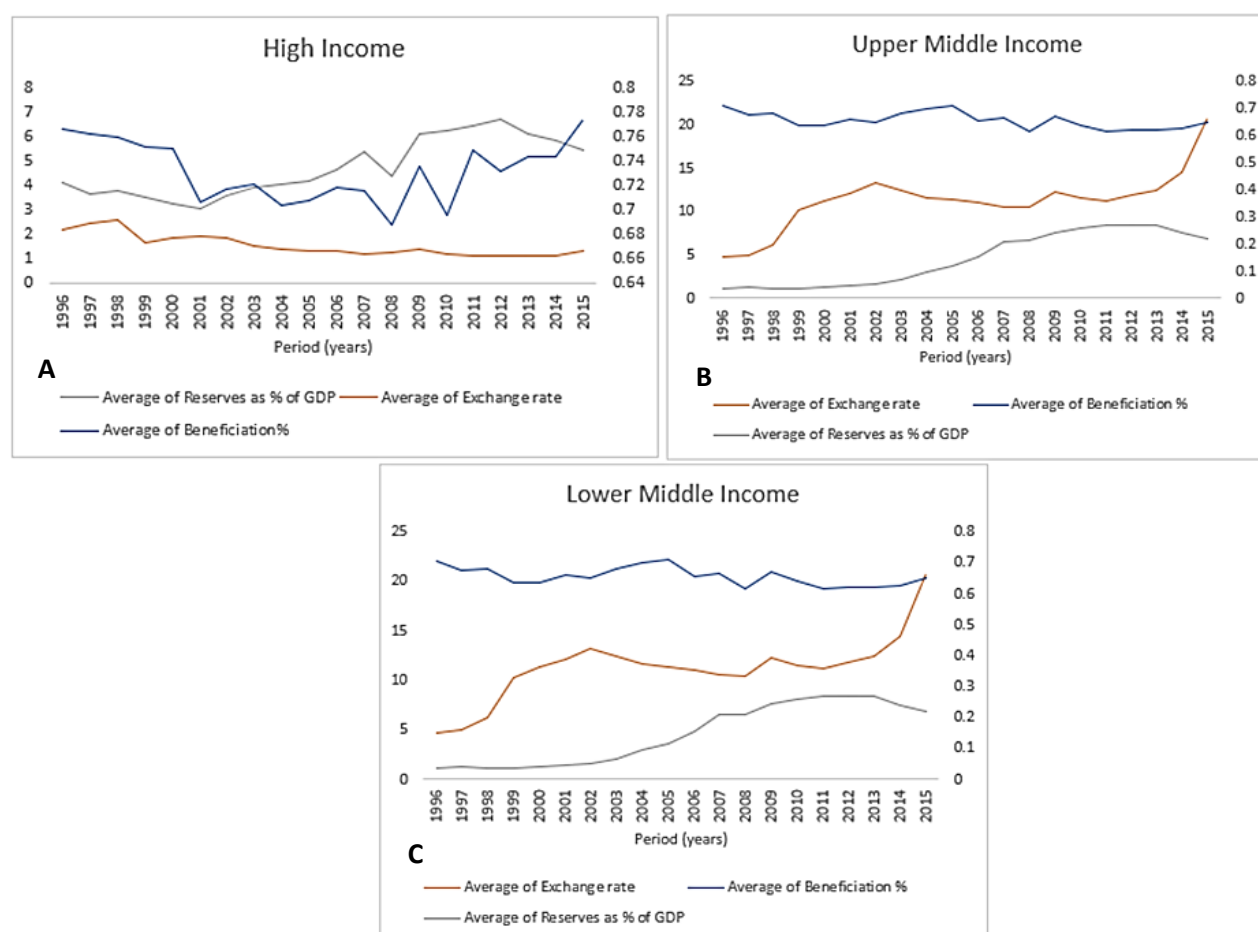


Figure 2: Time series plot of beneficitation, exchange rate, and foreign reserves for our sample countries grouped by income level according to the World Bank (source: <https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2020-2021>) for the study period (1996 -2015).

We can further test the robustness of beneficitation by ranking all 40 countries in our study by their beneficitation percentage difference over the past 15 years between 2000 and 2015. Table3 below shows country ranking by beneficitation Percentage change between 2000 and 2015. In Table3 below we see Vietnam ranking number 1 in terms of their beneficitation percent change, having increased by 58%. According to Busch (2017) Vietnam is one of Southeast Asia's outstanding performers and this is because of their impressive economic growth over the last 3-decades averaging 7.4% GDP per capita in 2000 and 6.4% in 2016. When we look at their export bucket which includes mobile phone handsets, as noted by Busch (2017) we can see that they export most finished good which have been beneficited in the country hence the impressive economic growth. On the contrary the lowest ranking country in the list is India with a percentage change of -46% in the same period.

When we look at other economic development measures such as Human Development Index (HDI), GDP growth rate and Unemployment rate, we see in Figure2A below how Vietnam as the highest-ranking country with a 58% increase in beneficitation over the study period (2000 – 2015), has improved its economic landscape. With an increase in beneficitation, we also observe a reduction in unemployment, an increase in HDI, and GDP growth rate.

India is the lowest ranking country having decreased their beneficitation measure by 46% over a 15-year period. To further understand the implication of reducing beneficitation measure, we plot a time series of beneficitation against other economic development measures (Figure 2B). From the graph we see that India's beneficitation measure has been on a decline even before 2000 and took a sharp dip in 2005 and again in 2008 and has not recovered since. GDP growth rate seems to be varying a lot and started declining in 2008 and this could be due to the 2007/2008 financial crisis. Unemployment rate has improved and the HDI is on a rise. Attiah (2019) indicates that countries like India abandoned the manufacturing sector and focused on the services sector due to the failure and slow pace of industrialisations. This observation can explain the decline in beneficitation for India. The relationship between the services vs manufacturing sector goes beyond the scope of this study and will not be further explored.

*Table 3: Country Beneficitation percentage change for year 2000 and 2015, ranked from highest to lowest percentage change.*

| Country Rank | Country             | Period | BF%  | Period | BF%  | % Change | Country Rank | Country      | Period | BF%  | Period | BF%  | % Change |
|--------------|---------------------|--------|------|--------|------|----------|--------------|--------------|--------|------|--------|------|----------|
| 1            | Vietnam             | 2000   | 0.21 | 2015   | 0.79 | 0.58     | 21           | France       | 2000   | 0.99 | 2015   | 0.94 | -0.05    |
| 2            | Thailand            | 2000   | 0.06 | 2015   | 0.40 | 0.34     | 22           | Colombia     | 2000   | 0.88 | 2015   | 0.83 | -0.05    |
| 3            | Russian Slovak Rep. | 2000   | 0.51 | 2015   | 0.71 | 0.20     | 23           | Chile        | 2000   | 0.54 | 2015   | 0.48 | -0.05    |
| 4            | Philippines         | 2000   | 0.27 | 2015   | 0.46 | 0.20     | 24           | Netherlands  | 2000   | 0.83 | 2015   | 0.77 | -0.06    |
| 5            | UK                  | 2000   | 0.58 | 2015   | 0.76 | 0.17     | 25           | Portugal     | 2000   | 0.98 | 2015   | 0.92 | -0.06    |
| 6            | Hungary             | 2000   | 0.73 | 2015   | 0.88 | 0.16     | 26           | Italy        | 2000   | 0.61 | 2015   | 0.54 | -0.08    |
| 7            | Peru                | 2000   | 0.44 | 2015   | 0.56 | 0.12     | 27           | Israel       | 2000   | 0.64 | 2015   | 0.54 | -0.11    |
| 8            | Turkey              | 2000   | 0.90 | 2015   | 0.98 | 0.08     | 28           | Tunisia      | 2000   | 0.69 | 2015   | 0.58 | -0.11    |
| 9            | Malaysia            | 2000   | 0.95 | 2015   | 0.99 | 0.04     | 29           | South Africa | 2000   | 0.72 | 2015   | 0.61 | -0.12    |
| 10           | Sweden              | 2000   | 0.78 | 2015   | 0.81 | 0.03     | 30           | Mexico       | 2000   | 0.42 | 2015   | 0.30 | -0.12    |
| 11           | New Zealand         | 2000   | 0.94 | 2015   | 0.97 | 0.03     | 31           | Estonia      | 2000   | 0.80 | 2015   | 0.65 | -0.16    |
| 12           | China               | 2000   | 0.87 | 2015   | 0.87 | 0.00     | 32           | Australia    | 2000   | 0.56 | 2015   | 0.40 | -0.16    |
| 13           | Canada              | 2000   | 0.78 | 2015   | 0.77 | -0.02    | 33           | Germany      | 2000   | 0.55 | 2015   | 0.37 | -0.18    |
| 14           | Denmark             | 2000   | 0.79 | 2015   | 0.77 | -0.02    | 34           | Ireland      | 2000   | 0.87 | 2015   | 0.69 | -0.18    |
| 15           | Brazil              | 2000   | 0.54 | 2015   | 0.51 | -0.03    | 35           | Latvia       | 2000   | 0.38 | 2015   | 0.19 | -0.19    |
| 16           | Austria             | 2000   | 0.56 | 2015   | 0.53 | -0.03    | 36           | Spain        | 2000   | 0.76 | 2015   | 0.56 | -0.20    |
| 17           | Czech Republic      | 2000   | 0.87 | 2015   | 0.83 | -0.03    | 37           | Indonesia    | 2000   | 0.80 | 2015   | 0.59 | -0.20    |
| 18           | Finland             | 2000   | 0.92 | 2015   | 0.89 | -0.04    | 38           | Korea, Rep.  | 2000   | 0.84 | 2015   | 0.63 | -0.21    |
| 19           | Japan               | 2000   | 0.97 | 2015   | 0.93 | -0.04    | 39           | Belgium      | 2000   | 0.50 | 2015   | 0.22 | -0.28    |
| 20           |                     |        |      |        |      |          | 40           | India        | 2000   | 0.85 | 2015   | 0.39 | -0.46    |



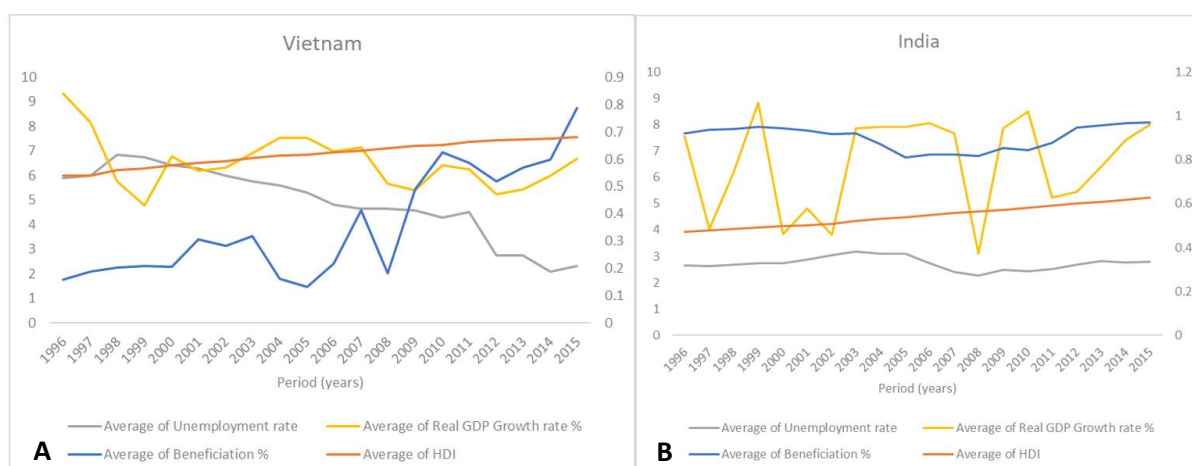


Figure 3: Time series plot for India and Vietnam comparing a 20-year trend of Beneficiation, GDP growth, Unemployment, and Human Development Index (HDI).

When we group the countries into income level groups and plot a timeseries for unemployment, Foreign Direct Investment (FDI), Human Development Index (HDI) and Beneficiation (figure 4 below), we see beneficiation and HDI trending very well in the Lower-Upper Income economies. This indicates that as the industrial sector improves, the lives of locals are improved. HDI is steeper in the Middle-Upper Income economies because they are at their development peak and gentler in the High-Income economies as they are more diversified and advanced already. In the Upper-Middle Income level we also see a correlation between Beneficiation and FDI, this could indicate that as countries receive more foreign investments, they improve their manufacturing sector and increase their mineral processing sector, however it is not easy to tell causality from the raw data. This study aims to establish if a relationship exists rather than causality.

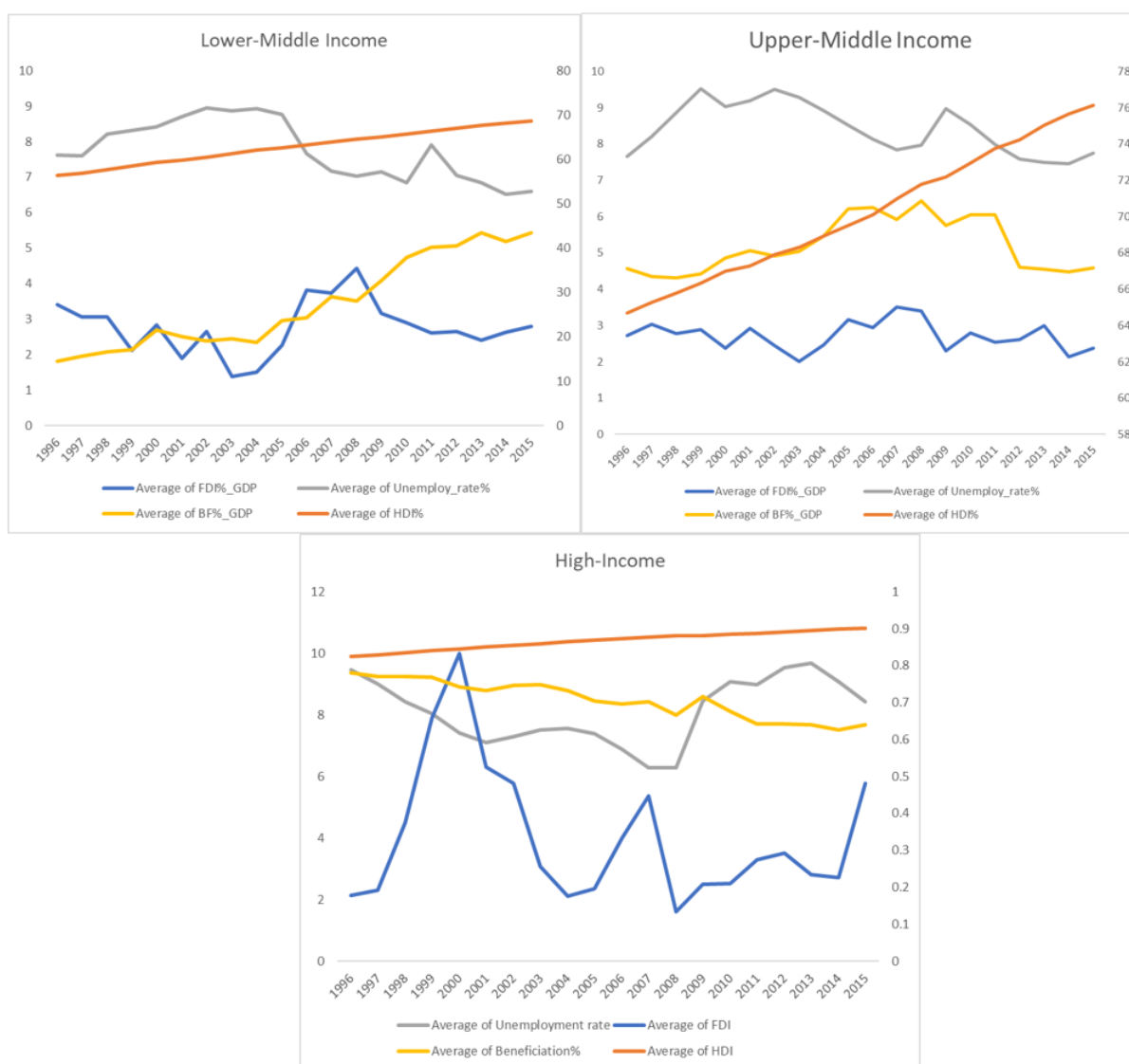


Figure 4: Time series plot of for unemployment, Foreign Direct Investment (FDI), Human Development Index and Beneficiation grouped by income level for the 1996 – 2015 period.

## 4.2. Panel Estimation

### 4.2.1. Panel Unit root test

We use unit root test to test for stationarity of the variables. If our data is none stationary, we can use cointegration to determine their relationship over a long term. We use Panel unit root test to test all variables in our model to determine if they are stationary or not. For the panel unit root test, our H0 states that the data has a unit root, and the alternative hypothesis states that the series does not have a unit root. From our panel unit root test, we found that Interest rate and beneficiation are stationary at level, exchange rate, foreign reserves, and GDP are stationary at first difference, whilst broad money is stationary at first difference with a trend. The results are shown in Table4 below.

Table 4: Dated Panel unit root test of 40 countries annual data from 1996 – 2015.

| Dated Panel unit root test of 40 countries annual data from 1996 - 2015 |     |     |
|-------------------------------------------------------------------------|-----|-----|
| Individual effects                                                      | Yes | Yes |

| Individual linear trends    | No        | No               |           |             |          |          |
|-----------------------------|-----------|------------------|-----------|-------------|----------|----------|
| Method                      | level     | first difference | Trend     |             |          |          |
| <b>Interest Rate</b>        |           |                  |           |             |          |          |
|                             | statistic | Probability      |           |             |          |          |
| Levin, Lin & Chu t*         | -7.85281  | 0.000000         |           |             |          |          |
| Im, Pesaran and Shin W-stat | -7.35053  | 0.000000         |           |             |          |          |
| ADF - Fisher Chi-square     | 200.184   | 0.000000         |           |             |          |          |
| PP - Fisher Chi-square      | 137.811   | 0.000100         |           |             |          |          |
| <b>Beneficiation</b>        |           |                  |           |             |          |          |
|                             | statistic | Probability      |           |             |          |          |
| Levin, Lin & Chu t*         | -3.61942  | 0.000100         |           |             |          |          |
| Im, Pesaran and Shin W-stat | -3.69852  | 0.000000         |           |             |          |          |
| ADF - Fisher Chi-square     | 142.58    | 0.000000         |           |             |          |          |
| PP - Fisher Chi-square      | 120.594   | 0.002300         |           |             |          |          |
| <b>Exchange Rate</b>        |           |                  |           |             |          |          |
|                             | statistic | Probability      | statistic | Probability |          |          |
| Levin, Lin & Chu t*         | -1.89308  | 0.029200         | -12.1405  | 0.0000      |          |          |
| Im, Pesaran and Shin W-stat | -1.56523  | 0.058800         | -10.031   | 0.0000      |          |          |
| ADF - Fisher Chi-square     | 87.4775   | 0.265700         | 258.865   | 0.0000      |          |          |
| PP - Fisher Chi-square      | 111.386   | 0.011700         | 208.756   | 0.0000      |          |          |
| <b>Foreign reserves</b>     |           |                  |           |             |          |          |
|                             | statistic | Probability      | statistic | Probability |          |          |
| Levin, Lin & Chu t*         | -5.12594  | 0.000100         | -17.7587  | 0.000000    |          |          |
| Im, Pesaran and Shin W-stat | 0.6797    | 0.751700         | -15.6423  | 0.000000    |          |          |
| ADF - Fisher Chi-square     | 75.8509   | 0.610600         | 383.855   | 0.000000    |          |          |
| PP - Fisher Chi-square      | 61.2545   | 0.941000         | 689.043   | 0.000000    |          |          |
| <b>GDP</b>                  |           |                  |           |             |          |          |
|                             | statistic | Probability      | statistic | Probability |          |          |
| Levin, Lin & Chu t*         | -1.06319  | 0.143800         | -11.353   | 0.000000    |          |          |
| Im, Pesaran and Shin W-stat | 1.41136   | 0.920900         | -9.55081  | 0.000000    |          |          |
| ADF - Fisher Chi-square     | 68.3703   | 0.819800         | 232.928   | 0.000000    |          |          |
| PP - Fisher Chi-square      | 43.6924   | 0.999700         | 206.097   | 0.000000    |          |          |
| <b>Money</b>                |           |                  |           |             |          |          |
|                             | statistic | Probability      |           | 0.000000    | -16.7375 | 0.000000 |
| Levin, Lin & Chu t*         | 6.48531   | 1.000000         |           | 0.000000    | -3.97578 | 0.000000 |
| Im, Pesaran and Shin W-stat | 9.1784    | 1.000000         |           | 0.000000    | -12.0034 | 0.000000 |
| ADF - Fisher Chi-square     | 6.98332   | 1.000000         |           | 0.000000    | 274.623  | 0.000000 |
| PP - Fisher Chi-square      | 12.2105   | 1.000000         |           | 0.000000    | 273.487  | 0.000000 |

### 4.3. Panel Regression

#### 4.3.1. Exchange rate estimation

We estimated the change in log of exchange rate as a dependent variable using panel least squares for a 20-year period sample (1996 – 2015) of 40 countries with a total of 800 balanced panel observations. The explanatory variables are output gap, broad money, interest rate gap and beneficiation. When we run the regression, we found that all our explanatory variables in the model have a significant effect on exchange rate. Notably, the beneficiation measure has a significant negative effect on the exchange rate, and this

confirms our first hypothesis that countries that have a higher beneficiation measure will have a stronger currency relative to the USA (see Table 5 below). The negative coefficient of beneficiation represents the expected results because an increase in beneficiation will lead to a decrease in the exchange rate, which represents an appreciation of the local currency.

Table 5: Estimation results for Eq. 3, log change of exchange rate as a function of macroeconomic fundamentals including beneficiation.

| $\Delta s_{it} = \beta_0 + \beta_1(i_{it} - i_{it}^*) + \beta_2(m_{it} - m_{it}^*) + \beta_3(y_{it} - y_{it}^*) + \gamma_1 B_{it} + \varepsilon_{it}$ |                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Variables                                                                                                                                             |                   |
| Constant                                                                                                                                              | 2.63*<br>(1.06)   |
| Output Gap                                                                                                                                            | -2.14*<br>(-6.22) |
| Broad Money Gap                                                                                                                                       | -0.02*<br>(0.01)  |
| Interest Rate Gap                                                                                                                                     | 3.34*<br>(1.04)   |
| Beneficiation                                                                                                                                         | -0.50*<br>(0.24)  |
| R-Squared                                                                                                                                             | 0.09              |
| F-statistic                                                                                                                                           | 19.17             |

\* significant at 1%, \*\* significant at 5%, \*\*\* significant at 10%. Std errors in parentheses.

For robustness we compare the full period model (1996 – 2015) with periods approaching a financial crisis using the 2007/2008 crisis (see Table 6 below). We used the period 1996 – 2006 as the pre-crisis period, 2000 – 2015 as the last 15 years of the study that includes the financial crisis, 2007 – 2013 as the crisis period, and 2013 – 2015 as the recovery period. In our results we observe a significant effect of the explanatory measures to exchange rate prior to the crisis, however when we run the model for 2007 – 2013. We found that our model holds for the longer period, but during financial crisis there seems to be a disruption in the exchange market that makes some of our explanatory variables insignificant.

Table 6: Exchange rate estimation results for Full period 1996 – 2015, pre-financial crisis 1996 – 2006, last 15 years of the study 2000 – 2015, during financial crisis 2007 – 2013, and post financial crisis (recovery period) 2013 – 2015.

| $\Delta s_{it} = \beta_0 + \beta_1(i_{it} - i_{it}^*) + \beta_2(m_{it} - m_{it}^*) + \beta_3(y_{it} - y_{it}^*) + \gamma_1 B_{it} + \varepsilon_{it}$ |                   |                  |                  |                   |                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|------------------|-------------------|------------------|
| Period                                                                                                                                                | 1996 - 2015       | 1996 - 2006      | 2000 - 2015      | 2007 - 2013       | 2013 - 2015      |
| Variables                                                                                                                                             |                   |                  |                  |                   |                  |
| Constant                                                                                                                                              | 2.63*<br>(1.06)   | 6.85*<br>(1.80)  | 2.34**<br>(1.21) | 0.48<br>(2.25)    | 2.63**<br>(0.00) |
| Output Gap                                                                                                                                            | -2.14*<br>(-6.22) | -2.06*<br>(0.66) | -2.11*<br>(0.44) | -2.84**<br>(1.23) | 4.10*<br>(1.39)  |
| Broad Money Gap                                                                                                                                       | -0.01*<br>(0.01)  | -0.01<br>(0.01)  | -0.01*<br>(0.01) | -0.01<br>(0.02)   | -0.01<br>(0.06)  |
| Interest Rate Gap                                                                                                                                     | 3.34*<br>(1.04)   | -1.52<br>(1.46)  | 4.61*<br>(1.4)   | 8.54*<br>(2.44)   | 14.7*<br>(3.85)  |
| Beneficiation                                                                                                                                         | -0.50**<br>(0.24) | -1.23*<br>(0.42) | -0.40<br>(0.27)  | 0.03<br>(0.42)    | 0.87<br>(0.57)   |
| R-Squared                                                                                                                                             | 0.09              | 0.08             | 0.08             | 0.03              | 0.17             |
| F-statistic                                                                                                                                           | 19.17             | 0.00             | 13.80            | 5.59              | 5.90             |

\* significant at 1%, \*\* significant at 5%, \*\*\* significant at 10%. Std errors in parentheses.

For a further robustness check we ran the analysis for countries grouped into income level to check if the results will be similar. From the regression results as shown in Table 7 below, we found that the model still holds and there is a significantly negative relationship between beneficitation and exchange rate, which is in line with our expected results. For high-income countries however we see a negative coefficient of beneficitation as expected, however it is not significant as expected.

Table 7: Exchange rate estimation results for Full period 1996 – 2015, the last 15 years of the study 2000 – 2015, during financial crisis 2007 – 2013, and post financial crisis (recovery period) 2013 - 2015.

| $\Delta s_{it} = \beta_0 + \beta_1(i_{it} - i_{it}^*) + \beta_2(m_{it} - m_{it}^*) + \beta_3(y_{it} - y_{it}^*) + \gamma_1 B_{it} + \varepsilon_{it}$ |                   |                  |                     |                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|---------------------|---------------------|
| Period                                                                                                                                                | All Countries     | High-Income      | Upper-Middle Income | Lower-Middle Income |
| Variables                                                                                                                                             |                   |                  |                     |                     |
| Constant                                                                                                                                              | 2.63*<br>(1.06)   | 2.1**<br>(0.90)  | -4.13*<br>(1.66)    | 7.8*<br>(2.60)      |
| Output Gap                                                                                                                                            | -2.14*<br>(-6.22) | -0.36*<br>(0.04) | -0.46<br>(0.11)     | -2.58**<br>(1.16)   |
| Broad Money Gap                                                                                                                                       | -0.01*<br>(0.01)  | 0.02<br>(0.01)   | -0.01*<br>(0.00)    | -0.03***<br>(0.02)  |
| Interest Rate Gap                                                                                                                                     | 3.34*<br>(1.04)   | -3.31*<br>(1.02) | -1.1**<br>(0.45)    | 47.48*<br>(8.1)     |
| Beneficitation                                                                                                                                        | -0.50**<br>(0.24) | -0.08<br>(0.09)  | -1.3*<br>(0.40)     | -2.16*<br>(0.55)    |
| R-Squared                                                                                                                                             | 0.09              | 0.99             | 0.90                | 0.50                |
| F-statistic                                                                                                                                           | 19.17             | 4412.11          | 100                 | 18.19               |

\* significant at 1%, \*\* significant at 5%, \*\*\* significant at 10%. Std errors in parentheses.

#### 4.3.2. Foreign Reserves estimation

We estimated the change in log of foreign reserves as a dependent variable using panel least squares for a 20-period sample (1996 – 2015) of 40 countries with a total of 800 balanced panel observations. We used the Hausman Test to determine the appropriate estimator for our model. The results from the Hausman Test as indicated in Table8 below, gave a probability of 4.21% which means we reject the null that states that random effect method is appropriate, and accept the alternative hypothesis. The panel regression was estimated using the fixed effect method.

Table 8: Results of the Hausman Test for appropriate estimator for the model.

| Correlated Random Effects - Hausman Test |                   |              |        |
|------------------------------------------|-------------------|--------------|--------|
| Test cross-section random effects        |                   |              |        |
| Test Summary                             | Chi-Sq. Statistic | Chi-Sq. d.f. | Prob.  |
| Cross-section random                     | 20.113466         | 4            | 0.0005 |

Running the fixed effect model for reserves we found that our explanatory variables have a statistically significant effect on foreign reserves including the beneficitation measure as shown in Table9 below. The model has an R-Squared value of 90% indicating that our model does fit the data and there is a smaller difference between the fitted values and observed data. Beneficitation has a significantly positive effect on foreign reserves. This is also consistent with our second hypothesis stating that countries that beneficite tend to accumulate more foreign reserves.

Table 9: Estimation results for Eq. 3, log change of foreign exchange reserves as a function of macroeconomic fundamentals including beneficitation.

| $\Delta fr_t = \varphi_f(i_t - i_r^*) + (\varphi_y y_{t-1}^* - \varphi_y y_{t-1}) + \varphi_s s_{t-1} + \varphi_B B_t + \varepsilon_{it}$ |                  |
|-------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Variables                                                                                                                                 |                  |
| Constant                                                                                                                                  | 21.10*<br>(0.44) |
| Interest Rate Gap                                                                                                                         | -2.00*<br>(0.63) |
| Output Gap                                                                                                                                | 1.04*<br>(0.22)  |
| Exchange Rate Gap                                                                                                                         | 0.90*<br>(0.10)  |
| Beneficitation                                                                                                                            | 0.28*<br>(0.10)  |
| R-Squared                                                                                                                                 | 0.90             |
| F-statistic                                                                                                                               | 103.79           |
| Prob(F-statistic)                                                                                                                         | 0.00             |

\* significant at 1%, \*\* significant at 5%, \*\*\* significant at 10%. Std errors in parentheses.

For robustness we compare the full period model (1996 – 2015) with periods approaching a financial crisis using the 2007/2008 crisis (see Table 10 below). We used the period 1996 – 2006 as the pre-crisis period, 2000 – 2015 as the last 15 years of the study that includes the financial crisis, 2007 – 2013 as the crisis period, and 2013 – 2015 as the recovery period. In our results we observe a significant effect of the explanatory measures to foreign reserves prior to the crisis, however when we run the model for 2007 – 2013, all our explanatory variables do not explain the dependent variable. When we run the model post the crisis, we see the beneficitation measure starting to significantly affect the independent variable.

Table 10: Foreign Reserve estimation results for Full period 1996 – 2015, pre-financial crisis 1996 – 2006, last 15 years of the study 2000 – 2015, during financial crisis 2007 – 2013, and post financial crisis (recovery period) 2013 – 2015.

| $\Delta fr_t = \varphi_f(i_t - i_r^*) + \varphi_y y_{t-1}^* - \varphi_y y_{t-1} + \varphi_s s_{t-1} + \varphi_B B_t + \varepsilon_{it}$ |                  |                  |                  |                 |                  |
|-----------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------|------------------|-----------------|------------------|
| Period                                                                                                                                  | 1996 - 2015      | 1996 - 2006      | 2000 - 2015      | 2007 - 2013     | 2013 - 2015      |
| Variables                                                                                                                               |                  |                  |                  |                 |                  |
| Constant                                                                                                                                | 21.10*<br>(0.44) | 20.08*<br>(0.86) | 20.94*<br>(0.49) | 24.9*<br>(0.99) | 22.79*<br>(1.15) |
| Interest Rate Gap                                                                                                                       | -2.00*<br>(0.63) | -1.07<br>(0.70)  | -2.83*<br>(0.88) | -1.11<br>(1.56) | -0.61<br>(1.07)  |
| Output Gap                                                                                                                              | 1.04*<br>(0.22)  | 0.03<br>(0.32)   | 1.00*<br>(0.25)  | 0.43<br>(0.36)  | 0.63<br>(0.40)   |
| Exchange Rate Gap                                                                                                                       | 0.90*<br>(0.10)  | 0.11*<br>(0.03)  | 1.1*<br>(0.14)   | 0.07<br>(0.37)  | 0.17<br>(0.43)   |
| Beneficitation                                                                                                                          | 0.28*<br>(0.10)  | 0.75*<br>(0.20)  | 0.57*<br>(0.10)  | -0.16<br>(0.15) | 0.35**<br>(0.17) |
| R-Squared                                                                                                                               | 0.90             | 0.10             | 0.92             | 0.95            | 0.99             |
| F-statistic                                                                                                                             | 103.79           | 5.7              | 114.10           | 96.76           | 364.18           |
| Prob(F-statistic)                                                                                                                       | 0.00             | 0.00             | 0.00             | 0.00            | 0.00             |

\* significant at 1%, \*\* significant at 5%, \*\*\* significant at 10%. Std errors in parentheses.

For further robustness check we ran the analysis with countries grouped into income level to see if the models still hold for our variable of interest. Table 11 below show the results of this robustness test for high-income, upper-middle income and lower-middle income economies. Our results show a significantly positive relationship between beneficitation and foreign reserves for all the income levels, the only exception

is noted for the Lower-Middle income countries where the coefficient of beneficiation is positive as expected but not statistically significant.

*Table 11: Foreign Reserve estimation results for Full period 1996 – 2015, for all countries compared to the High-Income, Upper-Middle Income and Lower-Middle Income levels.*

| $\Delta fr_t = \varphi_f(i_t - i_t^*) + \varphi_y y_{t-1}^* - \varphi_y y_{t-1} + \varphi_s s_{t-1} + \varphi_B B_t + \varepsilon_{it}$ |                  |                  |                     |                     |
|-----------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------|---------------------|---------------------|
| Period                                                                                                                                  | All Countries    | High-Income      | Upper-Middle Income | Lower-Middle Income |
| Variables                                                                                                                               |                  |                  |                     |                     |
| Constant                                                                                                                                | 21.10*<br>(0.44) | 20.18<br>(2.44)  | 6.35<br>(05.67)     | 21.67*<br>(1.32)    |
| Interest Rate Gap                                                                                                                       | -2.00*<br>(0.63) | 18.72*<br>(6.71) | 1.66**<br>(1.59)    | 20.16*<br>(5.18)    |
| Output Gap                                                                                                                              | 1.04*<br>(0.22)  | -0.01<br>(0.35)  | 1.57*<br>(0.36)     | 1.03*<br>(0.38)     |
| Exchange Rate Gap                                                                                                                       | 0.90*<br>(0.10)  | -0.37<br>(0.71)  | 0.02<br>(0.28)      | -0.04<br>(0.06)     |
| Beneficiation                                                                                                                           | 0.28*<br>(0.10)  | 1.13**<br>(0.52) | 4.61*<br>(1.28)     | 0.42<br>(0.32)      |
| R-Squared                                                                                                                               | 0.90             | 0.9              | 0.32                | 0.28                |
| F-statistic                                                                                                                             | 103.79           | 89.91            | 8.76                | 7.38                |
| Prob(F-statistic)                                                                                                                       | 0.00             | 0.00             | 0.00                | 0.00                |

\* significant at 1%, \*\* significant at 5%, \*\*\* significant at 10%. Std errors in parentheses.

#### 4.4. Exchange Market Pressure

From the above observations where we tested the effect of beneficiation to exchange rate and foreign exchange reserves, we observe a significant effect that beneficiation has on both variables. Applying the observed result to the exchange market pressure concept using Park and Mercado Jr. (2014)'s definitions of Exchange Market Pressure Index (EMPI) as a measure of the depreciation of local currency and reduction in foreign reserves. We found that beneficiation does play a vital role in decreasing exchange market pressure, this is because it has a significantly negative effect on exchange rate, and a significantly positive effect on foreign exchange reserves, this means that when the beneficiation measure is increased, exchange rate, which is the price of foreign currency (USA Dollar) in local currency will decrease, therefore strengthening the domestic currency, at the same time with an increase in beneficiation, we will see an increase in foreign reserves. This will therefore result in a decrease in EMPI, which can buffer financial stress and reduce the exchange market pressure.

## 5. Conclusion

In this study we empirically investigated the effect of beneficiation on the foreign exchange market looking at exchange rate volatility and foreign reserves accumulation. We observed that high income countries have a higher beneficiation measure followed by upper middle income, and lower middle income, respectively. There are several ways in which economies can be classified, however using the world bank's income classification, and how it correlates with the beneficiation measure we can conclude that countries that tend to add value to primary mining output tend to have a stable local currency and earn more foreign reserves than countries that export mining output in their raw primary form. There are some exceptions in the model like countries that tend to depreciate their currency to strengthen local manufacturing and make importing expensive like some south Asian countries. With these countries we observe and increased beneficiation measure, and increased foreign exchange reserves accumulation, but a depreciation in currency.

Our empirical results also validated our observation from the raw data. With regards to exchange rate, we found a negatively significant relationship between beneficiation measure and the exchange rate. This negative relationship means that with an increased beneficiation measure, countries will be able to strengthen their currency against the foreign currencies (US dollar in this study), therefore stabilising their financial markets. When we ran a regression for foreign exchange reserves, we observed a positively significant relationship between foreign reserves and beneficiation, which means that with increased value addition to mining outputs, countries would accumulate more foreign reserves which can be used as a buffer during financial crisis. This study does not conclude that beneficiation is the only way in which countries could strengthen their financial markets, however it is another measure which should be considered when looking at stabilising the financial markets by reducing currency volatility, and exchange market pressure.

Lastly in answering the research questions posed at the beginning of this paper, we do observe a statistically significant relationship between exchange rate and beneficiation, as well as between foreign exchange reserves and beneficiation. It is important to note that the significance of beneficiation to both the exchange rate and foreign reserves seem to be disrupted during the financial crisis (2007 – 2013). We observe that countries with a higher beneficiation measure tend to be classified as high-income countries. Low-income countries like Vietnam which in the past 20 years showed an increase in their beneficiation measure tend to have improved economic development measures such as GDP growth rate, HDI, and unemployment rate. Similarly, countries that decreased their beneficiation measure suffered the opposite and India is one such country. This answers that last question whether beneficiation can contribute to a stable financial market and overall development of an economy, and the answer is yes, through industrialisation and trading in value added goods the exchange market can be stabilised.



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