Exchange rate and Economic Growth - a comparative analysis of the possible relationship between them

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Exchange rate and Economic Growth - a comparative analysis of the possible relationship between them

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In this article, a comparative analysis has been done on the possibility of a correlation between economic growth and exchange rates. To represents the factor of growth GDP, inflation, growth has been examined in different cases. In the same way for exchange rates, nominal exchange rate, real exchange rate has been analysed based on the specific cases. Here we also see a machine learning approach to find the correlation in both short and long run time period. Some empirical test and data analysis done by many economists have also been clustered here to map the total overview in a better manner.

1 Introduction

Recently many studies have been done to found a robust relationship between exchange rate and gross domestic product (GDP) as an indicator of the economic development of a country. There is an exciting study regarding this topic by Hansumann et al. (2005). (*4*) In that study, they analyzed the determinants of growth episodes in a time period of the latter half of the 20th century. In that study, they found that in a country, the depreciation in real exchange rates helps to maintain the growth rates. According to the same study, the growth regression is based on a powerful assumption that suggests a single linear appropriate model for all countries in all-state. The effects of growths on competitive exchange price were first noticed in developing countries (*8*), and this finding is a great motivation behind choosing this topic. The same literature has interpreted a correlation between real exchange rate (RER) and economic growth as casualty running from RER levels to growth rates, i.e. more competitive RER levels generally favour growth. It also has been seen that for African countries, GDP has a significant relationship with the exchange rate where there is a nonsignificant relationship between exchange rate and interest rate and inflation. (*1*) So now, many developing and developing countries are trying to learn the patterns involved with the international trade flow and foreign exchange rates to determine that country's economic growth and economic stability. This knowledge of growth and strength can be helpful to decide on that country's import and export behaviour in coming times. In fact, there are possibilities that a country can extrapolate their predictions of economic growth from the exchange rate and correctly frame the trades in a correct manner. Here in this article, we have discussed the topic in several sections. In the literature preview section, a small discussion has been made about the motivation behind the topic with some background information on the topic.

In the next section, some empirical evidences with analysis have been presented to prove the correlation between GDP growth and exchange rate. In the next section, the problem has been seen from a machine learning perspective with the ANFIS system. The next section consists of some special cases in international trades from some case study article from reputed journals. Then how good the exchange rate is as a GDP has been discussed briefly.

2 Literature preview

Competitive real exchange rates also know as RER has a positive impact on economic growth. The main goal of a competitive RER strategy is to increase profitability in dynamic tradable activities to stimulate the expansion of the respective country. The RER is the relative price with labour between non-tradable and tradable. So, by keeping the rest factor unchanged, an increase in RER results in a higher rate of profit for tradables which induce investment in the economy. (*3*) So, by manipulating the nominal exchange rate a permanent favourable relative price configuration can be achieved for a specific period of time. From the empirical pieces of evidence, it can be seen that there is one to one correlation between the real exchange rate and the nominal exchange rate which can't be seen in the long run. (*7*)

The real exchange rate need not be affected permanently by the policy made for exchange which is made for the purpose of development strategy. A temporary deviation of the real exchange rate from the equilibrium state is sufficient to make a long term effect on the economy, this case is very commonly seen in the case of transitory real exchange rate overvaluation. There is a trade model developed by Krugman which shows how a transitory appreciation of currency results in a permanent contraction of the tradable sector. For example, we can show the deindustrialization in Britain in the 1980s after

the new tight monetary policy taken by Thatcher's government. (*10*) In 1998, Skott and Ross built a model of a dual economy to characterize Latin America's deindustrialization in 1990 after the currency overvaluation and liberalization of trade. Here in these both examples, the increasing dynamic return of the tradable sector is the main factor. From this observation, it can be said that a transitory appreciation of currency can dissipate the profitability of tradables if there is a clear decrease in domestic productivity during the transition period. When real exchange rate rebound to its long-run equilibrium position, the domestic firms will experience loss in productivity which make them less competitive for the international market. This leads to a fixed contraction in the tradable sector. This mechanism is also applicable for the case of transitory real depreciation, which induces a permanent expansion of the tradable sector. To have happened this mechanism, the relative price has to be enough durable and stable which make the firms invest in that economy. This can be achieved by the change in nominal exchange rates which depends on the degree of pass-through to domestic prices and wages. This also majorly depends on the labour market conditions.

Now if a devaluation happens in a developing country with a small open economy containing all possible stylized trajectories with non-trivial unemployment or underemployment, the real exchange rate of the country will take up a position at a competitive level and after that, the nominal exchange rate will get stabilized. So, the devaluation is increasing the profitability in the short-run in the tradable sector. The demand here is getting changed from tradable sector to non-tradable sector. So, the firms from the tradable sector with profit maximization policies will expand employment and output productivity. Due to the substitution effect and increase in positive income, the demand also will increase and these results increase in output in the nontradable sector also. Hence, an exchange rate policy with a competitive real exchange rate target will impact positively on the economy

of a short run economy. (*8*) Price for the non-tradable sector are generally determined by the conditions in the domestic market. If the output productivity in the non-tradable sector is very low, then the market supply condition will mainly depend on labour availability. For a developing country generally, the supply of goods from the non-tradable sector is quite elastic at the starting period of the development process because of the unemployment or underemployment condition of the country. The degree of elasticity generally varies with labour scarcity. So, for low-income countries like China, the supply is more elastic than middle-income countries like Chile and Argentina. This difference plays an important role in the development of the economy.

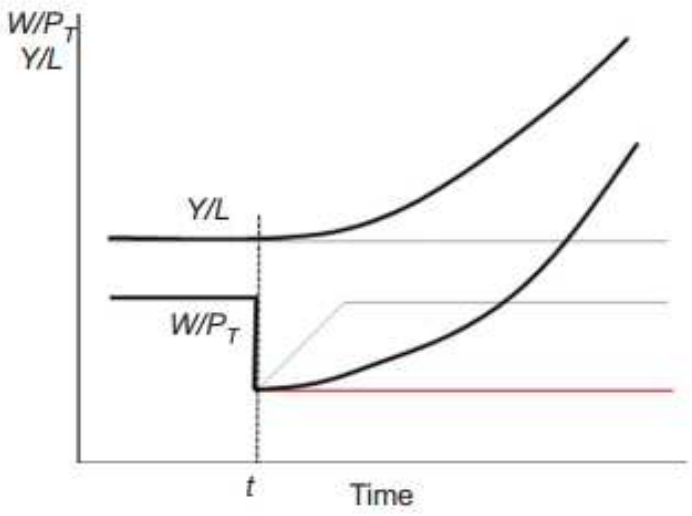

Figure 1: Stylized dynamics competitiveness of real exchange rates

The plot here is the illustration of three possible stylized dynamics competitiveness of real exchange rates in a developing country. This is measured from the distance between labour productivity (Y/L) and product wages (W/PT). Both of these are prime determinants of the profit rate in the tradable sector. So, the output production of the tradable sector may be operated with an increasing return to scale. At time t in the

plot, the devaluation happened and before that the tradable productivity and product wages are different. After the devaluation, the product wages got decreased and tradable price got increased. This lead to rising in profitability. Now here a crucial question is that this increase in profitability enough stable to trigger a sustained expansion in the tradable sector.This depends on two factors one is the country is a low-income country or middle-income country and secondly the macroeconomic policies taken by the government of that respective country for the growth and development purpose. (*11*)

3 Empirical test method

Here in this section, an empirical test has been discussed from an analysis report done by Missio et al. (2015). (*7*) They developed an empirical analysis that tries to find the relationship between the economic growth and the level of the Real exchange rate. They did this test for a selected group of countries. Initially, they estimated an index for the undervaluation of the real exchange rate. This undervaluation was proposed in a research article by Rodrik (2008) (*9*). So, this test consists of three steps:

1. The real exchange rate is obtained as follows:

   $lnRER_{it} = ln(XRAT_{it}/PPP_{it})$ - (1)

   RER_{it} = real exchange rate

   $XRAT_{it}$ = nominal exchange rate (in domestic currency)

   PPP_{it} = conversion factor (perchasing power parity)

   2cm i = countries

   2cm t = time period.

When the RER_{it} will have a value greater than one then the current value of the currency is smaller than the PPP indicated value. This is an undervalued condition.

2. At the next step, the real exchange rate estimated by the Balassa-Samuelson effect is adjusted. So, equation (1) now should be corporated by the difference in factor endowment. The per capita GDP (pibpcd) is a proxy variable for these endowments.

$$lnRER_{it} = \alpha_1 ln(pibpcd_{it}) + \mu_{it} + \eta_i \epsilon_{it} \qquad \text{- (2)}$$

μ_{it} = Fixed effect for entire time periods
η_t = Fixed effect for countries
ϵ_{it} = Error term

3. In the last step, the undervaluation index has been calculated by taking the difference between the exchange rate adjusted for the Balassa - Samuelson effect and the actual exchange rate.

$$Undervaluated_{it} = (lnRER_{it} - \overline{lnRER_{it}}) \qquad \text{- (3)}$$

$Undervalued_{it}$ = the exchange rate undervaluation index.
RER_{it} = value of real exchange rate from equation (2).

So, the defined index is comparable among countries and over time also. If the value of this index is greater than one then the exchange rate is such that the domestic price is cheaper than the currency of the reference country (mainly the dollar), so the domestic currency can be said as undervalued. Though here loga-

rithmic transformation has been done so the index is centred at zero.

Based on this index the relationship between the per capita growth rate of selected countries and the level of the real exchange rate of those countries can be explored very easily.

4 From a machine learning perspective

Recently machine learning has changed a lot of things in every field of science and technology where data analysis is required. This problem also can be viewed from a machine learning point of view to find the correlation between economic development and exchange rate. If the relation between them is statistically significant then we can make an ML model which can predict GDP from the exchange rate data in upcoming times. Here to represent the development we will take GDP. There is an article where some researchers tried to build an ML model by adaptive neuro-fuzzy inference system (ANFIS) (*5*). The data they used to build the models is in the following table:

		GDP($)			Exchange Rate		
Sl no.	**Country**	**min**	**max**	**average**	**min**	**max**	**average**
1	**AUS**	0.696666	1.933443	1.149393	25029.03	1181218	386021.4
2	**AUT**	0.682675	1.889494	1.023064	28628.07	441389.3	193187.4
3	**BEL**	0.682675	1.471942	0.920279	37554.56	526430.5	235570.4
4	**CAN**	0.978033	1.569318	1.212512	98753.86	1625361	731153.6
5	**CZE**	17.07167	38.59842	25.91141	119535.2	367171.7	219103.6
6	**DNK**	5.098131	10.59639	6.68557	16625.01	280838.7	116996.3
7	**FIN**	0.618707	1.11751	0.792339	15647.27	238376.1	110182.1
8	**FRA**	0.644185	1.369789	0.83916	84497.21	2765543	1078072
9	**DEU**	0.682675	1.871328	1.01687	314570.1	4030399	1847972
10	**GRC**	0.086941	1.11751	0.459027	6847.866	341817.8	143714.7
11	**HUN**	74.73538	286.49	197.7077	85479.37	262041.8	162834.5
12	**ISL**	74.73538	286.49	197.7077	85479.37	262041.8	162834.5
13	**IRL**	0.322786	1.200683	0.796804	7904.671	339477.5	99860.37
14	**ITA**	0.301092	1.11751	0.703161	195082.4	2326305	1199300
15	**JPN**	79.79046	350.6777	165.9102	19521.82	5369479	2629702
16	**KOR**	310.5558	1401.437	849.4495	19521.82	1872132	661140.4
17	**LUX**	0.0125	1.471942	0.894173	1993.145	88574.89	21986.44
18	**MEX**	0.0125	18.66406	5.750747	88574.89	2266350	889229.5
19	**NLD**	0.682675	1.642684	1.003958	51936.13	860688.8	382172
20	**NZL**	0.715403	2.378751	1.447566	10875.06	180995.1	71662.34
21	**NOR**	4.939225	8.991654	6.634258	13057.83	340619.8	133275.3
22	**POL**	0.95	4.346075	3.009694	226248.7	1039744	552488.1
23	**PRT**	0.122281	1.11751	0.635435	18320.86	316027.3	148818.7
24	**SVK**	0.709069	1.605086	1.021069	39563.45	165424	96361.94
25	**ESO**	0.345023	1.11751	0.710362	94839.19	1687613	738291.1
26	**SWE**	4.152192	10.32914	6.4192	18191.23	485284.1	180970.6
27	**CHE**	0.888042	4.37295	1.751544	44869.24	534902.7	226181.5
28	**TUR**	0.000011	3.020135	0.617803	62893.06	2007466	630117.1
29	**GBR**	0.357143	0.779246	0.546114	114500.8	2798060	1052168
30	**USA**	1	1	1	1075884	18624475	8057415
31	**CHL**	192.93	691.3975	474.1951	41480.37	415398.4	192748.7
32	**CHN**	1.498386	8.618743	5.987692	306861.5	19709788	5341534
33	**COL**	1796.896	3054.122	2264.379	266073.6	688817.3	456197.8
34	**EST**	0.683499	1.117052	0.839817	8421.739	39135.97	22191.19
35	**ISR**	0.001045	4.737825	2.676946	22370.85	318408.8	131419.9
36	**RUS**	4.55915	67.05593	28.38137	867605.8	3768772	2221892
37	**SVN**	0.115053	1.012973	0.713589	22408.29	67574.53	44303.44

Here to apply this method adaptive neural network should be used and this can map input/output data samples by the hybrid learning algorithm. They have used two methods for training the model, one is with backpropagation of all parameters and the other is a hybrid model with features of input classifiers. After the training, the ANFIS model was created with three bell-shaped membership function as the accuracy of this training model was better than the other one according to the predictions of the training model. In the AFNIS model, they have taken five intermediate AFNIS layers and for each layer, there is a specific function for the training procedure. After the analysis, the testing data has given a result with good enough accuracy. The results are as follows:

Variable	**Coefficient**	**RMSE**
Nominaql Effective Exchage Rate	0.25	0.18
GDP	-0.21	0.76

In Long-Run

Variable	**Coefficient**	**RMSE**
Nominaql Effective Exchage Rate	0.02	0.078
GDP	1.23	0.3

In Short-Run

From the above result, it can be seen that for the long run time period (upper table) nominal exchange rate has no significance on aggregate import price and GDP but in the short-run (the lower table) GDP is significantly influenced by the nominal effective exchange rate.

After comparing the predicted GDP with the testing data the model is giving the following plot:

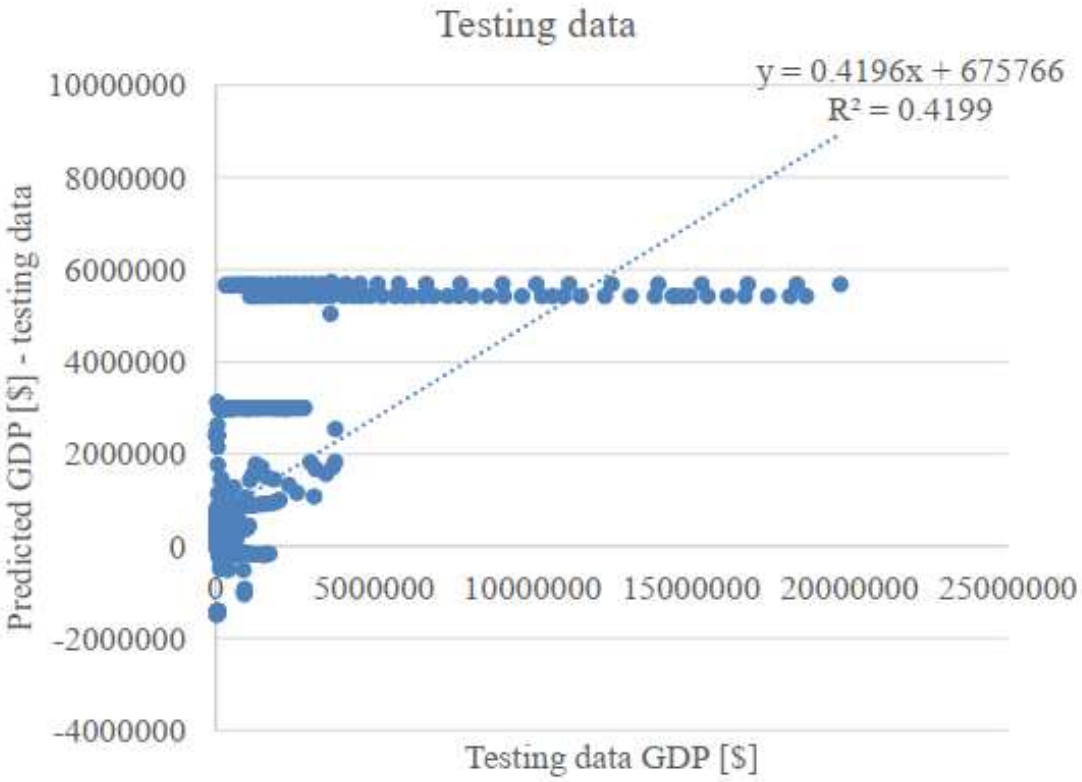

Figure 2: Comparison between testing data and data predicted by ML model

5 Undervaluation of Real Exchange Rate and Economic Growth across different countries

In this section, we are going to see the analysis done by Rodrik (2008) (*9*). The following figures are the plots of how developing countries are experiencing real undervaluation against that country's economic growth rate in the same time period ie. 1950 - 2004. All the plots are made by Dani Rodrik from the data of Penn World Tables (*9*).

So, here we can see plots of seven countries: India, China, Taiwan, South Korea, Uganda, Tanzania and Mexico. Each point in the graph represents the average of a time period of five years. In the first plot, we can see China's economic growth. The rapid increase in the annual growth of GDP per capita starting in the latter half of 70's decade closely parallels the increase in the undervaluation index (from an observation of undervaluation from 100 per cent to 50 per cent) and both undervaluation and growth rate plateau in the 90's decade. So, in recent years the yuan is very undervalued and China's government has not given enough attention to this undervaluation which has a significant role in the country's economic growth. In the case of India, the image of growth is almost the same as China's growth. India's GDP per capita has steadily increased from

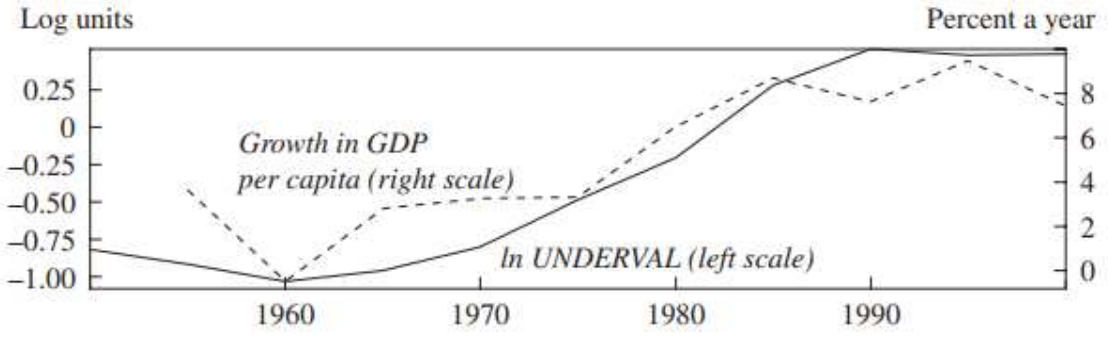

Figure 3: China

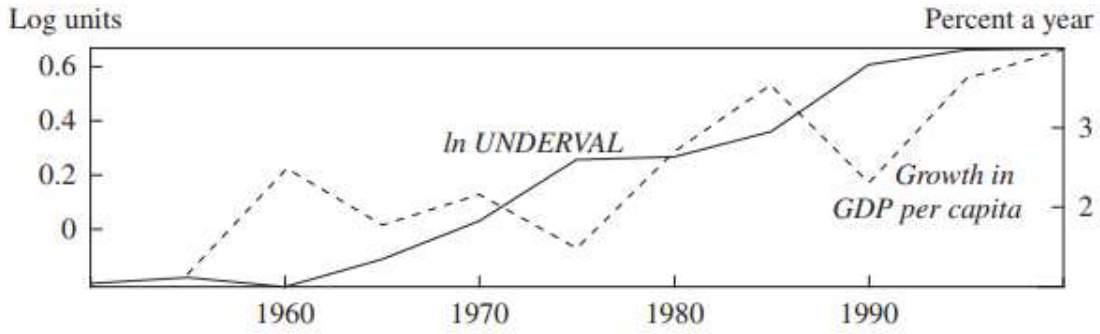

Figure 4: India

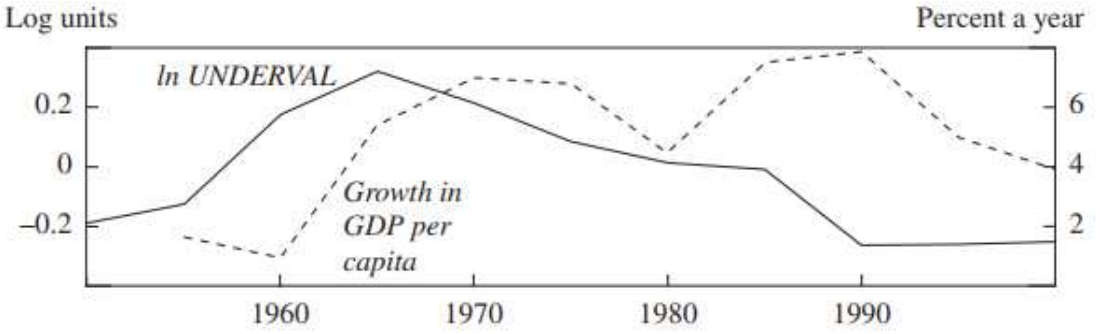

Figure 5: South Korea

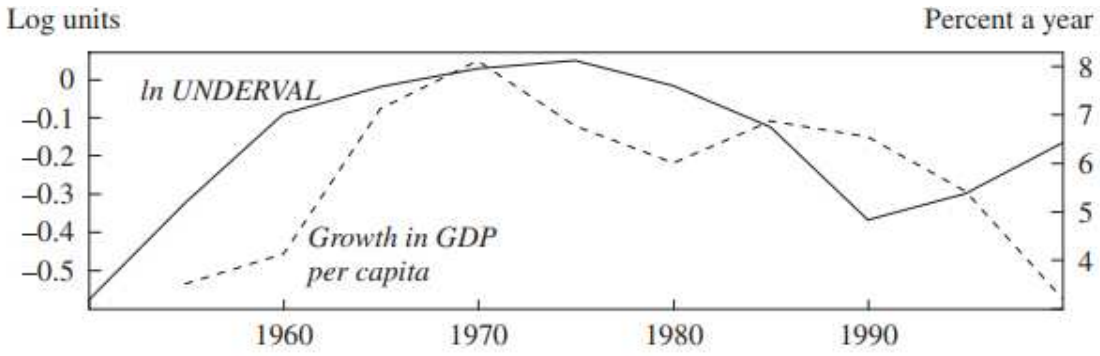

Figure 6: Taiwan

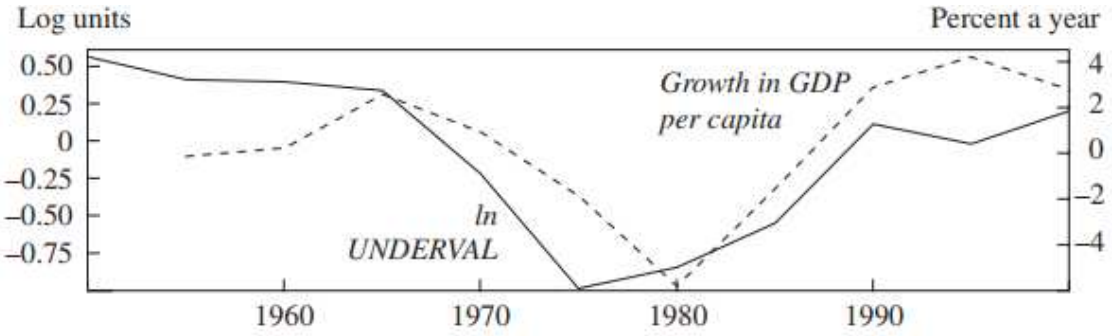

Figure 7: Uganda

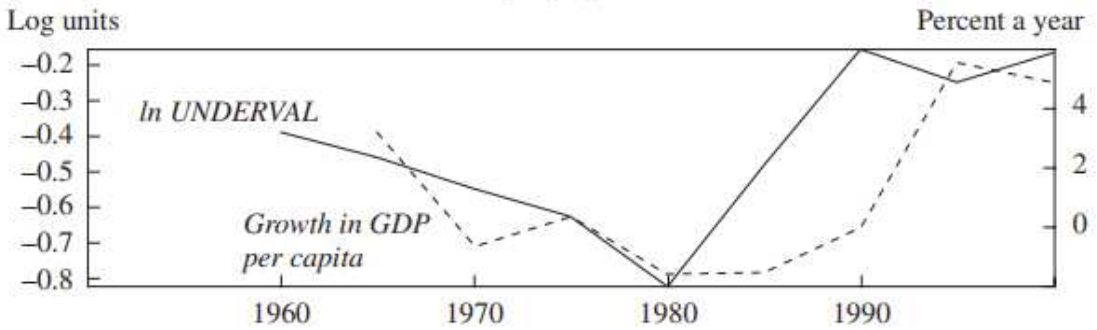

Figure 8: Tanzania

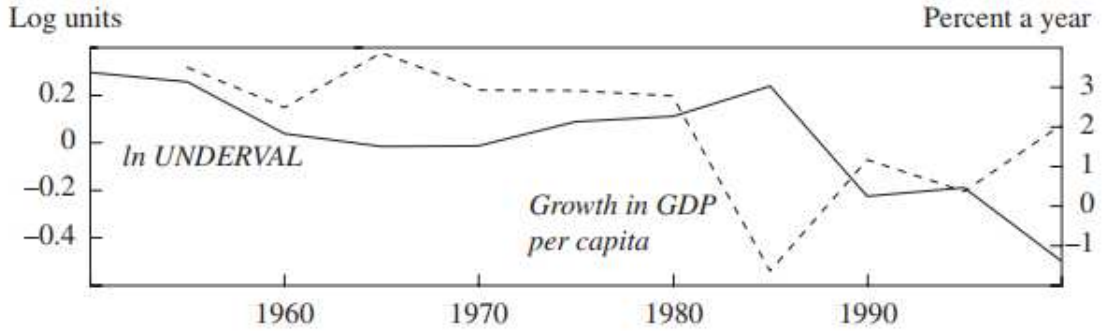

Figure 9: Mexico

a little more than one per cent per year in the 1950s to four per cent per year in the early 2000 decade. India's RER has moved from a small overvaluation to an undervaluation of almost sixty per cent. In the next two graphs for South Korea and Taiwan, it can be seen that the growth has been slowing down in the last few years of the graph and every step of this growth is accompanied by decreased undervaluation or increased overvaluation. So, this can be concluded that both undervaluation and growth exhibit an inverse U shape over time. Though this rule is generally specific to only Asian countries. In the case of African countries, the picture is not the same. For the graph of Uganda and Tanzania, the undervaluation index captures the turning points in economic growth very well. Slowing down of growth is accompanied by an increase in overvaluation and pickup in growth is accompanied by an increase in undervaluation. In the last picture, the correlation for Mexico has been plotted. Here we can see that the two series seem quite a bit out of sync, especially since 1981 when the correlation between undervaluation and growth turns negative rather than positive. This is kind of a reflection of the cyclical role of capital inflows in inducing growth in that country. Periods of capital inflow in Mexico are associated with consumptions led growth booms and currency appreciation. When the capital flows in the reverse direction, the economy tanks and the currency depreciates. So, there is a need for a general symmetric empirical model which can explain all these different types of individual cases.

6 Exchange rate: As a predictor of GDP

The exchange rate is one of the important factors that influence the GDP of an economy. Exchange rate and foreign currency exchange reserves are highly correlated which influence the GDP a lot. (*2*) There is a study by Agarwal and Agarwal (2013) where they analysed the impact of global capital flows on GDP growth rate, inflation and exchange

rate on the quarterly data of India from 1948 to 2010. The finding of the study indicates that the GDP is statistically significant in determining capital flows. A higher GDP can increase foreign investment by increasing the confidence of the investors. This eventually leads to growth in the economy. In another article by Tahir Khan (2013) (*6*), he worked on the cointegration test and found the long-run relationship between foreign exchange rate and inflation, which also suggests that these can be a good indicator of upcoming GDP.

7 Conclusion

In the conclusion, it can be said that still there are not enough generalised symmetrical model for the correlation between economic growth and exchange rate but we can see the patterns in every analysis across many country's economies. So, there is a possibility of a correlation between them. If this correlation can be generalised then it will be a great opportunity for policymakers because then they can predict the growth by seeing the exchange rates. Big data analytics can predict GDP from the exchange rate, and in this way government also can frame their policies to achieve some growth stability. The trade policy-making factors will be changed.

8 Acknowledgement

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