SEISENSE Journal of Management
Vol 3 No 4 (2020): DOI: https://doi.org/10.33215/sjom.v3i4.367 , 44-55
Research Article

A System Dynamics Model Of Exchange Rate Determination And Forecasting

Aima Khan*

University of Bergen, Norway
* Corresponding author: aimamhkhan@yahoo.com

Article History
Received 2020-05-04
Revised 2020-07-09
Accepted 2020-07-10
Published 2020-07-17

Keywords
Exchange rate
System dynamics
Fundamental factors
Feedback relationships

How to cite?
Khan, A. (2020). A system dynamics model of exchange rate determination and forecasting. SEISENSE Journal of Management, 3(4), 44-55. doi:10.33215/sjom.v3i4.367

Abstract

Objective: The objective of this paper is to develop a model of exchange rate determination and forecasting to provide reasonable forecasts for the exchange rate to facilitate long-term investments.

Design: The study develops the model using the system dynamics method. Grounded on the fundamental theories, the model incorporates nonlinear feedback relationships of interest rate, inflation, per capita income, terms of trade, and oil prices with the exchange rate.

Findings: The simulation results indicate the robustness of the model to mimic not only the long term past behavior of the exchange rate but also its ability to provide a reliable long-term forecast for the exchange rate. The model is portable and applies to any oil-exporting country after calibration.

Policy Implications: The study has practical implications for individuals, businesses, and the Government because they are all influenced by the exchange rate movements. Specifically, this model provides a useful tool for long term strategic financial planning of oil firms.

Originality: The study develops a model for exchange rate accounting for nonlinear feedback relationships among the variables.

Introduction

The exchange rate is one of the significant factors that may influence and is influenced by the economy of the country. It is one of the essential elements reflecting a country's economic health. The exchange rate movements influence the trade performance of many firms in any specific country and its balance of payments. The exchange rate is defined as the price of one currency in terms of another currency, determined by the demand and supply mechanism in the market. This demand and supply mechanism is a consequence of multiple factors of the economy. Specification of those factors that determine the exchange rate is still a challenge despite the vast amount of work done to explain the exchange rate volatility. This is evidenced by the presence of enormous theoretical models, and various modeling approaches (Meese & Rogoff, 1983) used to determine the exchange rate behavior. The monetary model of the exchange rate has been an essential part of exchange rate determination models, which relies on the fundamental variables of the economy to explain the exchange rate movements (Cerra & Saxena, 2010). Much empirical evidence is emerging due to advances in econometrics for testing the relationship between the exchange rate and the fundamental variables as predicted by the theoretical models. In the international finance literature, imperative theories, namely Purchasing Power Parity (PPP), International Fisher Effect (IFE), and Interest Rate Parity (IRP) are most widely used. These theories define international parity conditions that determine the exchange rate between two currencies. The PPP assumes that the price of an identical basket of goods in two countries is constant when measured in terms of common currency. Whereas IFE and IRP consider interest rate as a source of change between the currencies' exchange rates. Such use of international parity conditions to determine the exchange rate is labeled as the fundamental method that is expected to provide long-term trends rather than short-term predictions (J. Madura & Fox, 2011). It is because the exchange rate might deviate from its equilibrium level defined by PPP in the short run, but it is expected to revert to its mean in the long run (Dąbrowski, Papież, & Śmiech, 2014). Other methods of exchange rate determination are technical and market-based. These methods are linear.

Moreover, the empirical evidence is inconclusive (Öge Güney & Hasanov, 2014; Park & Park, 2013). It is ironic to note that these methods not only ignore the feedback processes but also do not utilize the fundamental causal structure put forward by the fundamental method. This might be one possible reason for the poor empirical performance of these models. This study is an endeavor to fill the gap by modeling the exchange rate through these fundamental theories using feedback loops and nonlinear relationships. The objective of this paper is to develop a system dynamics model of the exchange rate that embodies the structure that explains the relationship between exchange rate and the fundamental variables, enabling the replication of the past behavior and leading to reliable forecasts to facilitate the long term investment and financing decisions. First, the model is simulated to calibrate the historical exchange rate between Norwegian Kroner and the US dollar. Once the model can capture the long-term trends of exchange rate movements, the model is simulated to provide forecasts for the future and test various scenarios designed to assess the impact of changes in variables on the exchange rate.

The model developed in this study would provide forecasts for exchange rate movements from long term foreign investment and financing perspective for multinational companies generally and specifically for oil companies as it includes the impact of oil price fluctuations for an oil-exporting country. Since the Bretton Woods system ended in 1971, most of the countries followed the floating exchange rate policy, and exchange rate volatility has become inevitable(Kilicarslan, 2018). Exchange rate volatility is the change in the price of one currency in terms of another currency. Volatility is the movement of the price of currency around the balance value of exchange rate or short-term fluctuations from the long-term equilibrium trends of an exchange rate that leads to appreciation or depreciation of the currency(Oaikhenan & Aigheyisi, 2015). Appreciation or depreciation of the currency does significantly impact the profitability of foreign exchange transactions, relative prices of the country, foreign investment flows, including both direct and portfolio and stable economic growth

(Ajao, 2015; Martins, 2015). Changes in macroeconomic factors increase the uncertainty causing volatility in the exchange rate market. This uncertainty causes delays in investment decisions, negatively influencing economic growth through influencing investor confidence, capital, and trade flows (Oaikhenan & Aigheyisi, 2015). Thus, forecasting exchange rate movements is significant for making decisions regarding trade and capital flows, investments, and the economy. Exchange rate considerations are essential not only for trade volumes of a country but also for long term investments, the former appears on the current account balance whereas, the later on the capital account. Multinational companies undertake most of the foreign direct investment of the world, and the exchange rate plays an important role not only when the investments are made but also when payoff from these investments needs to be converted back to the local currency (Crowley & Lee, 2003).

In this article, the simple model of the exchange rate is developed, which accounts for the fundamental factors that play their role in exchange rate determination through demand and supply of currency. The study focuses on the structures generating the exchange rate trend between Norwegian kroner (NOK) and US dollar (USD) by using the system dynamics approach, based on interrelationship among inflation, interest rate, per capita income, terms of trade, oil prices, and exchange rate. The model operationalizes the PPP and IRP theories of the exchange rate to determine the exchange rate to provide empirical evidence if these fundamental models of exchange rate explain the exchange rate behavior. The model focuses on the Norwegian economy. Norway has allowed a free-floating exchange rate since 1992. Norway is an economy rich in natural resources, including petroleum, gas, hydropower, fish, and minerals. Thus, the exports of the country include these natural resources, mainly petroleum, gas, seafood, and shipping, with trade surplus historically in the trade balance. Oil and gas exports are almost half of the total exports of Norway[1]. Therefore, oil prices also play an important role in exchange rate determination. The economy is significantly influenced by the exchange rate movements due to dependence on exports from petroleum and other natural resources. This dependence also influences the per capita income of the country and terms of trade. Thus, an exchange rate model that develops a structure explaining the exchange rate movements is useful for developing an understanding of the exchange rate, specifically in the case of Norway. The study contains significance as it provides an exchange rate model based on fundamental macroeconomic factors. The factors are modeled in feedback and nonlinear relationships, thus making the relationship between the exchange rate and the factors more dynamic and close to the real world as opposed to the other statistical static models. The model provides a simple structure explaining the exchange rate movements, which makes it generic and possible to be used for other currencies as well. The forecasts generated by the model have implications for individuals, businesses, and the Government for their long-term decision making that involves the impact of the exchange rate.

The rest of the paper is organized as follows: Section 2 describes the variables and their relationships with the exchange rate. Section 3 discusses the structure of the system dynamics model. Section 4 provides the model calibration and scenario design. Section 5 discusses the implication of the results. Limitations and future research are given at the end

Literature Review

Fundamental Variables in Exchange Rate Determination

The study develops an explanatory model that incorporates the structural causes of the exchange rate behavior. This section discusses the macroeconomic factors modeled in a feedback relationship with the exchange rate as the exchange rate also does influence trade and other key macroeconomic variables of an economy.

[1] https://www.norskpetroleum.no/en/production-and-exports/exports-of-oil-and-gas/

Exchange rate

The exchange rate is one of the critical factors of a country's economic health, trade levels, and portfolio returns. The exchange rate represents the variable of interest aimed to be determined and forecasted through the causalities. The model incorporates the exchange rate for NOK per USD (NOK/USD) using a direct exchange rate quotation. Changes in exchange rate occur due to changes in demand and supply of the currencies (Jeff Madura, 2006). These changes in supply and demand of the currencies are due to various macroeconomic factors (Abbas, Iqbal, & Ayaz, 2012). Thus, the new exchange rate is determined at the equilibrium level, where the supply and demand of the currencies meet.

Interest rate: (International Fisher Effect, Interest Rate Parity)

Interest rate is defined as the rate that determines the charge on the use of money and reflects one of the critical determinants of the exchange rate. It is because the interest rate directly influences the demand and supply of the currency. As per IFE and IRP, the differential in interest rate leads to the difference in the forward exchange rate from the spot exchange rate (Perera, Silva, & Silva, 2018). Higher local interest rate promises a higher return on the local currency relative to other options and attracts more capital from individuals, investors, and foreign capital. Thus, higher local interest rate increases the demand for the currency and impact positively with the appreciation of the local currency and vice versa. The interest rate is used as a tool for monetary policy by the central banks due to its significant role in the supply and demand of the currency.

Inflation: (Purchasing Power Parity)

Purchasing power parity is one of the most controversial and prevalent theories of international financial management (Rogoff, 1996). The theory accounts for the relationship between exchange rate and inflation. The validity of the theory has implications for decision and policymakers of central banks, exchange rate markets, and multinational firms (Jiang, Jian, Liu, & Su, 2016). The implication is that if PPP holds, then nominal exchange rate fluctuations do not affect the trade flows. PPP assumes that the real exchange rate should return to an equilibrium level in the long run and should be mean-reverting (stationary) in the long run. If the real exchange rate is not stationary, it implies that there is no relationship between domestic and foreign prices and nominal exchange rate in the long run and invalidates the PPP hypothesis (Bahmani-Oskooee, Chang, Chen, & Tzeng, 2017). The theory implies that exchange rate adjustment is necessary for the purchasing power to be the same. Otherwise, consumers will shift purchases to wherever prices are lower until power is the same. Inflation is expected to hurt the home currency exchange rate. As inflation rises in a country, exports decline, and imports increase. This puts pressure on the country's currency, and the value of the currency declines (Kuttner & Posen, 2000). Thus, as per PPP, inflation would pressure to adjust the exchange rate until purchasing power becomes the same.

Per capita income

Per capita income influences and is influenced by the exchange rate movements. If the income of a foreign country rises, people would have more money to increase their spending, and imports of a foreign country would rise, resulting in appreciation of the local currency and vice versa.

Terms of trade (TOT)

The exchange rate plays a very significant role in the trade level of an economy. In the same way, exchange rate fluctuations are influenced by the imports and exports of the country as they impact the demand and supply of the currency. When there is an increase in exports, the demand for the local currency will increase, leading to an appreciation of the local currency. When imports increase, it negatively affects the domestic currency as people spend the money to import more goods for consumption. That increases the demand for foreign currency relative to domestic currency and results in deterioration of domestic currency.

TOT = foreign exports / imports …..(1)

Oil Prices

There has been evidence of the relationship between oil prices and the exchange rate in the literature (Kim & Jung, 2018; Reboredo, 2012). Oil prices play their role in exchange rate movements in the case of Norway as the country is an exporter of oil and gas, with oil and gas being a significant part of the exports. Theoretically, for an oil exporter, oil price shock transfers to the exchange rate through two primary channels. One is through terms of trade, and the other is through wealth effects (Bodenstein, Erceg, & Guerrieri, 2011). When oil prices increase, it positively influences the oil-exporting economy as international profits of the oil firms increase and demand the local currency increase to convert those profits back into local currency. Due to an increase in currency demand, local currency appreciates, and vice versa.

System Dynamics Model

System dynamics methodology is appropriate for modeling the exchange rate movements for multiple reasons. The model accounts for the feedback relationship among the fundamental factors and exchange rate. The Calibrated system dynamics model's forecasts are likely to be more reliable and informative than the other methods. Developing and testing the system dynamics model is an iterative process and includes five significant steps. The first step is problem articulation, which includes identifying the dynamic problem that needs to be solved and the critical variables involved and time horizon. The second step is dynamic hypothesis development that incorporates the details of the problem causing variables and causal loop diagram that incorporates the significant variables and relationships of the variables involved. The third step is the formulation that involves the model building. The relationships need to be defined as per theory and which have real-life meaning such as stocks, flows, auxiliary, parameters such as initial conditions and constants. The fourth step is testing the behavior of the system related to the purpose of the model. When the model is generating the right behavior for the right reasons, there comes the last step of policy formulation and evaluation where various policies or scenarios could be tested and evaluated. But the modeler does not necessarily need to follow these steps linearly and could move to any step forward or back during the modeling process (J. Sterman, 2000). System dynamics modeling allows for the inclusion of nonlinear behavior of the variables.

The purpose is to develop an exchange rate model to determine the exchange rate through fundamental causal variables. Exchange rate fluctuations are a complex phenomenon, and building a simplified explanatory model that replicates the long-term behavior is a challenging task. The model includes the fundamental factors that are expected to play their role in exchange rate fluctuations. Figure 1 summarizes the causal structure of the model. The exchange rate is represented as NOK/ USD. Thus, an increase in exchange rate refers to the depreciation of Norwegian kroner and vice versa. Reinforcing loop (R1) represents the role of expectations in the determination of future exchange rates. Expectations in the market are formed on the previous trends of the exchange rate.

Reinforcing loop (R2) demonstrates the feedback relationship between inflation and exchange rate. Exchange rate depreciation leads to an increase in inflation. An increase in inflation leads to depreciation of the exchange rate next time around. Reinforcing loop (R3) indicates the relationship between exports and exchange rates. Depreciation of the exchange rate impacts exports positively. It is because the products of Norway become cheaper for foreign countries when NOK depreciates. An increase in exports has a positive impact on the economy, and the exchange rate appreciates. When exports increases, the demand for NOK increases and results in an appreciation of NOK. Balancing loop (B1) represents the feedback relationship between the interest rate and exchange rate. When the exchange rate depreciates, interest rate increase to attract more capital as the interest rate is used as a tool to control the currency demand and supply. The inflow of capital has a positive influence on the exchange rate. Balancing loop (B2) accounts for the relationship between imports and the exchange rate. Depreciation of the exchange rate leads to a decrease in imports as they become expensive in terms of local currency. A decrease in imports leads to exchange rate appreciation. High per capita income indicates the overall strength of the country's economy and has a positive influence on the exchange rate leading to an appreciation of the local exchange rate. When there is an increase in oil prices, it leads to an appreciation of Norwegian kroner and vice versa. Given this feedback structure, the model is simulated to analyze the exchange rate behavior.

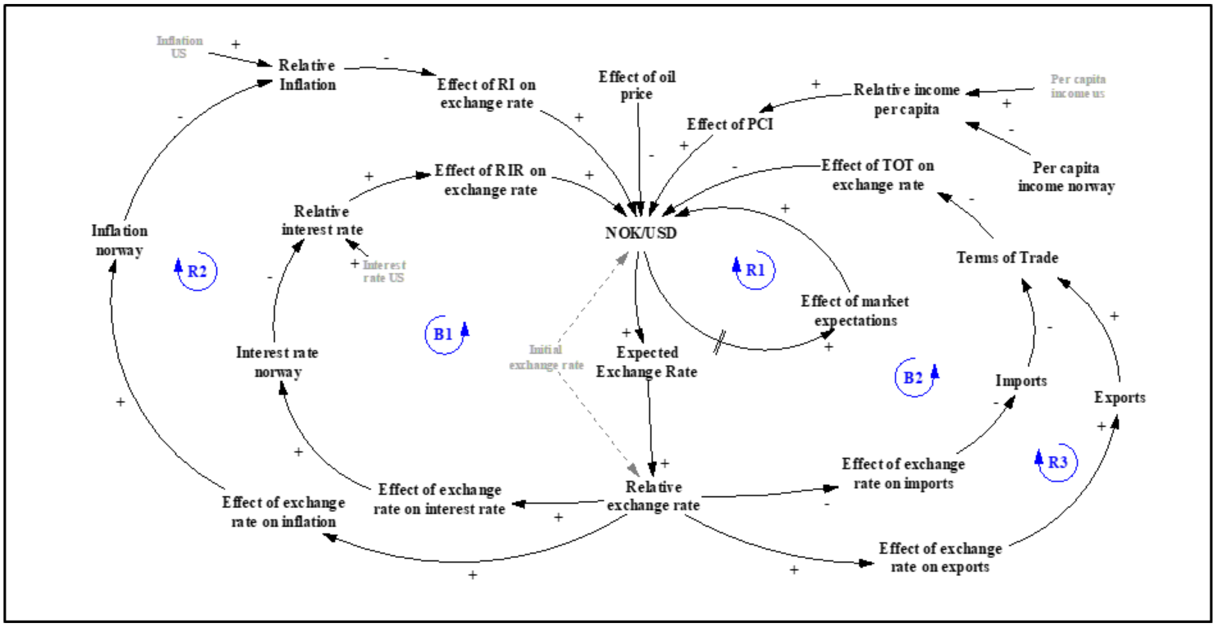

Figure 1 - Feedback structure of exchange rate module

Assumptions and initial values

Developing a simplified exchange rate model that can replicate the past behavior reasonably and provide reliable forecasts requires some assumptions about the model boundary and other elements. Therefore, assumptions are made to make this simplification.

- Only currency NOK is explored in terms of USD. The model does not take into account the interaction of the currency with any other currencies or economies. Thus, the model focuses on a single economy.
- The fundamental variables having the most significant impact theoretically and being the fundamental are included in the model.
- The initial values and historical data for the variables are obtained from secondary statistical resources such as OECD Data[2] and World Bank data[3] etc. The model initializes from 1995 and for the future is simulated until the year 2045.

Model Calibration and Scenario design

The model is used to calibrate the historical exchange rate and then produce the forecasts for the future. As per the system dynamics' rule, the structure of the model should be able to replicate the behavior of the variable

---

[2] https://data.oecd.org/

https://www.inflation.eu/

[3] https://data.worldbank.org/

being explored for the right reasons. The model has been validated during the development process, and validation tests reveal that the model performs reasonably for these tests. Figure 2 represents the simulated exchange rate behavior in 1995. The simulation outcome reveals that the model is able to capture the long-term trend of the exchange rate reasonably. To further validate the results, statistical significance tests are applied to validate the behavior prediction accuracy of the exchange rate model. Error analysis includes Root Mean Square Percent Error (RMSPE) and Theil inequality tests (J. D. Sterman, 1984). RMSPE estimates the normalized error magnitude, and MSE is a measure of total error between historical and simulated results. Theil inequality is a decomposition of these estimated errors into bias (Um), unequal variation (US), and unequal covariation (UC). Table 1 reports the figures from error decomposition and Theil inequality tests. The results reveal RMSPE of only 10%, and further decomposition reveals that error is 6% due to bias .03% due to unequal variation and 86% due to unequal covariation. A more substantial portion of unequal covariation reveals that the model is capturing the historical trend, and there is only a diversion point by point(J. D. Sterman, 1984).

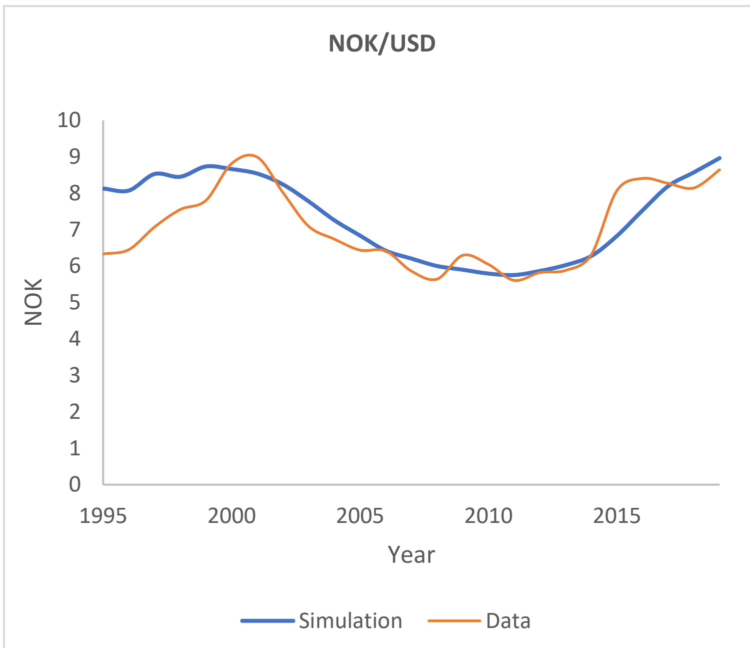

Figure 2 - Exchange rate behavior compared to exchange rate data

Table 1 - Error Analysis

Variable	RMSPE	MSE (units)	U^m	U^S	U^C
NOK/USD	0.108	5.58E-01	0.134	0.003	0.862

Scenario Design

The system dynamics model includes the critical relationships in feedback structure and makes it meaningful and useful to test various scenarios for the future to comprehend and estimate the impact of changes in the exchange rate and other variables of interest (Suryani, Chou, Hartono, & Chen, 2010). Scenarios have been designed to estimate how would the change in macroeconomic variables influence the exchange rate and, in turn, how the exchange rate would influence these macroeconomic variables (Table 2).

Table 1 - Scenarios

Scenarios	Variable	Change
Higher	Interest Rate	2.5%
Base case	Interest Rate	2%
Lower	Interest Rate	1.5%
Higher	Inflation	3.1%
Base case	Inflation	2.1%
Lower	Inflation	1.1%
Increase	Oil prices	+$10
Base case	Oil prices	$25
Decrease	Oil prices	-$10

Scenarios for interest rate and inflation of Norway have been designed and tested to analyze how would any percentage change in one of the variables impact the expected exchange rate. The base case interest rate in 2019 is around 2%; a higher case scenario assumes an interest rate of 2.5%- and lower-case scenario assumes an interest rate of 1.5%. For inflation, base case inflation was around 2.1% in 2019. In a higher inflation scenario, 1% higher inflation is assumed, and in lower inflation cases, 1% lower inflation is assumed. Due to the significance of oil prices in the Norwegian economy and exchange rate, oil price scenarios have also been analyzed to test how would any change in oil prices influence the exchange rate. In 2019, the base case assumed $25 per barrel. For higher oil prices, a $10 increase is assumed, and for lower oil prices $10 decrease is assumed.

Results

Simulation results illustrate the behavior of the variables based on the relationships as predicted by the theory. The simulation result from the base case for reference mode (NOK/USD) is given in Figure 2. Now, the model is simulated into the future to forecast the exchange rate behavior until the year 2045 under the base case scenario, assuming the current trends extrapolate into the future. Figure 3 demonstrates the exchange rate of forecasted behavior.

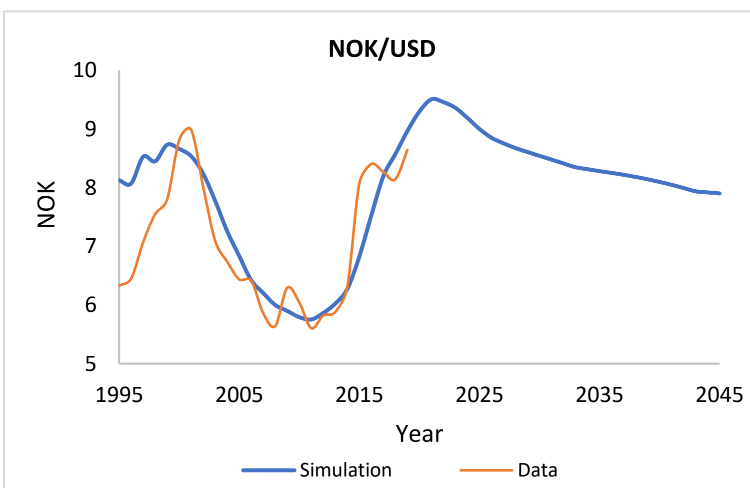

Figure 3 - Exchange rate behavior assuming Base case scenario

Assuming the current trends of significant macroeconomic variables, the exchange rate depreciates to 9.5 NOK/USD in the year 2021. It then starts to appreciate slowly until it reaches 7.9 NOK/USD by the end of the simulation period.

Now the model is simulated to test the scenarios. Figure 4 represents the exchange rate behavior under the assumed interest rate scenarios. The interest rate is the critical variable of interest rate parity theory. The interest rate and exchange rate have a feedback relationship. An increase in local interest rates leads to an appreciation of the exchange rate due to increased demand for the local currency and vice versa. As per the simulation results, a 0.05% increase in interest rate leads to an appreciation of Norwegian currency from 9.2 NOK/USD in 2020 to 8.4 NOK/USD in 2021 and 7.28 NOK/USD in 2045 assuming all other factors as per the base case. As per the lower interest rate scenario, a 0.05% decrease in local interest rate leads to depreciation of Norwegian currency from 9.2 NOK/USD in 2020 to 9.8 NOK/USD in 2021 and 9.03 NOK/USD in 2045.

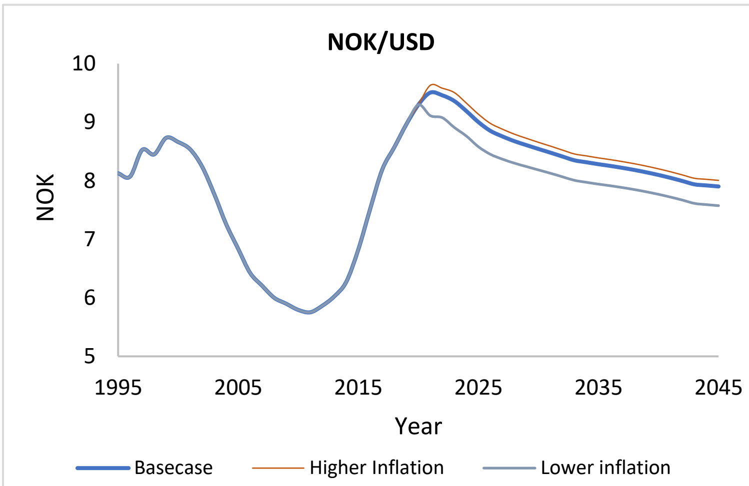

Figure 4 - Exchange rate under interest rate scenarios

Then, the model is simulated to analyze the inflation scenarios. Figure 5 characterizes the exchange rate under inflation scenarios. Inflation is the critical variable of PPP theory impacting the exchange rate. Exchange rates and inflation have a feedback relationship. An increase in local inflation levels leads to the depreciation of the local currency and vice versa. The simulation results reveal that assuming a 1% increase in inflation in the Norwegian economy leads to depreciation of NOK from 9.2 NOK/USD in 2020 to 9.63 NOK/USD in 2021 assuming all other factors remaining same. Lower inflation scenario (-1% than the basecase) reveals an appreciation from 9.2 NOK/USD in 2020 to 9.1 NOK/USD in 2021. This confirms the hypothesis that relative prices of a basket of goods play their role in the determination of the exchange rate.

Finally, the model is tested for changes in oil prices. Figure 6 embodies the exchange rate behavior under oil price scenarios. When there is an increase in oil prices, NOK appreciates, and vice versa. Assuming a $10 increase in oil prices from the basecase reveals an appreciation of the exchange rate from 9.2 NOK/USD in 2020 to 9.13 NOK/USD in 2021, given all other factors as per base case and by the end of the simulation period it reaches 7.60 NOK/USD. Under lower oil price scenario, which assumes a $10 decrease in oil prices, the local currency depreciates from 9.2 NOK/USD in 2020 to 9.92 NOK/USD in 2021. It stabilizes until it

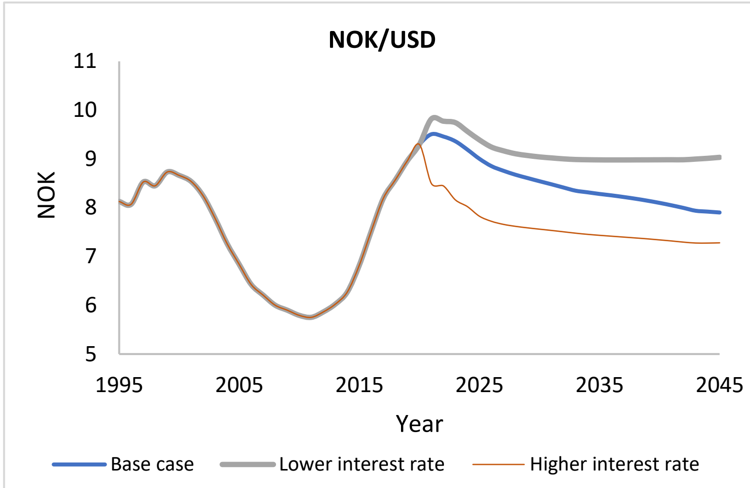

Figure 5 - Exchange rate under inflation scenarios

appreciates to 8.21 in the year 2045. As the country is an exporter of oil, the exchange rate is influenced by the changes in oil prices.

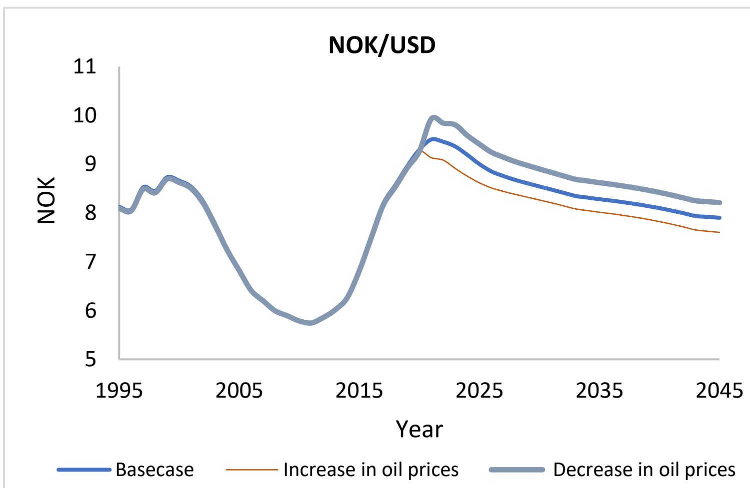

Figure 6 - Exchange rate under oil price scenarios

The simulation results reveal the behavior of the exchange rate is influenced by the key macroeconomic variables as predicted by the theory. Fundamental macroeconomic variables influence the exchange rate and thus can provide long term forecasts for the exchange rate. The study provides empirical evidence on the validity of the PPP and IRP in the determination of the exchange rate.

Conclusion

The objective of this paper is to develop a system dynamics model based on fundamental macroeconomic variables to determine and forecast the exchange rate. Feedback and nonlinear relationships among the interest rate, inflation, oil prices, terms of trade, per capita income, and terms of trade are modeled to calibrate the exchange rate behavior. The simulation results reveal that the variables, as per their predicted relationships by the theory, can replicate reasonable long-term exchange rate behavior. However, some short-term variations might be caused by some other factors or noises. Then, the model is simulated into the future to provide forecasts for the future from long term investments' perspective as the forecasting exchange rate is significant before making long term international investments. Then, some scenarios, including critical variables such as interest rate, inflation, and oil prices, are tested to analyze how would the changes in these critical variables influence the exchange rate. An increase in Norwegian inflation results in the depreciation of NOK. Whereas, an increase in interest rate has a positive influence and leads to the appreciation of the exchange rate. Oil price shocks impact the NOK, and an increase in oil prices is definite in the case of NOK as the country is an exporter of oil. The model explains and provides a simplified and generic model of the exchange rate determination based on fundamental macroeconomic variables.

The exchange rate is a significant economic variable. The study provides a simplified simulation-based model for the exchange rate for better understanding and forecasting of the exchange rate from a long term perspective based on fundamental theories. The study has practical implications for individuals, businesses, and the Government because they are all influenced by the exchange rate movements. The study has implications for investors accurately as based on the predicted exchange rate; they can hedge their exchange rate risk. The study also has implications for monetary policies as the study elaborates on the relationship of two primary monetary policy tools, interest rate, and inflation with the exchange rate.

Limitations and Future Research

The study has certain limitations. The study relies on fundamental variables only to forecast the exchange rate. The exchange rate model could further include other models of exchange rate determination and make a comparison to better forecast the exchange rate and get insights. The model could also be extended to include further economies.

Funding: This research has been funded by The Women University, Multan, Pakistan.

Conflicts of Interest: The authors declare no conflict of interest.

References

Abbas, Q., Iqbal, J., & Ayaz, L. (2012). Relationship between GDP, inflation and real interest rate with exchange rate fluctuation of African countries. *International Journal of Academic Research in Accounting, Finance and Management Sciences, 2*(3), 132-141.

Ajao, M. G. (2015). The determinants of real exchange rate volatility in Nigeria. *Ethiopian Journal of Economics, 24*(2), 43-62.

Bahmani-Oskooee, M., Chang, T., Chen, T.-H., & Tzeng, H.-W. (2017). Revisiting purchasing power parity in Eastern European countries: quantile unit root tests. *Empirical Economics, 52*(2), 463-483. doi: 10.1007/s00181-016-1099-z

Bodenstein, M., Erceg, C. J., & Guerrieri, L. (2011). Oil shocks and external adjustment. *Journal of International Economics, 83*(2), 168-184. doi: 10.1016/j.jinteco.2010.10.006

Cerra, V., & Saxena, S. C. (2010). The monetary model strikes back: Evidence from the world. *Journal of International Economics, 81*(2), 184-196. doi: 10.1016/j.jinteco.2010.03.003

Crowley, P., & Lee, J. (2003). EXCHANGE RATE VOLATILITY AND FOREIGN INVESTMENT: International Evidence. *The International Trade Journal, 17*(3), 227-252. doi: 10.1080/08853900390222171

Dąbrowski, M. A., Papież, M., & Śmiech, S. (2014). Exchange rates and monetary fundamentals in CEE countries: Evidence from a panel approach. *Journal of Macroeconomics, 41*, 148-159.

Jiang, C., Jian, N., Liu, T.-Y., & Su, C.-W. (2016). Purchasing power parity and real exchange rate in Central Eastern European countries. *International Review of Economics & Finance, 44*, 349-358. doi: 10.1016/j.iref.2016.02.006

Kilicarslan, Z. (2018). Determinants of exchange rate volatility: empirical evidence for Turkey. *Pressacademia, 5*(2), 204-213. doi: 10.17261/Pressacademia.2018.825
Kim, J.-M., & Jung, H. (2018). Dependence Structure between Oil Prices, Exchange Rates, and Interest Rates. *The Energy Journal, 39*(2). doi: 10.5547/01956574.39.2.jkim
Kuttner, K. N., & Posen, A. S. (2000). Inflation, Monetary Transparency, and G3 Exchange Rate Volatility. *SSRN Electronic Journal*. doi: 10.2139/ssrn.239300
Madura, J. (2006). *Exchange rate Determination; International financial management* (10th ed.): Cengage Learning.
Madura, J., & Fox, R. (2011). International Financial Management, Cengage Learning: EMEA.
Martins, J. F. d. S. (2015). Impact of real exchange rate volatility on foreign direct investment inflows in Brazil.
Meese, R. A., & Rogoff, K. (1983). Empirical exchange rate models of the seventies. *Journal of International Economics, 14*(1-2), 3-24. doi: 10.1016/0022-1996(83)90017-X
Oaikhenan, H. E., & Aigheyisi, O. S. (2015). Factors explaining exchange rate volatility in Nigeria: theory and empirical evidence.
Öge Güney, P., & Hasanov, M. (2014). Real interest rate parity hypothesis in post-Soviet countries: Evidence from unit root tests. *Economic Modelling, 36*, 120-129. doi: 10.1016/j.econmod.2013.09.017
Park, C., & Park, S. (2013). Exchange rate predictability and a monetary model with time-varying cointegration coefficients. *Journal of International Money and Finance, 37*, 394-410. doi: 10.1016/j.jimonfin.2013.05.003
Perera, P., Silva, N. L. C., & Silva, N. L. (2018). The impact of interest rate in determining exchange rate: Revisiting interest rate parity theory. *Journal for Accounting Researchers and Educators (JARE), 1*(1).
Reboredo, J. C. (2012). Modelling oil price and exchange rate co-movements. *Journal of Policy Modeling, 34*(3), 419-440. doi: 10.1016/j.jpolmod.2011.10.005
Rogoff, K. (1996). The purchasing power parity puzzle. *Journal of Economic literature, 34*(2), 647-668.
Sterman, J. (2000). System Dynamics: systems thinking and modeling for a complex world.
Sterman, J. D. (1984). Appropriate summary statistics for evaluating the historical fit of system dynamics models. *Dynamica, 10*(2), 51-66.
Suryani, E., Chou, S.-Y., Hartono, R., & Chen, C.-H. (2010). Demand scenario analysis and planned capacity expansion: A system dynamics framework. *Simulation Modelling Practice and Theory, 18*(6), 732-751. doi: 10.1016/j.simpat.2010.01.013