The Estimation and Comparison of Future Nominal Exchange Rate under Liberal and Regulated Forex Market Assumptions in Azerbaijan

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Abstract:

The purpose of this research is to estimate and compare the future nominal exchange rate under the assumed liberal and regulated foreign exchange market environments by considering the context of the Azerbaijan economy for the next 24 months since the beginning of 2022. The estimations are conducted by building a mathematical model based on the set of assumptions and simulating the model by applying Monte-Carlo simulation logic for global oil prices on the Python program. The purpose is to show how supply and demand forces may interact in the assumed liberal and regulated foreign exchange markets and determine the potential future nominal exchange rate and to show to what extent the nominal exchange rate would depreciate if the forex market is liberated. To have a control model against the simulated treatment model, this study also forecasts the nominal exchange rate for the next 24 months by employing the ARIMAX forecasting tool. In terms of the results, under the regulated forex market assumptions, in the treatment model, the nominal exchange rate depreciates from 1.7 USD/AZN to and becomes stable at 1.91 USD/AZN until the end of the second year. Whereas, in the control model, the nominal exchange rate meagerly fluctuates within the range of 1.7 and 1.73 USD/AZN for the next 24 months. Under the liberal forex market assumptions, in the treatment and control models, the nominal exchange rate depreciates from 1.7 to 5.07 USD/AZN and from 1.7 to 4.28 USD/AZN until the end of the second year, respectively. Moreover, by estimating mean absolute percentage error (MAPE), the estimated forecast accuracy of the treatment model under the liberal and regulated forex market assumptions are off by 28.02% and 9.11% compared with the forecast of the control model, respectively.

Keywords: oil price, nominal exchange rate, model simulation

1. Introduction

1.1. The purpose of establishing the State Oil Fund of the Republic of Azerbaijan

Azerbaijan is a hydrocarbon-rich post-soviet economy. At least for the last decade, on average, about 90% of the country's export revenue has been sourced from the oil-gas industry, which has become the fundamental provider of the foreign currency of the economy (The Statistics of the State Statistics Committee of the Republic of Azerbaijan, 2022). To accumulate the revenue gained from hydrocarbon resource exports, the government of Azerbaijan established the sovereign wealth fund, called the State Oil Fund of the Republic of Azerbaijan (SOFAZ), in 1999. SOFAZ is a legal public institution that officially functions independently from the government or the Central Bank of the Republic of Azerbaijan (CBAR). At the end of 2021, the value of the total assets of SOFAZ amounted to about 45 billion US dollars, which comprised approximately 86.5% of the total strategic foreign reserves of Azerbaijan (SOFAZ, 2022). The functions of SOFAZ encompass saving the revenue from the energy resources for the future generations, managing the accumulated strategic reserves, and implementing socio-economic projects without crowding the private sector (Azərbaycan Respublikası Dövlət Neft Fondunun "İllik gəlir və xərclər proqramının (büdcəsinin) tərtibi və icrası Qaydaları"nın təsdiq edilməsi haqqında, 2001).

Besides the mentioned functions, SOFAZ is also the biggest financer of the government budget and SOFAZ has been assigned the role of a foreign currency provider to the economy since 2016. Until the 2015-16 crisis, CBAR was the institution that provided the economy with foreign currency by engaging in transactions with commercial banks. During the 2015-16 crisis, CBAR lost about 11 billion dollars and was left with approximately four billion dollars of strategic reserves (The Statistics of CBAR, 2022). Therefore, since the beginning of 2016, SOFAZ has almost replaced the role of CBAR in terms of providing foreign currency to the economy through currency auctions (CBAR, 2016). Additionally, a significant portion of the government revenue is sourced from SOFAZ, which periodically transfers a part of its revenues gained from the oil-gas exports to the government budget for each fiscal year. Since 2015, on average, 45.3% of the government revenue has come from SOFAZ's annual transfers (SOFAZ, 2020). Having the roles of the government budget's biggest financer and the foreign currency provider of the economy give SOFAZ an irreplaceable role in guaranteeing the current exchange rate regime and contributing to the macroeconomic stability in Azerbaijan.

1.2. The cross-country analysis of oil-producing countries and the case of Azerbaijan

The case of Azerbaijan is compared with the Middle Eastern and Central Asian (MENA) oil-producing economies from 2014 to 2020, where Turkmenistan, Libya, Yemen and Iran are excluded from the list because of lack of data, being an outlier or not an oil producer. Starting with the level of fiscal breakeven oil price (FBOP), the term is identified by International Monetary Fund as the level of oil price at which fiscal balance is zero (table 1). At a given constant level of the government budget, the lower the level of FBOP, the higher the proportion of non-oil revenue within the government budget and the less reliance on the revenue from natural resources to fill the government budget. The level of FBOP in Azerbaijan is significantly below the average value of the FBOP level of the given sample for the mentioned seven years. In 2020, Azerbaijan falls behind Iraq, Qatar and UAE in terms of having a lower level of FBOP. However, despite having a lower FBOP level relative to the average value of the sample countries, Azerbaijan is around the mean value of government expenditure to nominal GDP ratio from 2014 to 2020 in the sample (table 2).

Table 1. Breakeven Fiscal Oil Price:

Breakeven Fiscal Oil Price, US dollars per barrel							
Country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Algeria	135,3	106,8	102,5	91,4	101,4	106,6	88,5
Azerbaijan	89,4	68,4	47,8	60,7	56,3	42,5	65,3
Bahrain	111,8	118,1	105,2	111,9	118,0	99,2	119,2
Iraq	102,1	59,1	46,3	42,1	45,4	52,3	55,2
Kazakhstan	71,6	115,1	113,5	105,2	37,9	68,4	155,0
Kuwait	56,0	48,7	41,6	52,6	54,4	57,4	79,8
Oman	101,5	100,1	103,8	86,4	80,3	67,9	87,9
Qatar	53,6	49,5	49,4	47,7	50,0	51,1	54,3
Saudi Arabia	106,3	94,2	86,5	83,7	88,5	81,8	76,6
UAE	91,0	64,7	53,9	60,9	66,9	62,3	60,1
Average	**91,9**	**82,5**	**75,1**	**74,3**	**69,9**	**68,9**	**84,2**

Source: International Monetary Fund Data, Regional Economic Outlook: the Middle East and Central Asia

Table 2. General Government Total Expenditure to Nominal Gross Domestic Product:

General Government Total Expenditure to GDP (%)							
Country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Algeria	40,6	45,8	41,7	38,6	37,8	37,9	37,8
Azerbaijan	36,4	38,7	35,4	35,5	33,1	32,3	40,3
Bahrain	28,4	36,5	35,0	32,2	33,7	32,8	35,2
Iraq	43,8	43,5	42,5	35,1	31,6	35,1	44,1
Kazakhstan	21,3	22,9	21,5	24,1	18,8	20,2	24,5
Kuwait	44,3	54,4	53,8	51,4	50,3	52,3	67,1
Oman	47,4	50,9	51,2	45,2	43,9	44,7	53,3
Qatar	32,3	38,6	40,1	34,7	28,9	32,6	34,5
Saudi Arabia	40,2	40,8	38,7	33,3	36,6	35,6	41,0
UAE	33,1	32,4	31,7	30,2	28,9	30,5	33,1
Average	**36,8**	**40,4**	**39,2**	**36,0**	**34,4**	**35,4**	**41,1**

Source: International Monetary Fund, World Economic Outlook Database, October 2021

In 2015-16, a sharp decline in the global oil price level caused significant problems in the economies that are profoundly concentrated on the oil industry. A decrease in oil price led to a decline in petrodollar windfall that guaranteed the macroeconomic stability through maintenance of fixed exchange rate regime and funding government budget in developing and emerging oil-producing countries. As an indicator of the macroeconomic turmoil, the nominal exchange rate significantly underwent devaluations in some oil-producing countries. Azerbaijan is far above the average value of the change in the nominal exchange rate, especially in 2015 and 2016 (table 3). Specifically, in the case of Azerbaijan, as the oil price collapsed, the trust in the local currencies that has been built during the oil boom period collapsed within several months. This led to the massive dollarization process in Azerbaijan that that melted down the foreign currency reserves of CBAR and CBAR was no longer able to maintain the exchange rate peg (Bayramov and Abbas, 2017; figure 3). However, since 2017, the nominal exchange rate gradually stabilized and fixed at 1.7 USD/AZN.

Table 3. Change in the Level of Nominal Exchange Rate:

Change in Exchange Rate Level (%)							
Country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Algeria	1,5	22,3	8,3	1,4	4,9	2,3	6,0
Azerbaijan	0,0	26,7	44,3	7,6	-1,2	0,0	0,0
Bahrain	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Iraq	0,0	0,1	1,2	0,2	-0,1	-0,1	0,8
Kazakhstan	16,4	21,3	43,4	-4,8	5,6	10,5	7,6
Kuwait	0,3	5,6	0,4	0,4	-0,5	0,5	0,9
Oman	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Qatar	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Saudi Arabia	0,0	0,0	0,0	0,0	0,0	0,0	0,0
UAE	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Average	**1,8**	**7,6**	**9,8**	**0,5**	**0,9**	**1,3**	**1,5**

Source: The World Bank, World Development Indicators (2022). Official exchange rate (LCU per US$, period average)

The oil rent to nominal GDP ratio is one of the signs of the degree of oil concentration in an economy. The case of Azerbaijan is noticeable above the average ratio value of the sample for the mentioned seven years (table 4). Such a concentration causes Azerbaijan to be sensitive to possible future negative oil shock exposures, and therefore, may endanger future macroeconomic stability.

Table 4. Oil Rent to Nominal Gross Domestic Product:

Oil rents to GDP (%)							
Country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Algeria	20,5	12,8	10,0	12,1	15,7	14,3	10,2
Azerbaijan	20,5	12,1	13,2	17,9	25,3	21,7	15,3

Bahrain	18,7	9,7	7,4	8,9	11,3	10,0	6,5
Iraq	45,5	36,3	31,8	37,8	44,2	39,3	32,3
Kazakhstan	13,6	6,8	7,1	10,0	15,6	13,8	9,3
Kuwait	51,1	37,2	32,4	37,1	45,1	40,5	31,6
Oman	36,1	21,4	18,3	21,8	26,7	24,9	19,4
Qatar	21,3	12,5	10,6	12,9	15,5	13,6	11,6
Saudi Arabia	40,4	23,6	19,6	23,7	29,3	24,6	17,7
UAE	23,0	13,1	10,8	13,0	16,6	16,3	11,5
Average	**11,4**	**8,9**	**7,5**	**8,5**	**9,6**	**8,3**	**7,0**

Source: The World Bank, World Development Indicators (2022). Oil rents (% of GDP)

Most of the oil-producing countries of the mentioned sample, accumulated oil revenues in the established sovereign wealth funds to preserve the residual amount of the oil revenues for a variety of purposes such as accumulating foreign strategic reserves as a guarantee for macroeconomic stability, providing fiscal sustainability and saving oil revenues for the future generations (Aslanli, 2015). The accumulated reserves sourced from the oil revenues were appreciable large enough to cover the nominal GDP of Azerbaijan which falls behind the majority of the oil-producing Gulf states in 2020 (table 5).

Table 5. Total Value of Sovereign Wealth Funds to Nominal Gross Domestic Product:

Total Value of Sovereign Wealth Funds (SWF) to Nominal GDP in 2020			
Country	**Total Asset Value of SWF (billion US Dollars)**	**Nominal GDP (billion US Dollars)**	**SWF Value to Nominal GDP**
Algeria	0,0	145,0	0,0%
Azerbaijan	43,2	42,6	101,4%
Bahrain	17,5	34,7	50,5%
Iraq	0,0	166,8	0,0%
Kazakhstan	128,7	171,1	75,2%
Kuwait	565,5	106,0	533,7%
Oman	42,6	74,0	57,6%
Qatar	345,0	144,4	238,9%
Saudi Arabia	834,4	700,1	119,2%
UAE	1 343,2	358,9	374,3%

Source: Schena et al. (2021) and Worldbank Dataset - GDP (current US$) in 2020

1.3. How does the currency auction mechanism function?

Since the 2015-16 oil crisis, the dollar demand of the economy has been satisfied through the currency auctions, held between SOFAZ and commercial banks, and monitored by CBAR. To create a flexible environment for commercial banks to participate in the forex market, CBAR introduced a new auction mechanism in 2016. SOFAZ sells foreign currency to commerical banks through these auctions, which play an important role in maintaining the current exchange rate regime. The auction mechanism allows market participants (buyers and sellers) to place their currency orders at the initial rate announced by the organizer of the auction. The official exchange rate for the next day is determined based on the weighted average exchange rate transactions between SOFAZ and commercial banks at the auctions and the interbank forex market. On days when there is no currency auction, the next day's nominal exchange rate is determined on the basis of the weighted average exchange rate formed based on the previous business day's purchase and sale deals (CBAR, 2016).

The currency auctions are held two times in a business week when the planned amount of US dollars is sold to commercial banks. In exchange for the supplied dollar, commercial banks provide SOFAZ with AZN amount (the local currency in Azerbaijan) based on the established exchange rate. SOFAZ transfers the acquired local currency amount, exchanged at the auctions, to the government budget. As a result, SOFAZ accomplishes two missions simultaneously: it provides the economy with foreign currency through commercial banks and partially funds the government budget (figure 1).

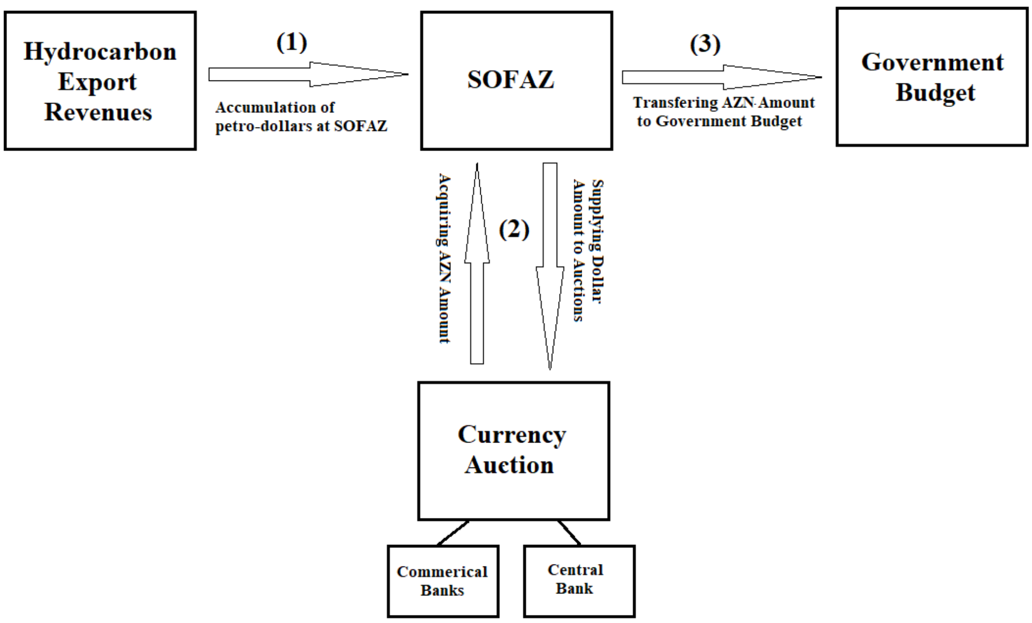

Figure 1. The Currency Auction and Transfer Mechanism

1.4. The link between dollar supply through the currency auctions and the government budget

Government expenditure plays a significant role in driving the economy. For the last ten years, the average share of the government expenditure to nominal GDP has been equal to 30.8% (The Statistics of CBAR, 2022). Annually, when the next fiscal year's budget is verified, the transfer amount from SOFAZ to the government budget as a part of the government revenue is also confirmed. The priority in the auction processes is to provide the government budget with the financial resources in local currency terms on time, and secondly, to provide commercial banks with the dollar amount. SOFAZ has to acquire the local currency equivalent of the US dollars per auction to fulfil the transfer quota per month. If the dollar demand by commercial banks is less than the planned US dollar supply by SOFAZ, CBAR clears up the excess dollar supply and provides the local currency amount to SOFAZ. The aforementioned statement can be proven based on the press release by CBAR: *"in 2021, supply prevailed over demand at 70% of currency auctions. Central Bank's buy interventions to the FX market amounted to 245 million US dollars"* (CBAR, 2022).

On the other hand, if the dollar demand by commercial banks is more than the planned US dollar supply, SOFAZ will satisfy the excess dollar demand by supplying more than required. The excess supply is provided by spending future auction dollar supplies now, meaning that within a fiscal year, SOFAZ will supply less than the pre-planned US dollar amount to the future auctions to offset the previous excess supply. The excess local currency amount sourced from the excess demand is kept and is gradually used to fulfil the future transfer quotas within a fiscal year. Thus, the annual aggregate dollar amount supplied to the currency auctions equals the US dollar equivalent of the annual aggregate government budget transfers within a fiscal year.

These statements can be proven by stating the press release provided by SOFAZ and analyzing the data provided below: *"The increase in expenditures in the first quarter of the current year (2020) can be explained by the fact that transfers to the state budget were made earlier during that period. This is sourced from the fact that the demand in the foreign exchange market was higher than in previous periods. However, we would like to note that SOFAZ's budget expenditures for 2020 are projected to be implemented at the level approved in the budget, and in this context, about 4 billion US dollars are expected to be sold through auctions*" (SOFAZ, 2020). The annual transfer from SOFAZ to the government budget and the sum of the currency auction amounts (both in the local currency terms) are matched in table 6. Though not identical, the pre-planned and confirmed transfer amount almost equals the amount supplied to the auctions. From the provided evidences, it is inferred that the annual aggregate US dollar amount supplied to the auctions is somewhat limited by the AZN equivalent of the transfers to the government budget at a determined exchange rate.

Table 6. The Annual Auction Amount and the Transfer to the Government Budget:

Year	Upper Bound of Transfers to the Government Budget, AZN mln	Annual Aggregate Auction Amount, AZN mln	Share of the Transfer to the Auction Amount
2016	7 615,0	7 768,0	98,0%
2017	6 100,0	6 184,9	98,6%
2018	9 216,0	10 982,3	83,9%
2019	11 364,3	11 209,5	101,4%

2020	12 439,9	12 415,3	100,2%
2021	12 200,0	11 370,5	107,3%

Source: SOFAZ (Multiple: 2016…2022); Author's calculation

From figure 2 and table 7, the monthly dollar supply to the auctions is somewhat stationary around the average estimated dollar supply per month. This confirms the fact that the excess dollar demand is satisfied on the account of the dollar supply of the future auctions, and therefore, the transfer amount constraint is kept intact.

Table 7. Estimated Average Dollar Supply at the Auctions per Month:

Year	Annual Aggregate Auction Amount, US dollar mln	Estimated Average Dollar Supply per Auction (assuming 100 auctions per year - twice in a business week)	Estimated Average Dollar Supply per Month
2016	4 881,3	48,8	406,8
2017	3 597,8	36,0	299,8
2018	6 460,1	64,6	538,3
2019	6 593,8	65,9	549,5
2020	7 303,1	73,0	608,6
2021	6 688,5	66,9	557,4

Source: SOFAZ (Multiple: 2016...2022); Author's calculation

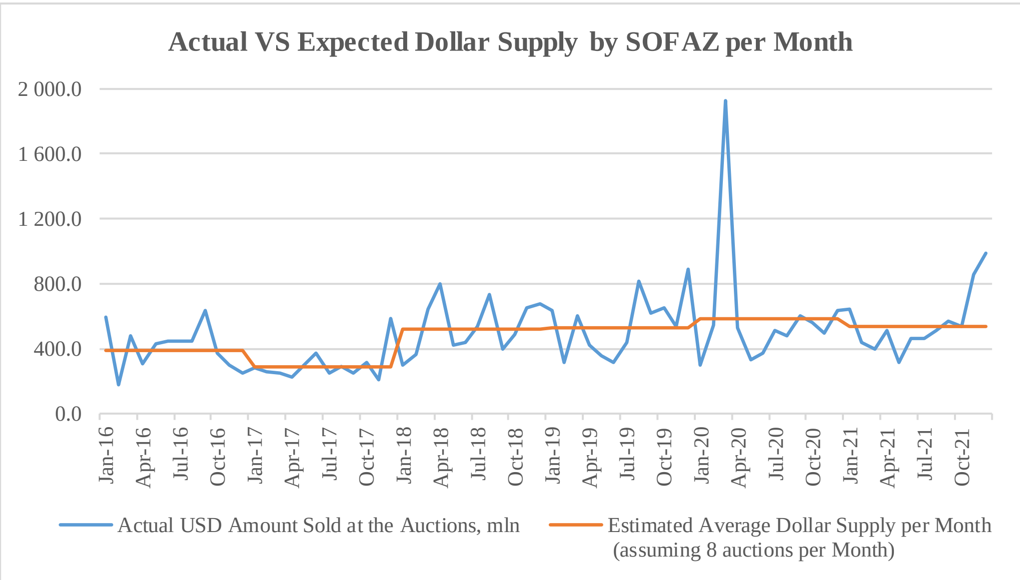

Figure 2. Actual and Expected Monthly Dollar Supply through the Auctions

Source: SOFAZ (Multiple: 2016…2022); Author's calculation

How much will be the transfer amount from SOFAZ to the government budget, and as a result, how much will be the expense of SOFAZ partially depends on the forecasted global oil price level for the next fiscal year, mentioning that certain expenditures in the state budget have to be met regardless of oil price dynamics. If the actual oil price is significantly higher or lower than the forecasted fiscal breakeven oil price (FBOP), the initially confirmed FBOP can be changed during a fiscal year (Hasanov, 2018). Higher (lower) global oil price causes FBOP to increase (decrease) and this leads to a higher (lower) transfer amount to the government budget in local currency terms, and therefore, more (less) foreign currency enters the economy through the auctions. At an aggregate level, as long as the approximate AZN amount of the transfer is equal to the approximate foreign currency amount entering the economy, the exchange rate can be assumed to remain the same. Simultaneously, as long as the global oil price is above FBOP, besides completely fulfilling the periodic government transfer, SOFAZ also accumulates additional reserves because its revenue will be higher than its cost. However, in case the global oil price dynamics decrease below the predicted FBOP, SOFAZ is unable to cover the transfer amount without melting its reserve stock. Therefore, the lower the global oil price relative to FBOP, the higher the speed of losing strategic reserve stock, and the higher the panic and suspicion about possible upcoming devaluation and macroeconomic instability by economic players (table 8).

Table 8. FBOP, the Global Oil Price and Average Exchange Rate:

Year	FBOP, Initial Confirmation	Average Annual Global Price of Brent Crude, U.S. Dollars per Barrel	FBOP, Confirmation after Change	Average Exchange Rate, USD/AZN
2011	80	111,1	100	0,7899
2012	80	112,0	100	0,7860
2013	100	108,8	100	0,7845
2014	100	98,9	100	0,7846
2015	90	52,4	90	1,0048
2016	50	44,0	25	1,6026
2017	40	54,4	40	1,7145
2018	45	71,1	55	1,6999
2019	60	64,0	60	1,7000
2020	55	42,3	35	1,7013
2021	40	70,4	40	1,6996

Source: SOFAZ (Multiple: 2011...2021); The Statistics of CBAR (2022)

1.5. Where does the excess dollar demand come from?

The primary driver of the excess dollar demand, beyond what is pre-planned for the auctions, comes from the expectations of economic players about possible upcoming devaluation and macroeconomic instability. The expectations are highly influenced by the global oil price dynamics. The perfect examples can be given by analyzing the periods such as the great recession, the 2015-16 oil crisis and the beginning of the global pandemics in 2020 when the global oil price plummeted from 133 to 41 US dollars/barrel, from 111 to 31 US dollars/barrel, and from 65 to 31 US dollars/barrel, respectively (FRED FED Database). For the global recession crisis and the 2015-16 crisis (when the CBAR was the provider of foreign currency), the official reserves decreased from 5.4 to 4.7 billion US dollars and from 15 to 3.9 billion US dollars, respectively (The Statistics of CBAR, 2022). In the case of global pandemics (when the provider of the foreign currency was SOFAZ), SOFAZ provided about 1.9 billion dollars at the auctions only in the March of 2020 when the estimated average monthly limit was approximately 608.6 million dollars (annual 7303.1 million US dollars divided by 12 months). Only, in the 2015-16 crisis, when about 11 billion dollar reserves were spent to satisfy the dollar demand, Azerbaijan experienced devaluation two times in 2015 (The Statistics of CBAR, 2022). These three cases prove that the sharp decline in the global oil price triggers economic players to demand excess dollar amounts, which becomes the driving melting force of the strategic reserves (figure 3).

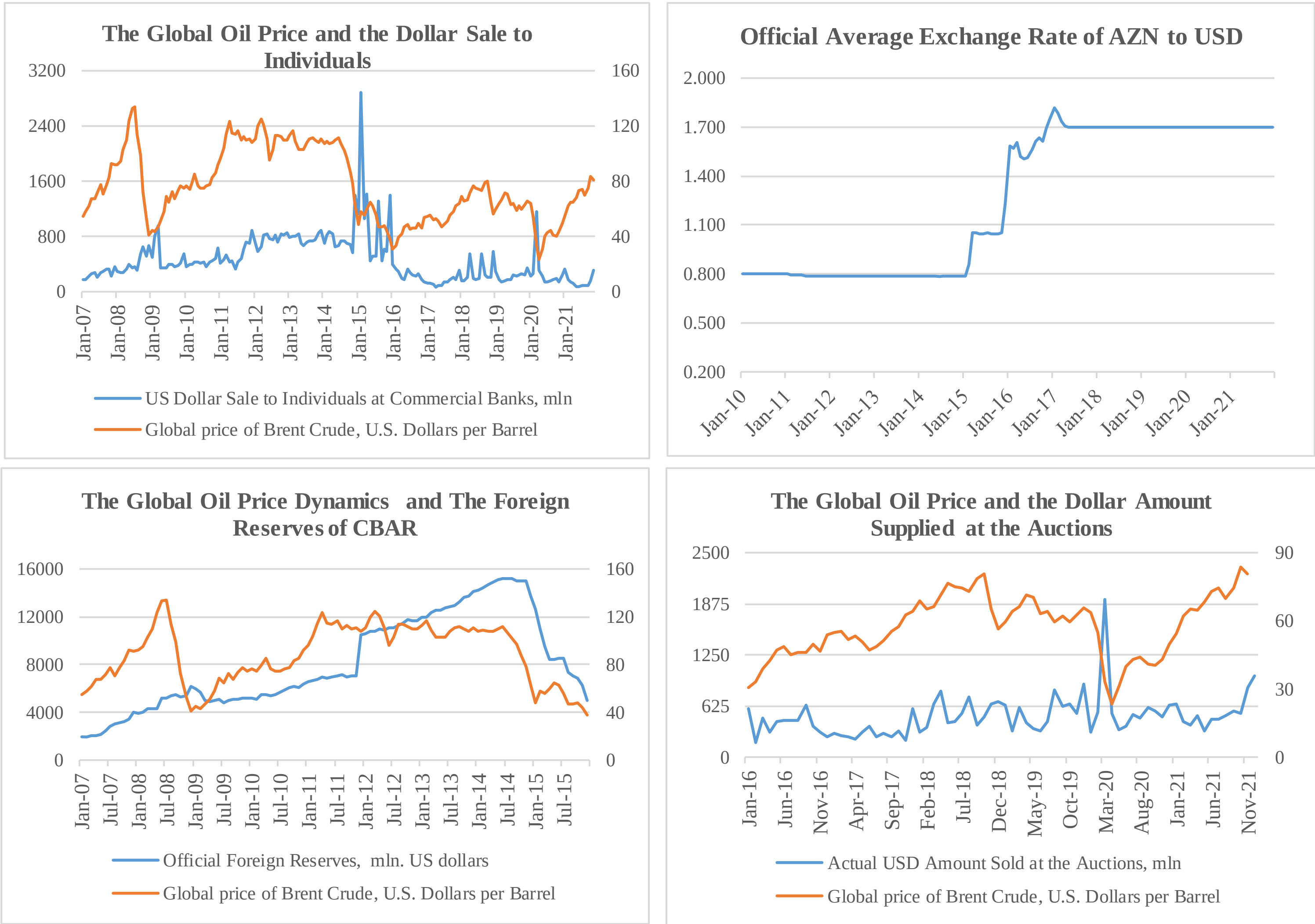

Figure 3. The Global Oil Price, Strategic Foreign Reserves, Dollar Sale by Banks, and Nominal Exchange Rate

Source: The Statistics of CBAR (2022); SOFAZ (Multiple: 2016...2022); FRED FED Database

1.6. How does the government intervene in the foreign exchange market?

The 2015-16 oil crisis demonstrates that the strategic foreign currency reserves, accumulated mainly on the account of oil-gas exports, play a key role in maintaining the fixed exchange rate regime. It is in the high interest of the government to protect the current strategic foreign reserves and use them with the most efficiency to sustain the macroeconomic stability through the maintenance of the current exchange rate, which has stabilized at 1.7 USD/AZN since the mid of 2017, and extrapolate the usage of the remaining reserves for future purposes. This is mainly achieved by imposing capital mobility measures on the foreign currency demand and controlling the foreign currency supply entering into the economy through the auctions. In order to constrain the demand, exchange and currency controls are imposed by conducting currency regulations, monitoring the fund transfers (by CBAR), and enacting the law to mitigate financial crime (Askerov et al., 2021). Capital mobility is constrained by requiring residents and non-residents about the written declaration and the purpose of the transactions that exceed the determined amount of the foreign currency limit that can be transferred out of the country (The State Customs Committee of the Republic of Azerbaijan, 2022). Simultaneously, to control the supply of the foreign currency amount entering the economy, the annual aggregate dollar supply to commercial banks at the auctions within a fiscal year is limited to the annual aggregate dollar equivalent of the transfers to the government budget, as is shown above.

Though effective in the short-run, as long as the supply and demand control measures are maintained, the sharp decline in the global oil price is less likely to adversely affect the current exchange rate regime despite the fact that it leads to panic among economic players about possible upcoming devaluation and macroeconomic instability. The example can be drawn from the 2020 global pandemic case when the global oil price decreased as low as 30 US dollars per barrel in March and April of 2020. During that period, SOFAZ supplied approximately two billion US dollars (when the estimated average monthly dollar supply was about 608.6 million US dollars) at the auctions only in March of 2020. However, the annual aggregate dollar supply at the auctions over the fiscal year of 2020 was still consistent with the dollar equivalent of the transfer amount to the government budget (table 6) and the exchange rate stability was still preserved at 1.7 USD/AZN (figure 3). The conclusion driven by this analysis is that the government intervention in the forex market by the means of controlling the supply of and demand for the foreign currency helps to artificially maintain the current exchange rate regime.

1.7. The purpose of this research

Without the government intervention in the forex market and with liberal forex market conditions, it is highly likely that the nominal exchange rate in Azerbaijan would not be fixed at 1.7 USD/AZN and would depreciate to further levels. The purpose of this research is to establish a mathematical model that may predict the future trend of the nominal exchange rate driven by exogenous oil price dynamics under the assumed liberal forex market assumptions for the next 24 months. To evaluate the reliability of the model, the same model is used to estimate the nominal exchange rate under the regulated forex market assumptions to analyze whether it reflects reality. To measure the prediction accuracy of the model, the established model is compared with the control model estimated through econometric forecasting tools. Finally, based on the results of the study, the policy implications are proposed about the time and conditions to liberalize the forex market.

2. Literature Review

This research divides the literature review about the determinants of exchange rate into two main parts: the factors coming from the supply side and the demand side. From the supply side, oil price dynamics and volatility in the crude oil market are considered to influence exchange rate stability. On the other hand, the demand for foreign currency and dollarization incentives, which leads to the exchange rate instability, is taken as an effect coming from the demand side.

2.1. Supply Side

From the supply side, the global crude oil price dynamics can be considered as an exogenous variable for emerging and developing economies that are highly concentrated on the oil industry and oil export revenues. The amount of petro-dollar circulating in an economy is expected to be one of the fundamental determinants of the exchange rate. Any sharp decline or increase in the global oil price should demonstrate its effect either indirectly on the exchange rate through the change in foreign reserves or directly on the exchange rate through expectations. To analyze to what extent the results of academic literature overlaps with the hypothesis, this study focuses on the empirical evidence from developing oil-exporting countries since 2015. Table 9 summarizes the literature review on the interconnection between oil price and nominal exchange rate, real exchange rate, and real effective exchange rate.

Table 9. The Global Oil Price Dynamics and Exchange Rate:

Author(s)	Main Key Words	Country	Method	Period
Alley (2018)	Oil Price; NER; Economic Diversification	Nigeria	ARDL; VAR	Jan 2008 – Dec 2015 (monthly)
Babatunde (2015)	Crude Oil; Oil Price; Shock; RER; Financial Sector	Nigeria	VAR; FMOLS; DOLS; CCR	Jan 1997 – Dec 2012 (monthly)
Basher et al. (2016)	Oil Shocks; RER	Oil Exporting & Oil Importing Economies	Markov-switching	Feb 1998 – Feb 2014 (monthly) (at least)
Bouoiyour et al. (2015)	Oil Price; REER	Russia	ARDL; Wavelet Coherence; Frequency Domain Test	Q1 1993 – Q4 2009 (quarterly)

Chekouri et al. (2021)	Oil Price; REER	Algeria	NARDL; Spectral Granger Causality; Wavelet Coherence	Q1 2004 – Q4 2019 (quarterly)
Henry (2019)	Oil Price Volatility; RER	Nigeria	ARDL	1986 – 2015 (annually)
Jahangard et al. (2016)	Oil Prices; RER	Iran	ARDL	1961 – 2014 (annually)
Lv et al. (2018)	Crude Oil Price; NER	Oil Exporting Countries	MS-VAR; MS-VECM	Jan 2000 – Dec 2015 (daily)
Musa and Maijama'a (2021)	Domestic Oil Price; NER; Inflation Rate	Nigeria	Johansen Cointegration; VECM Granger Causality	1985 – 2019 (annual)
Ndubuisi (2018)	Crude Oil Price; NER; Nigerian Stock Market	Nigeria	VECM; Variance Decomposition; Granger Causality	Jan 1995 – Dec 2016 (monthly)
Nouira et al. (2019)	Oil Price Shocks; NER Volatility	MENA countries	Asymmetric Causality Test; Asymmetric Generalized Impulsion Functions; Causality-in-variance Tests;	Jan 2001 – Dec 2017 (daily)
Olagbaju and Akinbobola (2016)	Oil Price Shocks; REER	Nigeria	Non-linear Specification; VAR; Granger Causality	Jan 2008 – Oct 2015 (monthly)
Olayungbo (2019)	Oil Price; NER; Trade Balance	Nigeria	Cointegration; Frequency Domain Causality	Q4 1986 – Q1 2018 (quarterly)
Osigwe (2015)	Oil Price; RER; Economic Performance	Nigeria	OLS; 2SLS	1960 – 2010 (annually)
Osuji (2015)	Oil Prices; REER; Foreign reserves	Nigeria	OLS; VAR	Jan 2008 – Dec 2014 (monthly)
Raji et al. (2018)	Oil Price; NER	Nigeria	VAR-GARCH; CCC-GARCH; DCC-GARCH	Jan 2001 – Dec 2015 (daily)
Twati (2021)	Crude Oil Price; NER	Libya	VAR	1995 – 2017 (annually)
Volkov and Yuhn (2016)	Oil Prices; NER; Conditional Exchange Rate Volatility	Russia; Brazil; Mexico; Norway; Canada	GARCH-M; Granger Causality; VECM	Sep 1998 – Aug 2012 (monthly)

To briefly highlight the definitions, the nominal exchange rate (NER) is meant to show the unit of local currency in terms of the unit of foreign currency. Whereas, the nominal effective exchange rate (NEER) shows the value of a local currency in terms of the weighted average of several foreign currencies. Real exchange rate (RER) and real effective exchange rate (REER) are determined in terms of NER and NEER adjusted by the ratio of the foreign price level to local price level or price deflator or index of costs, respectively (IMF DATA Help, n.d.; Czech National Bank, n.d.). An increase/decrease in the oil price should lead to the appreciation/depreciation of NER and NEER of a price-taker resource exporter economy. An increase in RER and REER leads to the loss of international competitiveness as exports become expensive and imports become cheaper. In reality, how quickly change in oil price dynamics transmits its effects on NER, NEER, RER and REER depend on the context of an economy, whether a country is an oil export or importer, transmission speed to the price level, government intervention level, liberal forex market environment, trade openness, reserve level etc.

2.1.1. The case of Nigeria

Several papers have been dedicated to studying the relationship between oil price dynamics and NER, specifically, in Nigeria, the top-10 oil exporter in the world. Alley (2018) and Raji et al. (2018) confirm that a decrease/increase in oil price leads to the deterioration/appreciation of NER. These results are consistent with economic intuition. As the exports of Nigeria concentrated on oil revenues, the global oil price dynamics determine the foreign currency inflow amount into the country and, therefore, play a significant role in determining NER.

Several studies use VECM Granger Causality and Johansen Cointegration test to see the causal relationship between oil price and NER both in the short-run and long-run, respectively, in Nigeria. By applying VECM Granger Causality technique, Musa and Maijama'a (2021) show the short-term causality from NER to domestic oil price with no long-run causality. The authors also show the existence of unidirectional causality from domestic oil price to NER with long-run causality. Ndubuisi (2018) finds positive short-term causality from crude oil price toward NER. Unlike the previous two studies, Olayungbo (2019) exhibits the short-term causality from oil price to foreign reserve, but no Granger causality between oil price and trade balance and oil price and NER.

By employing Johansen Cointegration test, Musa and Maijama'a (2021) and Ndubuisi (2018) affirm the long-run relationship between oil price and NER (also considering other variables used in their research). However, Olayungbo (2019) finds the existence of a long-run relationship only between oil price and foreign reserves. It should be mentioned that Granger causality demonstrates the relationship between variables from the statistical point of view and may lack economic intuition. It is illogical for change in NER to lead to a change in oil price dynamics unless a country is an economic superpower such as the USA. Therefore, the relationship is expected to go from oil price toward NER whether it is in the long-run or short-run for developing or emerging economies.

The relationship between Nigerian RER and oil price is also covered by academic literature. Babatunde (2015) shows that positive oil shock leads to the depreciation of RER, whereas negative oil shock causes it to appreciate. This anomaly is explained by Nigeria being also the main importer of refined oil products. Henry (2019) exhibits the negative relationship between crude oil price volatility and RER, significant only in the long run. Contrary to established results, one of the results of Osigwe (2015) is the negative impact of RER on oil price in Nigeria.

Finally, several researchers examine the interconnection between oil price and REER in Nigeria. Olagbaju and Akinbobola (2016) find the non-linear effect of oil price on REER. Meaning that a decrease in oil price is found to appreciate REER, leading to the loss of international competitiveness of Nigeria, whereas, an increase in oil price has no connection with REER movements. Osuji (2015) shows oil price has a unidirectional Granger causality on REER and foreign reserves.

2.1.2. Cases of other oil-exporting economies

Besides Nigeria, the interconnection between oil price and NER in other developing and emerging oil-exporting economies also has been analyzed. Volkov and Yuhn (2016) reveal that oil price shock has a significant effect on NER volatility in Russia, Brazil and Mexico, whereas, in Norway and Canada, the relationship is weakly significant. Nouira et al. (2019) realize that an increase in oil price leads to a change in NER, specifically, in Saudi Arabia and Tunisia. In some MENA economies, there exists a volatility spillover effect from the oil market to the forex market. Twati (2021) finds the existence of the only short-term relationship between NER and crude oil price, besides finding no Granger causality between NER and oil price in Libya.

Lv et al. (2018) analyze the relationship between NER and oil price under free-floating, managed floating, and soft-pegged exchange rate regimes. Firstly, under free-floating exchange rate regimes, the authors realize a bidirectional negative response between NER and oil price dynamics in the short run. Secondly, in the case of managed or pegged exchange rate regimes, due to government intervention in forex markets, the correlation between the crude oil market and NER weakens, however, the causal relationship cannot be fully eliminated regardless of the direction of the causality. Finally, in the economies that adopt managed floating exchange rate regimes, NER is insensitive to oil price dynamics during bullish times, but during bearish times.

In terms of RER, Jahangard et al. (2016) find that RER appreciation is caused by a higher level of oil price both in the short-run and long-run in Iran. Basher et al. (2016) show that, unlike oil supply shocks that have limited evidence, oil demand shocks create appreciation pressure upon RER in oil-exporting countries. Both for oil-exporting and oil-importing economies, the authors find RER being affected by global economic demand shocks.

By focusing on REER, Bouoiyour et al. (2015) exhibit a bidirectional long-run interconnection between oil price and REER in Russia. The authors also show the existence of a sharp causality from oil price to REER at lower frequencies by applying the frequency domain approach. Chekouri et al. (2021) find that an increase/decrease in oil price leads to the appreciation/depreciation of REER in Algeria, where the effect of a negative oil price shock is higher than the positive one. The authors also find the existence of a unidirectional Granger causality from oil price to REER in the medium and long terms. Another result is about the co-movement of REER and oil price, where REER is led by oil price both in the medium and long runs.

2.2. Demand Side

There can be a bidirectional relationship between currency substitution/dollarization and exchange rate volatility. Any massive volatility or immense depreciation of a local currency with respect to the US dollar is associated with macroeconomic instability. This may lead to the loss of trust and confidence in the local currency and, therefore, may trigger massive dollarization, or in the worst-case scenario, currency substitution. However, the process does not end there and may launch a vicious circle as high demand for foreign currency, sourced from exchange rate instability, may weaken the exchange rate further. To analyze the relationship between these two variables, the academic literature is analyzed since 2015 mainly for emerging markets and developing economies (not necessarily oil exporting countries). Table 10 shows the literature review on the interconnection between the dollarization/currency substitution process and NER, NEER, RER and REER.

Table 10. Currency Substitution/Dollarization and Exchange Rate:

Author(s)	Main Key Words	Country	Method	Period
Ajibola et al. (2021)	Currency Substitution; RER Volatility; Structural Breaks	Nigeria	ARDL	Q1 1995 – Q4 2018 (quarterly)
Bawa et al. (2015)	Currency Substitution; Ratchet Effect; NER and RER; Monetary Policy	Nigeria	ARDL Cointegration	1990 – 2013 (monthly)
Catão and Terrones (2016)	Dollarization; Currency Substitution; Monetary Policy; Emerging Markets	28 Emerging Economies; Peru (Case Analysis)	Pooled Mean Regression, Panel Regression with FE, LSDV	Q1 1993 – Q4 2014 (quarterly)
Kalyoncu et al. (2015)	Currency Substitution; NEER; Real Income; Nominal Interest Rate	Nigeria	Johansen Cointegration	1980 – 2013 (annual)
Musoke (2017)	Dollarization; Currency Devaluation; NER	Tanzania	GARCH	Jan 2000 - Dec 2014 (monthly)
Naceur et al. (2015)	Financial Dollarization; Financial Development; De-dollarization; NER	Central Asian Countries; Caucasian Countries	DGMM	Q1 2001 – Q1 2014 (quarterly)
Raheem and Asongu (2016)	Dollarization; Openness; Resources	Sub-Saharan Africa countries	Tobit regression	2001 – 2012 (annual)
Samreth and Sok (2018)	Asymmetric Effects; Currency Substitution; Dollarization;	Cambodia	ARDL	Q2 1994 – Q4 2017 (quarterly)

	NER			
Tweneboah (2015)	Dollarization; NER and RER Volatility	Ghana	E-Garch	Jan 1990 – Mar 2015 (monthly)
Udoh and Udeaja (2019)	NER Volatility; Financial Dollarization; Currency Substitution	Nigeria	Threshold ARCH	Dec 2009 – Sep 2018 (monthly)

To generalize the definitions derived from academic literature, currency substitution is described as the usage of foreign currency instead of local currency by local residences as a means of payment (Akçay et al., 1997; Calvo and Vegh, 1992; Kumamoto and Kumamoto, 2014; McKinnon, 1985). Whereas, dollarization is defined as using foreign currency instead of local currency as a means of the store of value and the unit of account (Calvo and Vegh, 1992). The aforementioned authors conclude that currency substitution is the next stage of the dollarization process. Both dollarization and currency substitution processes increase demand for foreign currency.

Several papers confirm NER instability leading to the dollarization process. Samreth and Sok (2018) find that change in NER has a positive, but the asymmetric effect on the dollarization process in Cambodia. Naceur et al. (2015) find that NER volatility and depreciation lead to dollarization of the deposits, but not dollarization of loans in Central Asian and Caucasian economies.

The economies that possess a concentrated natural resource export base benefit from high commodity prices. This leads to a high level of foreign currency inflow that can provide a country with a strong foreign currency reserve to support and maintain macroeconomic balance and the forex market. Therefore, there should be a negative correlation between high commodity prices and the dollarization process. In terms of empirical evidence, one of the results of Raheem and Asongu (2016) is that exchange rate volatility leads to dollarization, whereas a higher level of natural resource rent mitigates the process in Sub-Saharan African countries. Catão and Terrones (2016) also exhibit that a high level of commodity prices is also one of the determinants of the de-dollarization in Peru.

Academic literature has also focused its attention on the relationship between currency substitution and exchange rate volatility in Nigeria. Long-term exchange rate volatility, the sign of macroeconomic instability, is expected to decrease the functionality of local currency as a means of payment and launch the currency substitution process, the advanced stage of dollarization. Ajibola et al. (2021) realize that higher RER volatility leads to the currency substitution process both in the short-run and long run. Kalyoncu et al. (2015) find that NEER depreciation causes currency substitution based on the long-run relationship. Bawa et al. (2015) show that exchange rate uncertainty, expectations about exchange rate depreciation and exchange rate spread (by using NER and RER) significantly lead to currency substitution.

However, the relationship cannot be expected to be unidirectional. An intensive currency substitution/dollarization process increases demand for foreign currency, which may lead to further exchange rate instability in a fragile macroeconomic environment. To support the statement, Udoh and Udeaja (2019), Musoke (2017) and Tweneboah (2015) demonstrate that the dollarization process causes NER volatility in Nigeria, Tanzania and Ghana, respectively.

2.3. Insights from literature review on the Azerbaijan economy

Depending on the size of an economy and its ability to shape global oil supply and demand forces, an economy can either be capable of influencing the global oil price or incur any volatility shock coming from the global oil price dynamics by reflecting this volatility mainly on its forex market. Because Azerbaijan is a small oil-exporting economy, the global oil price dynamics can be completely treated as an exogenous factor for the Azerbaijan economy. Meaning that any sharp changes in the global oil price will directly transmit its effect on the economy through the exports, the primary foreign currency supply channel of the economy.

In terms of the relationship between exchange rate and foreign currency demand in Azerbaijan, as is seen in figure 3, a sharp decline in the global oil price triggers the panic about upcoming exchange rate devaluation and macroeconomic instability, and therefore, excessively raises demand for foreign currency. This puts high pressure on the exchange rate stability as the supply of and demand for foreign currency suddenly decrease and increase, respectively. The nominal exchange rate will not change, as long as the government is ready to spend from its reserves to some extent to maintain the forex market stability.

By considering the sensitivity of the economy to exogenous oil supply shock and the reaction of economic players to it, this research tries to estimate the future trend of the potential nominal exchange rate in Azerbaijan under the assumed liberal and regulated forex market assumptions, along with considering the structure of the Azerbaijan economy. Unlike academic literature that mainly focuses on the econometric estimations, this study primarily employs the Python program to simulate a mathematical model built upon several assumptions as a treatment model and compares the estimated simulation results with the control model, built based on econometric forecasting tool. This research can be treated as a benchmark paper to estimate the potential nominal exchange rate under different commodity price scenarios for resource-rich countries where the forex market is regulated by government.

3. Methodology

3.1. Assumptions

The mathematical model is built upon several assumptions by considering and combining the structure of the Azerbaijan economy with the assumed liberal and regulated forex market environments:

3.1.1. Forex Market

- The model assumes that the global oil price shock is the only factor that undermines macroeconomic stability and causes forex market instability.
- Because the majority of the dollar reserves are accumulated on SOFAZ and SOFAZ is the biggest dollar supplier in the economy, the forex market has a monopolistic nature.
- For the next estimated 24 months, the FBOP level remains at 50 US dollars per barrel regardless of the global oil price dynamics.
- Under the liberal forex market assumptions, there is no government intervention, meaning that there are no capital mobility measures and the annual aggregate dollar amount supplied at the auctions throughout a fiscal year is not limited and does not have to be necessarily less than or equal to the annual aggregate dollar equivalent of the transfers to the government budget.
- Under the regulated forex market assumptions, the forex market is regulated such that the annual aggregate dollar amount supplied at the auctions throughout a fiscal year is limited and has to be necessarily less than or equal to the annual aggregate dollar equivalent of the transfers to the government budget.

3.1.2. Market Players

- The whole model dynamics is driven by how economic players such as commercial banks demand dollar amounts by reacting to the global oil price trend.
- The value of the estimated nominal exchange rate is determined by the interaction of the supply and demand forces.
- The supply force is represented by SOFAZ, an independent economic player; however, it has the liability to satisfy the government budget revenue.
- The demand force is represented by commercial banks that demand dollar amounts for each period.

- Commercial banks and SOFAZ interact at the currency auctions and based on its reserve level, SOFAZ determines the estimated potential nominal exchange rate for the next period.
- If dollar demand exceeds what is supplied, SOFAZ has to use additional reserves to satisfy the additional demand.
- If the dollar supply exceeds what is demanded, the excess dollar is cleared up by CBAR.
- Regardless of the excess local currency amounts collected at the previous currency auctions, SOFAZ still consistently tries to acquire fixed local currency amounts at the auctions to fulfill fixed monthly transfers to the government budget.

3.1.3. Exchange Rate Determination

- The estimated potential nominal exchange rate is determined based on how much foreign currency enters the forex market and matches with the supplied local currency amount.
- The estimated potential nominal exchange rate always stays at the point of the recent devaluation and never revalues even under conducive conditions because it is in the interest of SOFAZ to preserve its assets by having devalued exchange rate.
- The economy is interested in maintaining a fixed exchange rate, rather than having a floating one. Therefore, the exchange rate regime is assumed crawling pegged type.
- If devaluation is unavoidable, the economy is interested in undergoing as minimum devaluation as possible such that it will preserve the assets of SOFAZ and incur the most minimum cost upon the economy.

3.2. Mathematical Model and Explanation

The subsections below mathematically explain the link between global oil price and nominal exchange rate in Azerbaijan under liberal and regulated forex market conditions. Table 11 describes the labels used in the mathematical model and their respective definition.

Table 11. Variable Description:

Label	Definition
T_t	AZN equivalent of the transfer to the government budget
e_t	Current nominal exchange rate
AS_t	Additional dollar supply by SOFAZ
TS_t	Total dollar supply by SOFAZ
TBD_t	Total banking demand for the US dollar
AGC_t	Additional reserve gained by CBAR
TD_t	Total dollar demand in the economy

P_t	Current global oil price
Q_t	Current oil production of the economy
β	The share of production cost within total oil revenue
$FBOP_t$	Fiscal breakeven oil price level
NED_t	Necessary economic demand for foreign currency
ϕ	Policy Factor
AD_t	Additional banking demand for the US dollar
gr	A constant growth rate of a minimum banking demand for the US dollar
$MinAD_t$	Minimum additional banking demand for the US dollar
SL_t	The current stock level of SOFAZ
TC_t	The periodic total cost of SOFAZ
θ	Tolerance factor
δ	Tolerance share
μ	The factor that increases threshold level
$\overline{SL}$	The minimum threshold of the SOFAZ's tolerance level
i	The international investment return rate
RS_t	The reserve amount that is ready to be supplied by SOFAZ without going for devaluation
$E[\min(e_{t+1})]$	Estimated potential nominal exchange rate for the next period

3.2.1. Supply Side = Demand Side

The US dollar equivalent of the fixed transfers to the government budget ($\frac{T_t}{e_t}$) plus the additional supply (AS_t) by SOFAZ is approximately equal to the total dollar supply by SOFAZ (TS_t) to commercial banks for a specific point of time (1). The total dollar demand (TD_t) equals the total banking demand for the US dollar (TBD_t) plus the additional reserve gained by CBAR (AGC_t) (2). The total dollar supply (TS_t) in the economy is expected to be equal to the total dollar demand (TD_t) in the economy at a specific point in time (3) (4):

(1) $\frac{T_t}{e_t} + AS_t = TS_t$

(2) $TBD_t + AG_t = TD_t$

(3) $TS_t = TD_t$

(4) $\frac{T_t}{e_t} + AS_t = \ TBD_t + AGC_t$

If the current global oil price (P_t) is less than FBOP level ($FBOP_t$), the total banking demand for the US dollar (TBD_t) will be greater than the dollar equivalent of the fixed transfers ($\frac{T_t}{e_t}$). The equation is satisfied by the rise of the additional supply (AS_t), the result of the panic in the economy about a possible upcoming devaluation of the nominal exchange rate and macroeconomic instability. The additional supply (AS_t) is provided on the account of the SOFAZ's assets and the additional gain by CBAR (AGC_t) becomes zero.

If the current oil price (P_t) is greater than or equal to FBOP level ($FBOP_t$), the additional supply of dollars (AS_t) becomes zero because there is no panic by economic players about expected devaluation or macroeconomic instability. In this case, SOFAZ only has to supply the dollar equivalent of the fixed transfer amount ($\frac{T_t}{e_t}$). If the dollar equivalent of the fixed transfers ($\frac{T_t}{e_t}$) is greater than the total banking demand for dollars (TBD_t), the forex market is cleared up by CBAR and the additional gain by CBAR (AGC_t) is positive. However, if the dollar equivalent of the fixed transfers ($\frac{T_t}{e_t}$) is just equal to the total banking demand for the US dollar (TBD_t), the additional gain by CBAR (AGC_t) is zero (6):

By re-writing the equation (4):

(5) $\frac{T_t}{e_t} - TBD_t = AGC_t - AS_t$

(6) $AS_t = \begin{cases} if\, FBOP_t > P_t,\ \frac{T_t}{e_t} < TBD_t \Rightarrow AS_t > 0\ (and\, AGC_t = 0) \\ if\, FBOP_t = P_t,\ \frac{T_t}{e_t} = TBD_t \Rightarrow AS_t = 0\ (and\, AGC_t = 0) \\ if\, FBOP_t < P_t,\ \frac{T_t}{e_t} > TBD_t \Rightarrow AS_t = 0\ (and\, AGC_t > 0) \end{cases}$

3.2.2. Demand Side

The total banking demand (TBD_t) for the US dollar is the total amount of dollars that commercial banks demand at the currency auctions. The total banking demand (TBD_t) consists of two main parts: the necessary economic demand (NED_t) and the additional demand (AD_t) for the US dollar by commercial banks (7):

(7) $TBD_t = NED_t + \phi \cdot AD_t$

The necessary economic demand (NED_t) is the minimum dollar amount that must be demanded to satisfy the necessary economic transactions such as paying for imported goods and services. The necessary economic demand (NED_t) is demanded regardless of the global oil price dynamics. It grows steadily (gr) each period because dollar transactions and the demand for imported goods and services is assumed to increase steadily, as a result of an increase in GDP (8):

(8) $NED_t = NED_0 \cdot (1 + gr)^t$

The additional banking demand (AD_t) is the demand that occurs when the current global oil price (P_t) decreases below FBOP level ($FBOP_t$). When the current global oil price (P_t)

decreases significantly below FBOP level ($FBOP_t$), it raises panic among the economic players about possible upcoming devaluation and macroeconomic instability. This triggers economic players to demand additional dollar amounts from commercial banks, which in turn, demand additional dollar amounts from SOFAZ at the currency auctions. The desire for the additional demand (AD_t) increases more and more as the current global oil price (P_t) decreases lower and lower below FBOP level ($FBOP_t$). Thus, the additional demand (AD_t) is the function of the minimum expected additional demand ($MinAD_t$) that occurs only during panic times, the current global oil price (P_t) and FBOP level ($FBOP_t$) (9) (10):

(9) $AD_t = MinAD_t \cdot \left[1 + \frac{FBOP_t - P_t}{P_t}\right]$

(10) $MinAD_t = \begin{cases} if\, P_t < FBOP_t, & MinAD_t > 0 \\ if\, P_t \geq FBOP_t, & MinAD_t = 0 \end{cases}$

Mentioning that this study tries to estimate potential nominal exchange rate under the liberal and regulated forex market assumptions, policy factor (ϕ) is added into the model where the factor takes the values '0' or '1', respectively (11):

(11) $\phi = \begin{cases} 0, & if\, Regulated\, Forex\, Market\, Assumption \\ 1, & if\, Liberal\, Forex\, Market\, Assumption \end{cases}$

By considering all the elements, the full representation of the total banking demand (TBD_t) under the liberal and regulated forex market assumptions, respectively, is as follows (12.1 and 12.2):

(12.1) $TBD_t = NED_0 \cdot (1 + gr)^t + \phi \cdot MinAD_t \cdot \left[1 + \frac{FBOP_t - P_t}{P_t}\right]$, where $\phi = 1$

(12.2) $TBD_t = NED_0 \cdot (1 + gr)^t$, where $\phi = 0$

3.2.3. Supply Side

The current reserve stock level (SL_t) of SOFAZ is the total value of SOFAZ's assets that is accumulated on the account of oil export revenue and investment return. The periodic total cost (TC_t) is the cost of SOFAZ for a specific point of time in which SOFAZ has to ensure transfers to the government budget and satisfy the dollar demand of the economy. SOFAZ is highly interested in sustainably protecting its stock level. Therefore, the current stock level (SL_t) minus the periodic total cost (TC_t) should be at least equal to or above the minimum threshold of the tolerance level or stock level ($\overline{SL}$). The minimum threshold of the stock level ($\overline{SL}$) equals the initial stock value of the starting date adjusted by the tolerance share (δ) multiplied by the tolerance factor (θ), meaning that the threshold level will always be below the current reserve stock level (SL_t) by the factor of the tolerance share (δ) (13) (14):

(13) $SL_t - TC_t \geq \overline{SL}$

(14) $\overline{SL} = Initial\,Stock\,Value \cdot (1 - \delta \cdot \theta)$

SOFAZ is ready to spend from its reserve stock without hesitation until its reserves are above the minimum tolerance level. If this threshold level is crossed, and therefore, if SOFAZ goes for devaluation to reduce dollar demand pressure, the tolerance factor (θ) increases and SOFAZ sets a new threshold target below the recent level. However, if the SOFAZ's assets accumulate in a positive trend such that the current reserve stock level (SL_t) is above the threshold target, at least, by the factor $(1 + \mu)$, the tolerance factor (θ) decreases to set a higher threshold level. Higher the SOFAZ's assets, the higher the threshold target to preserve what has been accumulated so far (15) (16):

(15) $\theta = 1$

(16) $\theta = \begin{cases} if\ SL_t \geq \overline{SL} \cdot (1 + \mu),\ \theta - k \\ if\ \frac{e_{t+1} - e_t}{e_t} > 0\ or\ SL_t < \overline{SL} \cdot (1 + \mu),\ \ \theta + k \end{cases},\ k \in [0, 1, 2 \ldots]$

The current stock level (SL_t) is the function of the remaining stock level from the previous period (SL_{t-1}), the investment return on the previous period stock level ($SL_{t-1} \cdot i$), the total revenue from oil exports adjusted by the production cost ($P_t \cdot Q_t \cdot (1 - \beta)$), and the investment return on the newly gained net profit from the oil exports ($P_t \cdot Q_t \cdot (1 - \beta) \cdot i$). Oil production and export revenue incur the production cost (β), which includes transfer cost, capital cost, operational cost etc. The production cost (β) is demonstrated as the share incurred upon the total oil export revenue ($P_t \cdot Q_t$) (17) (18):

(17) $SL_t = SL_{t-1} + SL_{t-1} \cdot i + P_t \cdot Q_t \cdot (1 - \beta) + P_t \cdot Q_t \cdot (1 - \beta) \cdot i$

(18) $SL_t = SL_{t-1} \cdot (1 + i) + P_t \cdot Q_t \cdot (1 - \beta) \cdot (1 + i)$

The periodic total cost (TC_t) of SOFAZ consists of the fixed transfers to the government budget adjusted by the expected minimum next period's exchange rate ($\frac{T_t}{E[min\,(e_{t+1})]}$) and the additional dollar supply (AS_t) during bearish oil price dynamics. Because the SOFAZ's assets are in dollar terms and the government budget is in local currency terms, the transfer amount is divided by the next period's expected minimum nominal exchange rate ($E[min(e_{t+1})]$) to acquire the expected dollar equivalent of the transfers ($\frac{T_t}{E[min\,(e_{t+1})]}$). The next period's expected minimum nominal exchange rate ($E[min(e_{t+1})]$) determines the dollar value of the transfers (T_t) at local currency terms now, and therefore, determines the periodic total cost (TC_t) at the current point of time. By targeting to preserve the SOFAZ's current assets, it is in the interest of the whole economy to have a minimum level of devaluation for the next period if devaluation is unavoidable. Therefore, devaluation should happen as minimum as possible such that it will ensure the protection of the SOFAZ's assets and transmit the most minimum devaluation cost to the economy (19):

$$(19)\ TC_t = \frac{T_t}{E[min(e_{t+1})]} + AS_t$$

By plugging the equations (18) and (19) into the equation (13):

$$(20)\ SL_{t-1} \cdot (1+i) + P_t \cdot Q_t \cdot (1-\beta) \cdot (1+i) - \frac{T_t}{E[min(e_{t+1})]} - AS_t \geq \overline{SL}$$

$$(21)\ E[min(e_{t+1})] \geq \frac{T_t}{SL_{t-1} \cdot (1+i) + P_t \cdot Q_t \cdot (1-\beta) \cdot (1+i) - \overline{SL} - AS_t}$$

Here, $SL_{t-1} \cdot (1+i) + P_t \cdot Q_t \cdot (1-\beta) \cdot (1+i) - \overline{SL}$ equals the reserve amount that SOFAZ is ready to supply for a specific point of time without going for devaluation (RS_t) (22):

$$(22)\ RS_t = SL_{t-1} \cdot (1+i) + P_t \cdot Q_t \cdot (1-\beta) \cdot (1+i) - \overline{SL}$$

By plugging the equation (22) into equation (21):

$$(23)\ E[min(e_{t+1})] \geq \frac{T_t}{RS_t - AS_t}$$

In equation (23), the numerator shows the transfer to the government budget in local currency terms (T_t). It also indicates the amount of AZN that is re-injected into the economy through the government expenditure; the denominator shows the reserves that are ready to be supplied (RS_t) minus the additional dollar supply (AS_t) where all are in dollar terms. Thus, the local currency amount divided by the dollar amount reveals the expected minimum nominal exchange rate for the next period ($E[min(e_{t+1})]$).

Moreover, it is assumed that the nominal exchange rate does not revalue and stays at the place of the recent devaluation. If the expected minimum future nominal exchange rate ($E[min(e_{t+1})]$) is greater than or equal to the ratio of the numerator and denominator, shown in the equation (23), the expected minimum future nominal exchange rate ($E[min(e_{t+1})]$) equals to the recent ratio value that has revealed the maximum result so far. Otherwise, it equals the current ratio value (24):

$$(24)\ E[min(e_{t+1})] = \begin{cases} if\ E[min(e_{t+1})] \geq \frac{T_t}{RS_t - AS_t},\ E[min(e_{t+1})] = max\left(\frac{T}{RS - AS}\right)\ USD/AZN \\ if\ E[min(e_{t+1})] < \frac{T_t}{RS_t - AS_t},\ E[min(e_{t+1})] = \frac{T_t}{RS_t - AS_t}\ USD/AZN \end{cases}$$

3.2.4. Final Step

If the current global oil price (P_t) is above or equal to FBOP level ($FBOP_t$), then there is no panic, and therefore, there is no need for further dollar supply. The additional supply (AS_t) becomes zero, and therefore, the expected minimum nominal exchange rate for the next period ($E[min(e_{t+1})]$) is the ratio of the transfers in the local currency (T_t) and the reserves that are ready to be supplied in dollars (RS_t) (25):

$$(25)\ E[min(e_{t+1})] \geq \frac{T_t}{RS_t}$$

However, if the current global oil price (P_t) is below FBOP level ($FBOP_t$), then the additional supply (AS_t) is greater than zero. Higher the additional supply (AS_t), the lower the denominator, and, thus, the higher the magnitude of an increase in the expected minimum nominal exchange rate for the next period ($E[\min(e_{t+1})]$), which means devaluation. Whereas, a rise in the reserves ready to be supplied (RS_t) generates the opposite effect in the equation, increases the maneuver potential of SOFAZ and decreases the possibility of upcoming devaluation (26) (27):

$$(26)\ E[min\,(e_{t+1})] \uparrow \geq \frac{T_t}{RS_t - AS_t\uparrow}$$

$$(27)\ E[min\,(e_{t+1})] \geq \frac{T_t}{RS_t\uparrow - AS_t}$$

Full demonstration of the model under the liberal forex market assumptions ($\phi = 1$) (28):

$$(28)\ E[min\,(e_{t+1})] \geq \frac{e_t \cdot (TBD_t + AGC_t - AS_t)}{(SL_{t-1} \cdot (1+i) + P_t \cdot Q_t \cdot (1-\beta) \cdot (1+i) - \overline{SL}) - (NED_0 \cdot (1+gr)^t + \phi \cdot MinAD \cdot \left[1 + \frac{FBOP_t - P_t}{P_t}\right] - \frac{T_t}{e_t})}$$

Full demonstration of the model under the regulated forex market assumptions ($\phi = 0$) (29):

$$(29)\ E[min\,(e_{t+1})] \geq \frac{e_t \cdot (TBD_t + AGC_t - AS_t)}{(SL_{t-1} \cdot (1+i) + P_t \cdot Q_t \cdot (1-\beta) \cdot (1+i) - \overline{SL}) - (NED_0 \cdot (1+gr)^t - \frac{T_t}{e_t})}$$

3.3. Control Model

The mathematical model, described above, is considered a treatment model. To analyze to what extent it effectively estimates future potential nominal exchange rate, a control model is established and compared with the treatment model. As the control model, the autoregressive integrated moving average (ARIMA) model combined with an exogenous variable (ARIMAX model) is employed to forecast the potential future exchange rate under the liberal ($\phi = 1$) and regulated ($\phi = 0$) market assumptions for the upcoming 24 months (30):

(30) $D(y_t, d) = \beta \cdot X_t + v_t$, where $v_t = \rho_1 \cdot v_{t-1} + \rho_2 \cdot v_{t-2} + \cdots + \rho_p \cdot v_{t-p} + \theta_1 \cdot \epsilon_{t-1} + \theta_2 \cdot \epsilon_{t-2} + \cdots + \theta_q \cdot \epsilon_{t-q}$, where p and q denote the number of autoregressors (AR) and moving averages (MA), respectively.

4. Parameter Determination and Model Processing

4.1.1. Oil Price Dynamics (P) and Treatment Model Simulation

The mathematical model consists of 24 iterations, where each iteration equals one month. The model is calculated 100,000 times by applying the logic of the Monte-Carlo simulation technique in the Python program. As an exogenous variable, the oil price is randomly determined based on the random integer generator function (*random.randomint()*) for the next 24 months within the range of [0;100]. Based on the 100,000 simulations, the arithmetic average of all simulation results is taken to estimate the average value of the parameters that are endogenously determined such as exchange rate. The approach is applied to the models with the regulated (ϕ = 0) and liberal (ϕ = 1) forex market assumptions.

4.1.2. Oil Production (Q)

The revenue from hydrocarbon resources mainly encompasses oil export revenue, along with natural gas revenue. This research focuses on the crude oil factor as it has a significantly larger share within the resource exports and plays a crucial role in managing the expectations of economic players. The daily barrel of crude oil produced by Azerbaijan will equal 657143.35 in 2022 (FRED FED Database: Crude Oil Production for Azerbaijan). Weighted average (gradually increasing the weight from the past data toward the recent one) is applied to the daily crude oil production from 2016 till 2022 to estimate the annual weighted average production growth rate, 3.79% per year. Based on the weighted average growth rate and the daily production volume of 2022, the daily production volume of 2023 is estimated to be 632224.80 barrels of crude oil (657143.35·(1-0.0379)). Converting the daily barrel production to the monthly one reveals 19988110.34 and 19230171.01 barrels of crude oil production per month in 2022 and 2023, respectively.

4.1.3. Production Cost (β)

At the annual level, the cost of the oil production is found by estimating β. The marginal annual gain of SOFAZ is assumed to be acquired through the oil revenue ($P_t \cdot Q_t$), net of production cost $(1 - \beta_t)$, accumulated further by investing and obtaining annual investment return (i_t).

$$P_t \cdot Q_t \cdot (1 + i_t) \cdot (1 - \beta_t) = Marginal\,Annual\,Gain_t$$

$$1 - \frac{Marginal\,Annual\,Gain_t}{P_t \cdot Q_t \cdot (1 + i_t)} = \beta_t$$

By considering the annual revenue of SOFAZ (SOFAZ, Multiple: 2016…2020), the weighted average (gradually increasing the weight from the past data toward the recent one) is applied to annual β_t values from 2016 to 2020 and is found to be 0.47, meaning that about 47% of the total oil revenue, accumulated via investment return, is spent to cover the production cost.

4.1.4. Fiscal Breakeven Oil Price (FBOP)

Based on projected fiscal parameters for the medium term, FBOP level is forecasted to be 50 US dollars per barrel for 2022 and 2023, respectively (Ministry of Finance of the Republic of Azerbaijan, 2021).

4.1.5. Initial Value of SOFAZ's and CBAR's Reserve Stocks

The total value of SOFAZ's assets was 45025.1 million US dollars on the 1st of January 2021 (SOFAZ, 2022). At the end of the December of 2021, the official foreign reserves of CBAR were 7075.0 million US dollars (The Statistics of CBAR, 2022).

4.1.6. Threshold Share (δ), Factor μ, and SOFAZ's Threshold Level ($\overline{SL}$)

In March 2020, the global oil price sharply decreased below FBOP level and about 1928 million US dollars were sold at the auctions. Because of the aforementioned government intervention mechanism, since April 2020, the auction dollar demand was tranquilized till the end of the year (figure 2). In March 2020, the total value of SOFAZ's assets was 41349.5 million US dollars (SOFAZ, 2020). Before squeezing the dollar demand, SOFAZ was let to use 4.66% (1928/41349.5) of its reserves to satisfy the skyrocketing dollar demand. Therefore, during simulating the model, rounded up by the nearest integer, the minimum threshold of the tolerance level ($\overline{SL}$) is adjusted if 5% of the reserves are melted.

Moreover, the factor μ is assumed to be 0.05, meaning that if the current stock level (SL_t) is equal to or above the threshold level by 105% (1 + μ), the threshold level ($\overline{SL}$) is increased by decreasing that value of the tolerance factor (θ). Finally, at the beginning of the iteration, the threshold level ($\overline{SL}$) equals 42773.85=45025.1·(1-0.05·1) ($\overline{SL} = Initial\,Stock\,Value \cdot (1 - \delta \cdot \theta)$). Depending on whether the reserves are melted by 5% or the current stock level (SL_t) is equal to or higher than the threshold level of 105% will determine the future trend of the threshold level of SOFAZ ($\overline{SL}$).

4.1.7. SOFAZ's Investment Return (i)

Weighted average (gradually increasing the weight from the past data toward the recent one) is applied to the annual investment return of SOFAZ from 2016 to 2021 (SOFAZ, Multiple: 2016...2021). The annual and monthly weighted average of the investment return equals 3.28% and 0.27% ($(1+0.0328)^{(1/12)}$ -1), respectively.

4.1.8. Transfer Amount (T)

Based on projected fiscal parameters for the medium term, the annual amount of SOFAZ's transfer to the government budget is forecasted to be 12710.0 and 11520.0 million AZN for 2022 and 2023, respectively (1059.17 and 960 million AZN per month for 2022 and 2023, respectively) (Ministry of Finance of the Republic of Azerbaijan, 2021).

4.1.9. Necessary Economic Demand (NED)

By taking the minimum value of the auction demand for each year from 2016 to 2021 and applying the weighted average (gradually increasing the weight from the past data toward the recent one), approximately 292 million US dollars of the necessary economic demand (NED) is estimated.

4.1.10. Growth Rate of NED (gr)

The necessary economic demand (NED) is assumed to grow each month based on the growth rate of total imports of the economy. Weighted average (gradually increasing the weight from the past data toward the recent one) is applied to the annual total import level from 2016 to 2021. The weighted average growth rate of annual and monthly total import level equals 2.62% and 0.22% ($(1+0.0262)^{(1/12)}$ -1), respectively. Meaning that the initial value of the necessary economic demand (NED) is estimated to be 292 million US dollars which grows 0.22% per iteration (The Statistics of the CBAR, 2022).

4.1.11. Minimum Additional Demand ($MinAD$)

It is expected that during decreasing oil price period, because of the high demand for foreign currency, the demand at the auctions will be higher than the average auction amount, in contrast to the increasing oil price period. The annual average auction amount value for year *t* is subtracted from each monthly actual auction amount of year t from 2016 to 2021. Weighted average (gradually increasing the weight from the past data toward the recent one) is applied to the values that are above the average value for the whole period. Thus, if the global oil price dynamics are below FBOP level, the minimum value of the additional foreign currency by commercial banks that occurs only during panic times will start from 221.62 million US dollars.

4.1.12. Policy Factor (ϕ)

The variable is set to be ‘0’ or ‘1’ for the regulated or liberal forex market assumptions, respectively.

4.2. Control Model Determination

ARIMAX model is run by using the Eviews forecasting package. Policy factor (ϕ) and FBOP ratio = $\left[\frac{FBOP_t - P_t}{P_t}\right]$ (taken from the equations (9) and (10)) are used as exogenous variables. The data of nominal exchange rate and Brent crude oil price are taken from the database of CBAR and FRED FED. The data consists of 132 observations and covers the period from January 2011 to December 2021. Two nominal exchange rate data from January 2022 to December 2023 are forecasted under the liberal ($\phi = 1$) and regulated ($\phi = 0$) forex market assumptions.

4.2.1. Variable Selection

Based on figure 3, this study concludes that the panic about possible upcoming devaluation, and therefore, additional foreign currency demand emerges when oil price decreases below FBOP level. In other words, there is exist an asymmetric effect of oil price on the foreign currency demand. Therefore, only positive values of the FBOP ratio (oil price below FBOP level) are considered and the negative values (oil price above FBOP level) are replaced with the value '0'. Also, the oil price that is used to estimate the FBOP ratio is randomly taken from one of the simulation results out of 100,000 simulations because the arithmetic average of 100,000 oil price simulations reveals the oil price values around 50 (the average of the range from 0 to 100) for 24 iterations. This sets the FBOP ratio to be almost '0' for all 24 months, mentioning that FBOP level is expected to be 50 US dollars per barrel for the next two years.

In terms of policy factor (ϕ), the nominal exchange rate has begun to stabilize around 1.7 USD/AZN since July 2017. For the model under the liberal forex market assumptions ($\phi = 1$) *Dummy Liberal* variable is used and assigned the value ‘1’ from July 2017 till December 2021 (to show that the forex market is regulated during this period) and starting from January 2022 to December 2023 value ‘0’ is assigned (to show that the forex market is unregulated during this period). For the model under the regulated forex market assumptions ($\phi = 0$) *Dummy Regulated* variable is used and assigned the value "1" from July 2017 to December 2023 (to show that the forex market is still kept regulated). Additionally, though until February of 2015 CBAR maintained the nominal exchange rate fixed at 0.78 USD/AZN, the forex market was not exposed to strict capital mobility measures. Therefore, the dummy values are assigned value ‘0’ before July 2017.

4.2.2. Optimal Model Selection

Augmented Dickey-Fuller and Philipps-Perron unit root testing are applied on the FBOP ratio and FX rate to analyze their stationarity (table 12). The FBOP ratio is similar to the standardized oil price growth rate and reveals stationary behavior at level form, whereas nominal exchange rate has a unit root and is stationary at a differenced form. Therefore, the first difference in the logarithm of the nominal exchange rate is set to be the dependent variable.

Table 12. Unit Root Test:

FBOP Ratio	Augmented Dickey-Fuller		
	None	Intercept	Intercept and Trend
Level	0,0000	0,0000	0,0000

FBOP Ratio	Philipps-Perron		
	None	Intercept	Intercept and Trend
Level	0,0000	0,0000	0,0000

FX Rate	Augmented Dickey-Fuller		
	None	Intercept	Intercept and Trend
Level	0,5933	0,7565	0,8084
First Difference	0,0000	0,0000	0,0000

FX Rate	Philipps-Perron		
	None	Intercept	Intercept and Trend
Level	0,6661	0,8023	0,9041
First Difference	0,0000	0,0000	0,0000

By using the automatic ARIMA forecasting tool (with a maximum likelihood approach), for both models with the liberal ($\phi = 1$) and regulated ($\phi = 0$) forex market assumptions the number of autoregressors (AR) and moving average (MA) are determined to be 1 and 11, respectively (1, 1, 11). The optimal number of AR and MA is determined by applying the Akaike information criterion.

The forecast model of the nominal exchange rate under the liberal forex market assumptions ($\phi = 1$):

$$\begin{aligned} D(\log(\text{FX rate}_\text{t}), 1) &= \beta_0 + \beta_1 \cdot \text{FBOP Ratio}_t \cdot \text{Dummy Liberal}_\text{t} + \beta_2 \cdot \text{FBOP Ratio}_\text{t} + \beta_3 \\ &\quad \cdot \text{Dummy Liberal}_\text{t} + v_t \end{aligned}$$

where $v_t = \rho_1 \cdot v_{t-1} + \theta_1 \cdot \epsilon_{t-1} + \theta_2 \cdot \epsilon_{t-2} + \cdots + \theta_q \cdot \epsilon_{t-11}$

The forecast model of the nominal exchange rate under the regulated forex market assumptions (ϕ = 0):

$$\mathcal{D}(\log(\text{FX rate}_\text{t}), 1) = \beta_0 + \beta_1 \cdot \text{FBOP Ratio}_t \cdot \text{Dummy Regulated}_\text{t} + \beta_2 \cdot \text{FBOP Ratio}_\text{t} + \beta_3 \cdot \text{Dummy Regulated}_\text{t} + v_t$$

where $v_t = \rho_1 \cdot v_{t-1} + \theta_1 \cdot \epsilon_{t-1} + \theta_2 \cdot \epsilon_{t-2} + \cdots + \theta_q \cdot \epsilon_{t-11}$,

5. Results and Conclusion

In the treatment model, the nominal exchange rates under the liberal (ϕ = 1) and regulated (ϕ = 0) forex market assumptions are estimated by simulating oil price 100,000 times and taking the arithmetic average of all simulation results for 24 iterations by applying Monte-Carlo simulation logic in the Python program. Because simulated individual outlier results occasionally reveal extremely higher values for the estimated nominal exchange rate and, thus, increase the arithmetic average of the 100,000 simulations, the cap of a maximum 1000% of depreciation is inserted into the simulation process. In terms of the control model, by applying the ARIMAX forecasting tool, the nominal exchange rates are forecasted under the same two assumptions. While applying ARIMAX forecasting framework, a random oil price scenario out of 100,000 simulations is selected because the average oil price calculated from all simulation results is almost around 50 US dollars per barrel, which sets the FBOP ratio to be near zero for the next estimated 24 months (figure 4).

Figure 4. Oil Price Scenarios

The ARIMA models under both liberal (ϕ = 1) and regulated (ϕ = 0) forex market assumptions are identical between the estimation period of January 2011 and December 2021, where the dummy values are assigned the value '1' from July 2017 till December 2021, and therefore, both models reveal the same results. The two models diverge for the forecast period of January 2022 and December 2023. The result of the ARIMA model is represented in table 13, where *Dummy Liberal* and *Dummy Regulated* are identified under the variable name *DUMMY*.

Table 13. ARIMA Model Results for the Estimation Period: Jan 2011 - Dec 2021:

Variable		Coefficient	Prob.
C		0,000	0,967
FBOP_RATIO*DUMMY		-0,067	0,083
FBOP_RATIO		0,064	0,000
DUMMY		0,001	0,856
AR(1)		0,609	0,009
MA(1)		-0,442	0,999
MA(2)		-0,443	0,999
MA(3)		-0,017	0,999
MA(4)		-0,162	1,000
MA(5)		0,091	1,000
MA(6)		0,167	1,000
MA(7)		-0,030	1,000
MA(8)		-0,292	1,000
MA(9)		0,190	1,000
MA(10)		0,526	1,000
MA(11)		-0,589	1,000
SIGMASQ		0,001	0,989
R-squared	56,9%	Mean dependent var	0,006
Adjusted R-squared	50,8%	S.D. dependent var	0,036
S.E. of regression	0,025	Akaike info criterion	-4,299
Sum squared resid	0,073	Schwarz criterion	-3,926
Log-likelihood	298,563	Hannan-Quinn criter.	-4,147
F-statistic	9,399	Durbin-Watson stat	1,974
Prob(F-statistic)	0,000		

Table 13 demonstrates the result of the control model for the estimation period of January 2011 and December 2021**.** The variables *FBOP RATIO* and *FBOP RATIO ·DUMMY* are strongly significant at 1% α level and weakly significant at 10% α level, respectively. The variable *DUMMY* solely has no statistically significant effect. The independent variables explain 50.8% of the variation in the dependent variable based on the result of the adjusted R square. In terms of the result of the model, other factors constant, setting *DUMMY* variable to obtain value ‘0’, when *FBOP RATIO* increases by 1%, the nominal exchange rate devalues by 0.064% (*FBOP RATIO* + *FBOP RATIO ·DUMMY* = 0.064 - 0.067·0= 0.064). Meaning that in the unregulated forex market, if oil price decreases below the FBOP level, there exist statistically significant devaluation pressure on the forex market. Setting *DUMMY* variable to obtain value ‘1’, the effect of *FBOP RATIO* is weakly significantly offset by the imposition of the regulation, mentioning that the net effect is almost zero (*FBOP RATIO* + *FBOP RATIO ·DUMMY* = 0.064-0.067·1= -0.003). Meaning that in the regulated forex market, any volatility in the oil price dynamics below the FBOP level has no impact on the nominal exchange rate. It should be noted that, mentioning the asymmetric effect of the oil price on dollar demand, the negative values of *FBOP RATIO* (when the oil price is above FBOP level) are replaced with the values ‘0’. Based on the displayed ARIMA forecast models, the next 24 months are forecasted under the liberal (ϕ = 1) and regulated (ϕ = 0) forex market assumptions for the period January 2022 and December 2023.

The comparison of the treatment and control models under the liberal (ϕ = 1) and regulated (ϕ = 0) forex market assumptions are presented in figure 5. Under the regulated forex market assumptions (ϕ = 0), in the treatment model, the nominal exchange rate depreciates from 1.7 to 1.91 USD/AZN in the first 12 months and becomes stable at 1.91 USD/AZN for the second year. Whereas, in the control model, the nominal exchange rate meagerly fluctuates within the range of 1.7 and 1.73 USD/AZN for the next 24 months. Under the liberal forex market assumptions (ϕ = 1), in the treatment model, the nominal exchange rate depreciates from 1.7 to 3.76 USD/AZN in the first year and further depreciates to 5.07 USD/AZN till the end of the second year. In the control model, the nominal exchange rate depreciates from 1.7 to 2.39 USD/AZN till the end of the first year, and further depreciates to 4.28 USD/AZN till the end of the second year.

To estimate the prediction accuracy of the treatment model relative to the control model, mean absolute percentage error (MAPE) is used:

$$MAPE = \frac{100\%}{n} \cdot \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|$$

where A_t is set to be the ARIMAX forecast values and F_t is set to be the simulation values of the nominal exchange rate. The higher the MAPE value, the lower the prediction accuracy. Under the liberal (ϕ = 1) and regulated (ϕ = 0) forex market assumptions, MAPE values equal to 28.02% and 9.11%, respectively. Meaning that the treatment simulation model estimation is off by 28.02% and 9.11% relative to the control ARIMAX forecast model, respectively.

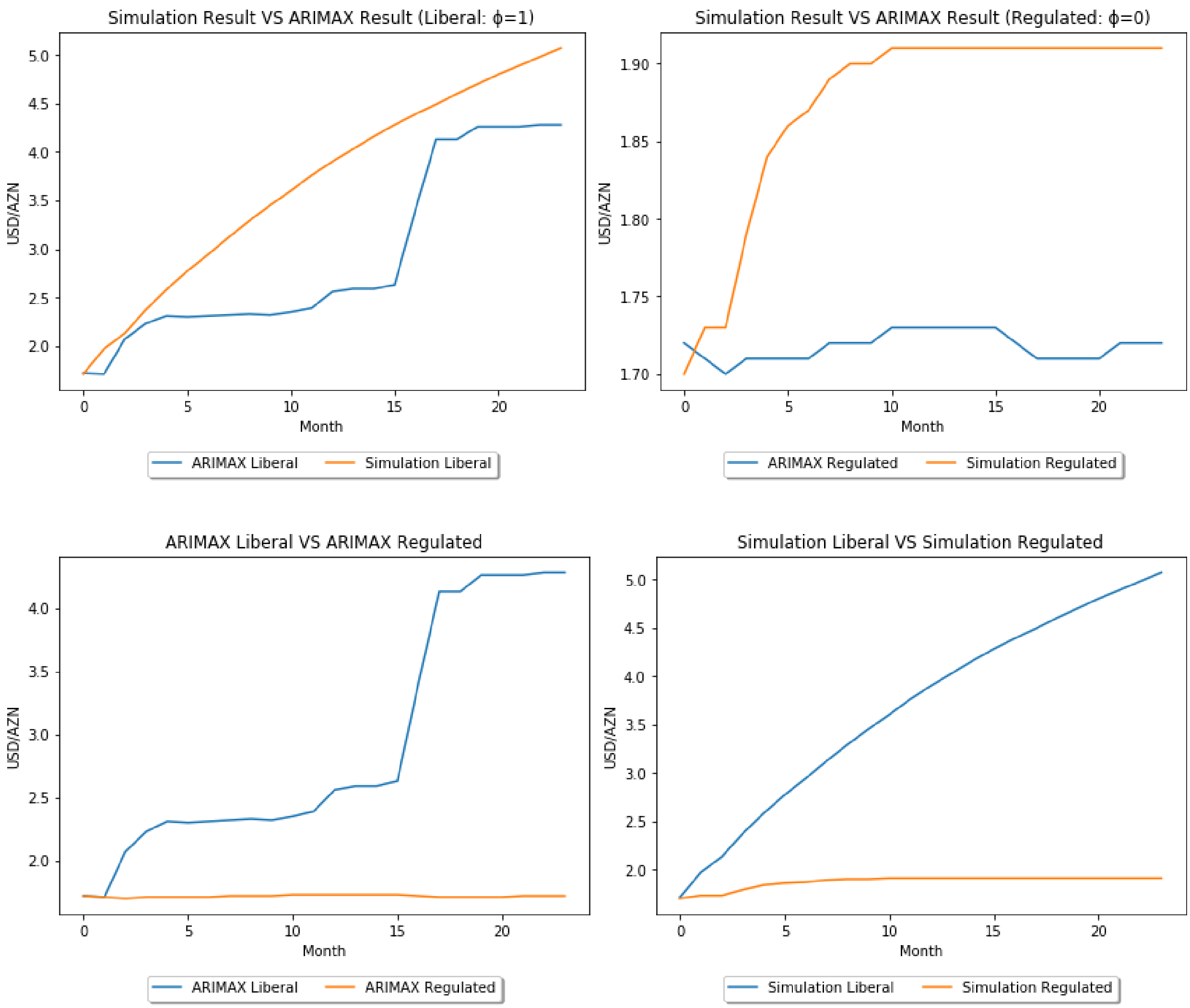

Figure 5. Estimation and Forecast of Nominal Exchange Rate

The treatment model overestimates the nominal exchange rate for the next two years relative to the control model under both liberal ($\phi = 1$) and regulated ($\phi = 0$) forex market assumptions. Despite higher MAPE value, under the liberal forex market assumptions ($\phi = 1$) the treatment model catches the trend of the depreciation similar to the control model. In the case of the model under the regulated forex market assumptions ($\phi = 0$), the MAPE value is relatively lower and the predicted values of both control and treatment models are significantly closer.

Comparing the model under the regulated forex market assumptions ($\phi = 0$) with the government prediction, according to projected fiscal parameters for the medium term, the nominal exchange rate is expected to stay at 1.7 USD/AZN rate till the end of 2025 (Ministry of Finance of the Republic of Azerbaijan, 2021). The simulated model reveals 0.21 USD/AZN value higher than the prediction of the Ministry of Finance until the end of the estimation period. However, in terms of volatility and fluctuation, the model reveals the nominal exchange rate to be fixed and stable as planned by the government.

5.2. Conclusion

The purpose of this research is to estimate the potential nominal exchange rate in Azerbaijan under the liberated forex market assumptions for the next 24 months since the beginning of 2022. As the main driver assumption, the annual aggregate foreign currency supplied through the auctions by SOFAZ is not necessarily limited to the annual aggregate dollar equivalent of the transfers to the government budget. Meaning that the forex market is assumed to be out of the government intervention and the assumed liberal forex market determines the nominal exchange rate by responding to the global oil price dynamics, along with considering the structure and the context of the Azerbaijan economy.

The treatment models under both liberal (ϕ = 1) and regulated (ϕ = 0) forex market assumptions overestimate the control models under the same assumptions, respectively. In terms of the model under the liberal (ϕ = 1) forex market assumptions, both the control and treatment model forecasts the depreciation of the nominal exchange rate to 4.28 and 5.07 USD/AZN, respectively, till the end of the second year. Though the forecast prediction error is higher, the treatment model can reflect the trend of the depreciation relative to the control model. The conclusion drawn from the estimation is that, as long as the economy is highly dependent upon oil revenues, any negative oil shock will be treated as a sign of upcoming recession and possible exchange rate devaluation. This panic would immediately reflect itself upon the forex market by devaluing AZN vis-à-vis USD further if the forex market is liberated.

In terms of the model under the regulated (ϕ = 0) forex market assumptions, the forecast accuracy error of the treatment model is relatively lower than the control model. Similar to the prediction of the Ministry of Finance, the treatment model reflects the stability of the nominal exchange rate for the next two years, though the estimation shows the depreciation by 12.35% (from 1.7 to 1.91 USD/AZN). The conclusion is that as long as the forex market is regulated, any negative exogenous shock may have a meager negative effect on the forex market and the nominal exchange rate is highly likely to be maintained at its position.

Besides the global oil price dynamics, the model results are sensitive to several parameters, especially to the threshold level ($\overline{SL}$), investment return (ι), and the cap level inserted into the model to avoid extreme outliers in the simulation process. The main insights of the sensitivity analysis are that, by adjusting the threshold level ($\overline{SL}$), SOFAZ decides how much reserves it is ready to supply to the forex market, and therefore, determines the future stability of the potential nominal exchange rate by manipulating the amount of foreign currency entering to the economy. In terms of the investment return (ι), the profitability level of the investment return on the SOFAZ's assets determines the future stock potential of SOFAZ. Higher the stock potential of SOFAZ, the higher the probability to maintain a stable exchange rate regime. Finally, the estimation of the nominal exchange rate is sensitive toward the inserted cap level, set to be the maximum 1000% depreciation, which rules out the occasional extreme outlier values that distort the average result.

As a policy implication derived from the results of this research, any sharp fluctuation in commodity prices may negatively affect the expectations of economic players in countries that are highly concentrated on natural resources. This may trigger massive volatility and depreciation of the nominal exchange rate through the process of intense dollarization. Such economies should significantly diversify their economy before liberalizing their forex market to avoid exchange rate volatility.

5.3. Extension

In terms of future research extension, the coefficients of the parameters are assigned based on the statistical analysis of the historical trend. Future research can extend the model by conducting regression analysis for satellite models and deriving the actual coefficients for the model parameters from econometric results. This is highly likely to increase the prediction accuracy of the simulation model and minimize MAPE. Secondly, the assumptions of the model can be manipulated further and future research may consider the estimation of the potential nominal exchange rate under different exchange rate regime scenarios. Finally, as time changes so do the characteristics of the economy. Possibly, over the evolution of the economy in the future, economic players may not only react to the global oil price dynamics but also to sudden changes in other macroeconomic variables such as GDP growth rate or inflation rate that directly or indirectly may affect their income, purchasing power and confidence on the local currency. Because the main driver of the additional supply (AS_t) is the additional demand (AD_t) function, the additional demand (AD_t) function can be extended further to encompass the factors that may cause panic among economic players if expectations are not met:

$$AD_t = MinAD \cdot \left[1 + \frac{FBOP_t - P_t}{P_t} + \frac{E(GDP_t) - GDP_t}{GDP_t} + \frac{E(CPI_t) - CPI_t}{CPI_t} \dots\right]$$

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