ABSTRACT

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Carry trade strategy is popular in countries where interest rate differentials are high. Australia was a popular country among carry traders for a long time, until Australian interest rate differentials started to narrow. Now emerging market countries received popularity among carry traders since interest rates tend to be much higher, for example in Russia or Mexico. Those countries are also resource-rich economies, which makes them sensitive to crises. During crisis, resource-rich countries' currencies start to devaluate at a much faster pace compared to developed resource-rich economies, causing mass selling of foreign investors assets. One of the reasons for higher devaluation might relate to carry trade as it tends to attract foreign speculative capital, which is sensitive to volatility causing fast unwinding. Hence, faster devaluation might deepen the crisis, whereas during the normal period currencies might be overvalued due to carry trade and thus hurt the export sector.

The contribution of this thesis is to observe and indicate the impacts of carry trade on the Russian economy and ruble. VAR model is used to study the existence of Granger causality between the carry trade to ruble, Australian dollar, Mexican peso and Brazilian real from 2002 to 2020. Also, to test if carry trade has an impact on the Russian economy via macroeconomic indicators and if the share of non-residents, ruble and carry trade have causality. The IRF, variance decomposition and Granger causality results are used to analyse the power and movement of tested variables of the VAR model. Results are also compared between Russian and Australian macroeconomic indicators from 2002 to 2020.

VAR model showed that there is a clear bidirectional Granger causality between all six currency pairs and carry trade. However, only ruble was significant through all defined periods (including crises). IRF showed that carry trade has a powerful negative impact on ruble, meaning that increasing carry trade appreciates ruble. VAR analysis showed that carry trade, ruble and share of non-residents have unidirectional causality. The last analysis showed that carry trade has a powerful negative impact on Russian export whereas in the case of Australia it was much lower and less significant.

In Conclusion, there is a strong relationship between carry trade, ruble, the share of non-residents and export. Overvalued ruble harms export whereas during the crisis devaluation of ruble is fast due to increased share of non-residents. In the case of Australia, carry trade impact was both less significant and volatile. Effective institutions and high level of democracy help Australia to mitigate risks from carry trade.

Key words	Carry trade, Russia, UIP, Australia, Institutions

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Carry trade on suosittu strategia maissa, joissa on suuret korkoerot. Australiassa on ollut pitkään suuret korkoerot, mikä on näkynyt carry traden suosiossa. Tällä hetkellä Australian korot ovat laskeneet ja carry treidaajat siirtyneet kohti kehittyviä markkinoita, sillä siellä on houkuttelevampi ympäristö korkeiden korkojen johdosta. Esimerkiksi Venäjällä ja Meksikossa korot ovat korkeita, mikä on näkynyt carry traden suosiossa. Nämä resurssirikkaat maat ovat todella haavoittuvaisia ulkoisille kriiseille. Kriisien aikana kyseisten maiden valuutat heikkenevät merkittävästi nopeammin kehittyneiden maiden valuuttoihin nähden, mikä johtaa ulkomaisten sijoittajien positioidensa nopeaan myyntiin. Yksi mahdollisista syistä valuutan nopealle heikkenemiselle voisi liittyä carry tradeen, sillä se houkuttelee paljon spekulatiivista pääomaa. Volatiliteetti voi laukaista spekulatiivisen pääoman ulosvirtauksen, mikä näkyy valuutan heikkenemisessä. Kriisin aikana valuutta heikkenee tavallista nopeammin ja kriisien ulkopuolella carry trade puolestaan vahvistaa valuuttaa, mikä vaikuttaa negatiivisesti vientiin.

Tämä tutkielman tavoitteena on selvittää carry traden vaikutuksia Venäjän talouteen ja ruplan kurssiin. VAR-malli on otettu käyttöön carry traden,ja ruplan sekä viiden muun valuutan välisen kausaliteetin selvittämiseksi vuodesta 2002 vuoteen 2020. Carry traden ja ruplan vaikutuksia Venäjän talouteen selvitetään muuttujilla, jotka ovat sidoksissa makrotalouteen vuodesta 2002 vuoteen 2020. IRF ja variance decomposition -menetelmiä käytetään vaikutuksien voimakkuuden ja suunnan analysoimiseksi. Tuloksia Venäjän makrotalouden indikaattoreista verrataan Australian indikaattoreihin.

VAR-malli osoitti, että carry traden ja kuuden valuutan välillä on kahdensuuntainen Granger-kausaliteetti. Ainoastaan rupla oli tilastollisesti merkitsevä kaikkien määritettyjen periodien aikana (mukaan lukien kriisit). IRF tulosten mukaan carry tradella oli voimakas negatiivinen vaikutus ruplan kurssiin. Tämä tarkoittaa, että carry traden kasvu vahvistaa ruplan kurssia. VAR-analyysi osoitti, että carry traden, ruplan ja ulkomaalaisten sijoitusten osuuksilla on yksisuuntainen kausaliteetti. Viimeisen analyysin perusteella carry tradella on voimakas negatiivinen vaikutus Venäjän vientiin, kun taas Australian tapauksessa vaikutus oli paljon pienempi ja tilastollisesti ei niin merkitsevä.

Carry tradella oli havaittu vahva kausaliteetti ruplan, ulkomaalaisten sijoittajien osuuksien ja viennin välillä. Yliarvostettu rupla heikentää vientiä, kun taas kriisien aikana rupla heikkenee nopeasti ulkomaalaisten sijoittajien spekulatiivisten positioidensa sulkemisen myötä. Australian tapauksessa carry traden vaikutus oli heikompi ja vähemmän merkitsevä. Tehokkailla instituutioilla ja vahvalla demokratialla on ollut vaikutusta carry traden riskien minimoimisessa.

Asiasanat	Carry trade, Russia, UIP, Australia, Institutions

IMPACTS OF CARRY TRADE ON THE RESOURCE RICH COUNTRIES' ECONOMY FROM A MACROECONOMIC PERSPECTIVE

CASE RUSSIA

Master´s Thesis
in Finance

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1 INTRODUCTION

The foreign exchange market – also known as the FX market or forex – determines exchange rates for floating currencies. Before the modern Forex market, currencies were linked to precious metals, such as gold and silver. The system prior to the modern foreign exchange market was known as the gold standard and that monetary system lasted up until World War 1. In 1944 the new monetary system was developed, and the leading Western countries signed the famous Bretton Woods Agreement, which made the U.S. dollar convertible to gold at a certain fixed rate. Additionally, all other leading currencies were valued concerning the U.S. dollar, which made it a dominant reserve currency. Due to various reasons, such as inflationary policy, the period of the Bretton Woods system was quite short, and it collapsed in 1973. The era of the modern foreign exchange began right after the Bretton Woods system when the government control of foreign exchange rate ended, and total floating and free-market conditions began. The FX market is now the biggest market in the world with its average daily turnover of $6,6 trillion, which is more than the equity and futures markets combined (Bank of International Settlements 2019). An annual FOREX market turnover is more than 18 times the world GDP, which is about 88 trillion U.S. dollars (World Bank 2020). Also, the FX market has the highest liquidity in the world due to its substantially large number of daily participants. (BIS Survey, 2019.)

The forex market is a global and geographically decentralized over-the-counter (*OTC*) market. Traders from around the globe are participating in trillions of U.S. dollars transactions every day. The last two decades that were associated with the substantial development of informational technology and globalization, increased the availability of foreign currency trading and financial markets for investors, which is also seen as a constant growth of the trading volumes. Globalization and the rising role of emerging markets have provided the FX market with even more currencies that are actively traded. Since the forex market has become such a global player, there is no doubt that macroeconomic events are affecting the FX market and vice versa. One of the main macroeconomic factors that have the most substantial impact on the foreign exchange market is inflation. Hence, the economic health of a country's economy is a fundamental factor in the exchange rate of its currency, and it can change quickly based on current circumstances and information. Other factors that have a major impact on exchange rates are capital market factors, such as stock, bonds and commodities, international trade numbers and political events. For example, Russia's ruble is heavily correlated with the price of commodities, such as crude oil and gas, due to its commodity-based economy. So, for example, if the oil price increases, it would most likely lead to the appreciation of the Russian rubble relative to the U.S. dollar or euro and vice versa. Information related to currency fluctuation is thus highly important for investors and it is driving their decision-making process.

The foreign exchange market is associated with a high level of uncertainty as no one can tell or predict for sure whether the market will go up or down. Unpredictable circumstances force investors to speculate, which is an act of trading currencies under the conditions of uncertainty with a plan to earn excess returns. Investors are using various currency trading strategies to speculate on the market. One of the most popular FX strategies is carry trade that is characterized as an "interest arbitrage". However, in the forex markets, it could be hard to separate speculating from common hedging processes, which appear when, for instance, a company trying to protect an anticipated or existing position from a fluctuation of foreign exchange rates. As mentioned before, due to the high liquidity and trading volumes, the FX market should be efficient, where prices should perfectly reflect information available to market players. Therefore, it must be impossible to earn excess returns from currency speculating as no arbitrage opportunities appear. Nevertheless, carry trade has a systematic ability to make an excess return in FX markets, which makes that strategy extremely interesting.

Carry trade is one of the most widely used currency speculation strategies. The strategy is quite simple, investors sell a borrowed low-interest-rate currency (funding currency) to finance an investment in high-interest currency (investment currency). Carry trade could also be executed through future contracts where investors sell forward currencies at a premium (forward premium) and buy forward currencies at discount (forward discount). Forward premium means that the forward rate is more than its spot rate (Cenedese et al. 2014). That kind of strategy has helped traders to earn excess returns in the FOREX market. There is a lot of research papers considering excess returns of the carry trade, but not that much research on the impacts on various countries' economies from a macroeconomic perspective. Hence, this master thesis will focus more on the macroeconomic and macrofinance aspects instead of speculative currency trading mechanics and strategy. However, there will be a clear and thorough explanation of carry trade's ability to earn excess returns in chapter two.

Investors and institutions such as hedge funds are constantly searching for profitable and stable carry trade opportunities (i.e., arbitrage), to invest billions of US dollars. Earlier the classic carry trade strategy was to sell Japanese yen due to its historically low-interest rate to finance an investment in Australian dollars which had a high-interest rate (Kim 2015, 64). Nowadays, the strategy is different, and investors observe more arbitrage opportunities in developing countries. Thus, for example, the Russian ruble became a popular carry trade currency, which eventually appreciated rubble's real exchange rate to a high level. Russian rubble became too appreciated compared to its current economic situation and structure. (Mikova et al. 2020, 2016). As a result, manufacturing and overall production of domestic goods became unprofitable, which then crashed the entire manufacturing industry in Russia. (Mironov & Petronevich 2015, 7.) Russian export shrink (despite oil & gas sector) and import increased due to a strong currency rate. Additionally, carry trade tend to increase the rate of foreign investments up to 50% in various securities market segments, such as derivatives, bonds, currency markets and so on (MOEX 2017). This is a quite dangerous scenario because carry trade investments are speculative investments, which means that, if some kind of shock or bad news will occur in the economy where those investments are, it will immediately trigger carry traders to take their investments out. As a result, the bubble which developed from the carry trade will eventually burst and subsequently crash the currency exchange rate. This chain reaction will sooner or later start a new crisis. (Dobrynskaya 2014, 1890.)

Previous research and studies were mostly concentrated on carry trades ability to earn excess returns in various economic circumstances and solving mathematical problems related to carry trade, such as the forward premium puzzle. However, the negative impacts of carry trade are not widely reported compared to other topics, although these impacts are quite easily observable in most previous studies and research papers. This study concentrates mainly on 5 papers have studied relationships between carry trade and crash risks with various macroeconomic determinants. Brunnermeier et al. (2008) provided evidence of a strong link between carry trade and currency crash risk. Authors used vector autoregressive (VAR) model with the impulse response addition for their analysis. Their paper states that investors or speculators invest in high-carry currencies which leads to currency crashes due to the sudden unwinding of these carry positions. One of the main reasons behind sudden unwind is increased risk aversion. Brunnermeier et al. (2008) conclude that macroeconomic fundamentals indicate which currencies have low or high interest rates and the long-run currency levels. Also, liquidity and capital immobility cause currency crashes and short-term currency underreaction to variations in fundamentals which is why their macroeconomic model was based on the hypothesis that risk premia is affected by market liquidity and funding constraints. Second study by Anzuini & Fornari (2012) was based on the Brunnermeier et al. (2008) paper where they concentrated more on the role played by macroeconomic shocks. More precisely, they examined the currency crashes by larger amount of macroeconomic variables such as demand, supply, monetary policy and confidence shocks. Authors also used VAR-model to analyse which of the four macroeconomic shocks are more suitable to explain the changes in foreign exchange rates, interest rate differentials and carry trade activity based on various currency pairs such as USDAUD and JPYAUD. Results showed that confidence shocks as well as demand shocks are playing the main role of carry trade activity.

Another paper is by Melvin & Shand (2016) who were examining the reasons behin the worst carry trade loss episodes in recent decades. Authors took long positions in the three highest interest rate currencies that were funded with three short positions in the lowest rate currencies. Positions were divided by three portfolios: developed markets, emerging markets and a combination of those both portfolios. Results showed that the largest drawdown was observed during the financial crisis of 2007-2008 and that there is no a such thing as a standard carry unwind. Unwind depends on many reasons, such as market risk, investors' confidence and interest rate differentials, which eventually have an impact on overall macroeconomic situation. In addition, study by Dobrinskaya (2014) shows that there is a strong link nowadays between currency and stock markets due to the increasing volume of carry trade activity by institutional investors. This means that downside risk and disaster risk of investment currencies is much higher due to the carry trade.

Compared to previous papers, Ready et al. (2007) emphasize importance of commodity trade when analysing excess returns of carry trade. Authors state that countries that heavily export commodities tend to have high interest rate compared to countries that export finished resources. Hence, "commodity currencies" attract massively carry traders and these interest rate differentials translate particularly fully into average returns on carry trade strategies. As a result, countries that are producing finished goods are more sensitive to productivity shocks, which makes their currencies a safe heaven, while commodity countries' currencies are riskier. Increased speculative positions increase significantly crash risk, however study indicates that countries with efficient institutions and high democratic degree are less sensitive to carry trades unwind.

1.1 The purpose of the study and contribution

The contribution of this thesis is to observe and indicate the impacts of carry trade on the Russian economy. Since carry trade is widely studied this thesis concentrates particularly on the Russian economy by observing two major crises that occurred in 2008 and 2014. The reason why those two crises were chosen is that the carry trade operations were quite massive during those crises. Hence, this study tries to figure out if there were similar factors related to carry trade that occurred during those two crises and that subsequently triggered the bubble burst. Additionally, the Russian scenario will be tested and compared to other countries to observe if there are similar aspects that are causing the bubble. Also, the opposite case scenario will be studied where carry trade had mainly neutral impacts on the economy (case Australia), to make analysis more sound.

1.2 Structure of the Thesis

This preliminary study plan is constructed as follows: the theoretical framework is provided in the second third and fourth chapters with the coverage of base theories, concepts and relevant previous literature review. Further data and methodological background are described, followed by an empirical section of the paper and concluding remarks. Chapters one two and three are aimed to introduce the research topic providing theoretical background. The second chapter stands for a brief introduction of market efficiency and arbitrage concept, evidence on forward premium puzzle and explanations of carry trade excess returns. The literature review on carry trade from the macroeconomic perspective is depicted in chapter three, including a brief introduction to the Russian and Australian economic background and their linkage to the carry trade as well as a comparison of other similar countries. The following chapter four describes data and methodology more accurately. Chapter five is showing empirical results obtained from conducted tests and observations. The last chapter six concludes the research suggesting some ideas for further research on the discussed issue.

1.3 Hypothesis and expected results

The hypotheses are:

- Carry trade has granger causality on the Russian ruble and the impact is more powerful compared to other currencies, especially after 2014
- Carry trade has granger causality on the Australian dollar, Brazilian real and Mexican peso
- Carry trade volatility of ruble, peso and real is higher compared to Australiandollar
- The Russian ruble and carry trade have common granger causality and impact on macroeconomic indicators
- Share of non-residents and carry trade have positive granger causality and are related to ruble appreciation/depreciation

The expected results are that the carry trade is causing significant impacts on the Russian economy and it keeps the Russian ruble exchange rate too high while the economy is not developing compared to Australia. As a result, export is declining due to a high currency exchange rate. A high currency exchange rate decreases the country’s competitiveness and makes its own production unprofitable, which is seen as a decline in the manufacturing industry sector. Eventually, countries goods that were previously produced domestically will be replaced by imported ones. On the other hand, the profitable carry trade is tempting foreign investors to invest money in the funding countries (Russia in this case) securities market, which will eventually increase the proportion of the foreign investors with foreign capital. Because carry trade is a speculative strategy, investors might take all their money out of the funding country, which will lead to a crash of the funding countries' currency. The expected result will be that the carry trade has a significant impact and causality on the share of non-resident investors, causing the ruble rate to appreciate or depreciate depending on the variability of foreign investors. The high proportion of foreign investors of the funding country's securities market (about 50%) might collapse the funding country's currency rate in case of mass selling. This will eventually lead to a massive devaluation which might lead to a crisis. As a result, this thesis could help to observe a similar factor that is constantly causing carry trade bubbles. Those factors could help to understand what impacts carry trade causes on the macroeconomy and why The last expected result is that some of those factors are also appearing in other countries' economies. These expected results might be very useful for further studies and a better understanding of the currency carry trade negative impacts.

2 CARRY TRADE MECHANISM

2.1 Market efficiency and arbitrage

The efficient Market Hypothesis states that prices reflect all available information on the market. Additionally, prices follow random walks since information flow is random. (Pilbeam 2005, 247.) For a FOREX, market inefficiency means that there is a possibility for developing a model that forecasts exchange rate fluctuations. According to Pilbeam (2005, 252), some patterns can be found that could predict exchange rate movements. Hence, it has to be possible for speculators to earn constantly risk-free excess returns as arbitrage opportunities arise. Also, the regulatory authorities may determine the optimal way to affect exchange rates and estimate the outcome of various economic policies. In contrast to the inefficient FX market, interventions in an efficient market are at a minimum level and traders are not able to earn excess returns from foreign exchange speculations, because arbitrage opportunities do not exist. In an efficient market, international traders are not motivated to change investments from domestic assets to assets that are denominated in foreign currency or the other way around. (Pilbeam 2005, 252–315.) It is important to notice that EMH is the joint hypothesis of risk neutrality and rational expectations, where risk neutrality is related to a situation where traders will choose investment opportunities that provide the greatest return despite risk embedded (Pilbeam 2005, 252–260). Literature considering FX market efficiency is pointing the ability of FX forwards to predict exchange rate movements. FX forwards tend to systematically predict exchange rate movements wrong and thus, traders may benefit from market inefficiency. We will discuss this more in the next chapters and before that, we will briefly cover basic theory regarding FX forwards and carry trade.

Forward foreign exchange market makes it possible to buy or sell currency at an agreed contract price and agreed date in the future. The forward exchange rate is established by an equal relationship between differences in interest rates among two countries and the spot exchange rate, which reflects foreign exchange market equilibrium under which arbitrage opportunities do not exist.

It is quite common to use exceptionally high leverage in speculative FX trading, which is in the range of 100:1. Not only big traders, such as hedge funds or investment banks, are able to use high leverage, but it is also available for the regular trader. An extremely high leverage ratio is because trades (spot) take two days for settlement. Hence, traders have an opportunity to speculate on the exchange rate movements before the spot markets settlement day. Notable thought is that investors operating in this kind of short-term trading speculation can make extremely huge investments, without having almost any amount of initial capital.

The effective exchange rate F is a forward rate, which can be derived as a covered interest rate parity (CIP):

(1) $$F_t = \frac{(1 + i_t^*)}{(1+i_t)} \times S_t$$

According to CIP markets anticipate that the exchange rate will change as much as the difference between two country's exchange rates. We can see from equation 1 that if the forward rate would differ from the CIP equilibrium, then investors would have an opportunity to make a risk-free profit. In other words, CIP is an arbitrage condition, and if CIP holds then arbitrage opportunities do not exist. (Taylor (1987.) In the next chapter, we will go thoroughly through various equilibrium models, such as CIP, and discuss how they are related to carry trade.

2.2 Equilibrium models

A good theory chapter contains a logical and causal structure combining the related subtheories that are focused on the core subject that we are trying to understand. The core subject of this theoretical part is the mechanism of carry trade and the sub-theories are purchasing power parity (PPP), covered interest rate parity (CIP), uncovered interest parity (UIP) and forward premium puzzle (FPP). Nearly any literature review about the theoretical part of carry trade subsumes those four sub-theories that build the ground for carry trade. Especially the forward premium puzzle, which states that the forward exchange rates have little if any power to predict changes in spot rates, is a key factor in explaining the excess returns of carry trade (Fama 1984). However, before moving straight forward to the forward premium puzzle, it is essential to have a basic understating of PPP, CIP and UIP. So next we will try to understand these three related frameworks and their assumptions before observing the puzzle, as it contravenes these frameworks.

2.2.1 Purchasing power parity

Purchasing power parity or PPP is one of the oldest and popular equilibrium models that compare various countries' currencies through a "basket of goods" approach. Regardless of its age and simplicity, PPP is also one of the most widely studied and controversial relations. (ECB 2020)

The simplest version of PPP is the absolute purchasing power parity (Absolute PPP) and it is founded on the law of one price. The law of one price states that the prices of an identical product, that countries are producing, should have the same price, if there are no trade barriers and costs, such as transportation costs, are excluded. (Miljkovic 1999.)

(2)
$$S = \frac{P^*}{P}$$

The absolute PPP theory predicts that market forces will cause the exchange rate to adjust when the price levels across countries are not the same. This prediction is shown in the formula (1), where P* is the foreign price index, P is the domestic price index and S is the spot exchange rate. If the domestic price index P is higher than the foreign price index P*, then the demand for foreign products will rise and appreciate the foreign currency P*. The demand for foreign products will rise as long as the equilibrium is achieved. (Taylor et al. 2001.)

Besides the absolute purchasing power parity, there is relative purchasing power parity, which takes inflation into account and is a more dynamic version of the absolute PPP theory. Relative purchasing power parity simply predicts a relationship between the movement in the exchange rate and the inflation rates of two countries over a specified period. (Taylor et al. 2001.)

(3)
$$\frac{S_{t+1} - S_t}{S_t} = \frac{\frac{P^*{}_{t+1}}{P_{t+1}} - \frac{P_t^*}{P_t}}{\frac{P_t^*}{P_t}} = \frac{(1+\pi^*)}{(1+\pi)} - 1$$

Equation (2) states that the nominal exchange rate's (S) relative change in the time period t – t+1 is determined by the foreign and domestic inflation rate ratio (π *and* π^*). Inflation lowers countries' purchasing power and thus a county with a higher/(lower) inflation rate will have lower/(higher) purchasing power compared to the counterpart. According to PPP theory, the exchange rate will adjust the equilibrium in the long run. (Rogoff 1996). Additionally, the real exchange rate must adjust the equilibrium and be constant, which means that any variations in the real exchange rate would illustrate deviations from purchasing power parity. Because these deviations shouldn't be constant, Begg et al. (2003) state that PPP forecasts real exchange rates to be mean-reverting which is more apparent in the long run. Especially PPP is a longer-term theory if we compare it to other equilibrium models, such as UIP where interim changes in exchange rates are not immediately affecting the prices of various countries. According to ECB (2020), many academics argue that the velocity of mean reversion could be slow and there is a possibility that a full return could never happen at all. This problem of rapid adjustment of specified as “PPP puzzle”. (Rogoff 1996).

From the macroeconomic point of view, PPP theory is one of the most important fundamentals determining exchange rates, but it has its limitations too. The main problem is that the theory’s condition is hardly fulfilled within a county. One of the main reasons why PPP condition is not satisfied is related to the factors such as transportation costs, trade barriers and imperfect information. For example, the law of one price assumes that there is perfect competition and no transportation costs or taxes between the two countries. Because in the real-world costs do exist, prices would tend to differ from similar goods apart. The same issue is with the non-tradable goods that are related to the service sector, where wages, productivity level and rents are different in each country. (Taylor 2006.) Thus, PPP has not much predictive power for most goods and products. According to Mishkin (2006, 435–437) PPP is based on relative price levels, which does not require exact equilibrium, but instead states that a rise in a country’s price level relative to the foreign country’s prices causes its currency to decline, is a more realistic model of PPP. Hence, it is in line with the condition of PPP when considering that the possible exchange rate changes do not need to reach a certain equilibrium.

2.2.2 Covered and Uncovered Interest Rate Parity

The covered interest rate parity states that the covered interest differential between two similar assets valued in different currencies should be zero. The exposure of exchange rate risk is covered with the use of a forward contract. If the covered differential deviations are more than zero, then it will represent riskless arbitrage opportunities and thus indicate inefficiency in the international capital markets. (Taylor 1986). CIP theorem assumes that all available information is present, exchange rates are market-determined and that investors are rational. According to the CIP theory, the domestic interest rate should be lower (higher) than the foreign interest rate by an amount that is equal to the forward premium (discount) in the domestic currency (Copeland 1994). Eaton and Turnovsky (1983) state that the CIP model assumes no arbitrage opportunities with the rational expectations, which means that investors will adjust the domestic interest rate (r) into parity with the foreign interest rate (r*) plus the forward discount or premium of foreign exchange (F). As a result 1–month returns on FX instruments in the U.S. and Russia are on average equalized. Accordingly, the formula of covered interest rate parity (CIP) can be derived as:

$$1 + r_t = (1 + r_t^*) \times {}^{F_t}/_{S_t} \qquad (4)$$

where r and r* are the domestic and foreign interest rates on similar assets defined over the same maturity, S is the spot exchange rate and F is the forward rate of the same maturity as the interest rate (Taylor 1986). Under this parity, an investor is involved in forward market repurchase agreement speculation, where the investor receives domestic currency in the amount of (1+r*t) x Ft/St and subsequently uses the profit to repay the domestic currency loan taken, which is (1+rt). Due to engaging in this speculation, expanded domestic borrowing raise the demand for domestic loans. Then, increased spot market purchases of domestic (foreign) currency generate excess supply (demand) and curtail (increase) the value of the domestic currency. The same action happens in the forward market. As a result, expanded demand for foreign currency investments generates a supply of foreign currency deposits, which will affect the banks to cut their interest rates for foreign currency deposits. Eventually, this process will continue as long as equality is re-established. (Copland 1994.) In sum, formula (3) assumes that profit from investments is zero when the exchange rate uncertainty is hedged with the FX forward contract.

According to the definition of previously mentioned the law of one price (LOP), similar securities must have an equal price. In a situation when the price is determined as a yield, then CIP assumes that two identical securities valued in various currencies must yield the same return whereas the exchange rate uncertainty is eliminated. As a result, we can conclude that systematic deviations from the formula (1) would contradict the law of one price (LOP) and put the theory of efficient market hypothesis (EMH) under question. Additionally, Copland (1994) states that while covered interest rate parity holds in general, it does not hold precisely due to the existence of factors such as transaction costs, political risks and deviations in domestic and foreign assets.

Unlike CIP, uncovered interest rate parity (UIP) implies that the no-arbitrage condition is met without the use of a forward contract to hedge the exposure of exchange rate risk. Thus, this interest rate parity is said to be uncovered. (Copland 1994.) According to UIP, the currency with the lower interest rate appreciates against the currency with the higher interest rate and vice versa until the equilibrium is achieved. Hence, the movement of the exchange rate is determined by the difference in nominal interest rates between two countries with various currencies. (Chinn 2007.) Additionally, Copeland (1994) states that to achieve equilibrium in UIP, a few assumptions should be met, such as investors are risk-neutral; funds must flow without any frictions; assets are substitutable. Thus, the average return in both currencies would be the same, for example, an investor who invested in a lower interest rate would get a profit from the appreciation of the currency whereas an investor who invested in a higher interest rate would suffer a loss from the depreciation of the currency. Since excess returns on average should be impossible to gain, investors are indifferent between holding risk-free assets in domestic or foreign currencies. However, it is important to notice that the conditions of UIP and

CIP such as free capital flow across countries and perfect substitutes of two countries risk-free assets could hold in developed countries, but not necessarily in developing countries, which have capital restrictions, regulations, sanctions and fixed exchange rates.

(5) $$1 + r_t = \frac{E_t(S_{t+k})}{S_t} \times (1 + r_t^*)$$

Equation (4) is the formula of UIP, where r_t and r_t^* are the domestic and foreign interest rates for the period t, $E_t(S_{t+k})$ is the expected future spot exchange rate at time t + k (k is the number of periods into future from time t) and S_t is the spot exchange rate at time t. When both parities UIP and CIP hold, it creates a relationship between the forward and expected future spot exchange rates. Dividing the equation (4) by equation (3) yields the following formula:

(6) $$1 = \frac{E_t(S_{t+k})}{F_t}$$

which can be rewritten as:

(7) $$F_t = E_t(S_{t+k})$$

Equation 6 is the unbiasedness hypothesis (where F_t is the forward exchange rate at time t), which states that the forward exchange rate is an unbiased predictor of the future spot exchange rate under specific conditions that are rational expectations and risk neutrality. If conditions don't hold, then there is an arbitrage opportunity to earn excess returns by speculating in forward FX markets that violate the arbitrage theory. (Razzak 2002.)

A vast literature has shown that UIP does not hold. For example, Fama's classical study (1984) has empirically shown the failure of UIP. Also, Engel (1996) and Lewis (1995) has both shown in detail reasons for the failure of UIP. Moreover, vast research has shown that exchange rates have moved in the opposite direction as UIP theory suggests. Low-interest rate currencies tend to depreciate high-interest rate currency, which creates arbitrage opportunities. As a result, UIP is violated which is widely known as "forward premium puzzle

2.3 Evidence on the forward premium puzzle

Failure of uncovered interest rate parity has been one of the most important puzzles of finance for the past several decades and there is a huge amount of literature dedicated to that parity failure and forward premium puzzle. The hypothesize of UIP shows that the carry trade gain due to the interest rate differential is negated by a corresponding depreciation of the investment currency. However, empirically the opposite holds, where the investment currency appreciates on average, although with a quite low predictive R^2 (Fama 1984). The failure of the UIP is often referred to as the forward premium puzzle, which is one of the main factors that makes the carry trade profitable. Thus, the main implication of the forward premium puzzle is that investors have an opportunity to make systematic gains by shorting the low yielding currency and taking a long position in the high yielding currency, which is known as the carry trade trading strategy. However, as we have previously mentioned, in the situation of risk neutrality, the future spot rate should be consistently predicted by a forward exchange rate. Nevertheless, the classical empirical studies by Bilson (1981) and Fama (1984) have been rejecting this prediction. Hansen et al. (1980) paper were one of the first studies where the simple efficiency hypothesis was rejected. Bilson extended previous studies of hypothesis by examining a data set of nine currencies from 1974 to 1980. The null hypothesis of a new statistical test stated that exchange rate derives as a random walk, which assumes that the best possible predictor of future spot rate is the current rate. This means that if the market meets the condition of efficiency then forward rates should be equal spot rates. As a result, Bilson found that the average return from a broad amount of speculative trading is strongly differing from zero, which indicates that either market is inefficient or transaction, risk premia and information costs impact the value of the forward premium.

Fama (1984) made a huge contribution to researching the forward premium puzzle that eventually provided breakthrough evidence on that topic. His paper divided forward premium into two pieces: risk premium and an expected depreciation premium placed on the information set available for traders. Eventually, he finds that the relative significance of the expected depreciation premium and the risk premium, that lead to establishing of regression framework:

(8) $$S_{t+1} - S_t = \alpha + \beta(f_t - S_t) + \mu_t$$

Where the left side of the equation is the future percentage change of currency rate at time period t – t+1 and the term in the parentheses is the forward discount. Equation (7) is also known as **Fama regression** which tests the unbiasedness hypothesis, where the null hypothesis is $\beta = 1$ and μ_t is the error term that equals the forward market forecast error. The null hypothesis $\beta = 1$ means that market should be efficient. However, Fama (1984) found that slope coefficient β not only equals 1 but instead on average much lower than zero, illustrating a bias in the forward exchange rate (Chinn 2007). Later, this paradox has been named in the international finance literature as the **forward premium puzzle**.

If uncovered interest rate parity is held, the expected average return for investors would be zero, because the interest differential (i.e., forward discount) would reflect the expected depreciation of the investment currency against the borrowed currency (funding currency). However, the null hypothesis of unbiasedness is rejected almost every time. According to the paper of Meese and Rogoff (1983), exchange rates fluctuations follow a near-random walk, which creates an opportunity for investors to gain from the interest differential without making any losses from the depreciation of the investment currency. Kenneth and Thaler (1990) noted in their paper that the average beta coefficient in equation (7) is approximately -0.88, which Engel (1995) also confirms in his studies. In general, if the beta coefficient is below 1 ($\beta < 1$) it suggests that a 1 percent increase in the interest rate differential is followed by a less than 1 percent depreciation in the funding currency. On the other hand, if the beta is below zero ($\beta < 0$) then an increase in the interest rate differential is followed by an expected appreciation in the funding currency, contributing a greater change in risk premia. Therefore, the negative coefficient implies that carry trade investors would also make a profit from the investment currency appreciation during the holding period in addition to the forward discount. However, the forward market in the emerging countries' currencies is less biased than in developed countries as well as the beta coefficient is also on average slightly above zero (Frankel & Poonawala 2010). In addition, Jylhä and Suominen (2011) argue that carry trade returns have been declining, pointing to evidence that the bias has been declining in general over the past forty years.

In sum, Fama and other notable economists have shown empirically that the forward exchange rate is a systematically biased predictor of the current spot rate and therefore creates profitable arbitrage opportunities. However, explaining the observed anomalies have been a difficult issue. There are a few reasons why the puzzle remains even when capital is frictionless according to covered interest parity (CIP). Conceivable explanations of this issue are divided into two camps focusing either on the invalidity of the rational expectations hypothesis or on the risk premium. Authors who suggest the second category are defining the systematic factor of the forward market's forecast errors as a risk premium where the first category of the invalidity of the rational expectations implies that market participants have systematic expectation errors. If we are suggesting rational expectations, then crash risk and funding constraints would be the explanations behind our issue. If rational expectations are refuted, then "peso problem", irrational expectations, learning and bandwagon effect would be taken into account. (Engel 1995.)

The majority of authors are behind the risk premium while at the same time maintaining the rational expectation hypothesis.

2.4 Explaining carry trade excess returns

In 1996, Charles Engel concluded that we don't have a model of expected returns yet that fits the data. His conclusion is still applicable today because numerous researchers have shown, since 1987, that many explanations for the forward premium bias do not work. However, we definitely cannot say that progress hasn't been made. As in any scientific field, progress is made in small increments. Hence, many things have been ruled out, but we still do not have yet a full explanation of the bias.

Fama (1984) defines that the risk premium on the holding foreign investments has to be both: negatively correlated with the forward premium and higher variance than the forward premium. However, financial models do not generate a premium able to produce the required magnitude of the forward bias. Fama (1984) demonstrates that derivations of beta from Fama regression illustrate the possible solution to explain the forward premium puzzle. Additionally, beta in formula (7) is the covariance of forward premium and exchange rate. If we assume that the market is efficient, expected change in the exchange rate is a sum of risk premium, forward premium and error term, then beta can be asserted as:

(9)
$$\beta = \left(\frac{\mathrm{Cov(FP,FP)}}{\mathrm{Var(FP)}}\right) + \left(\frac{\mathrm{Cov(RP,FP)}}{\mathrm{Var(FP)}}\right) + \left(\frac{\mathrm{Cov(ER,FP)}}{\mathrm{Var(FP)}}\right)$$

Where FP is forward premium, RP risk premium and ER non-rational expectations. (Orlov 2013, 28). The formula can be expressed in shorter two-term way:

(10)
$$\beta = 1 + \beta^{RP} + \beta^{RE}$$

The beta should equal 1 to satisfy the null hypothesis. Beta other than one will be evidence of either risk premium is $\beta^{RP} \neq 0$ or market inefficiency is $\beta^{RE} \neq 0$. The main idea behind the risk premium explanation is that investors are not risk neutral, and the bias on the forward rate's estimator of the spot rate indicates a risk premium. In contrast, Market Inefficiency or Non-Rational Expectations determine forward premium puzzle on the assumption that investors make mistakes when building certain expectations or processing information. (Fama 1984; Orlov 2013; Orlov 2016).

If we leave only second term β^{RP} from the previous equation and assume market efficiency, then for the null hypothesis to stand β^{RP} must be zero. In another way, beta would differ from null condition. In the situation where β is less than zero, which is regularly illustrated in empirical findings, β^{RP} should be greater than one in absolute value. Hence, two following conditions should be satisfied to explain the data: 1) $\text{Var}(\text{RP}) > \text{Var}(\text{FP})$, which mean that the variance of the risk premium should be higher in magnitude than the variance of the forward premium, and 2) strong negative correlation with the forward premium. (Fama 1984). Lustig and Verdelhan (2007) demonstrate by creating currency portfolios that investors can gain large excess returns by holding bonds from high-interest rate currencies, which have greater loading on US consumption growth risk. However, Burnside (2007) argues, that the forward premium puzzle is not solved and will remain as a puzzle because the stochastic discount factor of Lustig and Verdelhan's (2007) model is not correlated to carry trade portfolio returns. Additionally, Lustig et al. (2011) approach from a risk-based explanation perspective and illustrate a two-factor interest rate model. The model tries to explain the cross-sectional deviation in average excess returns between high and low interest rate currencies. The model's volatility measure predicts the systematic risk of currency markets without applying any interest rate or exchange rate data. The key finding was that investment currencies tend to depreciate and funding currencies appreciate in the situation of high volatility, which indicates that investors load up on overall risk by engaging in currency carry trade. Furthermore, Verdelhan (2010) shows in what way risk appearing from consumption habits is affecting the currency carry trade returns. He discovers that during difficult economic times in the home country, the interest rates are low, investors tend to be more risk-averse and consumption is close to the habit level. Therefore, the fluctuations in exchange rates reflect domestic consumption shocks when the home country's investor is more risk-averse than the investor in the foreign country where interest rates are high, suggesting positive carry trade excess returns.

Risk-based models seem to be yet unable to fully explain the forward premium puzzle. Academics found that stochastic discount factors that were developed from regular risk measures such as stock returns or consumption growth are all statistically uncorrelated with carry trade excess returns. Also, carry portfolios that were sorted according to their forward premium are also statistically uncorrelated. The currency carry trade returns must covary with the risk factor if the estimated excess returns from carry trade are not zero. In sum, without covariance, a risk-based explanation cannot work. (Burnside 2011 et al). The other possible explanation could be market inefficiency.

The second class of explanation, which is market inefficiency, concentrates on errors in measuring market expectations. Assuming market inefficiency and derivations of beta from Fama regression leave only term βRE from equation 10. Rare disasters (Peso Problems), liquidity constraints and learning are the group of explanations of forward bias puzzle.

One of the most popular explanations regarding market inefficiency is the Peso problem. The Peso problem is a situation where markets are behaving irrationally in the short term when market participants are anticipating unprecedented (but not impossible) event of high impact. Krasker (1980) was the first academic who named that situation the Peso problem. A classical example of the Peso problem is from the 1970s when the Mexican peso was traded at a forward discount for a few years, although peso was pegged to the US dollar. Hence, market participants were anticipating devaluation of the peso, which did not happen. In 1976 the depreciation of peso finally came in and before that speculators had (ex-post) continual profitable arbitrage opportunities until 1976 when actual devaluation happened. Rogoff (1980) suggests that the forward discount was a weak predictor of the changes in the currency's value, which was the reason why the devaluation did not happen. The efficient market hypothesis states that market participants are rational and learn immediately, however they are not sure about a future change in regimes. Thus, according to Lews (2011), this leads to inaccurate measures of expectations in the data and skewness in the distribution of forecast errors. As a result, these unprecedented events may bias β estimate in Fama regression. In addition, unobservable events that may appear in future, but not in the data sample are unquantifiable, which causes measurement bias (Krasker, 1980). According to that, we can assume that forward premium puzzle is a puzzle due to the measurement error. In sum, the peso problem is a small sample problem and it cannot explain the reason why estimates of β are frequently negative.

Another explanation regarding the market inefficiency is learning. According to the rational expectation hypothesis market participants are irrational if the hypothesis is rejected. However, market participants are not inevitably irrational because it may be that their forecasts are biased as they are continuously learning about the ongoing economic environment (Lewis 1989 koko). Lewis (1989) was one of the first academics who studied market inefficiency incorporating Bayesian learning. In the early 1980's the demand for U.S. dollar increased substantially when at the same time forward market anticipated the depreciation of dollar. Lewis tried to investigate how the substantial appreciation of U.S dollar in the early 1980's affected average forecast errors of dollar, when the market was learning about the new process of money.

Modern literature concerning rare events that lead to large negative payoffs aims to explain the forward premium puzzle with so-called "rare disaster" theory, which is often referred to as exchange rate movements that infrequently happen without fundamental news proclamations. Farhi and Gabaix (2011) show in their model that due to a mean-reverting process, countries vary in their exposure to rare global disasters. Farhi and Gabaix state that high-risk premium countries have depreciated high-interest rate and exchange rate, however as countries' risk premium mean reverts their exchange rate increases, indicating why interest rate currencies increase on average. Nevertheless, Burnside et al. (2011) argue that peso problem and rare disasters are not plausible, because the average return of the hedged carry trade is almost identical to the average return of the unhedged carry trade. They point that carry trades are still profitable even after covering nearly all of the downside risk with currency options. Burnside et al. (2011) created portfolios of hedged and unhedged carry trade excess returns and observed that disaster risk provides a significant explanation in currency returns, although not for all carry trade returns. As a result, the disaster risk premium explains on average one-third of carry trade returns in the sample period from 1996 to 2011. However, investors are still able to gain significant excess returns while they are hedged against huge currency crashes due to the remaining Gaussian (non-disaster risk). The authors notice the importance of disaster risk premia, especially in the outcome of the financial crisis, where disaster risk premia represent more than 50% points of the whole currency risk-return (Farhi et. Al., 2013). In addition, Jurek (2014) observes that carry trade excess returns remain positive and statistically significant while being crash-hedged, meaning that the excess returns of carry trade are not caused by peso problems. To conclude, the disaster risk premia is playing an important role in the currency markets and require wider attention. However, the disaster risk is an effect rather than a cause and therefore, we will go next through literature concerning funding constraints, because it is a more plausible explanation to UIP violations.

The empirical failure of peso problem or risk premium models explanations has developed various alternative explanations of the carry trade excess returns or i.e. the forward premium puzzle. One of the most famous studies explaining the forward premium puzzle is a study by Brunnermeier et al. (2009), where they demonstrate that funding liquidity measures forecast exchange rate movements. Academics assume that exchange rate movements are related to liquidity spirals.

Traders (e.g., dealers, hedge funds or investment banks) generate market liquidity and their capability to do so depends on traders' availability of funding. Contrarily, traders' funding (capital and margin requirements) depends on securities' market liquidity. Brunnermeier et al. (2009, 2201) point out that, under particular circumstances, margins are destabilizing, where funding liquidity and market liquidity are jointly strengthening, leading to liquidity spirals. If funding liquidity is under certain conditions limited, treaders become more eager to take on positions, which lowers market liquidity and increase volatility. As a result, the risk of financing a trade will rise due to the increase of market liquidity and thus increasing margins. (Brunnermeier et al. 2009, 2202—2205.) Brunnermeier et al. (2009b, 320–322) used data where they analysed 8 currencies (JPY, SWF, EUR, CAD, AUD, NZL, GBP, NOK) against USD. Analysis indicated that high-interest rate differentials forecast negative skewness for carry trade investment currencies. For example, JPY is a classic funding currency that has a negative interest differential and positive skewness. However, AUD and NZD have positive interest differential and negative skewness. According to Brunnermeier and Pedersen (2009, 314–315), speculators prefer to invest in securities with positive average returns and negative skewness, where positive average returns are compensation for generating liquidity to the market and negative skewness is due to the market participants' asymmetric reaction to fundamental shocks. Due to these shocks, speculators will make losses and are augmented when speculators will suddenly unwind their positions as they face funding constraints. Eventually, the value of the securities will devaluate even more which will lead to increased funding problems, higher margins and volatility in the market.

For example, JPY has positive risk reversal where call > put premium and AUD and NZD have negative risk reversal where call < put premium. Risk reversal in FX trading is the difference in implied volatility between alike call and put options. In other words, it is implied volatility of an out-of-the-money call option minus the implied volatility of an alike out-of-the-money put option. (Brunnermeier et al. 2009b, 316–317.) Negative risk reversal means that traders anticipate a higher devaluation probability of underlying FX. The magnitude of FX devaluation depends on the absolute value of the risk reversal, thus the higher the risk reversal the bigger is expected FX devaluation. Negative risk reversal is an expectation of negative skewness in the distribution of exchange rates. Traders will demand a risk premium or compensation for generating liquidity to the market and bearing that devaluation risk. Hence, to some extent, carry trade excess returns can be associated with the risk premium attributed to currency crash risk. (Brunermeier et al. 2009b, 315–317.)

It is important to mention that currency carry trade is highly leveraged and conducted by professional traders (Galati et al. 2007). Additionally, banks of the most popular funding countries are large traders in the local equity market themselves, and the market prices influence the accessible collateral of investors as the local equity is common collateral. Hence, in the situation when volatility increases in the local equity market, traders are unlikely to lend more money or admit local equity as collateral (Ferreira Filipe & Suominen 2014, 18–20.) The deviations of uncovered interest rate parity are decreased when traders lever up their carry trade positions, but as a result similarly traders' risk of compelled liquidation increases (Brunnermeier et al. 2009b, 325). Also, the hedging cots of carry trade portfolios become more expensive when the anticipated downside risk increases, leading to a negative effect on traders' willingness to speculate. As a result of the shocks that lead to speculator losses, market liquidity declines and capital constraints will probably compel speculative traders (such as hedge funds) to unwind their carry trades from investment currencies, which will then lead to a crash due to the sudden capital run. Brunnermeier et al. (2009b) point out that carry trade positions are experiencing losses mainly in the situations when speculators face funding constraints. (Brunnermeier et al. 2009, 341–342.)

As written above, funding constraints are especially relevant during financial turbulence and increased risk aversion. According to Brunnermeier et al (2009b, 314, 336–340), speculative carry trade activity and returns are declining during the weeks when the VIX index increases. The VIX measures the implied volatility of the S&P 500. Because VIX is derived from equity options, it is not linked to exchange rates. So, when the VIX increases, traders become more risk-averse which is seen as diminished speculation in the FOREX market. Consequently, the unwinding of carry trade positions will have an affect on other speculators leading to even greater losses. Thus, VIX is associated with the unwinding of carry trade positions when the liquidity is likely to dry up when VIX is at a high level. (Brunnermeier et al. 2009b, 336–340.) In addition, Clarida et al. (2009, 1375–1389) show that Fama regression generates a much higher beta coefficient than unity, which indicates that carry trade positions make losses. At the time when VIX is low, carry trade makes profit, since the beta coefficient is highly negative.

What makes the liquidity frictions theory important is that it explains the forward premium puzzle which is not depending on peso problems nor risk mechanism. If we assume that UIP holds, then a county in which interest rate start to increase would attract foreign capital, leading to an appreciation of the currency followed by a future depreciation of the exchange rate. However, in the liquidity frictions theory, the currency is appreciating slowly, as traders react to the interest rate increase gradually. So, holding on to carry trade position in this situation would be profitable, because of the deviations from UIP. Ferreira Filipe and Suominen (2014, 2) measured funding risk for carry trade applying crash risk and the stock options' implied volatility in Japan during the 2000–2011 and indicated that these measures explain 42% of the monthly carry trade returns.

In sum, the is a strong link between currency carry trade and crash risk. Taking a long position in high-interest currencies while taking a short position in low-interest currencies contribute negatively skewed returns, increasing exposure of carry trades to crash risk. However, it is still not sure what causes the crash risk on FX.

2.5 Relationship between carry trade and macroeconomics

In this chapter, we will discuss how carry trade is affecting country's economies and what consequences there might be.

Speculative capital inflows and reversals cause serious challenges for monetary authorities and economy overall, especially in emerging market countries. Currency carry trade is one of the main sources of speculative capital flows that could be enormously large. Hence, carry trade transactions raise concerns because they can pose significant risks to countries' economy. More precisely, large capital inflow appreciates domestic currency, pushing it away from its fundamentals, and thus reducing competitiveness.

Additionally, carry trade is associated with currency crash risk because it is funded usually by debt. Therefore, a shock that produces carry trade losses and cause speculative capital outflow, can be amplified by liquidity spirals. As mentioned, when speculators face funding constraints due to a shock, they will eventually close out their carry trade positions, leading to a further tightening of funding constraints and close-outs. (BIS Papers 2015, 1).

Carry trade was categorized as "low-risk alpha" and arbitrage before the financial crisis. During that time carry trade experienced favourable trading circumstances leading to an actual boom in the early 2000s. When the financial crisis hit, carry traders faced an enormous amount of currency unwinding causing a lot of turbulence in the global FX markets. Hence, carry trade bear huge attention after the crisis how tail-heavy strategy it is. Brunnermeier et al. (2008) state in their paper that the unwinding of carry trade positions may be really quick, leading to extremely high fluctuations in investment and funding countries' currencies. The unwinding of carry trade positions is most likely caused by external factors and is not necessarily dependent on currency's pair fundamental aspects (Galati et al. 2007). Sudden exchange rate movements that are not associated with news could be related to the unwinding of carry trade when speculators face funding constraints and increased volatility. This is because investment currencies are contingent on crash risk and the crash risk is positive interest rate differential. Positive interest rate differentials are related to negative conditional skewness of exchange rate movements, where the carry is interest rate differential that is associated with positive speculative net position on investment currencies. The increase of crash risk's price is dependent on carry trade return, where carry trade losses increase the price of crash risk. However it decreases speculator positions and the possibility of a crash. Hence, an increased level of risk aversion or global risk (measured by VIX) will decrease speculator' carry positions (unwind) and cause carry trade losses. Thus, a higher level of VIX indicates greater returns for investment currencies and reducing returns for funding currencies. (Brunnermeier et al. 2008, 313–314.)

Speculative carry trade inflows raise prices in various asset classes and thus decrease the domestic real rate (Palantin et al. 2014, 3). This is usually the first sign of carry trade bubble. According to Burstein, Eichenbaum and Rovelo (2005), if the economy's share of tradables in consumption services is small, then small deflationary shocks will bid up substantially prices of tradables, leading to a large appreciation of the nominal exchange rate. Moreover, the anticipation of furthermore carry trade activity increases the profitability of carry trade through the anticipated rise of the nominal exchange rate. The outcome of the increased carry trade activity and increased exchange rates depends on the country's economic structure. Hence, if the price of non-tradables are sticky enough and the official rate is sufficiently stable, a then positive outcome of future inflows on carry trade return would be greater than the negative impact on the inflows on domestic asset returns. The positive shocks on the interest rate differential increase capital inflow, which appreciates domestic currency. The longer that positive trend continues the bigger carry trade bubble would be. The bubble will burst after a series of negative shocks on the interest rate differentials, leading to huge and rapid capital outflow. (Palantin et al. 2014, 1–3.)

Next, we will discuss how carry trade is increasing interest rate differentials and point out possible consequences of that on Japan's macroeconomy. We will approach our explanation by observing Japan's economy from 1990 to 2010 when Japan experienced the highest carry trade activity from a funding country perspective. During that time, JPY was the most popular currency among carry traders. Hence, it is better to first understand basic carry trade principles that are affecting macroeconomy through Japan before moving to other countries, such as Russia and Australia.

2.6 Interest rate differentials

As we can notice from previous chapter 3.1, one of the most significant driving forces behind carry trade speculation and its activity is the interest rate differential. For example, the interest rates between US and Japan from 1999 until 2006 were near zero due to the Bank of Japan's quantitative easing policy. Similarly, the federal fund rate of U.S. dollar, which was then the target currency for yen, was at 5.25%. During that time, carry trade experienced long and solid growth attracting more speculative investors. However, in July 2006 Bank of Japan increased its interest rate to 0.25% and 0.5% in 2007 resulting in a corresponding unwind of the carry trade. This increased volatility caused carry trade losses which possibly accelerated the market's meltdown.

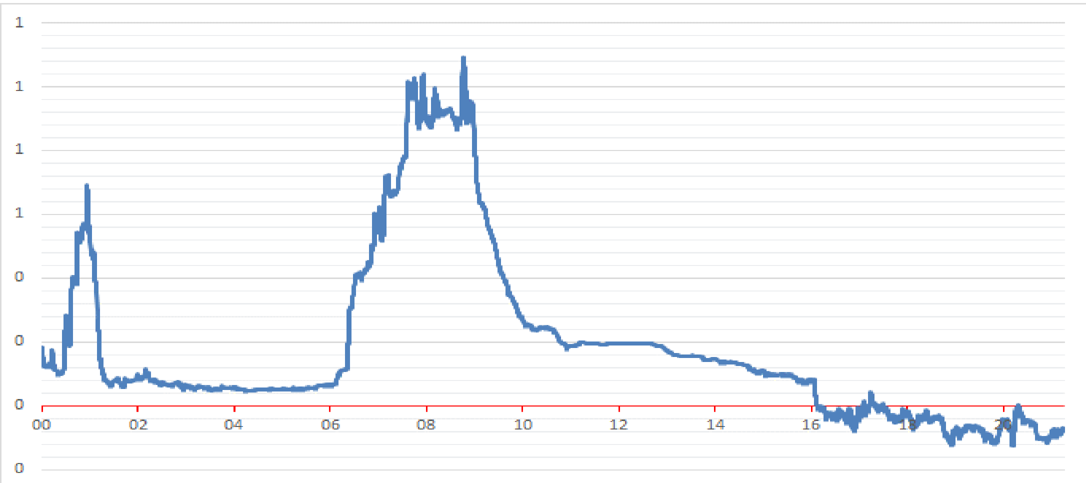

Figure 1 3-Month London Interbank Offered Rate (LIBOR), based on Japanese Yen (FRED 2021)

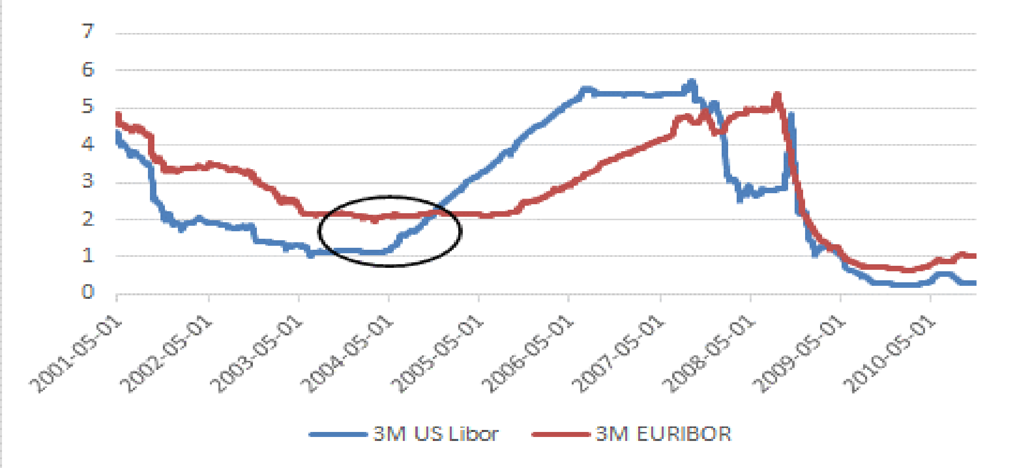

Figure 2 3-months US LIBOR rate and 3-months EURIBOR (FRED 2021)

Nevertheless, if the interest rates keep staying stable, it will then boost yen carry trade and subsequently increase the gap between interest rate spreads. As a result, increased interest rate spreads attract even more foreign speculative capital, which can lead to market crashes and bubbles. During the financial crisis, investors borrowed massively in yen due to its low-interest rate and converted the yen into high-interest rate currencies, such as the Australian or New Zealand dollar. As the crisis hit the global markets, carry trade positions faced huge unwound due to the narrowed interest rates differential, causing the yen to appreciate against other major currencies. The uncertainty about the overall effect of the subprime crisis increased substantially volatility in FX markets, which lead investors to unwind their carry trade positions. (Buiter 2007, 1–14.)

According to The Bank for International Settlements (BIS reports, 2014) from 2001 to 2004 before the financial crises, favourable carry trade conditions increased the turnover of Australian and New Zealand's dollars by 98% and 152% respectively. The results showed, that the extremely high growth of turnover, rises with an increase in the interest rate differential of major currencies against U.S. dollar. However, such exchange rate movements may also be explained by the growth in hedging-related turnover. 2001–2004 was a period when interest rate differentials widened, and exchange rate trends looked optimistic. As a result, this increased speculative capital as well as accelerated hedging activity. (BIS survey 2004, 69–74.) In 2007, average daily turnover increased by 69% since April 2004, to 3.2 trillion U.S. dollars. This increase was much greater than between 2001 and 2004. In addition, transactions and turnover between reporting dealers and non-reporting financial institutions, such as pension funds, hedge funds, insurance companies and mutual funds increased over two times between 2004 and 2007. New Zealand dollar, which is a high yield currency, attracted a great number of investors in 2007 that lead to a massive increase. Also, the share of emerging market currencies faced a huge increase in total turnover, to almost 20%. (BIS 2007, 1.) These changes indicate that carry trade was a highly popular strategy at that time and JPY was the main funding currency.

According to the BIS 2010 survey, during the financial crisis in 2008, increased FX volatility and risk aversion forced investors to close risky speculative positions, like carry trade. Closing carry trade positions means selling the high yielding currencies (e.g., AUD/NZD) and buying back the funding currencies (JPY in most cases). As a result, funding currencies become less attractive to use for funding new carry trade positions due to the briefly increased interest rates. Eventually, the massive buyback of JPY caused by unwinding carry trades, appreciated sharply the JPY (7.7% against the Australian dollar on 16 August 2008), causing massive losses. The record fast JPY strengthening followed the bankruptcy of Lehman Brothers in September 2008. BIS survey 2010, states that due to the limited market liquidity across different asset classes, investors turned to spot FX markets to hedge risk exposures, e.g., proxy hedging. Downside risk in US equities was hedged by buying JPY, in Europe by selling EUR and in emerging market equities by using emerging market currencies. Additionally, the financial crisis changed investor behaviour quite interestingly, where trading by households and small non-bank institutions has expanded tremendously. The most active investors were Japanese retailers representing 30% or more of spot Japanese yen trading (i.e., over $20 billion per day). (BIS 2011, 28–39.)

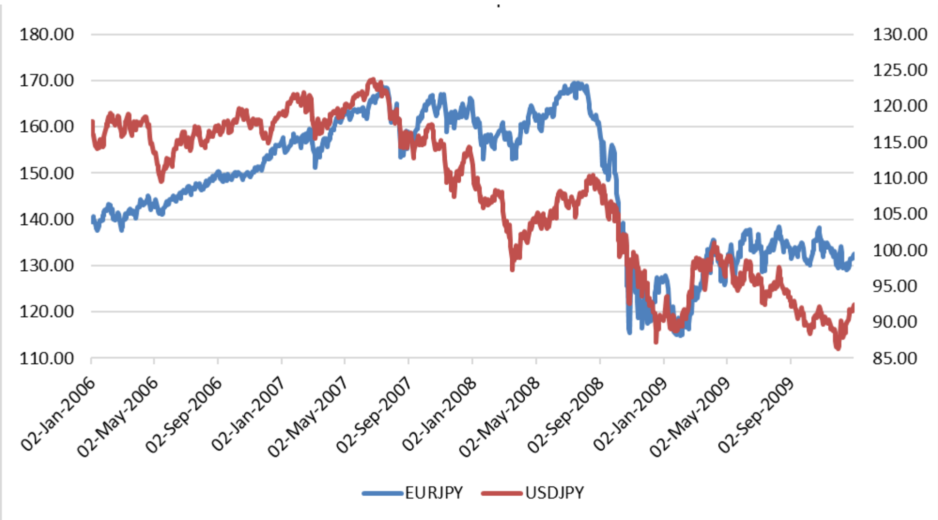

Figure 3 EURJPY and USDJPY spot rates (Eikon 2021)

It is important to notice that export heavy countries with open economies are extremely vulnerable to a global crisis and they have higher than average beta. Japan is a typical heavy export country where well-known companies like Sony, Toyota and Honda are great contributors to the Japanese GDP and employment. Hence, appreciation of JPY will significantly reduce the competitiveness of the Japanese export sector, especially during a time of crisis when the demand is below average. Similarly, resource-rich countries like Australia, Russia or Norway could face FX problems related to carry trade unwind. Countries that export commodities tend to have high-interest rates, whereas countries that import commodities and export finished consumption goods, such as Japan or Switzerland, tend to have a low-interest rate on average. Resource-rich countries' currency is usually closely related to the value of commodities. Hence, when the commodity prices fall, which is quite usual during a time of crisis, the value of these currencies is also threatened. However, commodity currencies do not depreciate on average; instead, they create a positive average return, which provides a boost to a carry trade strategy. (Ready et al. 2017, 2630–2631.)

Despite the export sector, carry trade has also a negative impact on various asset classes. Due to the zero-interest-rate policy initiated by the Bank of Japan, the allocation of world liquidity has been hampered. Funds that have been denominated in cheap yen between 2000 and 2010, supported asset classes, such as bonds, stocks and commodities. When the carry trade collapse, monetary liquidity meets constraints, leading to increased volatility in the market. One of the main driving forces behind this is the heavily leveraged carry trade positions that have been invested across various asset classes. Hence, traders have to close or liquidate their carry positions to meet the margin call, if the value of the underlying asset decreases. As a result, this might cause a snowball effect when the market will continue to tumble further. This will also appreciate the yen causing additional damage to the Japanese economy. (Shirakawa 2010, 1–3.)

The global crisis of 2008 is not the first case where carry trade had a role in the bubble burst. Before the GFC was the so-called dot-com bubble between 2000 and 2002, which was caused by a hype behind IT and internet technologies. Investors were overconfident and thought that anything associated with the IT and internet would be an extremely profitable investment. The news that Japan is getting into a recession and FED's announcements about aggressive interest rate increases, possibly triggered the bubble burst. The crisis had a highly negative impact on all assets, but especially on Nasdaq and Nikkei. (Goodnight & Green 2010, 116–128; Shirakawa 2010, 1–11.) Hence, increased FX volatility and risk-averse force investors to close risky positions, such as carry trade, which lead to the unwinding of capital.

As the global economic situation stabilized after the crisis, we can observe strong evidence of the carry trade come-back. For example, after the financial crisis in 2009, investors started to borrow dollars at a very low interest rate to invest in various assets. Similarly, Australia and New Zealand raised interest rates to 3.75% and 2.5% respectively (Eikon 2021). Eventually, this kind of circumstance attracts traders to open carry trade positions by selling U.S. dollars and funding it by buying Australian or New Zealand dollars. In addition, The FED continuously sent signals to speculators that the interest rate will remain low for a quite long period, sowing seeds of the next crisis.

2.7 Political risks, institutions and central banks

Dimic et al. (2016) demonstrate in their model that political risk has a huge impact on the carry trade returns and positive economic outcomes. When political risks are low (high), then carry trade returns are also low (high). Political risk is high in countries where: the government is unable to implement planned reforms, socioeconomic pressure on government actions, inefficient financial markets, low level of legal system and low-quality bureaucratic processes. In sum, political risk is high in countries where the corruption level is high and institutions are not working efficiently. These risks are quite common in developing countries with a high-interest differential, where carry trade returns are higher on average compared to developed countries. Conversely, political risk in developed countries is low and is not affecting significantly carry trade returns. Dimic et al. (2016) point out that the individual carry trades demonstrate heterogeneous exposure to political risk over various assets and currencies sorted by forward discount. Political risk related to carry trade is already priced only in the high-interest rate differential countries. Heterogeneous exposure of carry trades to political risk is causing difficulties for market participants to forecast future spot exchange rates of politically unstable countries and thus strengthening the forward premium puzzle. However, there is not enough economic magnitude to show that political risk completely explains the forward premium puzzle. Nevertheless, political risk is a substantial factor that could explain the negative impact of carry trade on countries macroeconomy. Hence, we will emphasize political risk when observing negative impacts in various countries.

Besides political risks, central banks play an important role in the possible outcome of carry trades, especially in small open economies. We can imagine a situation where investors from large economies with low-interest rates invest speculative capital into small economies with high-interest rates. This situation leads to a feedback loop in which the speculative capital inflow constantly appreciates the small country's exchange rate and develop inflationary pressure. Central bank reacts to that situation by increasing rates, which cause even more speculative capital inflow. (Burnside 2015, 245–248.) Burnside (2015) argues that slow exchange rate dynamics and inflation-targeting central bank, lead to a feedback loop situation. The model that was created by Plantin and Shin (2011) and demonstrated in Burnside's paper (2015), shows that bubbly equilibria may emerge when the exchange rate strengthens for a sufficient time and then reverts strongly towards its fundamental value. The model also shows that the way of how the central bank responds to inflationary pressure affects the possibility of currency's depreciations. The stronger response to inflationary pressure, the more likely is the realization of paths with occasional sharp devaluations of the recipient economy's currency. Plantin et al. (2014, 23–25) provide three approaches to how the central bank can avoid carry trade bubbles: "*using a measure of inflation that is titled towards trada-*

bles, adding a term that is sufficiently decreasing in the exchange rate appreciation to the interest-rate rule, or simply targeting the realized real rate". These approaches help the central bank to reduce official rates in response to increased carry trade activity. Overall, a decrease in the official rate is the effective and applicable way of response when foreign speculative capital flow rises domestic prices. However, institutions, central banks and financial markets have to be efficient to succeed in carry trade regulations.

Acharya and Steffen (2014) point out that the eurozone's banks risks during 2007–2013 can be explained as a form of carry trade and that the carry trade behaviour was pervasive among those banks. When the banks had access to short-term unsecured funding in wholesale markets, they seem to have engaged in the long peripheral sovereign bond positions. On the upside, the bank could profit from carry, which is the differential between the long-term peripheral sovereign bonds and the bank's short-term funding costs. However, on the downside, which realized, the differentials between the two legs of the carry trade diverged even further, causing substantial losses for banks and raising concerns about their solvency and liquidity. The correlations between the bond yields of the European main economies, such as Germany or France, and peripheral sovereign bond yields were over 95% in 2005 and negative in 2010. Markets were unwilling to finance banks' investments in risky sovereign debt, which explains the negative yields in 2010. As a result, long-term bonds of European main countries became more demanded, and it can be said that "*the banks lost on both sides of the carry trade*".

2.8 Negative impacts of capital inflow

After the crises and especially after the financial crisis, countries started to practice expansionary macroeconomic policies to foster economic recovery. However, the huge amount of global liquidity, in pair with the enhanced economic expectations in emerging markets, have doubled recovery, leading to a much higher growth compared to advanced economies. Thus, emerging markets are experiencing abundant capital inflows, which could lead to certain challenges. On the other hand, capital inflows contribute several benefits to the recipient economies, for instance, the capital inflow improves domestic financial markets and supports domestic savings in financial investments with foreign resources. (BIS Papers 2011, 239.) Cuadra et al. (2011) point out that, despite the benefits, the speed and magnitude of capital inflow to emerging economies could bring significant risks. Cuadra et al. (2011) argue that a high increase in capital inflow has caused concerns about excessive exchange rate appreciation, leading to an adverse impact on exports and growth. In addition, the large inflows may develop an unsustainable expansion of credit, generate bubbles and increase financial fragility. Due to the sufficiently inefficient institutions and volatile economies, developing countries are extremely vulnerable to sudden stops, that lead to a massive capital outflow, causing problems to financial stability and economic activity.

After the financial crisis in 2009, capital flows started to return to the emerging markets, which can be explained by a mix of the following factors: improved fundamentals and widened interest rate differentials. According to Cuadra et al. (2011, 242) in the case of commodity-exporting emerging economies, improved fundamentals (i.e., improved growth prospects) have boosted their trade due to the increase in commodity prices. Subsequently, higher commodity prices contribute fundamental pressure to appreciate domestic currencies.

On the other hand, low-interest rates in developed countries have forced to search for yield among developing countries, due to their high-interest rates. As a result, investors started to open carry trade positions, which stimulated carry trade activity and capital inflow. As mentioned, the capital inflow may have benefits for the receiving county, for example contributing further financing to economies with limited local savings, making then domestic financial markets more liquid and deeper (Cuadra et al. 2011, 242). However, it is important to remember that the massive capital inflow from carry trade is speculative capital, which could pose significant risks. Cuadra et al. (2011, 242) list the following carry trade challenges: exchange rate appreciation, financial stability concerns and risks of a sudden reversal in capital flows. Academics emphasize the importance of various policy measures that mitigate the risks associated with carry trade. The possible policy measures in response to large capital inflow are: modifying the macroeconomic policy stance, fostering the process of reign reserve accumulation and implementing macroprudential measures. Nevertheless, policymakers should be extremely careful when implementing a suitable policy mix to mitigate the large capital inflows. They must first analyze whether large capital inflow is driven by carry trade (short-term development) or fundamentals, which is quite a difficult task. If the capital inflow is driven by short-term considerations (i.e., carry trade), then the following policy responses are the most suitable for emerging economies:

- **Macroeconomic policy**: relaxing the monetary policy stance to diminish the interest rate differentials, and therefore make carry trade transactions redundant. However, this policy is effective if there are no inflationary concerns, otherwise reducing the policy rats would just stimulate inflationary pressure. On the other hand, increasing rates to face inflation concerns may attract even more carry traders, which could accelerate capital inflow.
- **Foreign reserve accumulation**: large reserves may be used as a buffer during the external shocks and reduce the capital outflow by providing foreign exchange liquidity to the local financial markets. Thus, diminishing the turmoil

triggered by a high exchange rate volatility. Additionally, foreign reserves can be used to lower the probability of self-fulfilling speculative attacks.

- **Macroprudential regulation and supervision**: there are various sets of policy responses related to macroprudential tools. For example, reserve requirements or credits ceilings can be used to avoid credit expansions. To improve the financial system's resilience and avoid shock, capital requirements can be used. A macroprudential tool that has been largely used in emerging markets countries to cope with capital inflows is capital control. Capital control is used by limiting asset transactions through taxes, qualitative limits or outright prohibitions. (Cuadra et al. 2011, 244–247.)

Also, policymakers should thoroughly analyze the benefits and the costs related to the various policy measures and their consequences. According to Cuadra et al. (2011, 259), possible costs of policy measures could limit policymakers' margin of manipulating the capital inflows and thus have some impact on the economy in the medium and long term. Cuadra et al. (2011) provide an example of long-lasting sterilization interventions that could lead to massive quasi-fiscal costs, which could compromise the central bank's ability to manage open market operations. Hence, some actions and policy measures against the capital inflow could cause serious distortions in the economy. In addition, developing countries have limited abilities to assess responses to cope with large capital inflows, because these countries have to also enhance their fundamentals.

Overall, efficient fiscal and monetary policies that aim to stabilize the macroeconomic situation, which will then improve investors' confidence are necessary for emerging economies to cope with massive capital inflows. Also, developing countries require structural economic reforms to have a more competitive and flexible economy. Thus, to gain some more abilities to cope with capital inflows, emerging economies need to have better fundamentals and a more competitive economy (Cuadra et al. 2011, 259).

In sum, the negative impacts of carry trade on macroeconomy are:

- massive exchange rate appreciation
- financial stability concerns
- risks of a sudden reversal in capital flows
- developing unsustainable expansion of credit
- generating bubbles
- increasing financial fragility
- decreasing competition and subsequently reducing export
- bid up asset prices and property valuations

In the next chapter, we will examine the Russian scenario concerning the carry trade activity and its negative impacts. The Russian economy is quite specific, so before going straight into the negative impact we will first briefly examine Russia's post-Soviet background and then go through the negative impacts. Before comparing Russian negative impacts to other countries, we will also examine very shortly those countries backgrounds, to make our analysis easier to understand.

3 DATA AND METHODOLOGY

In this chapter, we will briefly go through various challenges in analyzing carry trades. We will also go through data sources and various analysis methods that were used in this study. Also, the regression analysis will be shortly described.

3.1 Description of the data

First, the study is limited by choosing three resource-rich countries. Those countries are Russia, Australia and Mexico. The structure of Mexico's and Brazil's economies is similar to the Russian economy. Those countries are categorised as resource-rich and developing economies, which makes the comparison more sound. Also, the reason why Mexico was chosen as a comparison country is that their institutions are both inefficient and are highly dependent on oil export, meaning that those economies face similar risks. Australia has been associated as a country that mainly benefited from carry trade operations rather than experienced challenges or at least overall impact is close to neutral. Hence, the Australian case will be compared to the Russian and Mexican scenario and analysed how carry trade is affecting resource-rich countries' economies and why. As this study is concentrated on Russia, the analysis is much deeper on Russia compared to other countries. The period is limited by the two crises (2008 and 2014) that occurred in Russia and are related to carry trade. Also, Latin American countries and Australia have faced shocks during those crises, which make comparison more sound. The main factors were observed during those crises are fluctuation of foreign exchange rates, interest rates, inflation, the proportion of foreign investors in the securities market, the difference between real and nominal interest rates, carry-to-risk ratio and changes in export/import development. Listed factors were examined before and after crises. Further periods (for example, shock caused by COVID-19) are excluded. Russian data has at some extent issues with reliability. This concerns mainly the official data (i.e., Bank of Russia or CBR) which is not as reliable as it was a few years ago due to the changed political course in Russia. However, Russian data is better available compared to Latin American countries, which is why the analysis of the Russian economy is deeper. The Mexican data is also quite challenging, especially the official data from central banks, where not all the data is available or updated and is in English. Surprisingly, official Australian data was not as broadly presented as the Russian data from 2000 to 2020, although it is the most reliable and accurate among observed countries.

The data sources that we used to analyse currency and interest rates data, were Thomson Reuters Eikon, Bloomberg, Datastream, Federal Reserve Economic Data (FRED) and World Bank. For specific country's data (such as the proportion of foreign investors in the securities market) we used sources from MICEX (Russian stock market data), World Bank, countries' central banks, BIS, STISTA, IMF and research papers.

3.2 Analysis of methods

Although carry trade raises relevant policy issues and could pose significant risks, it is nearly not possible to measure it precisely. Most academic studies related to carry trade focus on the excess returns from various carry trade strategies that can be proven to be profitable or on publicly available data on carry trade positions taken in particular markets that are in line with carry trade. However, as mentioned, only a limited amount of information is available on what actual strategy certain investors or institutions have implemented, the mechanics of carry trade positions and indicators used to track carry trades. (BIS Papers No 81 2015, 1–2.) As a result, it is quite difficult to point out how far investors and institutions are engaged in carry trades, and how big such trades are. In addition, most of the foreign exchange trading is exercised through the OTC market in the form of spot and swap transactions. Hence, the most consistent and reliable data that is related to transactions over the OTC-market, is only available at low frequencies. Also, the data usually do not identify the nature or the counterparties of the transactions, thus providing only indirect data on carry trade activity. Some central banks provide OTC data, but it is generally not rich. Next, we will go briefly through methods that were used in this study to track, measure and determine the attractiveness of carry trades.

3.3 Methodology of econometric analysis

In this thesis, numerous regressions were made in STATA for observing statistical causality and significance of carry trade on Russian, Australian, Mexican and Brazilian currencies. Further, carry trade's impact and causality on Russian and Australian share of non-resident investors were examined and compared. In addition, EURRUB and USDRUB carry trade total returns, export index, inflation, 3 - month deposit interest rate, MOEX10 (index of the 10 most liquid assets on the Moscow stock exchange) and GDP values belonging to Jan 2002 – Dec 2019 period were used to examine the macroeconomic effect and causality of ruble changes and carry trade on the Russian economy.

Brunnermeier et al. (2008) and Anzuini & Fornari (2012) showed that VAR-model is an effective method of analysing causalities between carry trade and multiple macroeconomic variables based on time-series data. This model is widely used in empirical economic cycle analysis, as it has shown to be a controllable and flexible way to observe economic time-series. Especially, VAR-models have been efficient in explaining the rich dynamic structure of the relationships between macroeconomic variables (Bjonrland 2000). Hence, VAR-model was selected as a main econometric model for our analysis. In addition to previously mentioned studies, we applied studies by Bilan et al. (2018) and Wu & Yu (2017) who examined relationships of ruble exchange rate to various macroeconomic factors by using VAR-model, impulse-response functions (IRF) and variance decomposition. We would use the same method to analyse the impact of carry trade on ruble and vice versa.

As mentioned, for our econometric analysis, we used the VAR method to study the effects and causality of carry trade returns. VAR method was developed by Sims (1980) and uses the Granger causality test model (Granger, 1969) as its basis. The model helps to examine the interrelation between the selected series. VAR models consist of the regression of the current and past values of every variable, and they show the dynamic relationship between these variables. VAR models are used primarily to study the relationship between the macroeconomic variables and to study the dynamic effects of random (accidental) shocks on the system created by these variables. VAR modelling based on the Granger Causality Test analyses the relation between the variables using variance decomposition and the impulse-response functions (IRF). VAR modelling is very sensitive to the selected lag length. In the VAR analysis, the lag lengths of the variables, which will be included in the model, should be selected to capture the dynamic relations among these variables. Furthermore, VAR models make strong forecasts possible by including the lagged values of dependent variables (Kumar et.al., 1995: 365).

$$y_t = a_1 + \sum_{i=1}^{p} b_{1i}\, y_{t-i} + \sum_{i=1}^{p} b_{2i}\, x_{t-i} + v_{1t}$$

(11)

$$x_t = c_1 + \sum_{i=1}^{p} d_{1i}\, y_{t-i} + \sum_{i=1}^{p} d_{2i}\, x_{t-i} + v_{2t}$$

x_t = [$x_{1t}, \ldots, x_{mt}$]^T is a vector of observation on the current values of the variables,
a_1 = is a matrix of parameters, vector variables,
b_i = is a matrix of parameters in the lagged variables of vector x_t, where the number of lags is equal to p,
v_t = [$v_{1t}, \ldots, v_{mt}$]^T contains vectors of the model equation residuals.

There are a few assumptions for VAR models:

1) The variables in the model are stationary

2) There is no serial autocorrelation
3) Every error term has a mean of zero

To interpret the resulting coefficients from the estimated VAR model, two tests are used for it: the impulse-response analysis and variance decomposition method. Impulse-Response functions allow us to trace out the time path (current and future values) of the variables in our model to a one unit increase in the current value of the VAR errors. In other words, what is the effect of one unit shock in "X" on "Y". Whereas the variance decomposition displays the percentage of the error made forecasting a variable over time due to a specific shock, i.e., how much of the variability in the dependent variable is explained by its “own shocks” against the “shocks in the other variables in the system”.

3.4 Methods of calculating carry trade activity

3.4.1 Indicators of incentives for carry trades

One of the frequently used indicators of incentives of carry trade is a carry-to-risk ratio that is the interest rate differential divided by the option-implied volatility of the exchange rate (BIS Papers No 81 2015, 20). The higher ratio, the higher is the profitability of carry trades. During the crisis carry-to-risk ratios have declined from their peaks, meaning that investors who seek profit from carry trades unwind massively their positions. With this indicator, we can assume that certain country attracts investors who bring speculative capital.

Another indicator is the nominal or real effective exchange rate, which signals whether carry trade excess returns are at risk. If the real exchange rate is not adjusted, it may indicate that there is a greater probability of a sudden currency crash that could affect the profitability of carry trades (BIS Papers No 81 2015, 1–2). When interest rate differentials are widening, it signals to investors that there is a profitable carry trade opportunity, especially when the target country’s currency is appreciating.

3.4.2 Indicators of position-taking

Many central banks can track foreign positions or share of non-residents in certain financial instruments that are relevant to carry trade. However, while the activity of non-residents and their counterparties can be to some extent recognized, we can not still for sure assume that such activity is related particularly to carry trades.

The very large upward trend in the share of non-residents of domestic debt securities, when the volatility is low, the currency is appreciating and interest rate differential is sufficiently widening, is a signal of carry trade activity. If the share of non-residents in domestic sovereign bonds is associated with carry trade, then we would assume that the share of foreign investors will increase when the incentives for carry trades (i.e., carry-to-risk ratio) rise. We can observe this from our case countries that share of non-residents has been growing before crises when, for example, carry-to-risk ratio and interest rate differentials were increasing. Accordingly, after the crises, the share of non-residents decline. The higher is the percentage of foreign investors, the higher could be the potential unwind of speculative capital. Important to notice, that the stability of the economy, monetary policies and effectiveness of institutions have a massive effect on the unwinding of foreign investors during the crisis. Besides the share of non-residents in domestic debt securities, the share of foreign positions in derivatives markets and FX markets is also relevant to carry trade activity. Also, in these markets share of foreign investors has been increasing rapidly before the crises and declined during the crises. Especially short-term instruments term of 2–30 days is very popular among carry traders. According to Galati et al. (2007, 30), the simplest approach of carry trade implementation involves exchanging borrowed funds into the destination currency in the spot market. This is common for investing in emerging-market assets. If the carry trade operation requires simultaneous short forward positions in the funding currency and long positions in the destination currency, then the data on the size of the net positions by currency on future exchanges would be useful. Similarly, if the borrowed funds are exchanged into the destination country's currency spot market, then the foreign exchange turnover data would be relevant. (Galati et al. 2007, 38). However, derivative instruments, like FX futures, forwards, swaps and options may be related to hedging activity rather than carry trades.

4 CARRY TRADE IN RUSSIA, AUSTRALIA AND LATIN AMERICA

Before going to empirical analysis, we will go through the Russian economical background and observe relevant factors that indicate carry trade activity. Also, we will shortly analyze Australian and Mexican backgrounds.

4.1 The impact of carry trade on crises in 2008–2009 and 2014

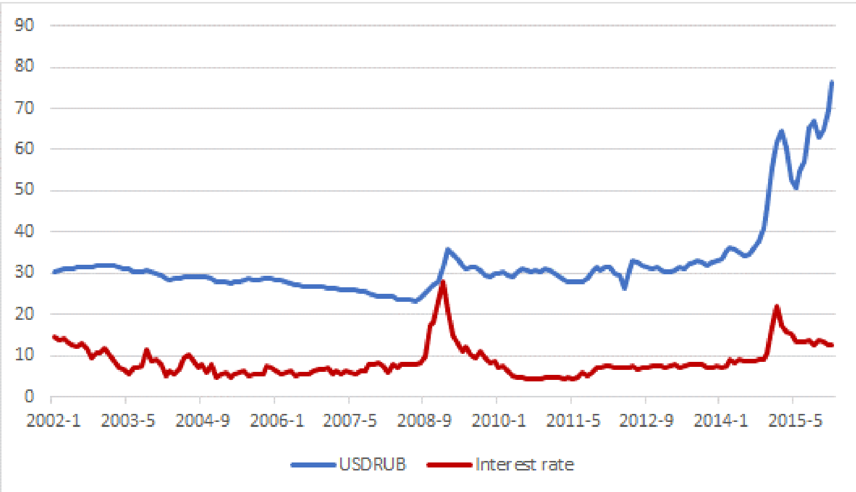

Figure 4 Average of USDRUB daily spot rate and 3-months Russian interbank rate from 2002 to Dec-2015 (World Bank 2021)

At the beginning of 2000, strong and gradually appreciating ruble created an illusion of a sufficiently stable and competitive economy. In fact, ruble increased mainly because of extremely expensive Brent crude oil, which peaked at $143.95/barrel in 2008. The Russian overall economic situation was continuously worsening year by year, due to the lack of urgent economic/political reforms and extremely strong dependency on oil production. However, carry trade experienced favourable circumstances between 2002 and 2008, leading to the strengthening of ruble. Also, the CBR's "strong ruble" policy accelerated carry trade activity and speculative capital inflow. Eventually, interest rate differentials widened to a record high level, causing huge damage to the export sector, and therefore surging enormously import of any kind of goods.

Accordingly, Russian producers could not compete with other counterparties, because of the strong ruble. Thus, oil and gas were almost the only sector, that could still compete in the global market, leading to the situation where Russian export consisted mainly of raw goods instead of highly valuable finished goods. That made the economy very volatile and highly reliable on commodity prices. Additionally, liquidity that was generated by the extremely high oil prices in the middle of the 2000s, was converted into foreign currencies and went abroad. Instead, liquidity could have been left to the domestic companies and banks, which could then use it for investments and for developing purposes of overheating the financial sector. This could have helped interest rates to stabilize.

Overvalued ruble boosted import and capital outflow but halted non-resource sectors (excluding the service sector and real estate). According to CBR (2021), the retail price index (RPI) rose over 2 times in Russia between 2000 and 2007. Also, the inflation and manufacturing costs rose approximately as much as RPI. Similarly, importing goods became extremely profitable, causing huge problems for the manufacturing sector. As we can see, carry trade has a significant impact on the Russian economy through the export sector, which we will examine more thorough by using the VAR model in chapter 5**.**

Extremely overvalued ruble, as it was in the middle of the 2000s, stimulated large capital outflow. As we can see from figure 6, from the 1990s to 2019 (excluding 2006 – 2007 when Russia faced speculative carry trade) Russia experienced constant capital outflow by the private sector. Thus, all the positive balance between export and import was going abroad. In other words, all the positive differences between export/import and earnings from commodities were flowing away and thus hampering the economy. Huge capital outflow that occurred mainly due to the increased risk-averse triggered rapid unwind, which followed the same pattern that was explained by Brunnermeier et al. (2008).

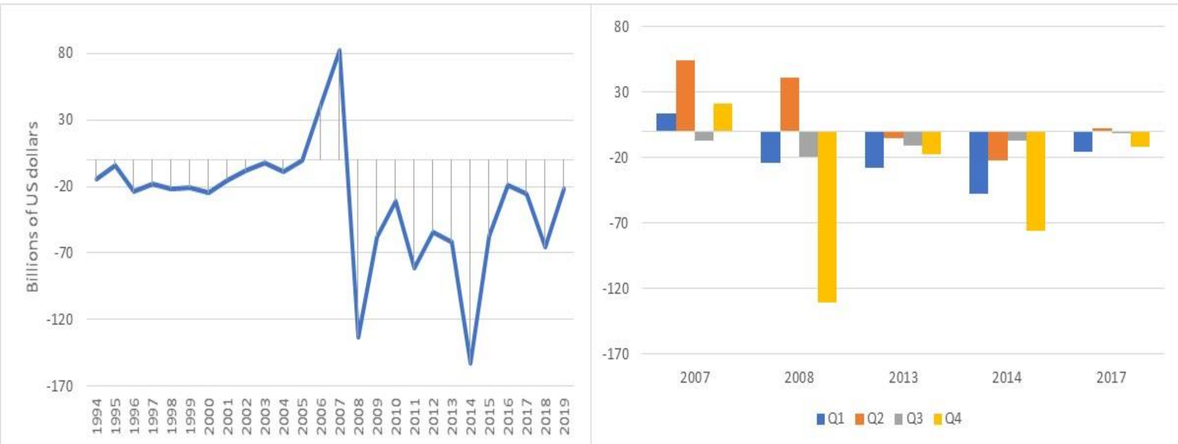

Figure 5 Net Capital Export/Import by Private Sector. Based on the Balance of Payments, Flow Data (CBR 2021)

Overvalued ruble and large interest rate differential attracted a huge amount of carry traders, which eventually accelerated the bubble that burst in 2008. The Great Recession hit Russian financial markets during 2008–2009, which was also compounded by political risks after the war with Georgia and by the collapsing price of Urals crude oil. World Bank (1, 2012) stated that the Russian economy was better prepared than many other emerging countries to face the crisis, however, its structural challenges and strong dependence on commodity prices made its impact more negative than it otherwise could be. Carry trade has played a great role in that crisis by unwinding a record amount of speculative capital and devaluating ruble. From graph 6 we can see that when ruble was constantly strengthening and interest rate differential widening, the net capital inflow by the private sector in 2006 was $41.4 billion, in 2007 $82.4 billion and the first half of 2008 $17.1 billion. It was unprecedented since the capital was constantly outflowing each year from the 1990s. Also, the Russian MICEX index, which is the main ruble-denominated benchmark of the Russian stock market, surged 84% from 2006 to 2008 (MICEX 2021). As we can notice, the Russian market was booming and attracted massively speculative capital, also via carry trade. As a result, when the bubble burst, the Russian economy lost $149.8 billion as a capital outflow in the second half of 2008 and $57.1 billion more in 2009. In addition to the currency crash, where ruble devaluated approximately 60% from 23,13 USD/RUB (Jun 2008) to 36,43 USD/RUB (FEB 2019), other major economic indicators, such as GDP, stock market value, inflation, capital outflow and CBR's reserves worsened also massively (CBR 2021).

The story about the strong ruble continued also during 2009–2014, where annual inflation varied from 6% to 11% and the interest rate was over 10%. Rubel fluctuated around 30 against the U.S. dollar until it collapsed over two times at the end of 2014. The extremely strong and stable ruble with the combination of high-interest rate, attracted once again a lot of investors to take advantage of the favourable carry trade opportunity and to earn speculative excess returns. Increased volatility and risk-averse burst the bubble for the second time, causing once again a huge unwinding of speculative capital. The factors that triggered the bubble burst were the same as during the bubble burst of 2008. One of the main factors that caused the crash in 2014 were appreciation of the U.S. dollar to EUR, sharp drop in oil & gas prices, a general decline in the Russian economy growth during 2013–2014, increased political risk (Occupation of the Crimea and the war with Ukraine) and increased volatility in FX market due to the CBR's new monetary policy (gradually liberating ruble to a free float) (Bank of Russia 2015, 1–11). Those factors developed the momentum for the bubble burst, where carry trade most likely increased the velocity of that burst. From figure 7, we can see how high the carry-to-risk ratio was and how it was growing from 2010 to 2014. The carry-to-risk ratio is a measure of the attractiveness of carry trade transactions, which illustrates the ratio of interest rate differential by specific country to the particular currency volatility with time. The higher the ratio, the higher is the profitability of carry trade for traders. (Bank of Russia, 2018.) Hence, we can see that the carry-to-risk ratio peaked in 2014, just before the crisis, meaning that the carry trade was extremely popular in Russia during that time and that carry trade played a certain role in capital outflow that affected the ruble rate. It is not surprising that a combination of strong and fixed ruble with a successful oil & gas industry is attractive for carry traders. Especially when developed countries set very low rates, investors started once again looking at the emerging markets to gain excess returns and started to practice various speculative strategies, like carry trade. In the middle of 2014, when average oil prices decreased accompanied by high volatility of the currency market, carry trade became less attractive.

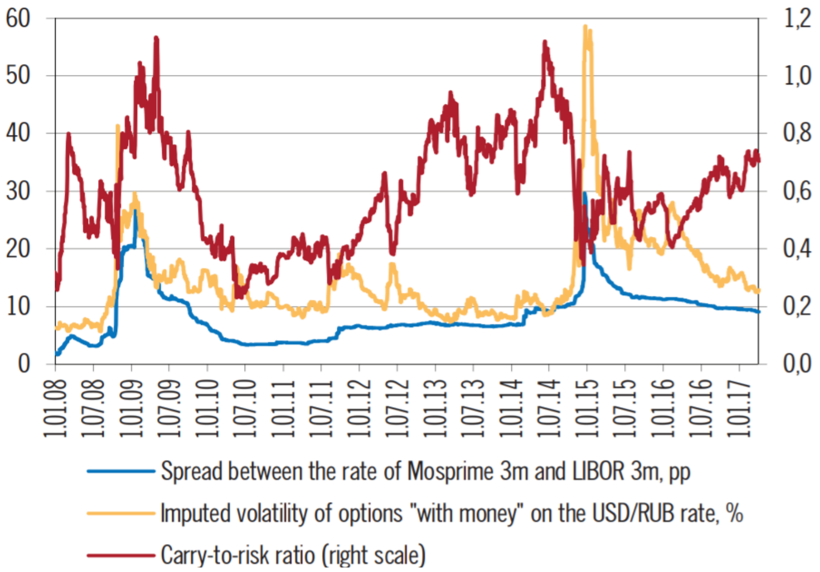

Figure 6 Dynamic of carry-risk ratio in Russia from 2008 to 2017 (CBR 2017)

Just before the crash, the share of non-residents in OFZ reached 25.6% (945 billion Russian rubles) and later in May of 2015 share of non-residents surged to 17.9% (Bank of Russia 2021). Figure

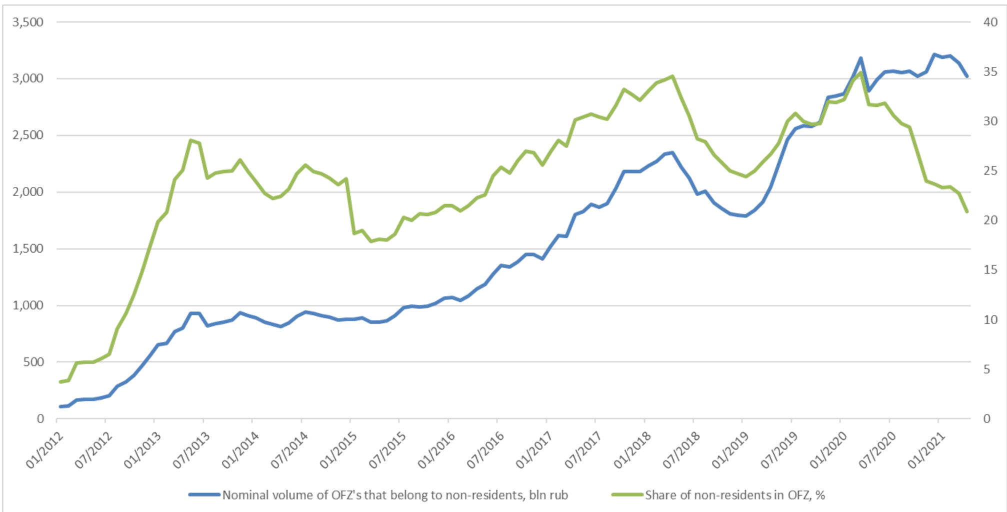

Figure 7 Share of a non-resident in OFZ and their volumes (CBR 2021)

The share of non-residents in the equities market (MICEX) in 2012 was 37% and in August 2014 it peaked at 59%. Eventually, after the crash of ruble, it dropped to 51% in March of 2015. The share of non-residents increased across all market segments before the crash of December 2014. In the derivatives market share of non-residents increased from 38% to 47% (2013–2014), in the fixed income market from 18% to 19% and in the FX market, the share increased from 10% to 12%. (MICEX 2013–2015.) Even if only 10% of that all non-resident volume belongs to carry traders, we can then assume that carry trade had a significant role in the ruble crash in 2014, where the sudden stop led to massive ruble devaluation. At that time, net capital outflow by the private sector, in the fourth quarter of 2014 reached 84.6 billion U.S. dollars and in the first quarter of 2015, it increased to 32 billion U.S. dollars (CBR 2012–2016). The credit institution's claims on financial derivatives (securities, FX, other funds and derivatives) with a term of settlement of 2–30 days are popular among speculators, especially among carry traders. From figure 9**,** we can see how those transactions of short-term instruments, followed a similar pattern in both crises of 2008 and 2014. In April of 2007 claims on foreign exchange delivery (2 to 30 days) were 21.4 billion U.S. dollars and in the April of 2008, they hiked to 43.1 billion U.S. dollars, which is a 101% increase. Similarly, claims increased in the May of 2014 to 46.1 billion U.S. dollars, which is a 133% increase compared to May of 2013.

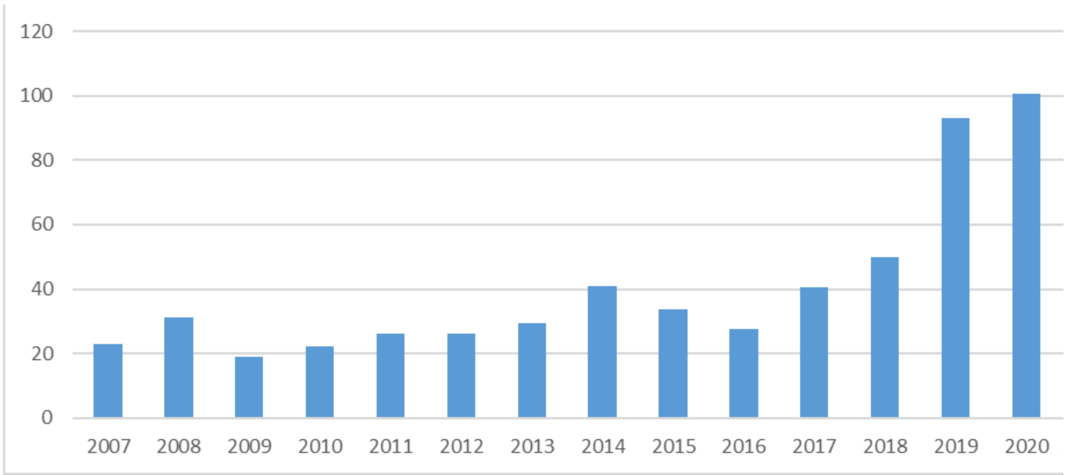

Figure 8 Claims on foreign exchange delivery, from 2 to 30 days (CBR 2021)

In addition, after both crises we can observe a decrease in those claims, illustrating the unwind of speculative capital. Since 2015, claims of foreign exchange delivery have been rapidly increasing, which means that there is a lot of investors who have opened short-term speculative positions that are vulnerable to crash risk. When the crisis hit in 2014, ruble depreciated against major world currencies. In 2014, the exchange rate of the U.S. dollar against the ruble surged by 72% to 56.2 rubles for one U.S. dollar as of January 2015, whereas the euro rose by 52% to 68.4 rubles for one euro. In addition, the

Russian sovereign credit rating was downgraded from investment grade to speculative in January of 2015 (Reuters 2015). This resulted in higher volatility and considerably higher yields. Due to the downgrade of credit rating, some large institutions and investors were not allowed to invest in certain financial instruments, causing capital to unwind. According to the Bank of Russia (2015), credit rating downgrade raised fear over foreign investors, causing a flight from Russian assets, where the Russian domestic debt market experienced substantial loss. The share of non-residents in the OFZ market grew from 107 billion rubles to 945 billion rubles in July 2014, which is 26% of the whole OFZ market. In March 2015, the share of non-residents declined to 18% reflecting that investors were not willing to keep their assets in Russia.

According to the Bank of Russia's financial stability report (2018), In 2017, the capital inflow started to increase, which was mainly caused by the attractiveness of carry trade transactions. The carry-to-risk ratio started to rapidly increase in 2017 Q1, due to the improved economic prospects and widening interest rate differentials. The share of non-residents in the OFZ market rose from 27% as of October 2016 to 30.1% as of April 2017. Also, the ruble started to strengthen due to the capital inflow attracted by carry trade. The share of non-residents in the OTC market was over 50% across all open positions of FX instruments. FX forwards contained 57% of non-residents and FX swaps over 70% in 2017 Q1. (Bank of Russia 2018, 9–11). In 2017, we can observe similar patterns that happen earlier, such as strengthening ruble, decreasing inflation and volatility and widening of interest rate differentials. One of the main factors that boosted the Russian economy was the increased oil prices. We may argue that this time the situation is exactly the same as in the previous crises. However, the ruble rate is much lower as it was previously, giving thus more flexibility to the Russian economy.

4.2 Case Australia

4.2.1 Background and positive impacts

Australia is a resource-rich country with a highly developed economy. As of 2021 Australian nominal GDP was 12th-largest, PPP-adjusted GDP 18th-largest, 25th-largest goods exporter and sixth biggest country (World Bank 2021). Australia's top export products in 2015 were: iron ores & concentrates (15.5% share of total), coal (11.7%), education-related travel services (5.9%), natural gas (5.2%), personal travel services (5%), Gold (4,6%) and beef (2.9%). Hence, the Australian economy relies on natural resources, but despite that, the economy has been stable and resilient. (Parliament of Australia 2021.) It is quite common for resource-rich countries, like Australia, to import most of the consumer goods instead of producing them, due to the extremely high competition, where the nearest trading partners are India, China, Japan and Southeast Asia's countries. Thus, developing own competitive manufacturing sector is highly difficult. Australia is trying to take advantage of its geological location and rich geological structure to preserve its position as a highly developed country with a strong economy. Also, governmental policy is playing a crucial role in sustaining that position. Due to resource-rich geology, Australia has a vast amount of natural resources that have high demand around the globe. Thanks to the convenient geographical location, Australia became the most important trade partner for many developing Asian countries, that are constantly facing a huge need for those resources. With an effective and reasonable governmental policy, Australia has strong democracy, highly efficient institutions, low political risks and a stable economy. In addition, by effectively manipulating interest rates, taxes and tariffs and by stimulating carry trade, Australia managed to sustain strong positions among other major economies. (Ready et al. 2017.)

According to the BIS survey (2019), the Australian dollar has been the fifth most traded currency for a long period, although it is not a major economy on the global scale. This is mainly due to the Royal Bank of Australia's (RBA) policy that aims to keep interest rates high (highest among developed countries) since 1983 when the AUD started to float. A high-interest rate attracts speculative capital, such as carry trade, and appreciates the national currency, leading to increased import. As a result, the strengthened Australian dollar makes imported goods cheaper, which is not only seen as higher profits for importers but also as increased welfare, since Australian citizens can buy imported goods at a lower price. According to International Monetary Fund (IMF 2021), Australian GDP per capita was 62,723 USD in April 2021, which is the 9th-highest in the world. However, the GDP per capita has been slightly declining after the most active carry trade period.

Carry trade helps to stabilize the currency rate by declining its volatility, which is caused by the fluctuations of commodity prices. This is mainly because speculators are not willing to unwind their capital when the commodity prices are highly fluctuating, knowing that the Australian economy is strong and resilient and political risks are low enough to save their investments. Stable and high valued currency mitigates the inflation growth rate and keeps it at a low level. For example, in 2007 when the carry trade activity was highly intense, the inflation rate was only 2.36% (Statista 2021). Capital inflow, although speculative, boost the foreign exchange reserves of RBA and stimulates the demand for Australian dept securities. Due to the low political and economic risks, the possibility for a potential financial bubble burst is quite low. On the other hand, high valued currency diminishes the profit of commodity exporters, which consequently decrease the income distribution by improving income inequality. This allows to utilize natural resources more efficiently and prevents the potential dominance of the commodity sector.

High valued currency has also the other side of the coin that is hampering the non-tradables sector. A stable and strong currency has raised enormously prices of the real estate and services sector, which is one of the Dutch disease's symptoms. Australia is facing a huge property bubble, causing RBA to take a more thorough approach to regulate financial mechanisms. For example, due to the decreased demand on commodities caused by COVID-19, the business activity has also shrunk in Australia, which triggered RBC to lower interest rate to the record minimum rate of almost 0%. Eventually, this has led carry traders to lose their ability to earn excess returns. However, unlike in Russia, no massive capital unwinding (sudden stop) or currency collapse has been noticed.

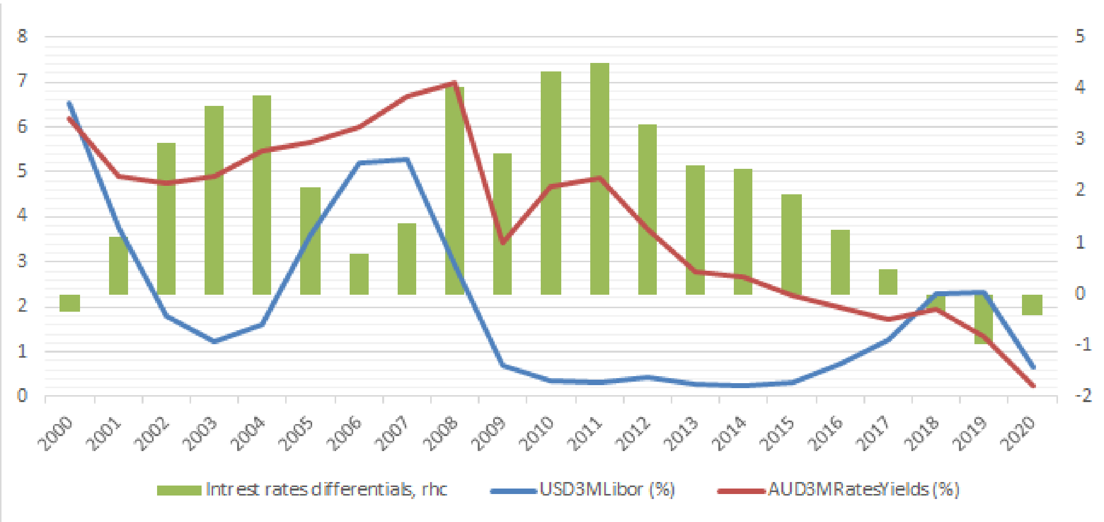

Figure 9 Interest rate differentials of Australian dollar from 2000 to 2020 (FRED 2021)

When comparing interest rate differentials in figure 10 and carry-to-risk activity in figure 11, we can observe how both indicators are moving in the same direction. Both crashed in 2008 and stated to grow at the beginning of 2010. This indicates that narrowed interest increased risk-averse which lowered the carry-to-risk ratio in 2008. However, GDP and export sector did not experience similar drawbacks as in Russia. A further empirical examination will be provided and discussed in chapter 5.

Figure 10 Carry-to-risk ratio in Australia from 2004 to 2013 (CBR 2017)

4.3 Case Mexico and Latin America

In this chapter, we will observe carry trade activity and its impacts on Latin American countries from a macroeconomic perspective. Mexico would be the main Latin American country of our analysis. The reasons why we focus on Mexico are that this country experienced multiple sudden stops in the recent past and the dynamics of sudden stops are closely related to other emerging market countries' sudden stops, like in Russia. Moreover, the Latin American region has been hit quite hard by the financial crisis and the consequences are resembling the Russian scenario and it is a resource-rich country.

Before the great financial crisis, Mexico experienced two crises associated with large sudden stops. The first one was the debt crisis in the early 1980s. The second was the peso crisis, which occurred by a forced devaluation of the peso that led to a massive capital outflow from the government debt market, in 1994. (Benigno et al. 2020). The financial crisis as of September of 2008, has had significant unfavourable impacts on resource-rich and developing countries in Latin America. The consequences of the financial crisis for the Mexican economy are mainly the same as what happened in Russia. The slowdown of the global economy accompanied by the decreased commodity prices have hampered sufficiently the terms of trade. Similarly, increased risk aversion and asset sell-offs by offshore investors have significantly affected exchange rates, stock market indices and interest rates of emerging markets in Latin America. According to the Bank of Mexico (2016), Mexico is highly dependent on trade with the USA, especially manufactured export. Hence, the slowdown in the US has a significant impact on Mexico's economy, and the appreciating domestic currency, due to the carry trade, is worsening the situation by hampering the manufactured export. Also, increased volatility triggered by the disclosure of derivative-related losses by some of the major Mexican companies has risen the cost of financing for domestic firms (Bank of Mexico 2016.)

After the financial crisis, capital flows started to return to the emerging economies, as well as to Latin America. This happened mainly due to the improving growth prospects that were boosted by increased commodity prices, which is quite typical for a resource-rich country. (Cuadra et al. 2011, 242). Hence, the domestic currency started to appreciate and interest rate differentials widened. Low-interest rates in developing countries forced investors to seek profit from emerging markets, especially in Mexico. As a result, “search for yield” attracted a massive number of foreign investors to Latin America, where they invested via carry trade due to the attractive interest rate differentials. In 2008 Q4, foreign investments increased from 1.6 billion U.S. dollars to 14.14 billion in Q4 of 2011. In 2009 Q1, the share of non-residents in portfolio investments surged from 14% (US$ 760 million) to 66% (US$ 9.3 billion) in 2011 Q1. The exchange rate appreciated in Mexico less compared to other Latin American countries. For example, the peso strengthened approximately 20% from April 2009 to May 2011, whereas other countries, such as Chile, Brazil and Colombia appreciated 25%, 44% and 40%, respectively. Similarly, the interbank rate was reduced from 8.25% in December 2008 to 4.5% in July 2009. Eventually, Latin American countries, especially Mexico, was fuelled by a speculative capital that was vulnerable to a potential sudden stop. (Cuadra et al. 2011). Narrowed interest rate differentials have diminished carry trade returns after 2008. The attractiveness of carry trades has been reduced by the lack of availability of financing for speculative leverage positions, partly because of a change in regulation after the global financial crisis. Similarly, hedge funds’ investment strategy and behaviour towards carry trade have also changed, which is seen as declined carry trade positions. However, there is still evidence of acquiring by non-residents of domestic debt securities or long forward positions in target countries’ currencies, which is in line with carry trades. (BIS Papers No 81 2015, 1–2.)

4.3.1 Carry trade activity and position taking

According to BIS Papers No 81 (2015), there is three main strategies to implement carry trades. The following strategies are: acquiring debt denominated in the target country’s currency, as observed in numerous Latin American countries; taking a long position in the target countries currency in the (deliverable) swap market, which is observed in Mexico; and taking a long position in the non-deliverable forward market, which is also common in numerous Latin American countries. The main funding currency for carry trade in Latin America is USD, but in Mexico, JPY was also a significant funding currency, but not anymore due to the lower USD interest rates. (BIS Papers No 81 2015, 14.).

Figure 12, shows how attractive carry trade was in Latin America from 2000 to 2014. The data show how carry trade returns were positive, except in 2008, 2011 and 2013 during the crisis. As mentioned, this is associated with currency crash risk as carry trades are funded by debt. Hence, the shock that generates losses can be amplified by liquidity spirals. We can observe that in Mexico, the carry-to-risk ratio was very volatile before 2009, experiencing massive capital flow and outflow, thus destabilizing peso.

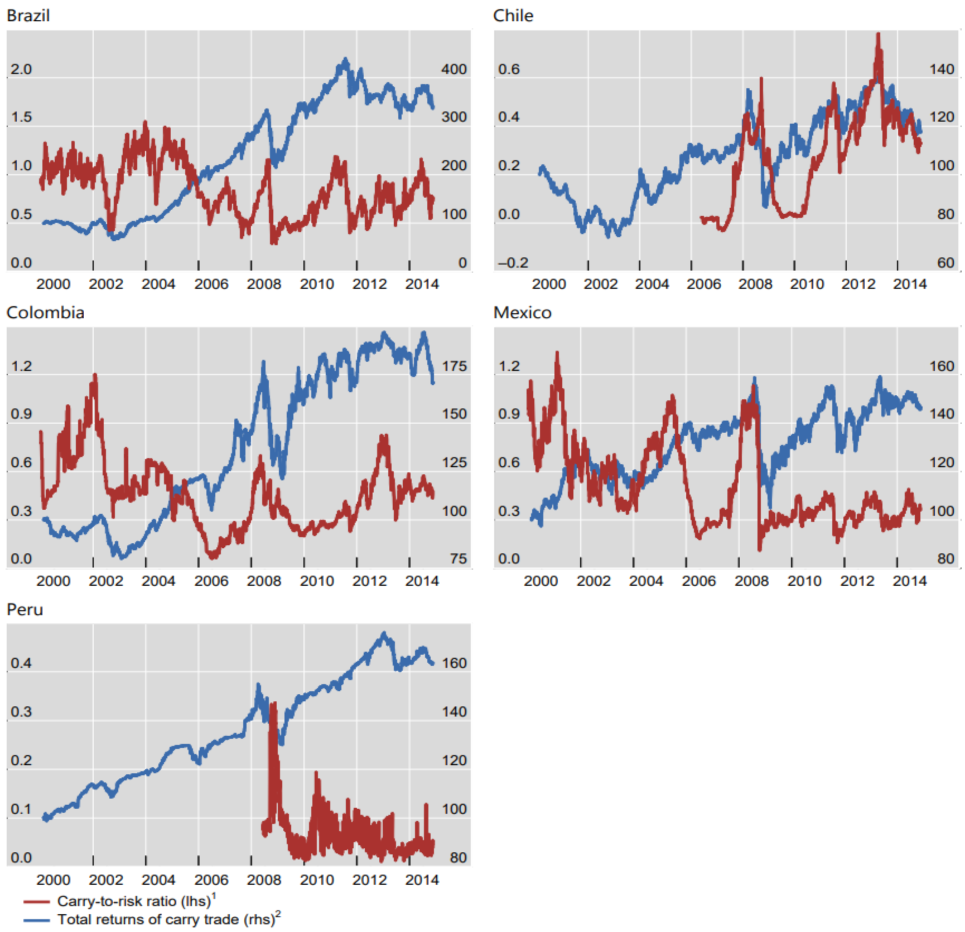

Figure 11 Indicators of incentives for carry trades. Strategies with US dollar as a funding currency and local currency as target currency (BIS Papers No 81 2015, 30)

Figure 13 shows carry trade activity in Latin American countries. Despite Chile, foreign investors' holdings have significantly risen and are very large. For example, the share of non-residents of domestic sovereign debt is approximately 19% in Brazil, 37% in Mexico and 42% in Peru. However, due to the regulatory restrictions, the share of non-residents is quite small in Chile. (BIS Papers No 81 2015, 22).

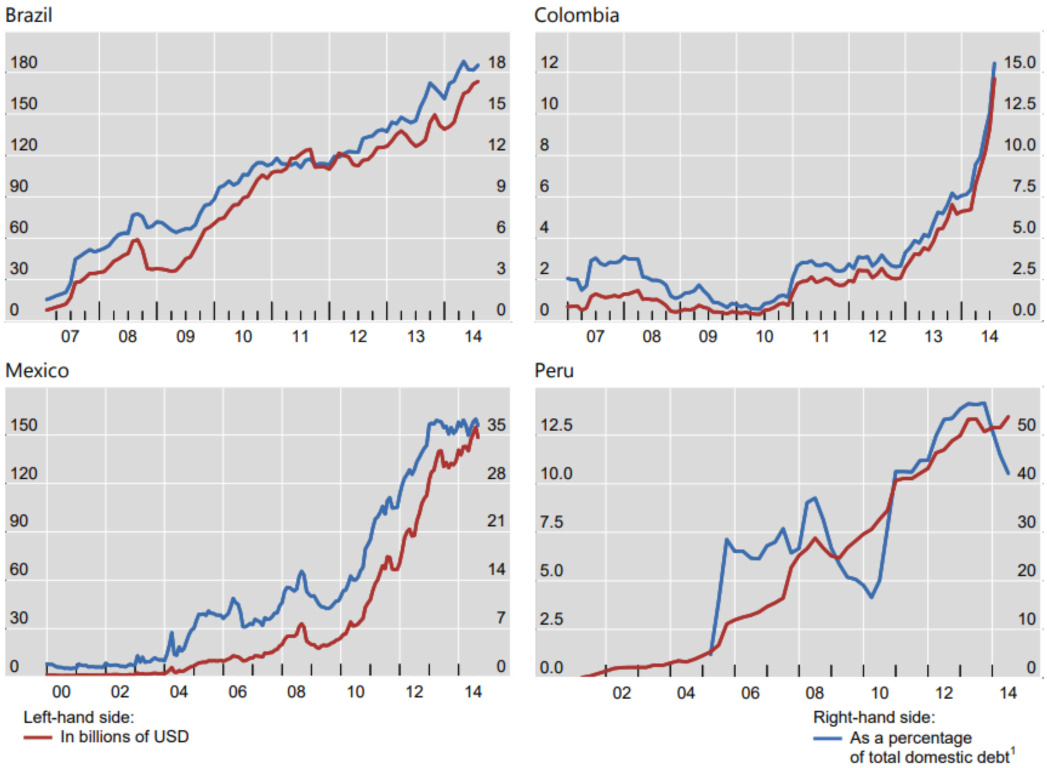

Figure 12 Foreign investors' holdings of domestic sovereign debt (BIS Papers No 81 2015, 32)

In Mexico, from nearly \$10 billion to almost \$150 billion (i.e., from approximately 10% to 35%) during the same period. This has been a huge increase, indicating that carry trade has played a significant role. Graph 14 illustrates the relationship between the attractiveness of carry trade and foreign investors positions in forward markets. As mentioned, short-term financial instruments, like swaps, are extremely popular among carry traders. In Latin America, foreign investors will have an incentive to take a long forward position in the destination country's currency that will appreciate, and which interest rates will increase in the domestic currency relative to funding currency (BIS Papers No 81 2015, 23)

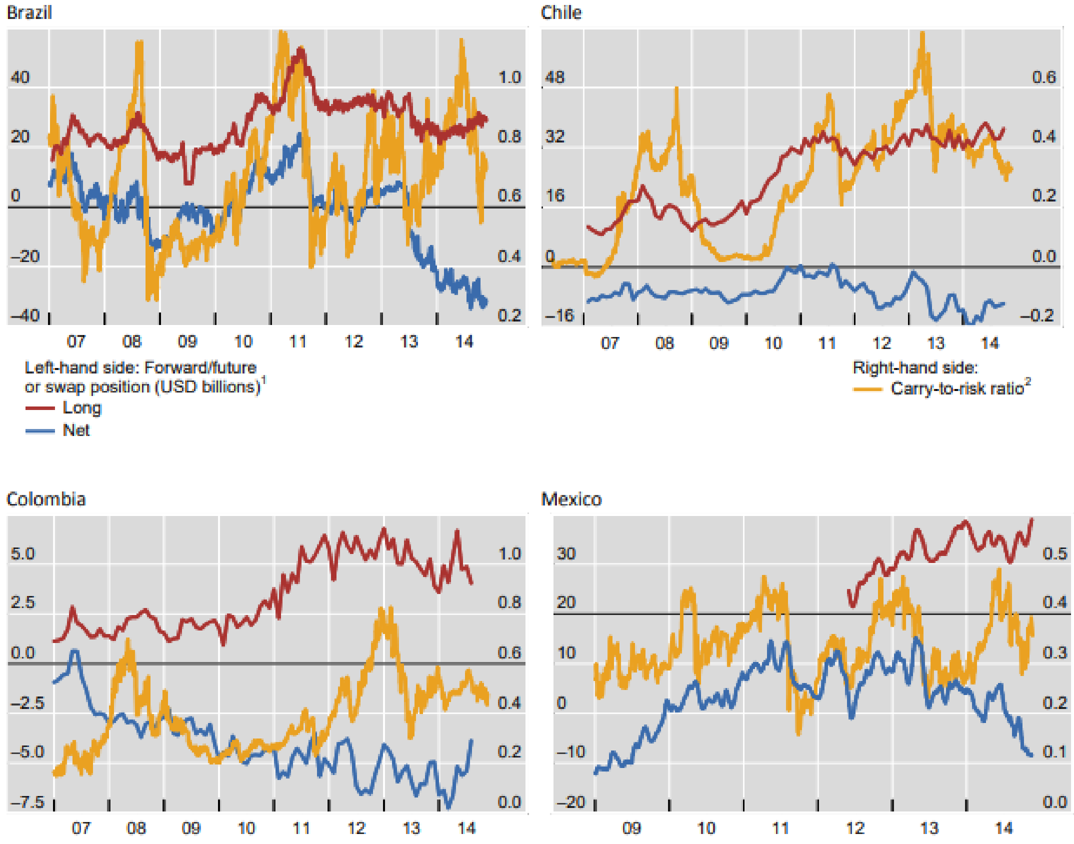

Figure 13 Non-residents' forward/futures or swap positions and carry trade incentives (BIS Papers No 81 2015, 34)

Also, if the domestic country's currency rate will fall the reverse would be true. As we can see from the graph, this relationship is obvious. (BIS Papers No 81 2015, 24).

We cannot tell for sure how big portion of these foreign holdings are related particularly to carry trade, but because Latin America has been a popular target region among carry traders, we can be sure that there has been and is still sufficient carry trade activity.

4.4 Comparing carry trade impacts on four resource-rich countries' economies

Russian and Mexican economies had similar patterns in performance before and after the crises. It is not surprising, because they are closely related to each other in terms of commodity dependency and the effectiveness of institutions. However, both countries implement governmental policies differently and Russia has larger reserves, which affect the performance. Additionally, sanctions that were imposed against Russia increased volatility and political instability after 2014. Those sanctions amplified the crisis, causing the massive unwind and ruble devaluation. On the contrary, Australia performed the best among those countries, where its economy was stable and resilient during and after the crises. Nevertheless, speculators are risk seekers meaning that they will make short-term investments as long as carry trade is attractive and beneficial enough, despite the political risks and volatility. Next, we will compare countries' macroeconomic indicators to show how they performed before, during and after crises, when carry trade activity varied from highly attractive to unprofitable. We have mentioned key impacts of carry trade regarding macroeconomy in chapter 3. Below is a reminder of those impacts from a macroeconomic perspective:

- massive exchange rate appreciation
- financial stability concerns
- risks of a sudden reversal in capital flows
- developing unsustainable expansion of credit
- generating bubbles
- increasing financial fragility
- decreasing competition and subsequently reducing export
- bid up asset prices and property valuations

From 2002 to 2008, Russian and Mexican currencies gradually appreciated, although the annual inflation rate in Russia varied from 16% to 8.5% and from 3.9% to 5.5% in Mexico. Similarly interest rates in both countries varied from 7% to 15% and from 5% to 10% respectively (Figure 28). Under those circumstances of extremely wide interest rate differentials and high inflation, both currencies strengthened to 24.5 USDRUB and 10.6 USDMXN in 2007. In 2008 during the crash, both currencies devaluated to 35.5 USDRUB and 15 USDMXN respectively.

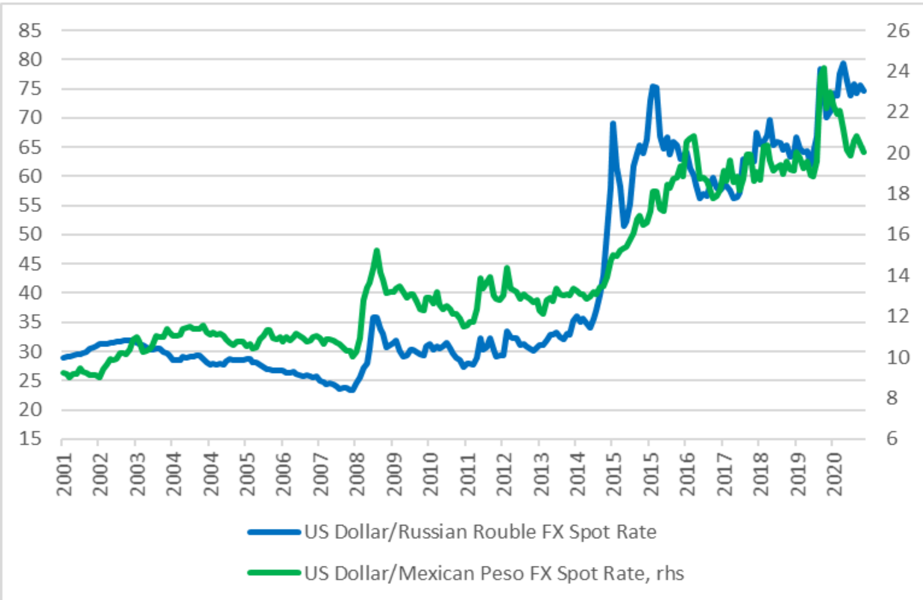

Figure 14 FX Spot rates of Russian ruble and Mexican peso against U.S. dollar, monthly, (%) (Eikon 2021)

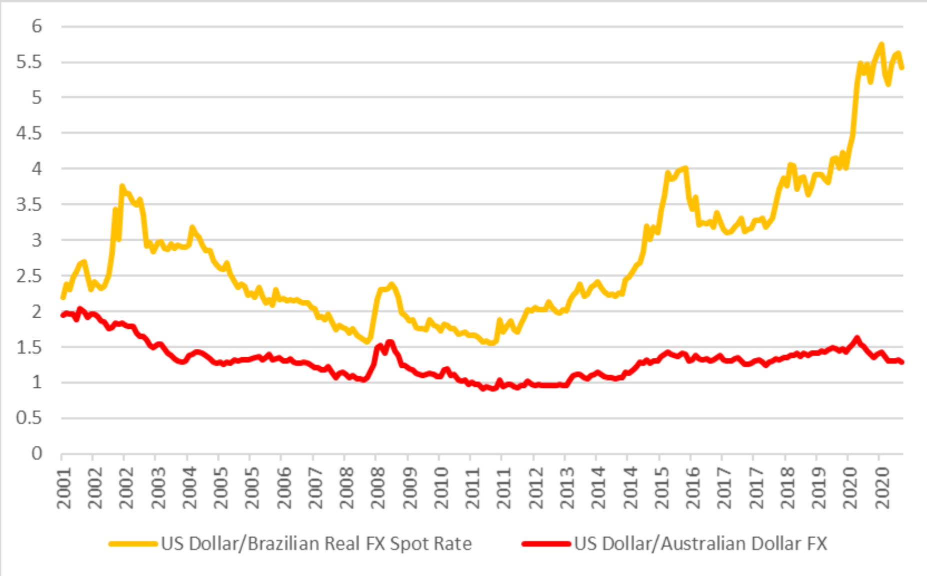

Figure 15 FX spot rates of Australian dollar and Brazilian real against U.S. dollar, monthly, (%) (Eikon 2021)

Brazilian real also faced a rapid appreciation from 3.6 USDBRL to 1.56 USDBRL just before the crisis. Annual inflation and 3-months interest rate varied with similar variance as in Russia, from around 14% to 4% and 27% to 10%. The same indicators varied at a much lower variance in the case of Australia, when comparing it to Russia, Mexico and Brazil. This is easily observable in figures 17 and 18.

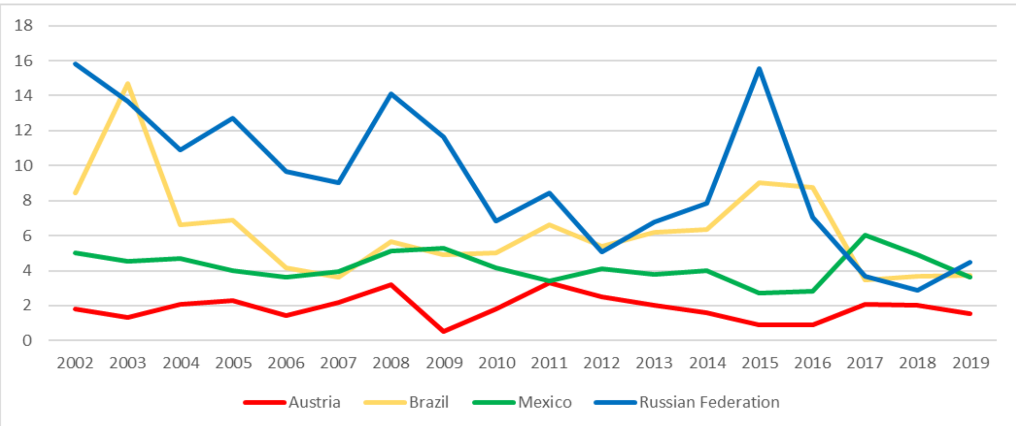

Figure 16 Annual inflation (CPI) grouped by Australia, Brazil, Mexico and Russia, (%) (World Bank 2021)

During the crises, all four countries experienced capital outflow. Russia and Latin American countries experienced the largest outflow, which affected currency rates. In 1Q 2009, Russian ruble devaluated to 35.9, Mexican peso to 14.27 and Brazilian real to 2.3 against the U.S. dollar. The carry-to-risk ratio was fluctuating a lot in Russia, Mexico and Brazil before the financial crises. In Russia, it varied from 1.1 to 0.2, In Mexico from 1.0 to 0.15 and in Brazil from 1.5 to 0.3. All four countries faced the largest dip during the financial crisis, which affected all macroeconomic indicators. However, the dip was not significant in Australia, whereas Russia and Mexico experienced a huge decline. Due to the increased volatility and narrowed interest rate differentials, carry traders closed their speculative position, which caused massive unwind that amplified capital outflow and currency devaluation.

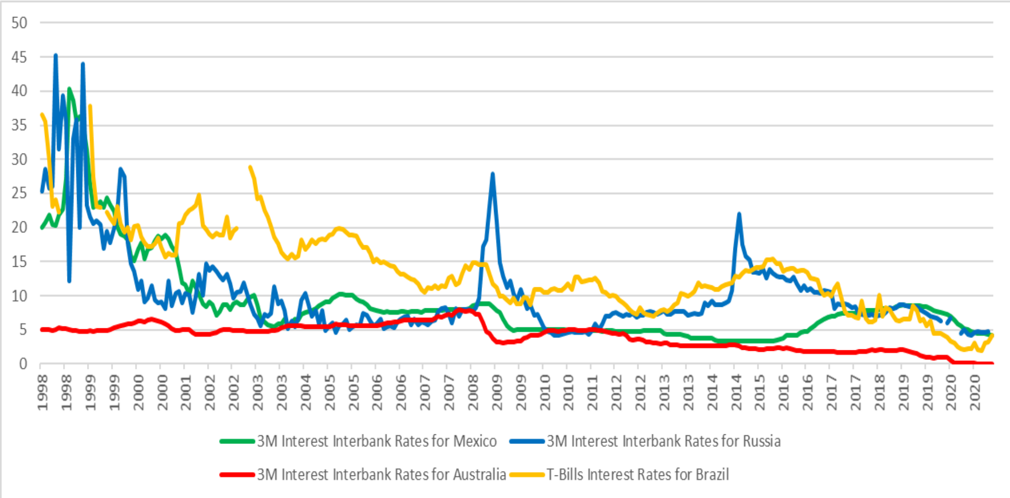

Figure 17 Interest rates for Mexico, Russia, Australia and Brazil, monthly (%). 3MM interest interbank rates for Russia, Mexico and Australia and T-Bills interest rates for Brazil (FRED 2021).

However, Australian economy was not affected similarly by the financial crisis and there wasn't any sign of capital outflow, although its carry-to-risk ratio varied from 0.4 to 0.0. Australian 3-months interest rate was constantly at 5% level from 1998 to 2008 and inflation rate was also quite stable from 2002 to 2008, which stayed at 2% level. As in other countries, where carry trade was very attractive, Australian dollar was gradually appreciated against the U.S. dollar from 2002 to 2008. The AUD appreciated from 2 to 1 against the U.S. dollar. However, despite the huge interest rate differentials and constantly appreciating currency, Australia did not face similar capital outflow and survived the financial crisis the best among all developed countries (Reserve Bank of Australia 2021). The outcome of the global financial crisis is observable in the figures above, where all the previously mentioned indicators did not experience sharp variation. Right after the crisis, when interest rates started to stabilize, speculators engaged new carry trades to profit from new arbitrage opportunities. Although interest rates in Russia, Mexico and Brazil were still at a sufficiently high level, domestic currencies were devaluating, making carry trade less attractive yet, during the crisis. When the domestic currency stabilized, carry traders started again taking advantage of that opportunity, causing further currency appreciation. This tendency is seen in Russia after the 2008 and 2014 crises. After 2014 crisis, 3-months interest rate was much higher than in 2008, which stimulated higher carry trade activity. However, ruble did not devaluate as much as in 2014 due to the massive interventions of the Central Bank of Russia, leading to a fast carry trade recovery.

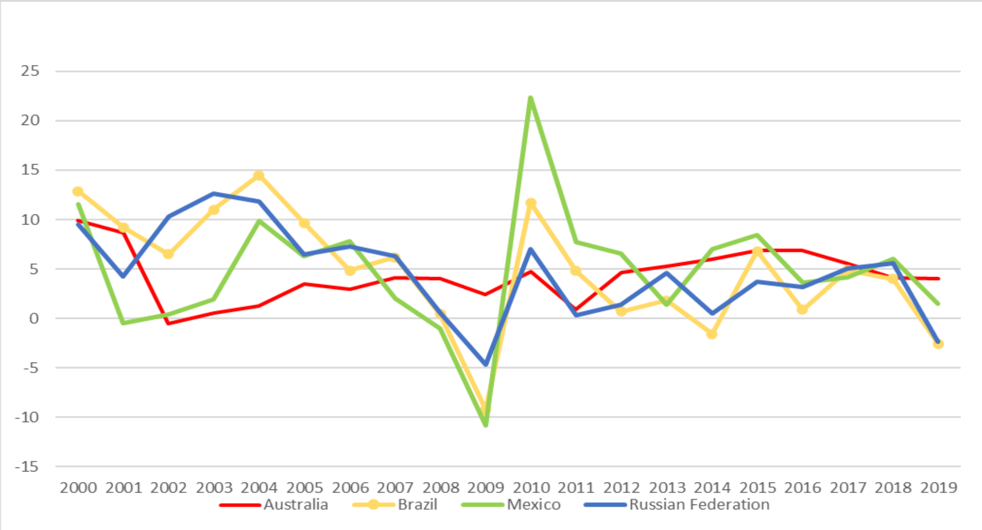

Figure 18 Annual export growth rate of goods and services in Australia, Brazil, Mexico and Russia from 2000 to Dec-2020, (%) (World Bank 2021)

As mentioned, a currency that is strengthening due to the speculative carry trade is hampering the country's export sector. In that case, the currency rate is not reflecting fundamentals, which might give the wrong impression of the country's economy. This issue is mainly associated with the other three countries rather than with Australia. Australia has a resilient and strong economy with efficient institutions and the highest level of democracy. This is usually not the case with Russia, Mexico and Brazil. Hence, we can observe large variations across all macroeconomic indicators and in the capital outflow. Figure 19 shows how the export of goods and services was rapidly declining from 2004 to 2009 when the carry trade activity was very high, leading to appreciation of domestic currencies. This in turn affected competitiveness level and increased massively import. Again, Australian export was still growing compared to Russia, Mexico and Brazil. Before 2008, the price of commodities, especially oil prices, experienced extremely powerful growth. Hence, the resource sector in our four countries was not negatively affected by appreciated currencies. For example, in Russia, the oil and gas sector was rapidly growing, however, the manufacturing sector faced serious challenges, especially the production of finished goods. It is quite common for resource-rich countries to export mainly natural resources rather than finished goods. High dependence on natural resources makes the economy vulnerable to various crashes on increased volatility on the global market. This is also easily observable in figure 31, where Russian, Mexican and Brazilian export crashed in 2008. The same effect is observable after 2014 when the annual growth of four countries' export of goods and services continued to increase, although in the case of Russia, Mexico and Brazil the growth was more volatile compared to Australia. Export started to face immediate decline when the carry trade activity increased again, causing the domestic currencies to appreciate, and thus boosting import. Figure 19 shows how Mexican, Russian and Brazilian export sectors are experiencing those changes, whereas Australian export is quite stable and constantly growing by 4.6% on average each year from 2009 to 2019.

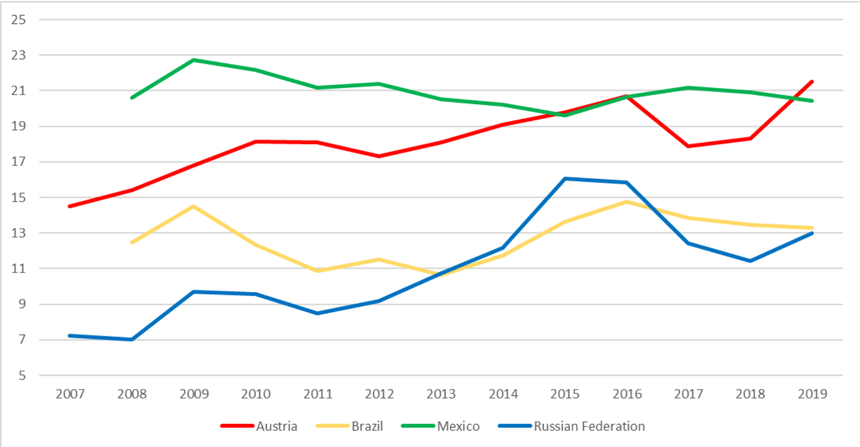

Figure 19 Share of high-technology exports (annual % of manufactured exports) of Australia, Mexico, Brazil and Russia from 2007 to Dec-2019 (World Bank 2021)

The same is observable in Figure 20, where is shown high-technology export as % of manufactured export. For resource-rich countries, this percentage is quite low, especially compared to developed countries. However, even here Australian export was slowly growing after the crisis of 2008 where the other three countries experienced a decline. When carry trade activity decreased and domestic currencies depreciated, export experienced growth in all four countries until the next crisis. After the shock of 2014, high-technology exports surged until 2016, when carry trade activity started to increase.

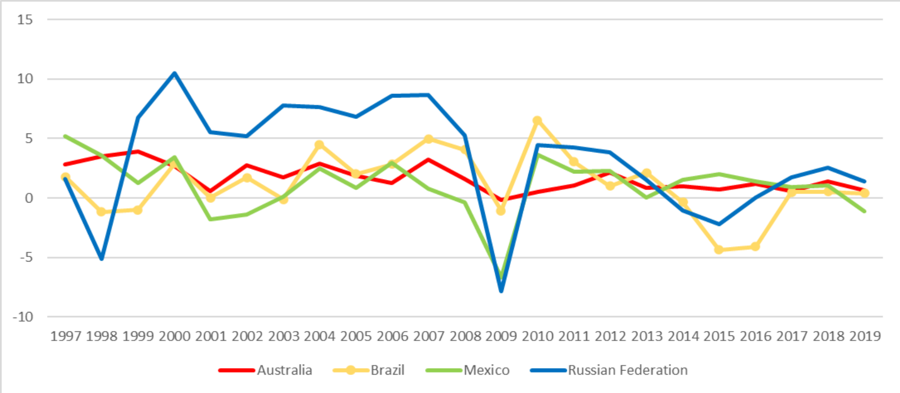

Figure 20 Annual GDP per capita growth from 1997 to Dec-2019, (%) (World Bank 2021)

Figure 21 is a very important indicator that shows how resilient and progressive is each countries' economy. Despite the various global crises and commodity shocks, the Australian economy demonstrated extremely resilient and stable economic performance, which is seen as quite stable GPD growth. In addition, Australian dollar attracted massively carry traders from 1997 to 2013. However, there have not been observed any significant negative impacts on the Australian economy. In contrast, the variation of GDP in Russia, Mexico and Brazil has been significantly more volatile compared to Australia. The Russian GPD has faced the sharpest dip in both crises compared to other countries. Although all four resource-rich countries were popular among carry traders and have attracted a sufficient amount of speculative capital, only Australia managed to be the most resilient economy that outperformed the rest. Also, the capital outflow was the least in Australia.

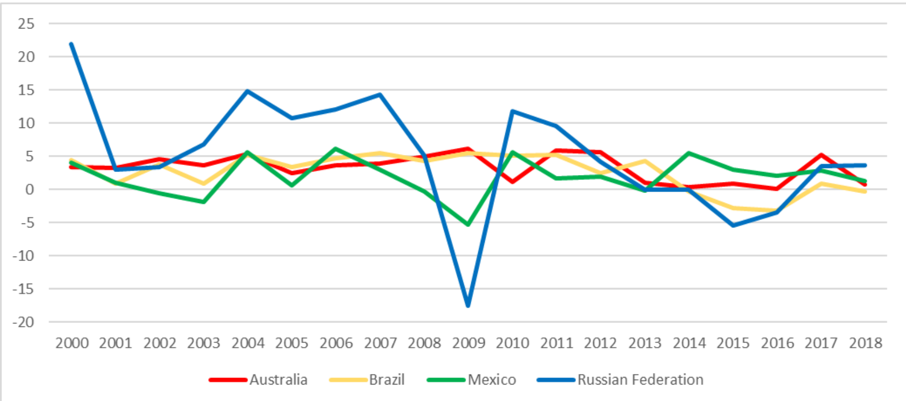

Figure 21 Annual adjusted net national income growth rate from 2000 to 2019, (%) (World bank 2021)

Figure 22 illustrates citizen's welfare development across four countries, which is calculated by deducting consumption of fixed capital and natural resource depletion from GINI. As a result, the strengthened Australian dollar makes imported goods cheaper, which is not only seen as higher profits for importers but also as increased welfare, since Australian citizens can buy imported goods at a lower price.

5 EMPIRICAL RESULTS AND ANALYSES

To examine the causality and significance of carry trade on countries currencies VAR model was applied. We will divide our analysis into 3 parts:

- Analysis 1 is for the currency pairs and carry trade from 2002 to 2020,
- Analysis 2 is for the ruble, carry trade and macroeconomic indicators and,
- Analysis 3 is for the share of non-residents

The data set is comprised of the time series of the following variables:

Exchange rates: USDRUB, EURRUB, USDUAD, JPYAUD, USDMXN and USDBRL
Carry trade returns: CT USDRUB, CT EURRUB, CT USDAUD, CT JPYAUD, CT USDMXN and CT USDBRL

The most used method to analyse the stationarity of time series is the Augmented Dickey-Fuller (ADF) unit root test. The ADF-test results are presented for all VAR models in the Appendix. ADF-tests show that the analysed time series were all stationary after implementing the first-order difference (D is a sign for the first difference), meaning that variables don't include a unit root. As a result, we are able to estimate the VAR model for all models.

The determination of lag numbers of the series is one of the most important decisions to be made for the VAR analysis. Akaike information criterion (AIC) is categorized as the most optimal criterion for the VAR analysis. Thus, it was used to determine the lag lengths required for the VAR in our study (Anderson et al. 2004; Johansen 1995).

The Lagrange multiplier (LM) test for autocorrelation in the residuals of VAR models was implemented for all VAR models. Data in Appendix show that there was no autocorrelation identified (values should be over 0.1). Also, the stability condition of the eigenvalue was checked after estimating the parameters of the VAR. According to (Johansen 1995), if a VAR is stable then it is invertible and has an infinite-order vector moving-average representation. Hence, if the VAR is stable, impulse-response (IRF) functions and forecast error variance decomposition have known interpretations. The VAR model is stable if the modulus of each eigenvalue of matrix A is less than one, which is seen in Appendix. (Lutkepohl 2005, 14–27.)

In addition to autocorrelation, VAR stability and ADF tests goodness of fit test-Jarque-Bera (normality test) was implied. The goodness of fit test measures if sample data has skewness and kurtosis that are normally distributed. If it is close to zero, it means that the data is normally distributed. Jarque-Bera test was chosen over other normality tests, because it gives more reliable results with large datasets (Lutkepohl 2005).

5.1.1 Analysis 1

The data frequency is daily, covering the period from 01.01.2002 to 01.01.2020, so the time series length is 4697 items. The source for the data is Reuters Eikon and Bloomberg. Bloomberg calculates historical carry trade returns based on the uncovered interest rate parity, which provides us a reliable proxy for carry trades (Huiming & Laux 2014). The carry trade strategy is the following: short low-interest-rate currency and long high-interest rate currency, i.e. borrowing in USD and investing RUB for a fixed time period of time without any trading in-between. Carry trade returns value is 100 at the beginning of 01.01.2002.

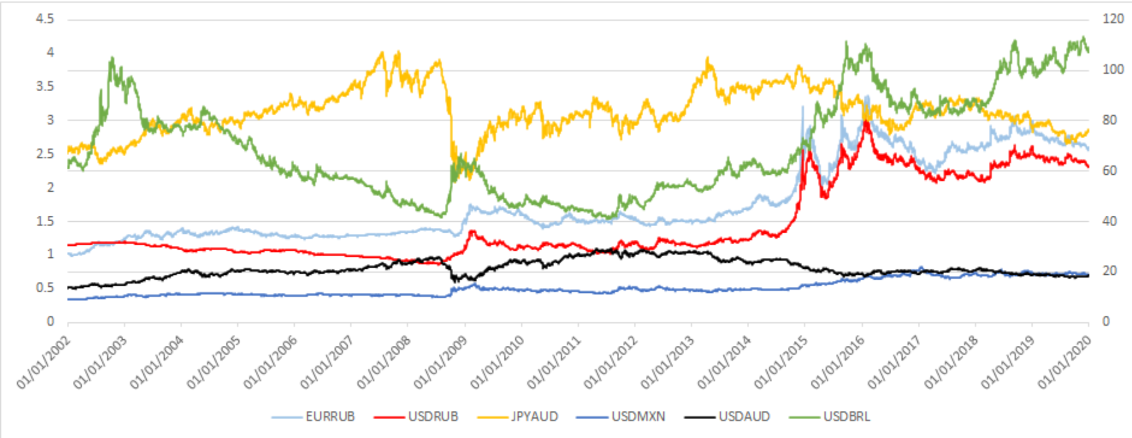

Figure 22 FX spot rates of USDRUB, EURRUB, USDMXN, JPYAUD, USDAUD (lhs) and USDBRL (lhs)

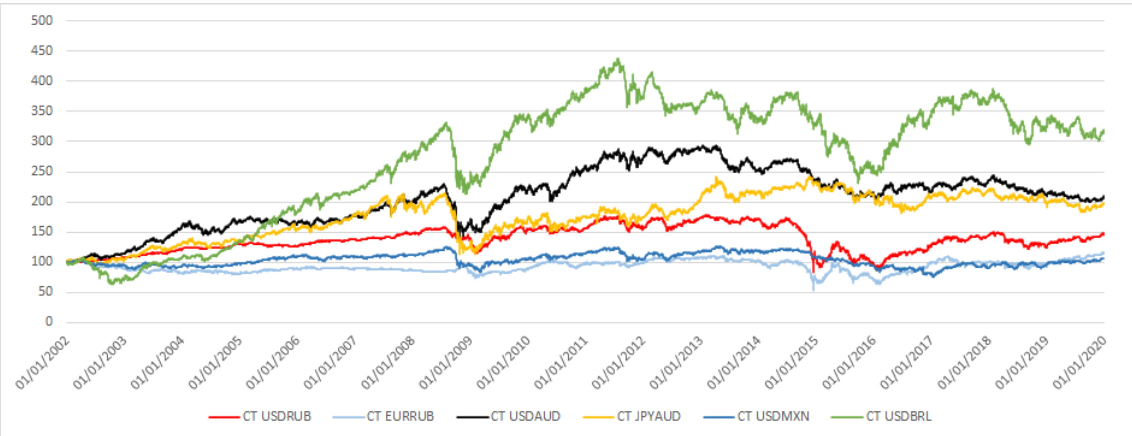

Figure 23 Dynamics of six currencies carry trade returns indices (01.01.2002 = 100)

Figures 23 and 24 show the opposite variation pattern of carry trades and currencies. That allows to formulate that the strengthening of investment currency, for example, USDRUB is negatively correlated with the increase of carry trade returns (depreciation of investment currency is seen as a downward curve).

The period subjected to the analysis was divided into four periods to observe different variations in relation between the currency pairs and carry trades before, during and after crises:

Period 1 – 01.01.2002 – 01.01.2020 (whole observation period)

Period 2 – 01.01.2008 – 30.01.2009 (financial crisis)

Period 3 – 02.06.2014 – 30.06.2015 (energy crisis, sanctions on Russia and ruble is set to flow)

Period 4 – 01.07.2014 – 01.01.2020 (post 2014 crisis period)

The equations below illustrate USDRUB and CT USDRUB formula for VAR model analysis. The same formula was used also for other currency pairs and carry trades.

(12)

$$D.USDRUB_t = a_1 + \sum_{i=1}^{p} a_i\, D.USDRUB_{t-i} + \sum_{i=1}^{p} b_i\, DCT\_USDRUB_{t-i} + e_{1t}$$

$$DCT\_USDRUB_t = \beta_1 + \sum_{i=1}^{p} a_i\, D.USDRUB_{t-i} + \sum_{i=1}^{p} b_i\, DCT\_USDRUB_{t-i} + e_{2t}$$

The term D is a first difference order of variable.

x_t = [$x_{1t}, \dots, x_{mt}$]^T is a vector of observation on the current values of the variables,
a_1 = is a matrix of parameters, vector variables,
a_i = is a matrix of parameters in the lagged variables of vector x_t, where the number of lags is equal to p,
e_t = [$e_{1t}, \dots, e_{mt}$]^T contains vectors of the model equation residuals.

In our first regression analysis, the x_t vector consists of two variables: currency pair's spot exchange rate (for example USDRUB) and this currency pair's carry trade return index.

The number of lags, tests for VAR model suitability and Granger causality coefficients of variables can be seen in table 1 (a detailed explanation of tests can be found at the beginning of this chapter). Results are divided into four examination periods. All variables are normally distributed, stable and have no autocorrelation, meaning that we can include them in our VAR model. The Granger causality test shows strong causality between variables if the coefficient is under 0.1. If both variables have coefficients under 0.1, then it means that they have bidirectional causality. It can be seen that there is bidirectional causality between carry trade and domestic currencies in all currency pairs during the whole observation period (period 1). USDRUB and EURRUB are the only pairs that had bidirectional causality between carry trade in all observation periods. All currency pairs had bidirectional causality between carry trades in the financial crisis (period 2), but not during the 2014 crisis (period 3). Only ruble and peso had causality during 2014, however, peso was not significant between 2014–2020 (period 4).

The IRF function is used to identify and determine the directionality and volume of the impulse by the series included in the VAR model to the response or shocks in the error terms. Figures 25 and 26 show the IRF functions of USDRUB to carry trade return changes over four periods. The time horizon (expressed in days) is stated on the horizontal axis of figures 25 and 26. The vertical axis is showing the X reaction caused by the change of Y. Although, the IRF function gives us information on the direction, size and the pass-through of the impulse coming from the carry trades and the own side to the currency pairs, they do not include information related to the importance of those impulses for the variance of those variables. Hence, the variance decomposition analysis is used to identify how the other series in the VAR model react when an impulse or a shock is implemented to one of the series.

Table 1 Result of autocorrelation, normality, stability and granger causality tests and a number of lags. Table sarts with VAR DUSDRUB DCT_USDRUB variables where D means first difference order and CT carry trade.

VAR DUSDRUB DCT_USDRUB	Period 1 (2002-2020)	Period 2 (Financial crisis)	Period 3 (2014 crisis)	Period 4 (2014-2020)
Number of lags	3	8	2	3
LM-test coefficent of ac	0.78806	0.65379	0.34313	0.29785
Stability of VAR variables	Stable	Stable	Stable	Stable
Granger coefficent				
DUSDRUB -> DCTUSDRUB	0.000***	0.000***	0.002***	0.000***
DCTUSDRUB -> DUSDRUB	0.000***	0.000***	0.000***	0.000***
Normality (J-Bera)	0.000***	0.000***	0.000***	0.000***
VAR DEURRUB DCTEURRUB	**Period 1 (2002-2020)**	**Period 2 (Financial crisis)**	**Period 3 (2014 crisis)**	**Period 4 (2014-2020)**
Number of lags	45	46	3	9
LM-test coefficent of ac	0.523	0.61933	0.28295	0.89301
Stability of VAR variables	Stable	Stable	Stable	Stable
Granger coefficent				
DEURRUB -> DCTEURRUB	0.000***	0.000***	0.000***	0.000***
DCTEURRUB -> DEURRUB	0.000***	0.000***	0.000***	0.000***
Normality (Jarque-Bera test)	0.000***	0.000***	0.000***	0.000***
VAR DUSDAUD CTUSDAUD	**Period 1 (2002-2020)**	**Period 2 (Financial crisis)**	**Period 3 (2014 crisis)**	**Period 4 (2014-2020)**
Number of lags	8	8	2	2
LM-test coefficent of ac	0.42846	0.79581	0.86498	0.84757
Stability of VAR variables	Stable	Stable	Stable	Stable
Granger coefficent				
DUSDAUD -> DCTUSDAUD	0.000***	0.005***	0.18	0.354
DCTUSDAUD -> DUSDAUD	0.001***	0.005***	0.125	0.178
Normality (Jarque-Bera test)	0.000***	0.000***	0.000***	0.000***
VAR DJPYAUD CTDJPYAUD	**Period 1 (2002-2020)**	**Period 2 (Financial crisis)**	**Period 3 (2014 crisis)**	**Period 4 (2014-2020)**
Number of lags	9	6	2	2
LM-test coefficent of ac	0.2486	0.42135	0.87772	0.84385
Stability of VAR variables	Stable	Stable	Stable	Stable
Granger coefficent				
DJPYAUD -> DCTJPYAUD	0.000***	0.005***	0.773	0.117
DCTJPYAUD -> DJPYAUD	0.000***	0.001***	0.731	0.250
Normality (Jarque-Bera test)	0.000***	0.000***	0.000***	0.000***
VAR USDMXN CTUSDMXN	**Period 1 (2002-2020)**	**Period 2 (Financial crisis)**	**Period 3 (2014 crisis)**	**Period 4 (2014-2020)**
Number of lags	17	3	2	2
LM-test coefficent of ac	0.42064	0.82119	0.93306	0.12386
Stability of VAR variables	Stable	Stable	Stable	Stable
Granger coefficent				
DUSDMXN -> DCTUSDMXN	0.001***	0.001***	0.057*	0.239
DCTUSDMXN -> DUSDMXN	0.000***	0.001***	0.09*	0.474
Normality (Jarque-Bera test)	0.000***	0.000***	0.000***	0.000***
VAR DUSDBRL DCTUSDBRL	**Period 1 (2002-2020)**	**Period 2 (Financial crisis)**	**Period 3 (2014 crisis)**	**Period 4 (2014-2020)**
Number of lags	2	7	1	4
LM-test coefficent of ac	0.30495	0.57142	0.45902	0.74778
Stability of VAR variables	Stable	Stable	Stable	Stable
Granger coefficent				
DUSDBRL -> DCTUSDBRL	0.003***	0.001***	0.8	0.940
DCTUSDBRL -> DUSDBRL	0.005***	0.001***	0.255	0.118
Normality (Jarque-Bera test)	0.000***	0.000***	0.000***	0.000***

The first box of IRF figure 25 (bottom left corner, DUSDRUB, DCTUSDRUB) shows the effect of a one-standard-deviation impulse of USDRUB spot rate or shock on the CT USDRUB during the whole time period. A one standard deviation shock on USDRUB spot has a negative effect on the CT USDRUB. In other words, when

USDRUB spot increases (depreciates), the CT USDRUB will decrease. The magnitude of the shock is one standard deviation. After one period effect is positive and after 4 periods goes back to initial values. During the financial crisis, USDRUB spot rate's shock was a lot more volatile but followed the same pattern, until it went to initial values after 20 periods. The overall impact of carry trade on USDRUB spot rate was very small.

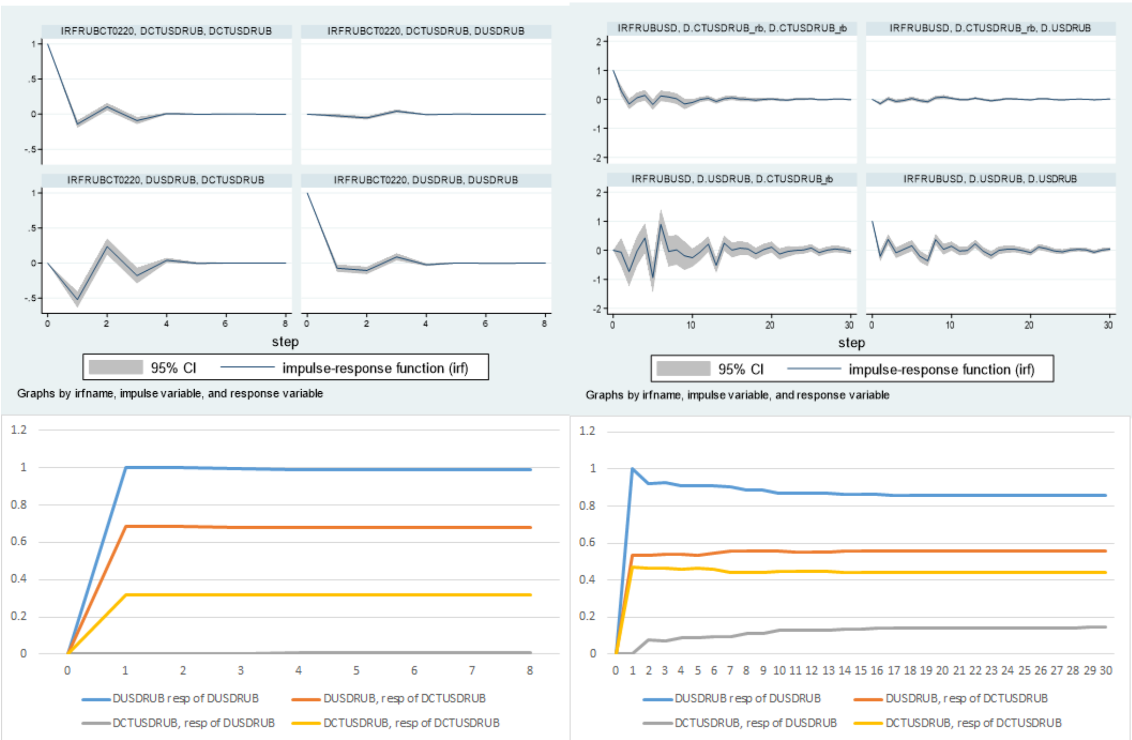

Figure 24 IRF and variance decomposition (bottom) result for USDRUB. 2002-2020 periods are shown on the left side and the financial crisis on the right side. For example, "DUSDRUB, DCTUSDRUB" shows response of DCTUSDRUB on USDRUB.

The same table (two figures below IRF results) also shows the results of variance decomposition. As mentioned, variance decomposition displays the percentage of the error made forecasting a variable over time due to a specific shock. In other words, how much of the variability in the dependent variable is explained by its "own shocks" vs the shock in the other variables in the model. As we can see, during the whole observation period (lower-left corner), 99% of the variability in USDRUB spot rate is due to the shock on itself whereas 67% changes of CT USDRUB are explained by USDRUB spot rate. Around 30% of the variability in CT USDRUB is due to the shock on itself and 0.008% changes of USDRUB spot rate are explained by CT USDRUB. During the first 10 days of the financial crisis, 90% of the variability in USDRUB spot rate is due to the shock on itself. After 20 days it drops to 82%. 55% changes of CT USDRUB are explained by USDRUB spot rate, which is higher than in the previous period. Also, the variability in CT USDRUB due to the shock on itself is 15% higher and 18% changes of USDRUB spot rate are explained by CT USDRUB.

During and after the crisis of 2014, table 26 shows (2014 crisis on the left and 2014–2020 on the right side) that USDRUB spot shock on the CT USDRUB follows a similar pattern as in the previous periods, although much less volatile compared to the financial crisis. However, CT USDRUB shock on the USDRUB spot rate is positive during the first period after which it is going down to the negative values and at the end goes back to initial values. This means carry trade had a powerful impact on ruble when it started to float after 2014. When CT USDRUB increases, the USDRUB spot rate will decrease (appreciate against USD). The left graph below the IRF graphs shows that during the crisis of 2014, 97% of the variability in USDRUB spot rate is due to the shock on itself. 70% changes of CT USDRUB are explained by USDRUB spot rate. Around 30% of the variability in CT USDRUB is due to the shock on itself and 3% changes of USDRUB spot rate are explained by CT USDRUB. A similar pattern is observed after the crisis of 2014, however, the variability of CT USDRUB that is explained by USDRUB spot rate and variability of CT USDRUB that is due to the shock on itself are both higher.

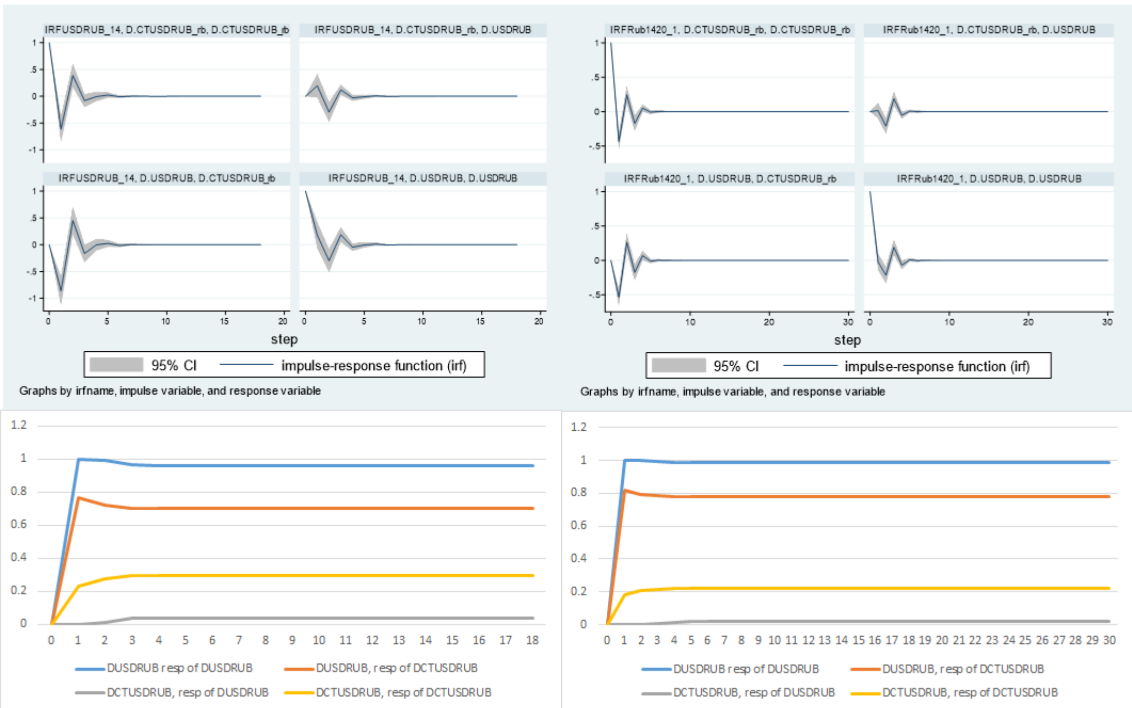

Figure 25 IRF and variance decomposition (bottom) result for USDRUB. 2014 crisis is shown on the left side and 2014–2020 period on the right side.

Due to a large size, other figures of the IRF and the variance decomposition results are shown in the appendix. In the case of EURRUB and CT_EURRUB IRF function, the pattern is the same as in the USDRUB model, but much more volatile and it takes much more periods to stabilize. Also, the variance decomposition results are almost identical. In the case of USDAUD spot rate and CTUSDAUD IRF, only the shock on USDAUD spot on the CT USDAUD had an effect. During the two first days of the 2002–2020 period, the effect was positive. It then decreased to negative values (lowest value in period 3), peaked in period 6 and at the end went down to the negative area. In other words, when USDAUD spot increases, the CT USDAUD also increased during the two first days, then it had the opposite reaction.

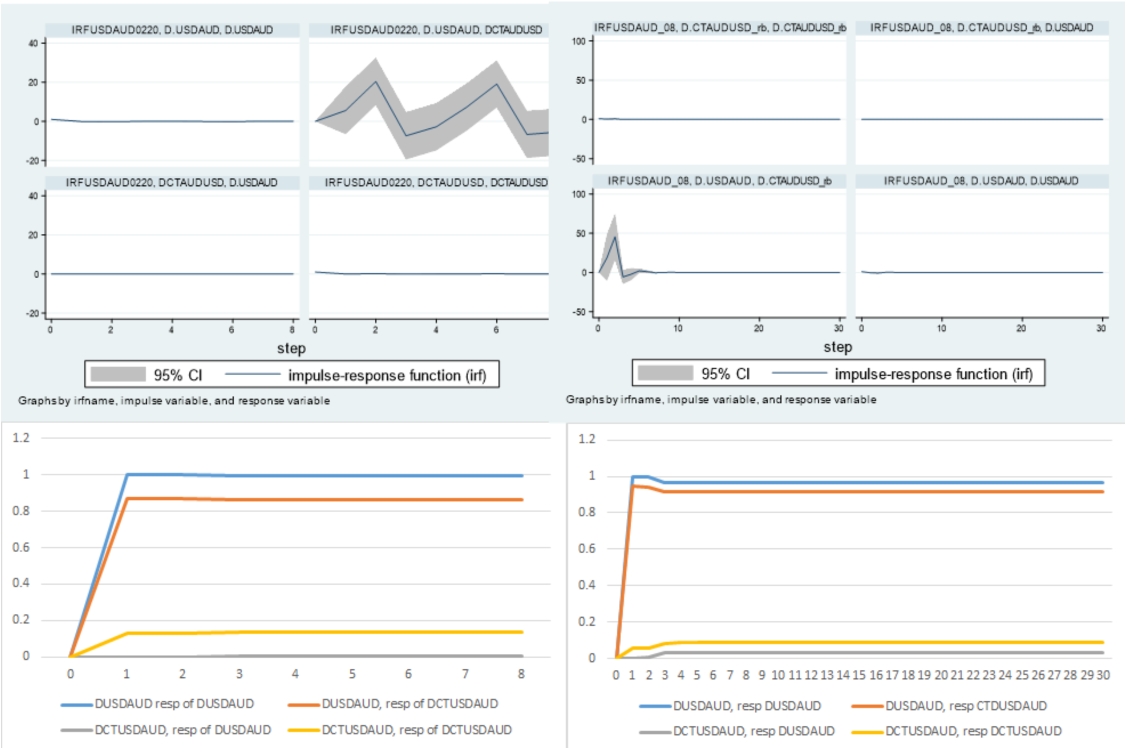

Figure 26 IRF and variance decomposition (bottom) result for USDAUD. 2002–2020 periods are shown on the left side and the financial crisis on the right side.

The financial crisis had a similar movement but less volatile, whereas shocks during the periods of the crisis of 2014 and 2014–2020 on USDAUD spot rates have a negative effect on the CT USDAUD until they reach initial values after 5 days. In other words, when USDAUD spot increases (depreciates), the CT USDRUB will decrease. All other currency pairs' IRF results show a similar pattern as USDAUD, but with different volatility. Compared to USDRUB, USDAUD impulses and responses are less volatile, especially compared to the financial crisis, and have fewer negative periods. Also, the effect of a one-standard-deviation impulse of CT USDRUB or shock on the USDRUB rate is much greater compared to other currencies and especially to USDAUD and JPYAUD where the impulse of carry trade to domestic currency's spot rate is zero. In other words, carry trade has more significant and powerful bidirectional causality on ruble compared to its peers. Thus, variation of carry trade has a significant impact on ruble and vice versa, causing through ruble rate variations other impacts on the macroeconomic indicators

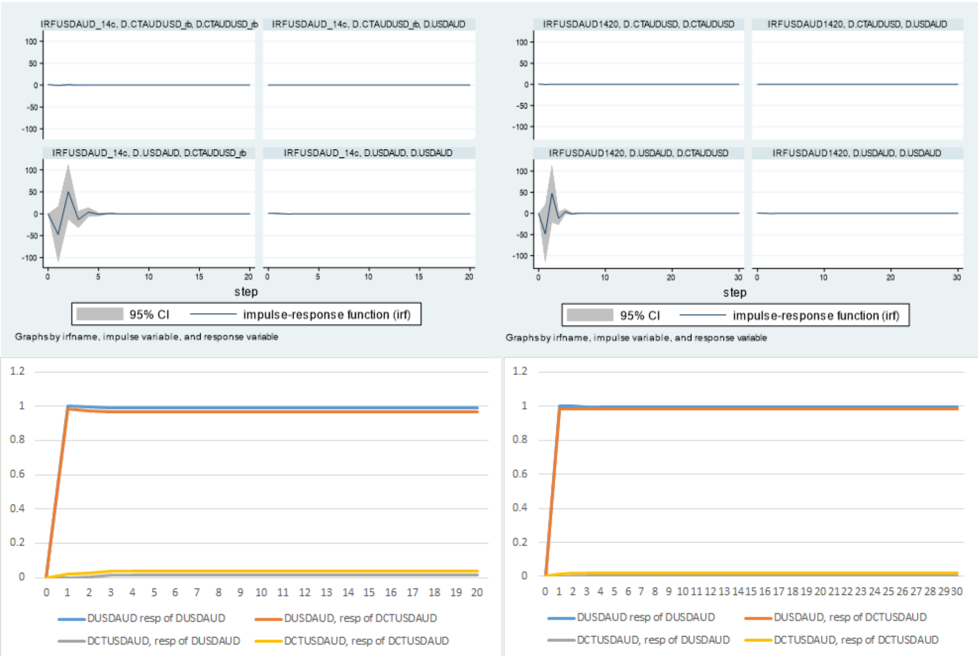

Figure 27 IRF and variance decomposition (bottom) result for USDAUD. 2014 crisis is shown on the left side and 2014–2020 period on the right side.

All other currency pairs' IRF results show a similar pattern as USDAUD, but with different volatility. During the financial crisis, JPYAUD, USDAUD, USDMXN and USDBRL currencies had a positive impact from carry trade for the first days. USDUAD stabilized quite quickly whereas other currencies had relatively high volatility until the complete stabilization. However, during 2014 JPYAUD and USDBRL had a similar effect as in 2008, although BRL was much less volatile. Other currencies experienced a negative impact, like the USDRUB.

5.1.2 *Analysis 2*

The second analysis was made for analysing carry trade and ruble changes and causality on the Russian macroeconomic indicators. In addition, Australian macroeconomic indicators were briefly tested for causality and compared to Russian IRF results. Variables that were included in the model: USDRUB spot exchange rate, USDRUB and EURRUB carry trade returns, inflation, 3-month ruble interbank rates, MOEX10 and Russian export index. For Australia, due to the lack of relevant data only USDAUD spot rate, USDAUD carry trade, 3-month interbank interest rate, GDP and export index were included. The data frequency is monthly, covering the period from 01.01.2002 to 01.12.2019, so the time series length is 216 items. The logarithm of all series was taken here as well. The source for the data is Reuters Eikon, Bloomberg and FRED.

The equations for the VAR models are below:

(13) $$y_t = a_0 + \sum_{i=1}^{p} \mathrm{a}_i\, y_{t-i} + \sum_{i=1}^{p} b_i\, x_{t-i} + \sum_{i=1}^{p} \varphi_i\, \mathrm{z}_{t-i} + \sum_{i=1}^{p} \tau_i\, \mathrm{c}_{t-i} + \sum_{i=1}^{p} \sigma_i\, \mathrm{w}_{t-i} + \sum_{i=1}^{p} \delta_i\, \mathrm{r}_{t-i} + \sum_{i=1}^{p} \delta_i\, \mathrm{b}_{t-i} + \sum_{i=1}^{p} \theta_i\, \mathrm{m}_{t-i} + v_{1t}$$

y_t = [$\mathrm{y}_{1t}, \ldots, y_{mt}$]^T is a vector of observation on the current values of the variables,
a_1 = is a matrix of parameters, vector variables,
a_i = is a matrix of parameters in the lagged variables of vector y_t, where the number of lags is equal to p,
v_t = [$\mathrm{v}_{1t}, \ldots, \mathrm{v}_{mt}$]^T contains vectors of the model equation residuals.

For USDRUB equation, variables that are included in model are USDRUB spot, CT_USDRUB, 3-month-interest rate (RUB3M), GDP, MOEX10, CPI and export index (EXP). For EURRUB equation is the same, but USD is replaced with EUR. All variables are lagged and in first difference order. Similarly, we would have the same equation for Australia with Australian macroindicators (excluding CPI):

(14) $$y_t = a_0 + \sum_{i=1}^{p} \mathrm{a}_i\, y_{t-i} + \sum_{i=1}^{p} b_i\, x_{t-i} + \sum_{i=1}^{p} \varphi_i\, \mathrm{z}_{t-i} + \sum_{i=1}^{p} \tau_i\, \mathrm{c}_{t-i} + \sum_{i=1}^{p} \sigma_i\, \mathrm{w}_{t-i} + \sum_{i=1}^{p} \delta_i\, \mathrm{r}_{t-i} + \sum_{i=1}^{p} \delta_i\, \mathrm{b}_{t-i} + \sum_{i=1}^{p} \theta_i\, \mathrm{m}_{t-i} + v_{1t}$$

Table 2 shows bidirectional and unidirectional Granger causalities on variables included in our USDRUB and EURRUB VAR models. As the tables demonstrate, there is bidirectional causality between USDRUB & CT USDRUB and EURRUB & CT EURRUB even after including several other variables that are closely related to currency pairs. We can also observe that there is a large number of unidirectional causalities between carry trades and macroeconomic variables, for example, CT USDRUB cause export.

Table 2 Granger causality test results for Russian ruble, carry trade and macroeconomic variables. First column shows relation to the variable in the second column. Variables USDRUB & CT USDRUB, 3-month interest rate & MOEX10, GDP & MOEX10, EURRUB & CT EURRUB, EURRUB & MOEX10, MOEX10 & 3-monht interest rate and MOEX10 & GDP have bidirectional granger causality whereas other variables in table have unidirectional causality.

Granger causality results	
Bidirectional causality	
USDRUB & CT USDRUB	
RUB3M & MOEX10	
GDP & MOEX10	
Variable	**Unidirectional causality**
GDP to	USDRUB
GDP to	CT USDRUB
GDP to	RUB3M
USDRUB spot to	EXP
USDRUB spot to	MOEX10
CPI to	USDRUB spot
CPI to	CT USDRUB
CPI to	EXP
RUB3M to	CT USDRUB
RUB3M to	EXP
CT USDRUB to	EXP
MOEX to	EXP

Granger causality results	
Bidirectional causality	
EURRUB & CT EURRUB	
EURRUB & MOEX10	
MOEX10 & RUB3M	
MOEX10 & GDP	
Variable	**Unidirectional causality**
CPI to	CT EURRUB
GDP to	EURRUB spot to
GDP to	RUB3M
MOEX10 to	EURRUB spot
MOEX10 to	RUB3M
CT EURRUB to	EXP
EURRUB spot to	EXP
RUB3M to	EXP
MOEX10 to	EXP
CPI to	EXP
CT EURRUB to	MOEX10
EURRUB spot to	MOEX10

In figure 29, we can see that the greatest responses to a CT USDRUB change within standard deviation are given by the interest rate and export index. The response given by the interest rate to the CT USDRUB rate within standard deviation is negative for 4 months and then it is stable. However, the confidence level interval of the interest rate variable is quite large indicating that the results are not significant. Similarly, CPI has a negative effect for 5 months and then stable, but the confidence level is also not quite significant during the first 5 months. The response given by the export index is positive and peaks during the first month after which it goes down to a negative area for the next two months and stabilizes. The response of MOEX10 is positive for one month and then it is negative for two months. After 5 months it goes to initial values. USDRUB spot rate's response to carry trade is quite powerful and has a negative effect for four months. However, the response given by the GDP to a CT USDRUB rate is around zero. In the case of euro, most variables have the same effect but are more powerful compared to ruble.

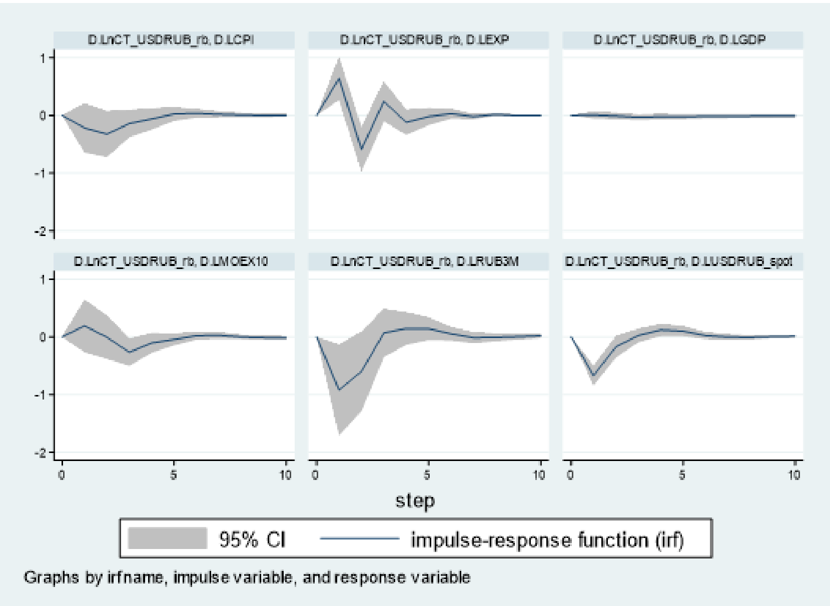

Figure 28 IRF results of macroeconomic indicator responses to USDRUB carry trade

Figure 30 shows EURRUB carry trade IRF results that are quite similar to USDRUB with a few exceptions. First, EURRUB spot rate's response to carry trade is very powerful and has a negative effect for four months. Second, response to MOEX10 is also more powerful and volatile.

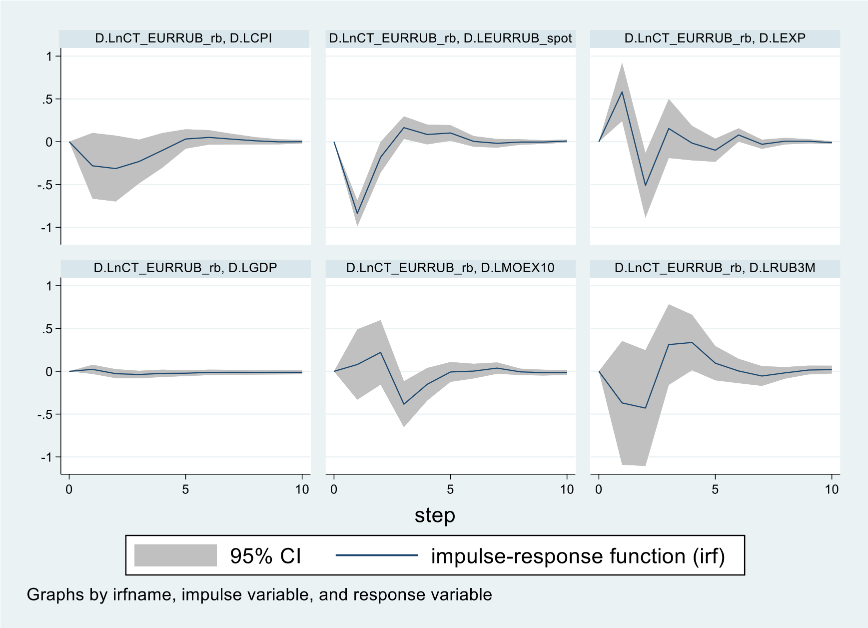

Figure 29 IRF results of macroeconomic indicator responses to EURRUB carry trade

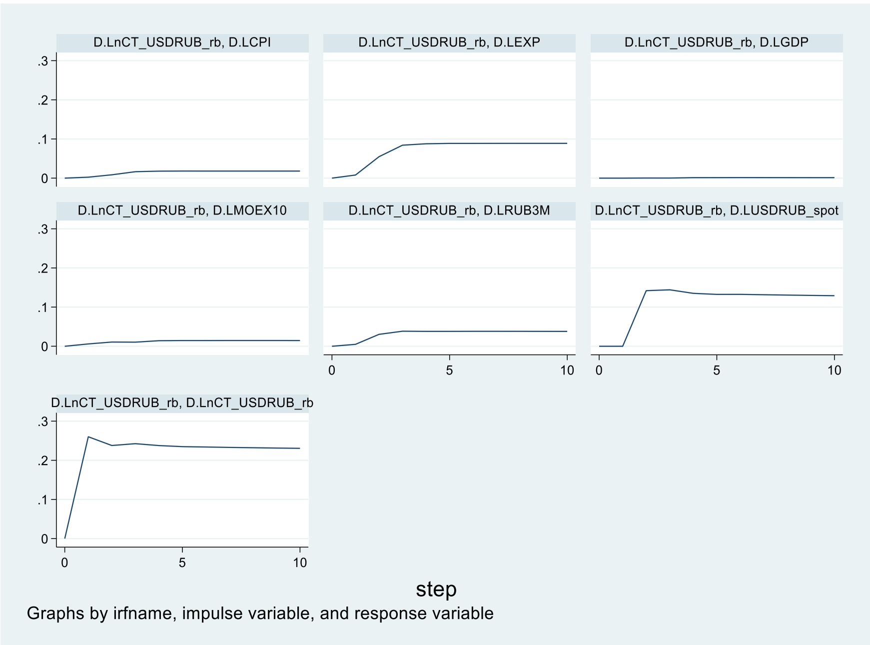

Figure 30 Variance decomposition results of USDRUB carry trade to macroeconomic indicators

Figure 31 shows the results of the variance decomposition, where we can see that the greatest explanatory power for CT USDRUB is CT USDRUB itself as of 25% for the first months, after which it declines and stabilize at a 22% level. The second highest explanatory power for carry trade is USDRUB spot rate that is 15% during the first months and then stabilizes at the 12% level. Other semi-powerful explanatory variables are export to CT USDRUB (9%) and three months interest rate to CT USDRUB (4%). GDP, CPI and MOEX10 have variability of approximately 0%. In the case of euro, only CT EURRUB on itself and EURRUB spot have significant explanatory power that is around 80% and 60% respectively. All other variables have either 0% or near to that variability.

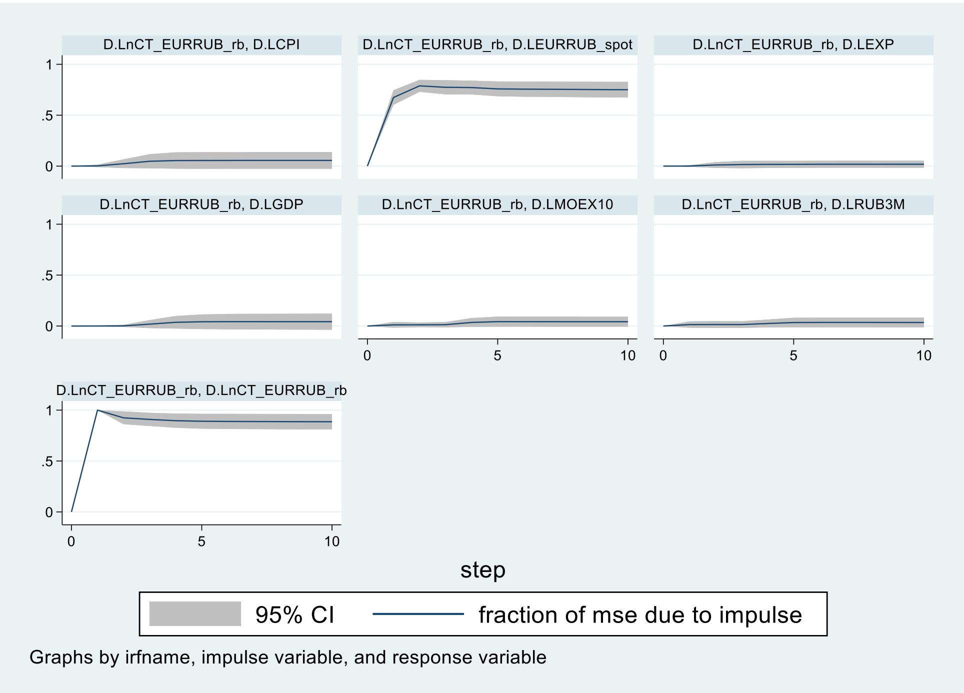

Figure 31 Variance decomposition results of EURRUB carry trade to macroeconomic indicators

In sum, results of Granger causality showed bidirectional causality between USDRUB & CT USDRUB and EURRUB & CT EURRUB meaning that there is still significant causality. Other bidirectional causalities appeared between EURRUB & MOEX10, 3 months ruble interest rate & MOEX10 and GDP & MOEX10. USDRUB and carry trade have unidirectional causalities on export and CPI, GDP and interest rate have causalities on USDRUB and carry trade, meaning that there is significant causality of carry trade changes to variables that have a powerful impact on the Russian overall macroeconomic situation.

According to the impulse-response function performed under the VAR analysis, carry trade shocks within the limits of standard deviation creates various effects on macroeconomic variables. The greatest response can be observed in interest rates, however not significant due to the wide confidence intervals. When carry trade increases the interest rate decreases in the first two-three months and stabilises after 4–5 months. Other significant effects are related to export, where the increase of CT USDRUB increases export for the first month and then goes to the negative area for two months. After the fifth month, it reaches initial values. This means that Russian export reacts negatively to increased carry trade with lags of a couple of months. Also, CT USDRUB has a negative impact on CPI and USDRUB spot rate, where those variables are in a negative area for the first 4 months and stabilize. In other words, increasing carry trade appreciates ruble for four months. Carry trade activity is also higher when inflation goes down. IRF results also show that ruble carry trade has a more powerful impact on the domestic currency and vice versa compared to other countries, meaning that ruble is more volatile to carry trade, especially after 2014.

Table 3 Granger causality test results. Australian dollar, carry trade and macroeconomic variables

Granger causality results		
Bidirectional causality		
EXP & CT USDAUD		
Variable	**Unidirectional causality**	**Significance**
USDAUD spot to	CT USDAUD	0.000
USDAUD spot to	GDP	0.000
EXP to	GDP	0.086
CT USDAUD	Interest rate	0.006

Table 3 shows that export index and USDAUD carry trade have bidirectional granger causality, meaning that they cause each other. Another causality to the macroeconomic indicator that carry trade have is the unidirectional causality of USDAUD carry trade to the interest rate. Comparing IRF results of CT USDAUD to Australian macroeconomic indicators, USDAUD spot rate has the greatest impact, which is negative for 3 periods. The interest rate was significant in the case of Australia, and the response of the 3-month interest rate to USDAUD carry trade is positive for the first period. It then fluctuates for 9 months and stabilizes. The result of interest rate IRF means that when the interest rates increase, USDAUD carry trade also increases due to the increased interest rate differentials. Response from the export index is much less volatile, powerful and significant compared to the Russian export index response. Response of GDP is also zero.

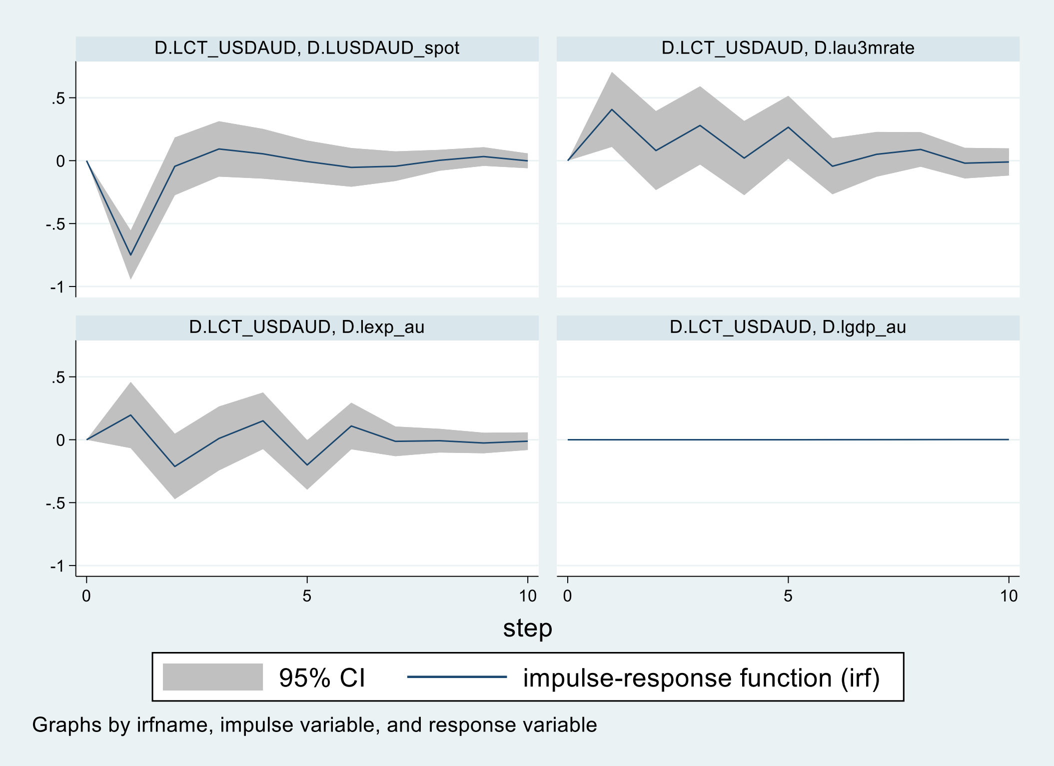

Figure 32 IRF results. Responses of Australian macroeconomic indicators to USDAUD carry trade

In the case of response to USDAUD spot rate, carry trade has the greatest impact, which is negative for the first month and then peaks at the second month. The effect goes up and down until it is stable after 10 months. The export index has also a powerful impact, which is positive for the first month and then goes down to the negative area for the next 3 months. It then stabilizes after 10 months. The interest rate has also a positive impact for the first month, but it is not as significant as in the previous IRF related to USDAUD carry trade. GPD is also zero.

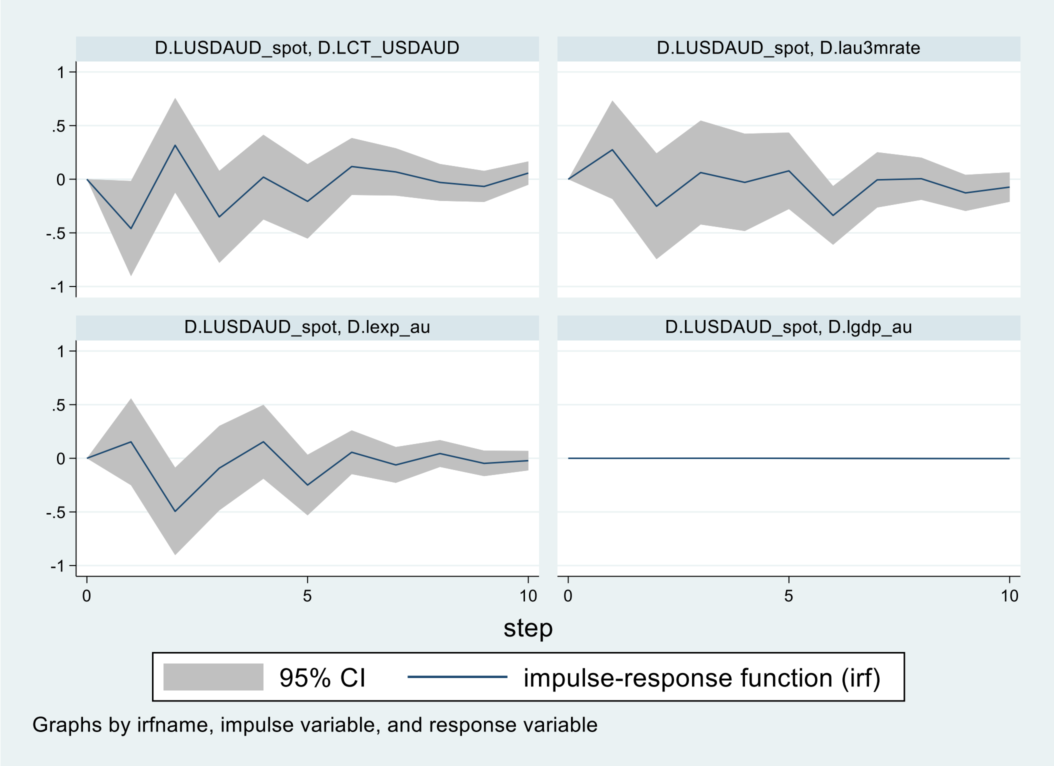

Figure 33 IRF results. Responses of Australian macroeconomic indicators to USDAUD spot rate

From figure 35 we can see that USDAUD spot rate has the greatest explanation power as of 18%, where the 3-months interest rate has second greatest variability (4%) and export index third greatest variability (4%). GDP's explanation power is zero percent.

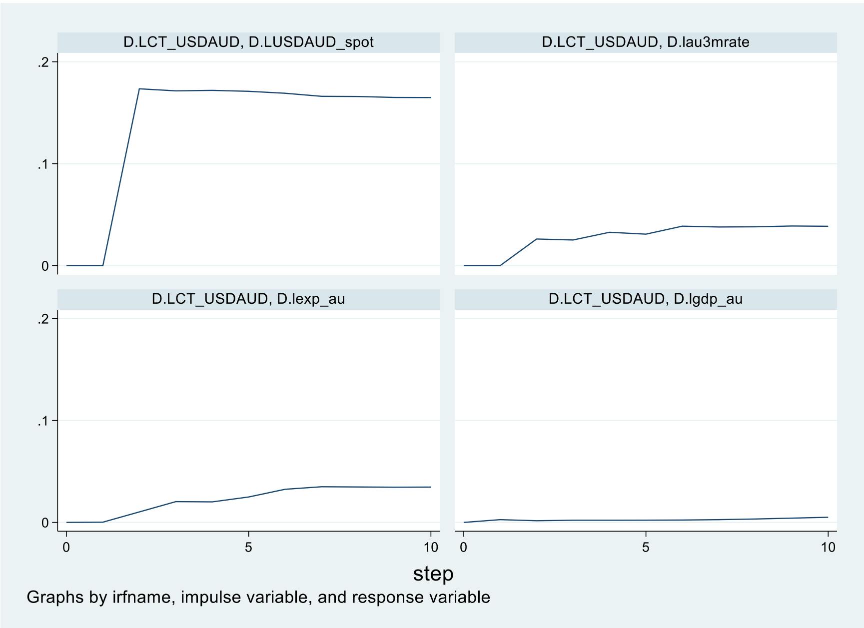

Figure 34 Variance decomposition results of USDAUD carry trade to macroeconomic indicators

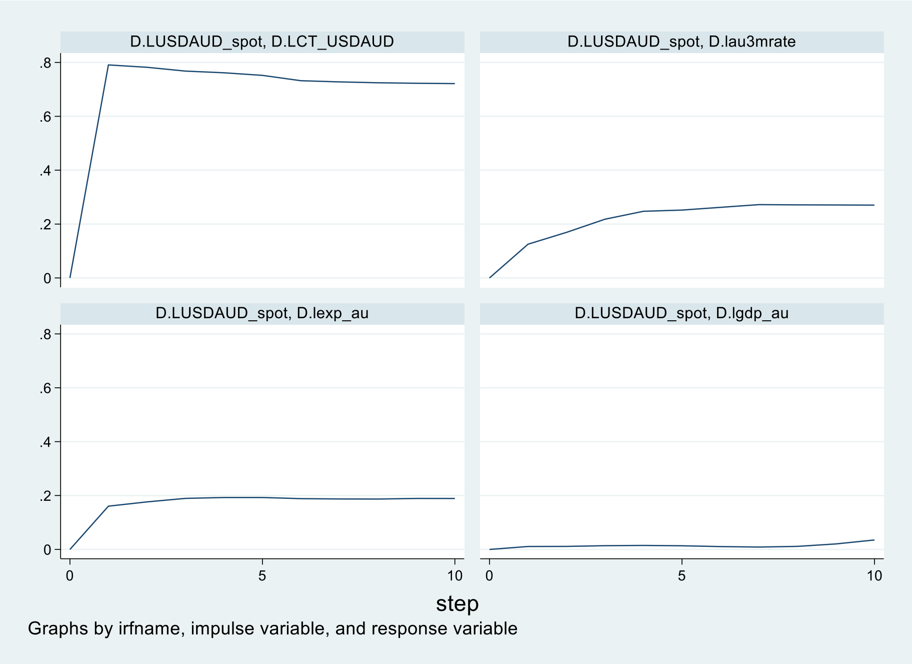

Figure 35 Variance decomposition result of USDAUD spot rate to macroeconomic indicators

Figure 36 shows that the greatest explanatory power for USDAUD spot rate is USDAUD carry trade (78%). The interest rate's variability is 22% whereas export index variability is 20%.

5.1.3 Analysis 3

In the last VAR model analysis, we will explore the impacts and causality of variation of the non-resident on Russian ruble (unwinding) and USDRUB carry trade. In this VAR model, we use the same variables as in the previous regression, despite the share of non-residents variable which is the share of foreign investors in the Russian government's OFZ bonds. We also took the natural logarithm of all series. The data frequency is monthly, covering the period from 30.01.2014 to 30.12.2020, so the time series length is 84 items. The source for the data is Reuters Eikon, Bloomberg (carry trade) and CBR.

Equation's parameters Non_res, CT_USDRUB, USDRUB_spot express respectively share of non-residents in OFZ, USDRUB carry trade and USDRUB spot exchange rate. The term L express the natural logarithm of these variables and D is the first difference order of variables.

(15)

$$D.LUSDRUB\_spot_t = \beta_0 + \sum_{i=1}^{r} a_i D.LNon\_res_{t-i} \sum_{i=1}^{r} \varphi_i D.LUSDRUB\_spot_{t-i} + e_{2t}$$

$$D.LNon\_res_t = a_0 + \sum_{i=1}^{r} a_i D.LNon\_res_{t-i} + \sum_{i=1}^{r} \varphi_i D.LUSDRUB\_spot_{t-i} + e_{1t}$$

(16)

$$D.LNon\_res_t = a_0 + \sum_{i=1}^{r} a_i D.LNon\_res_{t-i} + \sum_{i=1}^{r} \omega_i D.LCT\_USDRUB_{t-i} + e_{1t}$$

$$D.LCT\_USDRUB_t = \beta_0 + \sum_{i=1}^{r} a_i D.LNon\_res_{t-i} + \sum_{i=1}^{r} \omega_i D.LCT\_USDRUB_{t-i} + e_{2t}$$

Table 4 demonstrates that there is unidirectional causality between CT USDRUB & share of non-residents (non-residents from this moment) and USDRUB spot rate to non-residents.

Table 4 Granger causality test results for USDRUB, CT USDRUB and non-residents

Granger causality results		
Variable	**Unidirectional causality**	**Significance**
USDRUB to	Non-Residents	0.001
CT USDRUB to	Non-Residents	0.000

Figure 37 shows IRF results of the share of non-residents impulses to the relevant carry trade and USDRUB spot rates. The greatest impacts are the impacts of the variables on themselves. However, we can observe a significant positive effect of carry trade to share of non-residents, meaning that carry trade increases the share of non-residents. The effect stabilizes after 4 months. The impact of non-residents on carry trade is not significant. In the case of USDRUB, the share of non-residents decreases when USDRUB increases (depreciates), meaning that current circumstances are not that attractive. Effect of non-residents on USDRUB rate is negative after the first month, meaning that the increasing share of foreign investors appreciates ruble rate.

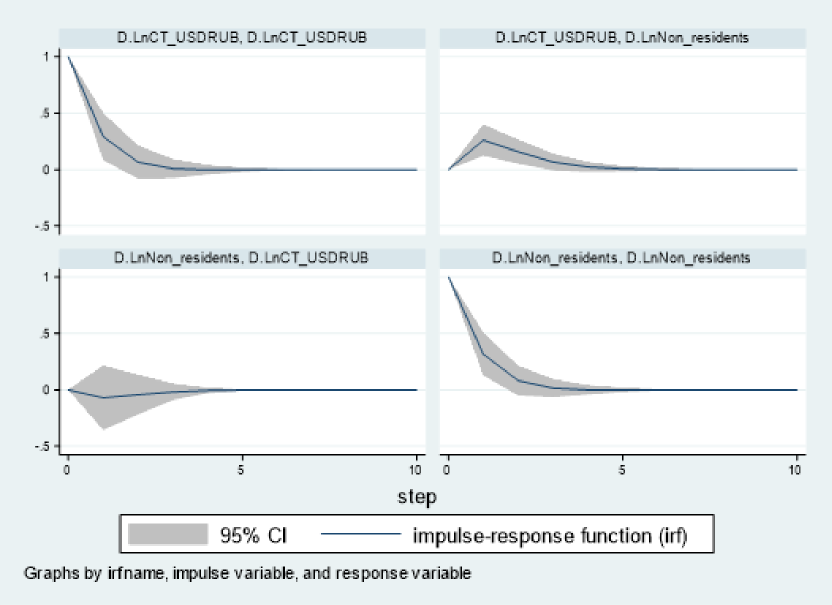

Figure 36 IRF results of CT USDRUB and share of non-residents

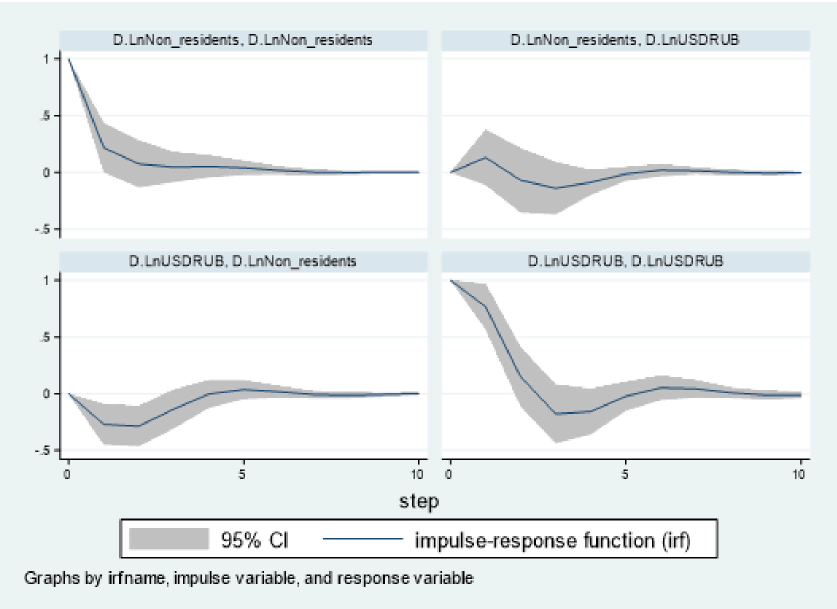

Figure 37 IRF results of USDRUB and share of non-residents

The variance decomposition analysis that is shown in figure 40, shows that the greatest explanatory power is also on the variables themselves. Explanatory power for carry trade to non-residents is around 20%. Variability of non-residents to carry trade is not significant. Explanatory power for USDRUB to non-residents is around 20%, but the intervals of confidence level are quite wide. Explanatory power for non-residents to USDRUB is around 0%.

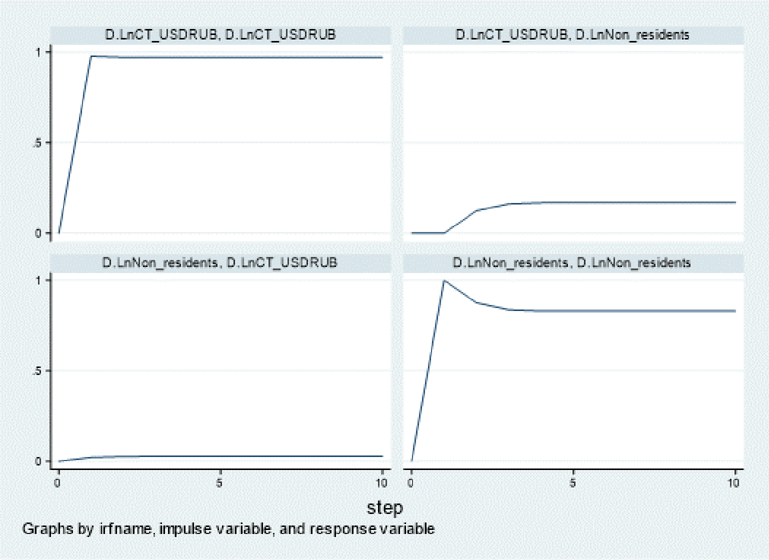

Figure 38 Variance decomposition results of CT USDRUB and share of non-residents

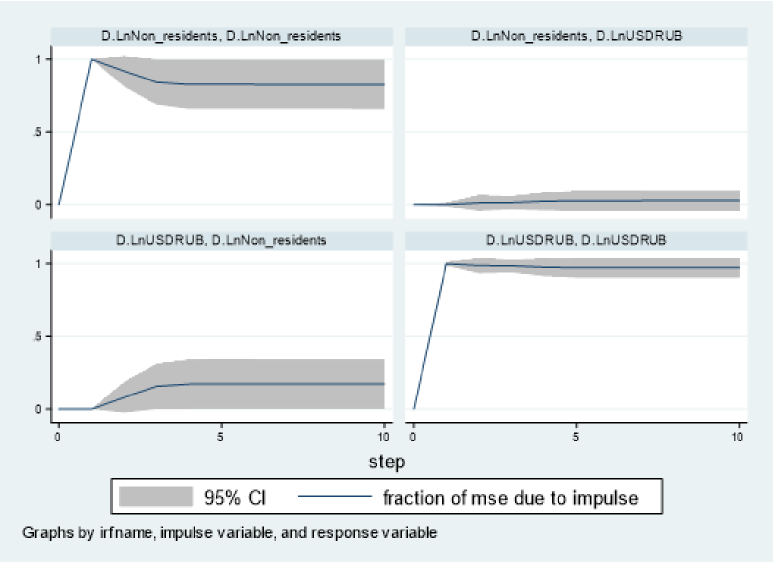

Figure 39 Variance decomposition results of USDRUB and share of non-residents

Results show that there is unidirectional Granger causality of non-residents to ruble and carry trade. As IRF results show when a share of non-residents increases, ruble decrease or appreciates and carry trade increases. Hence, when the massive unwinding occurs and ruble goes down, we can assume that part of this unwinding is due to the carry trade. Due to the lack of relevant data, we couldn't provide similar econometric analysis for Australia.

Overall, carry trade played a substantial role as Russian new monetary policy generated attractive circumstances for carry traders, where ruble was overvalued and stable, the inflation rate was also stable and the interest rate high. Increased carry trade boosted ruble and interest rate differential even further, thus amplifying the challenges related to the export and manufacturing sector. As a result, the Russian economy was characterized in the middle of the 2000s as a commodity economy due to its high dependency on the oil & gas sector and small manufacturing sector, leading to a situation where almost everything (excluding raw resources) was imported. Also, increased speculative capital inflow bid up asset prices and their demand, but on the other hand, raises volatility. Eventually, the bubble which growth was boosted by carry trade collapsed, causing a massive capital outflow and devaluation of ruble. Although a high-interest rate attracts speculative capital and may cause massive unwind during the crash, there is also a positive impact. After the crash, a fairly high-interest rate bring foreign investors to take advantage of extremely risky arbitrage opportunities, leading to a domestic currency stabilization in the short term.

In 2014, due to the increased political risks, Western countries imposed sanctions against Russia that added new concerns that raised volatility. As a result, a combination of declined oil prices and political risks triggered once again the bubble that was amplified by carry trade. Even a small proportion of carry trade is a problem for consumers and entrepreneurs, because increased speculative capital inflow raises the cost of loans, leading to increased prices of consumer goods. It also affects the budget, for example, in case of the increased carry trade, the Ministry of Finance of the Russian Federation should pay higher coupons, which forces the government to find another way of financing a budget deficit.

Although ruble strengthened rapidly in 2017, foreign investors are not considering Russia as a strong economy, due to its high sensitivity to shocks. Without the active interventions and actions of the Central Bank of Russia, even small volatility could surge inflation rate over 10% as it was at the beginning of 2000, causing massive unwind of OFZ's and other instruments where non-residents are.

Russian governmental policies affect substantially on carry trade activity and its impacts on the Russian economy. Compared to Australia, the Central Bank of Russia is not independent and it makes decisions based on what is beneficial for the elite of the Russian establishment. Hence, keeping ruble stable and overvalued by huge interventions was very important for the government, while oil prices plunge and the economy is in the downturn. A stable and strong ruble creates an illusion for Russian citizens' that economy is doing good and there is no crisis coming on.

6 CONCLUSIONS

The purpose of this study was to,

- Identify carry trade activity and estimate its potential amount in resource-rich countries, concentrating mainly on Russian and Australian economy
- Identify and explain possible impacts of carry trade on Russian, Mexican and Australian macroeconomy
- Compare the economic performance of those resource-rich countries to each other by analysing through the crisis of 2008 and 2014 and statistically analyze and prove that:
  - Carry trade has Granger causality on the Russian ruble and the impact is more powerful compared to other currencies, especially after 2014
  - Carry trade has Granger causality on Australian dollar, Brazilian real and Mexican peso
  - Carry trade's volatility of ruble, peso and real is higher compared to Australian dollar
  - Russian ruble and carry trade have common Granger causality and impact on macroeconomic indicators
  - Share of non-residents and carry trade have positive granger causality and are related to ruble appreciation/depreciation

The study methods were a literature review on carry trade both from its theoretical and macroeconomic side and an empirical study. Russian, Mexican, Brazilian and Australian macroeconomic indicators were analysed from carry trade perspective and compared to each other. In addition to that, a large econometrical analysis was performed to indicate Granger causality between currencies and carry trade. Results showed that there is significant Granger causality and carry trade has a statistically significant impact on ruble appreciation/depreciation and through that on the macroeconomic indicators as well.

After the introduction, carry trade mechanics and its linkage to the macroeconomy were examined. In the carry trade mechanics chapter, UIP and CIP, which are two relevant parity equilibrium models for carry trade, were examined. UIP suggests that the exchange rate of the high-interest rate currency is expected to depreciate, thus closing any arbitrage opportunities (in respect to the low-interest rate currency) from investing in that currency. Hence, if UIP holds, then estimated changes in the exchange rate would offset the interest rate differential, causing excess returns to be zero. The second equilibrium model CIP, states that the interest rate differential between a low yielding and high yielding currency would be the same as the spread between the forward and spot exchange rates of the two currencies. This spread would be the expected change in the exchange rate with a risk premium. We have demonstrated in chapter two that according to numerous empirical evidence, UIP usually fails to mean that carry trade transactions yield positive returns. According to Fama (1894) and Hodrick (1980), investors may earn excess returns just by going short in a low-interest rate currency portfolio and going long in a high-interest rate currency portfolio.

In chapter 3, the linkage of carry trade to the macroeconomy and its practical examples has been examined through the classic JPY/AUD strategy. Interest rate differentials, political risks, institutions, central banks and capital inflow have been identified as driving forces behind the carry trade activity and its outcome on the macroeconomy. By implementing reasonable governmental policies, the target country could take advantage of carry trade speculative capital inflow, or at least mitigate the risks. For that, it must have effective institutions (i.e., independent central bank and efficient financial markets), low corruption, stable and strong economy. The concrete tools for it are macroeconomic policies, foreign reserve accumulation and macroprudential regulation and supervision. This is the main reason why Australia has not suffered from a very attractive carry trade. In contrast, for Russia and Mexico, the outcome of massive carry trade has been mainly negative. Both countries are developing countries, where institutions are not efficient, corruption is high, and the economy is very sensitive to shocks.

VAR model showed Granger causality of carry trade to all domestic currencies, Russian macroeconomic indicators and Australian macroeconomic indicators. IRF and variance decomposition showed the direction and power of variables. However, when observing various periods, not all currencies had Granger causality, expect ruble that was significant through whole observation period as well as through both crises. From the IRF results we observed that carry trade has greater and more negative effect on the Russian export compared to Australian. In addition, in the case of Russia we managed to demonstrate through the IRF that carry trade increases share of foreign investors, thus increasing speculative capital. Hence, increasing carry trade appreciates domestic currency and makes export less competitive. When the volatility increases, foreign investors start to unwind positions and causing possible mass-selling. In the case of Australia, export index did not experience same effects from growing carry trade, and thus suffers less from speculative trading.

When we compared Russian, Mexican, Brazilian and Australian economies by macroeconomic indicators on which carry trade have exposure, we noticed that Australia outperformed all three countries by all metrics. Russia and Mexico were the most volatile whereas Brazil's performance was moderate. The main observed impacts of carry trade on resource-rich countries were: appreciation of domestic currency despite the bad fundamentals, decreasing competitiveness level thus hampering export sector and increasing import, widening of interest rate differential, attracting massively short-term speculative capital and bid up asset prices. If the economy is unstable and sensitive to shocks, then the risk for sudden stops followed by a massive crash is very likely. All those negative impacts could be mitigated by a reasonable government and monetary policies that require efficient institutions and a stable economy. However, there is also good impacts of carry trade from which resource-rich country with a stable economy and efficient institutions could benefit. Strengthening domestic currency is lowering the inflation rate and making imported goods cheaper. It is quite typical for resource-rich countries to import most of the consumer goods. Hence, appreciating currency increases purchasing power, leading to improved welfare. Also, during the high volatility, in the short-term carry traders will adjust inefficiencies by seeking arbitrage opportunities.

In theory, high-interest rates in a certain economy are a sign of high inflation and an uncompetitive economy, in which domestic currency is devaluating. Interest rate differential reflects the magnitude of currency devaluation of a high-interest rate country against a low-interest rate country (UIP). However, in practice, interest rate adjustments do not follow the UIP, thus creating arbitrage opportunities for speculative investors. Speculators, who are “searching for a yield”, are ready to take high risks despite the bad fundamentals of a target country. By that, speculators who exercise carry trade transactions by investing money in a country with high-interest rates and bad economic fundamentals, tend to appreciate currency, which enhances economic fundamentals. As a result, carry trade creates a false picture of a country’s economic situation. Sufficient speculative capital generated by carry trade could have various impacts on the macroeconomy of a specific country. Those impacts could be good or bad, depending on a specific country’s monetary policy’s purpose and targets. Also, the political (sanctions) and economic (commodity shocks) stability, as well as effectiveness of institutions, play a major role in the outcome of carry trade transactions. In authoritarian and corrupt regimes, the government’s elite is closely related to the country’s export of commodities due to self-enrichment purposes. In that case, the elite’s target is to protect and enhance massive returns from the commodity sector by forcing the country’s central bank and other financial institutions to devaluate the domestic currency. As a result, it will decrease returns and volume of carry traders and similarly increase the overall wealth of the elite and other stakeholders who are closely related to commodity export. Thus, this is one of the main reasons why the welfare gap between developing and developed countries is that massive.

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APPENDIX

Appendix 1. Descriptive statistics of analysis 1 varibales, time-series data from 2002 to 2020

Variable	Obs	Mean	Std. Dev.	Min	Max
USDRUB	4,697	39.09476	15.29613	23.1531	82.3675
EURRUB	4,697	47.43335	15.61247	26.36	90.1766
JPYAUD	4,697	1.208641	.137315	.9274	1.7922
USDAUD	4,697	1.276795	.2189454	.9074	1.9736
USDMXN	4,695	13.63372	3.241749	9.002	21.9555
USDBRL	4,697	2.602032	.7397398	1.5391	4.2592
CTUSDRUB	4,697	138.1481	20.80601	85.088	177.8997
CTEURRUB	4,697	92.93988	9.34417	55.4486	116.5425
CTAUDUSD	4,697	207.6333	47.90013	99.6544	293.5093
CTAUDJPY	4,697	177.7393	36.13177	96.0599	242.6403
CTMXN	4,697	104.3588	10.22639	77.2262	127.3442
CTBRL	4,697	274.903	100.0528	65.0332	437.2473

	USDRUB	EURRUB	JPYAUD	USDAUD	USDMXN	USDBRL	CTUSDRUB	CTEURRUB	CTAUDUSD	CTAUDJPY	CTMXN	CTBRL
USDRUB	1.0000											
EURRUB	0.9721	1.0000										
JPYAUD	0.0442	-0.0696	1.0000									
USDAUD	0.2260	0.0385	0.6470	1.0000								
USDMXN	0.9211	0.9413	0.0349	0.0199	1.0000							
USDBRL	0.8035	0.6992	0.3025	0.6093	0.6628	1.0000						
CTUSDRUB	-0.3593	-0.1949	-0.4169	-0.8366	-0.0759	-0.6110	1.0000					
CTEURRUB	0.0101	0.0059	-0.0104	-0.2319	0.2018	-0.0692	0.6124	1.0000				
CTAUDUSD	0.2041	0.3591	-0.5334	-0.8570	0.3787	-0.2623	0.7456	0.4324	1.0000			
CTAUDJPY	0.4958	0.6200	-0.7319	-0.5880	0.5671	0.0613	0.4328	0.2499	0.7991	1.0000		
CTMXN	-0.4883	-0.3678	-0.5676	-0.6771	-0.4417	-0.6950	0.7350	0.3356	0.5302	0.3625	1.0000	
CTBRL	0.3109	0.4635	-0.4165	-0.7398	0.5133	-0.2252	0.6966	0.4638	0.9278	0.7987	0.4352	1.0000

Appendix 2. Descriptive statistics of analysis 1 variables, time-series data for the financial crisis

```
. corr USDRUB EURRUB USDAUD JPYAUD USDMXN USDBRL
(obs=284)
```

	USDRUB	EURRUB	USDAUD	JPYAUD	USDMXN	USDBRL
USDRUB	1.0000					
EURRUB	0.6272	1.0000				
USDAUD	0.8542	0.1894	1.0000			
JPYAUD	0.8915	0.3279	0.9797	1.0000		
USDMXN	0.9014	0.3745	0.9464	0.9768	1.0000	
USDBRL	0.8590	0.2846	0.9628	0.9781	0.9753	1.0000

```
. corr USDRUB EURRUB USDAUD JPYAUD USDMXN USDBRL CTUSDRUB_rb CTEURRUB_rb CTAUDUSD_rb CTAUDJPY_rb CTMXN_rb CTBRL_rb
(obs=284)
```

	USDRUB	EURRUB	USDAUD	JPYAUD	USDMXN	USDBRL	CTUSDR~b	CTEURR~b	CTAUDU~b	CTAUDJ~b	CTMXN_rb	CTBRL_rb
USDRUB	1.0000											
EURRUB	0.6272	1.0000										
USDAUD	0.8542	0.1894	1.0000									
JPYAUD	0.8915	0.3279	0.9797	1.0000								
USDMXN	0.9014	0.3745	0.9464	0.9768	1.0000							
USDBRL	0.8590	0.2846	0.9628	0.9781	0.9753	1.0000						
CTUSDRUB_rb	-0.9602	-0.4487	-0.8853	-0.8774	-0.8853	-0.8606	1.0000					
CTEURRUB_rb	-0.0030	-0.7490	0.4575	0.3414	0.2902	0.3707	-0.1373	1.0000				
CTAUDUSD_rb	-0.8488	-0.1728	-0.9935	-0.9667	-0.9379	-0.9603	0.8985	-0.4615	1.0000			
CTAUDJPY_rb	-0.8780	-0.2979	-0.9777	-0.9932	-0.9742	-0.9819	0.8822	-0.3586	0.9762	1.0000		
CTMXN_rb	-0.8563	-0.3133	-0.9207	-0.9482	-0.9871	-0.9640	0.8628	-0.3274	0.9236	0.9589	1.0000	
CTBRL_rb	-0.8035	-0.2120	-0.9234	-0.9328	-0.9482	-0.9763	0.8394	-0.4036	0.9389	0.9566	0.9706	1.0000

Appendix 3. Descriptive statistics of analysis 1 variables, time-series data for the crisis of 2014

```
. corr USDRUB EURRUB USDAUD JPYAUD USDMXN USDBRL
(obs=282)
```

	USDRUB	EURRUB	USDAUD	JPYAUD	USDMXN	USDBRL
USDRUB	1.0000					
EURRUB	0.9519	1.0000				
USDAUD	0.8701	0.7328	1.0000			
JPYAUD	0.2786	0.1723	0.4498	1.0000		
USDMXN	0.8354	0.6923	0.9742	0.4064	1.0000	
USDBRL	0.7255	0.5520	0.9496	0.4147	0.9537	1.0000

```
. corr USDRUB EURRUB USDAUD JPYAUD USDMXN USDBRL CTUSDRUB_rb CTEURRUB_rb CTAUDUSD_rb CTAUDJPY_rb
> CTMXN_rb CTBRL_rb
(obs=282)
```

	USDRUB	EURRUB	USDAUD	JPYAUD	USDMXN	USDBRL	CTUSDR~b	CTEURR~b	CTAUDU~b
USDRUB	1.0000								
EURRUB	0.9519	1.0000							
USDAUD	0.8701	0.7328	1.0000						
JPYAUD	0.2786	0.1723	0.4498	1.0000					
USDMXN	0.8354	0.6923	0.9742	0.4064	1.0000				
USDBRL	0.7255	0.5520	0.9496	0.4147	0.9537	1.0000			
CTUSDRUB_rb	-0.9887	-0.9534	-0.8521	-0.1969	-0.8069	-0.7062	1.0000		
CTEURRUB_rb	-0.9005	-0.9798	-0.6251	-0.0695	-0.5701	-0.4300	0.9203	1.0000	
CTAUDUSD_rb	-0.8836	-0.7540	-0.9985	-0.4325	-0.9676	-0.9389	0.8709	0.6532	1.0000
CTAUDJPY_rb	-0.0368	0.0207	-0.1535	-0.9475	-0.1083	-0.1158	-0.0462	-0.0886	0.1379
CTMXN_rb	-0.8552	-0.7198	-0.9761	-0.4032	-0.9988	-0.9454	0.8290	0.6029	0.9716
CTBRL_rb	-0.7506	-0.5894	-0.9536	-0.4058	-0.9464	-0.9936	0.7403	0.4805	0.9478

	CTAUDJ~b	CTMXN_rb	CTBRL_rb
CTAUDJPY_rb	1.0000		
CTMXN_rb	0.1078	1.0000	
CTBRL_rb	0.1117	0.9425	1.0000

```
. sum EURRUB JPYAUD USDAUD USDMXN USDBRL CTUSDRUB_rb CTEURRUB_rb CTAUDUSD_rb CTAUDJPY_rb CTMXN_rb
>  CTBRL_rb
```

Variable	Obs	Mean	Std. Dev.	Min	Max
EURRUB	282	58.21918	9.654954	45.8825	85.7125
JPYAUD	282	1.047199	.0257688	.979	1.1022
USDAUD	282	1.191639	.0912152	1.053	1.3176
USDMXN	282	14.21746	.9558636	12.8665	15.7389
USDBRL	282	2.654285	.3398663	2.1937	3.292
CTUSDRUB_rb	282	79.93766	15.25942	51.23524	104.7536
CTEURRUB_rb	282	88.55696	11.96243	55.29676	104.1166
CTAUDUSD_rb	282	92.47687	6.530629	83.75853	102.9254
CTAUDJPY_rb	282	102.3515	2.43051	97.71987	109.2756
CTMXN_rb	282	92.33406	5.617889	84.09866	100.3961
CTBRL_rb	282	92.03105	8.638855	75.34138	104.6206

Appendix 4. Descriptive statistics of analysis 1 variables, time-series data from 2014 to 2020

. corr USDRUB EURRUB JPYAUD USDAUD USDMXN USDBRL
(obs=1,436)

	USDRUB	EURRUB	JPYAUD	USDAUD	USDMXN	USDBRL
USDRUB	1.0000					
EURRUB	0.9434	1.0000				
JPYAUD	0.6053	0.5619	1.0000			
USDAUD	0.8162	0.6932	0.7874	1.0000		
USDMXN	0.6254	0.5606	0.7575	0.6935	1.0000	
USDBRL	0.8027	0.7506	0.7596	0.9253	0.6719	1.0000

. corr USDRUB EURRUB JPYAUD USDAUD USDMXN USDBRL CTUSDRUB_rb CTEURRUB_rb CTAUDUSD_rb CTAUDJPY_rb CTMXN_rb CTBRL_rb
(obs=1,436)

	USDRUB	EURRUB	JPYAUD	USDAUD	USDMXN	USDBRL	CTUSDR~b	CTEURR~b	CTAUDU~b	CTAUDJ~b	CTMXN_rb	CTBRL_rb
USDRUB	1.0000											
EURRUB	0.9434	1.0000										
JPYAUD	0.6053	0.5619	1.0000									
USDAUD	0.8162	0.6932	0.7874	1.0000								
USDMXN	0.6254	0.5606	0.7575	0.6935	1.0000							
USDBRL	0.8027	0.7506	0.7596	0.9253	0.6719	1.0000						
CTUSDRUB_rb	-0.6486	-0.5593	0.0610	-0.3041	0.0582	-0.2365	1.0000					
CTEURRUB_rb	-0.3224	-0.3457	0.3836	0.1259	0.3902	0.1155	0.8763	1.0000				
CTAUDUSD_rb	-0.8201	-0.6814	-0.7154	-0.9883	-0.6027	-0.8951	0.4088	-0.0217	1.0000			
CTAUDJPY_rb	-0.6242	-0.5535	-0.9605	-0.7379	-0.6876	-0.6917	0.0917	-0.2042	0.6832	1.0000		
CTMXN_rb	-0.6308	-0.5083	-0.4263	-0.4844	-0.8012	-0.4218	0.3343	0.0790	0.4445	0.4982	1.0000	
CTBRL_rb	-0.5641	-0.4578	-0.1250	-0.5181	0.0704	-0.5545	0.7527	0.5802	0.6123	0.2211	0.0970	1.0000

. sum USDRUB EURRUB USDAUD JPYAUD USDMXN USDBRL CTUSDRUB_rb CTEURRUB_rb CTAUDUSD_rb CTAUDJPY_rb CTMXN_rb CTBRL_rb

Variable	Obs	Mean	Std. Dev.	Min	Max
USDRUB	1,437	60.88446	7.995314	33.9233	82.3675
EURRUB	1,437	69.30973	7.751431	46.281	90.1766
USDAUD	1,437	1.331343	.0900189	1.053	1.4917
JPYAUD	1,437	1.191012	.0947771	.979	1.4066
USDMXN	1,436	17.94352	2.018647	12.9168	21.9555
USDBRL	1,437	3.421036	.4860505	2.2018	4.2592
CTUSDRUB_rb	1,437	75.50752	9.85986	49.82678	101.2708
CTEURRUB_rb	1,437	91.66813	11.69991	54.37331	114.2825
CTAUDUSD_rb	1,437	82.44243	5.338591	73.5248	100
CTAUDJPY_rb	1,437	92.20869	5.533844	80.50442	107.0355
CTMXN_rb	1,437	80.51187	7.220476	63.40556	100.2978
CTBRL_rb	1,437	86.01125	9.446589	60.80823	101.6584

Appendix 5. Descriptive statistics of analysis 2 variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Nonresidents	84	1777.94	766.0124	815	3213
USDRUB	84	60.65734	10.91818	33.76984	77.5887
CT	84	91.54445	10.66792	63.8517	111.4084

Appendix 6. Descriptive statistics of analysis 3 variables

```
. sum USDRUBSPOT CTUSDRUB_rb RUB3M GDP EXP MOEX10 CPI
```

Variable	Obs	Mean	Std. Dev.	Min	Max
USDRUBSPOT	216	39.09381	15.31216	23.34946	77.17899
CTUSDRUB_rb	216	138.3234	20.81921	91.7156	177.447
RUB3M	216	7.940773	4.050824	2.815909	24.60227
GDP	216	100.083	1.280598	97.1821	104.3744
EXPORTindex	216	167.2696	17.06811	128.1508	212.358
MOEX10	216	2907.07	1297.688	474.9162	5229.202
CPI	216	9.237963	4.08166	2.2	19

	USDRU~OT	CTUSDR~b	RUB3M	GDP	EXPORT~x	MOEX10	CPI
USDRUBSPOT	1.0000						
CTUSDRUB_rb	-0.3545	1.0000					
RUB3M	0.3482	-0.4062	1.0000				
GDP	-0.1918	0.2665	-0.2003	1.0000			
EXPORTindex	-0.1835	-0.3001	-0.2510	-0.0840	1.0000		
MOEX10	0.6493	0.3734	-0.0254	0.1021	-0.4321	1.0000	
CPI	-0.3910	-0.5131	0.2941	-0.0247	0.3519	-0.7114	1.0000

	EURRUB~t	CTEURR~b	RUB3M	GDP	EXPORT~x	MOEX10	CPI
EURRUBSpot	1.0000						
CTEURRUB_rb	0.0375	1.0000					
RUB3M	0.3040	-0.2424	1.0000				
GDP	-0.1495	0.1349	-0.2003	1.0000			
EXPORTindex	-0.2371	-0.2442	-0.2510	-0.0840	1.0000		
MOEX10	0.7454	0.3847	-0.0254	0.1021	-0.4321	1.0000	
CPI	-0.4787	-0.6117	0.2941	-0.0247	0.3519	-0.7114	1.0000

Variable	Obs	Mean	Std. Dev.	Min	Max
CT_USDAUD	216	205.5229	47.25165	98.6794	286.4109
USDAUD_spot	216	1.276843	.2187678	.9276	1.947735
GDP_AU	217	100.091	.5418716	98.95685	101.1971
AU3M_rate	217	3.975899	1.790388	.88	7.9
AU_EXP	217	9468.297	3821.672	3631.238	18604.55

	CT_USD~D	USDAUD~t	GDP_AU	AU3M_r~e	AU_EXP
CT_USDAUD	1.0000				
USDAUD_spot	-0.8601	1.0000			
GDP_AU	0.1067	-0.0726	1.0000		
AU3M_rate	-0.3888	-0.0679	0.0339	1.0000	
AU_EXP	0.5339	-0.1916	0.3178	-0.7282	1.0000

Appendix 7. Stationarity test (ADF) for analysis 1 variables, time-series data from 2002 to 2020

Stationarity Test of Variables

Variables	ADF	1% Critical Value	5% Critical Value	10% Critical Value	Conclusion
USDRUB	-0.516	-3.430	-2.860	-2.570	Non-Stationary
DUSDRUB	-70.595***	-3.430	-2.860	-2.570	Stationary
CTUSDRUB	-2.119	-3.430	-2.860	-2.570	Non-Stationary
DCTUSDRUB	-65.686***	-3.430	-2.860	-2.570	Stationary
CTEURRUB	-2.234	-3.430	-2.860	-2.570	Non-Stationary
DCTEURRUB	-70.858***	-3.430	-2.860	-2.570	Stationary
EURRUB	-1.140	-3.430	-2.860	-2.570	Non-Stationary
DEURRUB	-69.794***	-3.430	-2.860	-2.570	Stationary
CTUSDAUD	-2.248	-3.430	-2.860	-2.570	Non-Stationary
DCTUSDAUD	-71.310***	-3.430	-2.860	-2.570	Stationary
USDAUD	-2.277**	-3.430	-2.860	-2.570	Stationary
DUSDAUD	-71.272***	-3.430	-2.860	-2.570	Stationary
CTJPYAUD	-2.259	-3.430	-2.860	-2.570	Non-Stationary
DCTJPYAUD	-70.932***	-3.430	-2.860	-2.570	Stationary
JPYAUD	-3.534***	-3.430	-2.860	-2.570	Stationary
DJPYAUD	-71.909***	-3.430	-2.860	-2.570	Stationary
CTMXN	-2.469	-3.430	-2.860	-2.570	Non-Stationary
DCTMXN	-72.224***	-3.430	-2.860	-2.570	Stationary
USDMXN	-0.940	-3.430	-2.860	-2.570	Non-Stationary
DUSDMXN	-70.788***	-3.430	-2.860	-2.570	Stationary
CTBRL	-1.706	-3.430	-2.860	-2.570	Non-Stationary
DCTBRL	-73.297***	-3.430	-2.860	-2.570	Stationary
USDBRL	-0.728	-3.430	-2.860	-2.570	Non-Stationary
DUSDBRL	-72.294***	-3.430	-2.860	-2.570	Stationary

Note: variables that contain L in the beginning are natural logarithm of original variables. Variables with D are first-order differentials of original variables. ***,** and * represent 1%, 5% and 10% significance levels, respectively.

Appendix 8. Stationarity test (ADF) of analysis 2 variables, time-series data of the financial crisis

Stationarity Test of Variables

Variables	ADF	1% Critical Value	5% Critical Value	10% Critical Value	Conclusion
USDRUB	4.911	-3.457	-2.879	-2.57	Non-Stat
DUSDRUB	-15.7***	-3.457	-2.879	-2.57	Stationary
CTUSDRUB	2.754	-3.457	-2.879	-2.57	Non-Stat
DCTUSDRUB	-14.032***	-3.457	-2.879	-2.57	Stationary
CTEURRUB	-0.023	-3.457	-2.879	-2.57	Non-Stat
DCTEURRUB	-15.338***	-3.457	-2.879	-2.57	Stationary
EURRUB	3.186	-3.457	-2.879	-2.57	Non-Stat
DEURRUB	-16.269***	-3.457	-2.879	-2.57	Stationary
CTUSDAUD	-0.105	-3.457	-2.879	-2.57	Non-Stat
DCTUSDAUD	-17.561***	-3.457	-2.879	-2.57	Stationary
USDAUD	-0.271	-3.457	-2.879	-2.57	Non-Stat
DUSDAUD	-18.016***	-3.457	-2.879	-2.57	Stationary
CTJPYAUD	0.011	-3.457	-2.879	-2.57	Non-Stat
DCTJPYAUD	-18.264***	-3.457	-2.879	-2.57	Stationary
JPYAUD	-0.202	-3.457	-2.879	-2.57	Non-Stat
DJPYAUD	-18.12***	-3.457	-2.879	-2.57	Stationary
CTMXN	0.039	-3.457	-2.879	-2.57	Non-Stat
DCTMXN	-16.984***	-3.457	-2.879	-2.57	Stationary
USDMXN	0.283	-3.457	-2.879	-2.57	Non-Stat
DUSDMXN	-17.552***	-3.457	-2.879	-2.57	Stationary
CTBRL	-0.726	-3.457	-2.879	-2.57	Non-Stat
DCTBRL	-17.73***	-3.457	-2.879	-2.57	Stationary
USDBRL	-0.617	-3.457	-2.879	-2.57	Non-Stat
DUSDBRL	-18.055***	-3.457	-2.879	-2.57	Stationary

Note: variables that contain L in the beginning are natural logarithm of original variables. Variables with D are first-order differentials of original variables. ***,** and * represent 1%, 5% and 10% significance levels, respectively.

Appendix 9. Stationarity test (ADF) for analysis 1 variables, time-series data of the crisis of 2014

Stationarity Test of Variables

Variables	ADF	1% Critical Value	5% Critical Value	10% Critical Value	Conclusion
USDRUB	-1.298	-3.458	-2.879	-2.57	Non-Stat
DUSDRUB	-17.324***	-3.458	-2.879	-2.57	Stationary
CTUSDRUB	-1.275	-3.458	-2.879	-2.57	Non-Stat
DCTUSDRUB	-16.853***	-3.458	-2.879	-2.57	Stationary
CTEURRUB	-1.358	-3.458	-2.879	-2.57	Non-Stat
DCTEURRUB	-16.871***	-3.458	-2.879	-2.57	Stationary
EURRUB	-1.497	-3.458	-2.879	-2.57	Non-Stat
DEURRUB	-16.609***	-3.458	-2.879	-2.57	Stationary
CTUSDAUD	-0.808	-3.458	-2.879	-2.57	Non-Stat
DCTUSDAUD	-18.299***	-3.458	-2.879	-2.57	Stationary
USDAUD	-0.763	-3.458	-2.879	-2.57	Non-Stat
DUSDAUD	-17.928***	-3.458	-2.879	-2.57	Stationary
CTJPYAUD	-2.22	-3.458	-2.879	-2.57	Non-Stat
DCTJPYAUD	-16.371***	-3.458	-2.879	-2.57	Stationary
JPYAUD	-2.03	-3.458	-2.879	-2.57	Non-Stat
DJPYAUD	-16.397***	-3.458	-2.879	-2.57	Stationary
CTMXN	-0.694	-3.458	-2.879	-2.57	Non-Stat
DCTMXN	-18.348***	-3.458	-2.879	-2.57	Stationary
USDMXN	-0.527	-3.458	-2.879	-2.57	Non-Stat
DUSDMXN	-17.906***	-3.458	-2.879	-2.57	Stationary
CTBRL	-0.829	-3.458	-2.879	-2.57	Non-Stat
DCTBRL	-18.237***	-3.458	-2.879	-2.57	Stationary
USDBRL	-0.566	-3.458	-2.879	-2.57	Non-Stat
DUSDBRL	-18.797***	-3.458	-2.879	-2.57	Stationary

Note: variables that contain L in the beginning are natural logarithm of original variables. Variables with D are first-order differentials of original variables. ***,** and * represent 1%, 5% and 10% significance levels, respectively.

Appendix 10. Stationarity test (ADF) for analysis 1 variables, time-series data from 2014 to 2020

Stationarity Test of Variables

Variables	ADF	1% Critical Value	5% Critical Value	10% Critical Value	Conclusion
USDRUB	-3.342**	-3.43	-2.86	-2.57	Stationary
DUSDRUB	-39.58***	-3.43	-2.86	-2.57	Stationary
CTUSDRUB	-2.369*	-3.43	-2.86	-2.57	Stationary
DCTUSDRUB	-38.086***	-3.43	-2.86	-2.57	Stationary
CTEURRUB	-1.241	-3.43	-2.86	-2.57	Non-stat
DCTEURRUB	-38.328***	-3.43	-2.86	-2.57	Stationary
EURRUB	-3.206**	-3.43	-2.86	-2.57	Stationary
DEURRUB	-38.635***	-3.43	-2.86	-2.57	Stationary
CTUSDAUD	-3.139**	-3.43	-2.86	-2.57	Stationary
DCTUSDAUD	-40.178***	-3.43	-2.86	-2.57	Stationary
USDAUD	-2.942**	-3.43	-2.86	-2.57	Stationary
DUSDAUD	-39.87***	-3.43	-2.86	-2.57	Stationary
CTJPYAUD	-2.358	-3.43	-2.86	-2.57	Non-stat
DCTJPYAUD	-37.559***	-3.43	-2.86	-2.57	Stationary
JPYAUD	-1.851	-3.43	-2.86	-2.57	Non-stat
DJPYAUD	-37.857***	-3.43	-2.86	-2.57	Stationary
CTMXN	-2.589*	-3.43	-2.86	-2.57	Stationary
DCTMXN	-38.392***	-3.43	-2.86	-2.57	Stationary
USDMXN	-2.425	-3.43	-2.86	-2.57	Non-stat
DUSDMXN	-37.988***	-3.43	-2.86	-2.57	Stationary
CTBRL	-2.012	-3.43	-2.86	-2.57	Non-stat
DCTBRL	-41.537***	-3.43	-2.86	-2.57	Stationary
USDBRL	-2.242	-3.43	-2.86	-2.57	Non-stat
DUSDBRL	-42.911***	-3.43	-2.86	-2.57	Stationary

Note: variables that contain L in the beginning are natural logarithm of original variables. Variables with D are first-order differentials of original variables. ***,** and * represent 1%, 5% and 10% significance levels, respectively.

Appendix 11. Autocorrelation test (LM) and VAR stability test for analysis 3 variables (Non–residents and USDRUB)

```
. varlmar

  Lagrange-multiplier test
 +--------------------------------------+
 | lag  |       chi2    df   Prob > chi2 |
 |------+-------------------------------|
 |   1  |    5.9630     4     0.20193    |
 |   2  |    4.4871     4     0.34408    |
 +--------------------------------------+
  H0: no autocorrelation at lag order

. varstable

  Eigenvalue stability condition
 +----------------------------------------+
 |        Eigenvalue         |   Modulus   |
 |---------------------------+------------|
 |   .3178182 +   .542223i   |   .628502   |
 |   .3178182 -   .542223i   |   .628502   |
 |   .4996768                |   .499677   |
 |   -.150438                |   .150438   |
 +----------------------------------------+
  All the eigenvalues lie inside the unit circle.
  VAR satisfies stability condition.
```

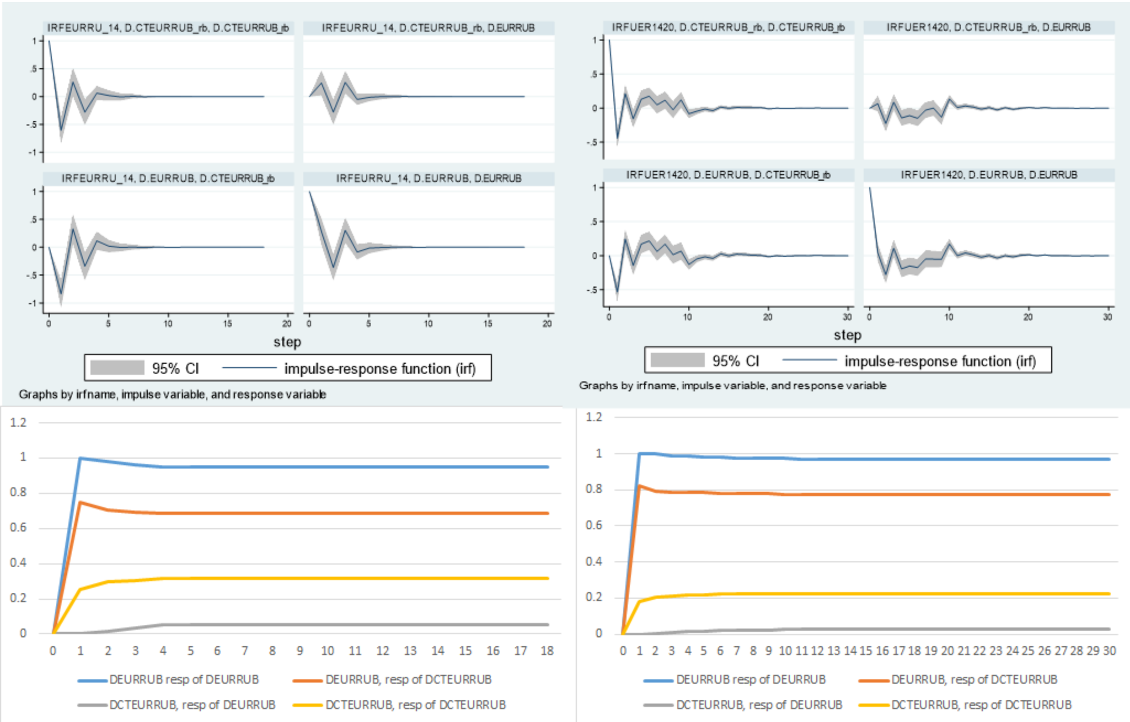
Appendix 12. Autocorrelation test (LM) and VAR stability test for analysis 3 variables (Non-residents and CT USDRUB)

```
. varlmar

   Lagrange-multiplier test
  +--------------------------------------+
  | lag  |      chi2    df   Prob > chi2 |
  |------+-------------------------------|
  |   1  |   71.8730    49     0.01829   |
  |   2  |   49.9920    49     0.43375   |
  +--------------------------------------+
   H0: no autocorrelation at lag order

. varstable

   Eigenvalue stability condition
  +----------------------------------------+
  |        Eigenvalue          |  Modulus  |
  |--------------------------+-------------|
  |   .9198654                 |  .919865  |
  |   .3540208 +   .482236i    |  .598233  |
  |   .3540208 -   .482236i    |  .598233  |
  |  -.4303778 +  .3027118i    |  .526174  |
  |  -.4303778 -  .3027118i    |  .526174  |
  |   .5191692                 |  .519169  |
  |  -.4259416                 |  .425942  |
  |   .1325799 +  .3730877i    |  .395944  |
  |   .1325799 -  .3730877i    |  .395944  |
  |   .3223338 +  .1648183i    |  .362028  |
  |   .3223338 -  .1648183i    |  .362028  |
  |  -.2665192                 |  .266519  |
  | -.03946134                 |  .039461  |
  |  .01717394                 |  .017174  |
  +----------------------------------------+
   All the eigenvalues lie inside the unit circle.
   VAR satisfies stability condition.
```

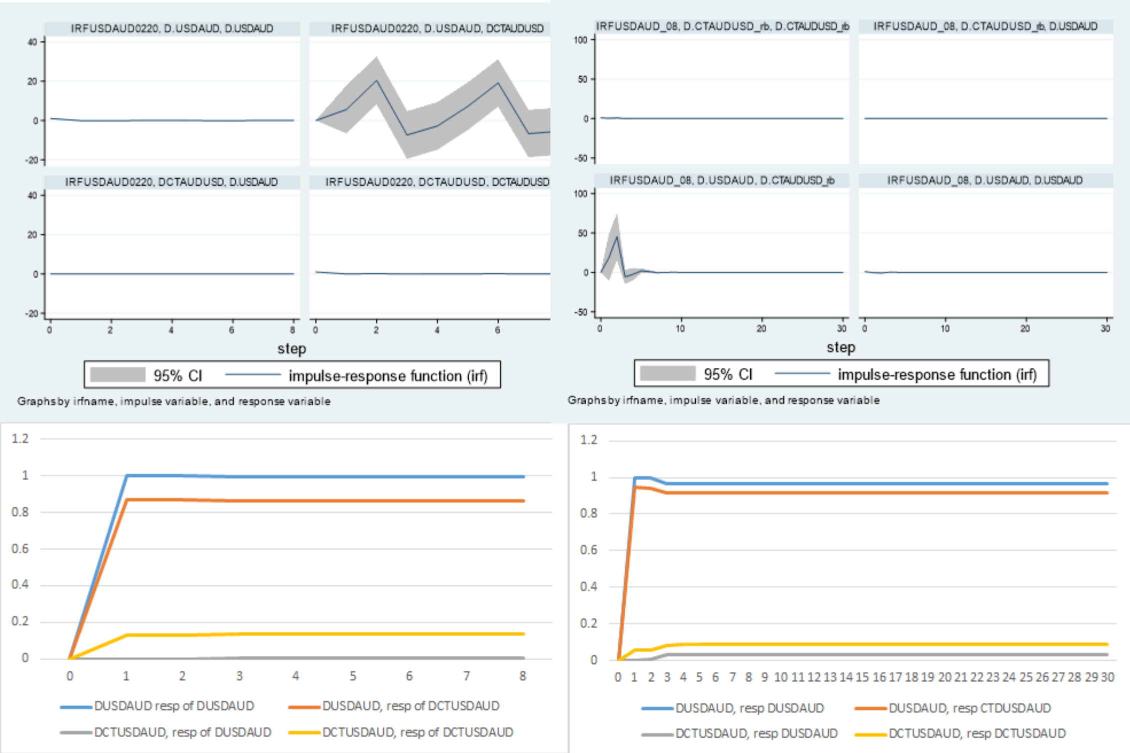
Appendix 13. Autocorrelation test (LM) and VAR stability test for analysis 2 variables

```
. varlmar

   Lagrange-multiplier test
  +--------------------------------------+
  | lag  |      chi2    df   Prob > chi2 |
  |------+-------------------------------|
  |   1  |   51.8950    49     0.36168   |
  |   2  |   54.6792    49     0.26773   |
  +--------------------------------------+
   H0: no autocorrelation at lag order

. varstable

   Eigenvalue stability condition
  +----------------------------------------+
  |        Eigenvalue         |   Modulus  |
  |--------------------------+-------------|
  |      .92531               |    .92531  |
  |    .3626927 +  .4654332i  |   .590063  |
  |    .3626927 -  .4654332i  |   .590063  |
  |   -.4401186 +   .389476i  |   .587704  |
  |   -.4401186 -   .389476i  |   .587704  |
  |   .08065079 +  .4291776i  |    .43669  |
  |   .08065079 -  .4291776i  |    .43669  |
  |    .4195294               |   .419529  |
  |    .3667632 +  .1890665i  |   .412627  |
  |    .3667632 -  .1890665i  |   .412627  |
  |   -.3191969 + .04258251i  |   .322025  |
  |   -.3191969 - .04258251i  |   .322025  |
  |   .05991579               |   .059916  |
  |  -.05361354               |   .053614  |
  +----------------------------------------+
   All the eigenvalues lie inside the unit circl
   VAR satisfies stability condition.
```

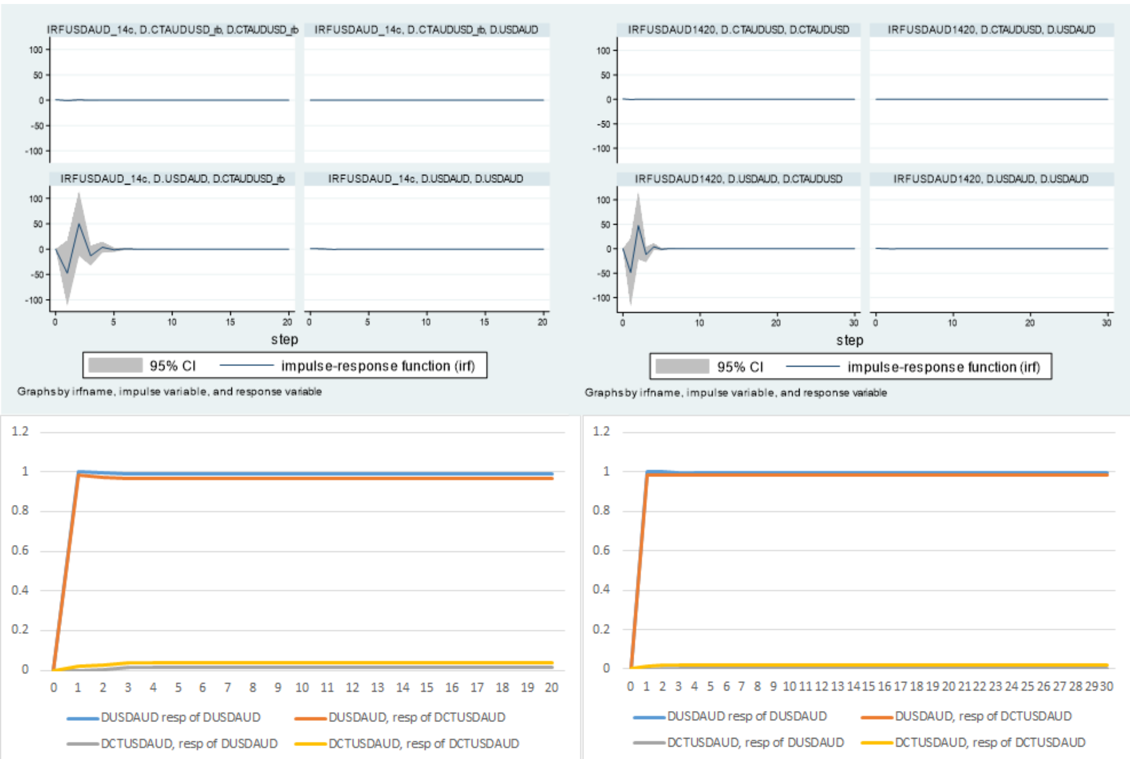
Appendix 14. IRF and variance decomposition results for analysis 1, time-series data from 2002 to 2020 and the financial crisis. Figure is showing results of EURRUB carry trade impact to EURRUB spot rate. Both variables have first difference order.



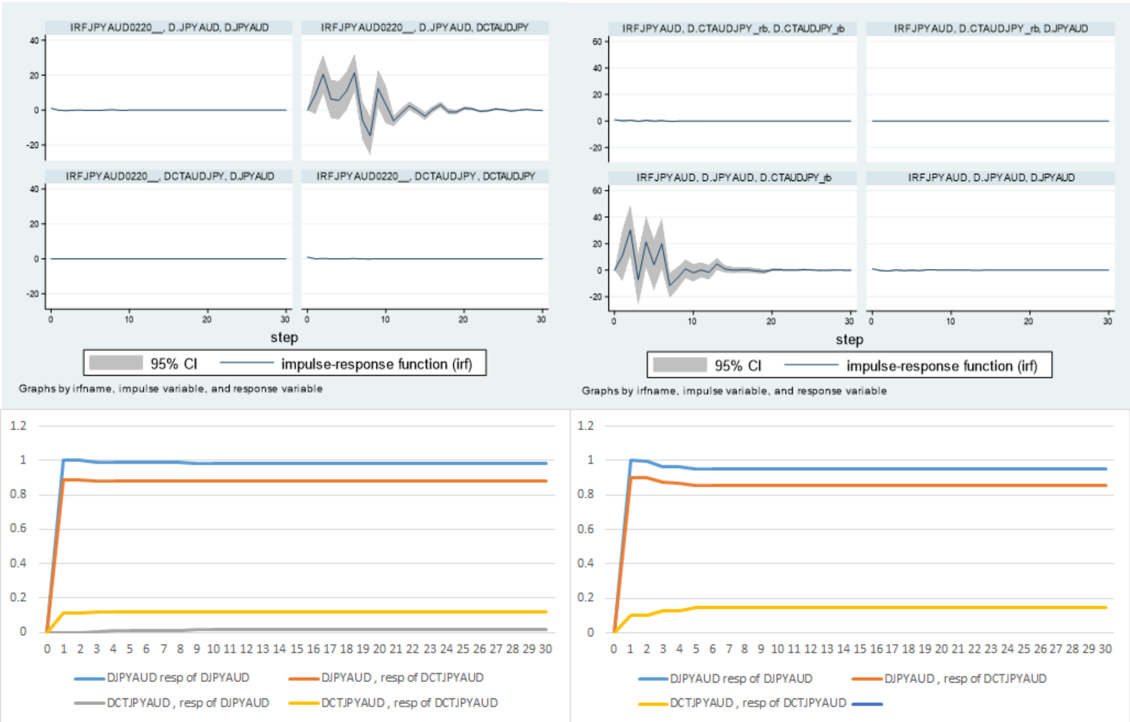
Appendix 15. IRF and variance decomposition results for analysis 1, time-series data from 2002 to 2020 and the financial crisis. Figure is showing results of USDAUD carry trade impact to USDAUD spot rate. Both variables have first difference order.



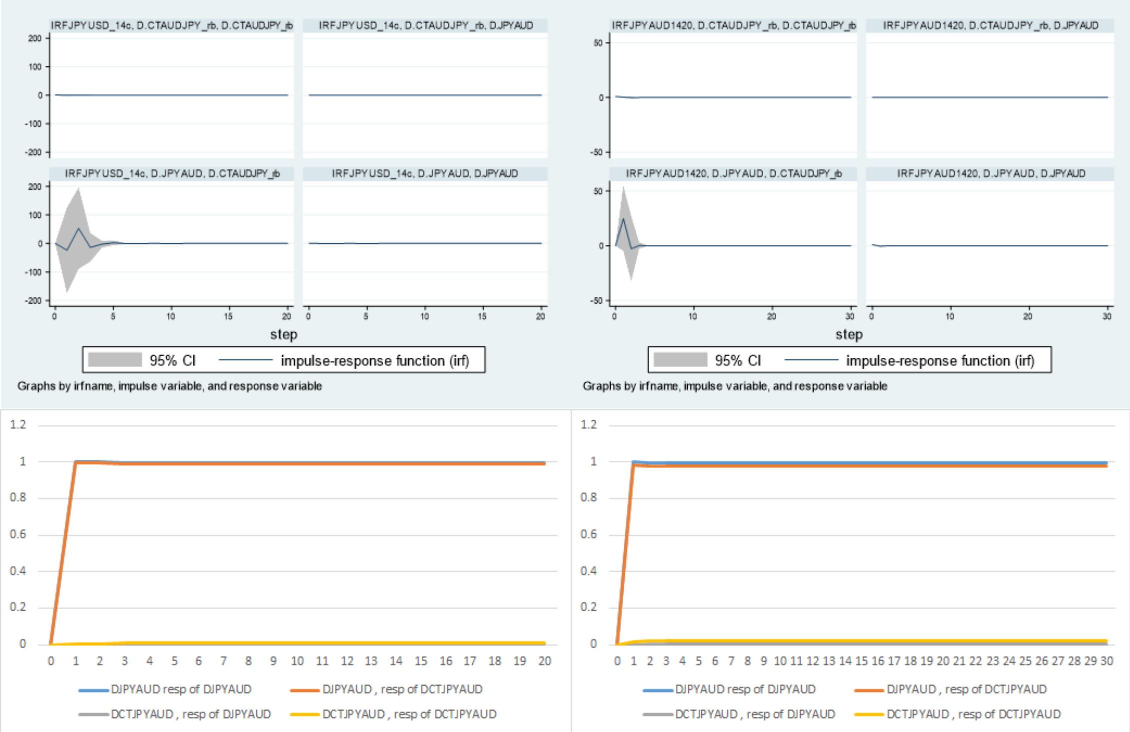
Appendix 16. IRF and variance decomposition results for analysis 1, time-series data of two crisis 2014 and the financial crisis. Figure is showing results of USDAUD carry trade impact to USDAUD spot rate. Both variables have first difference order.



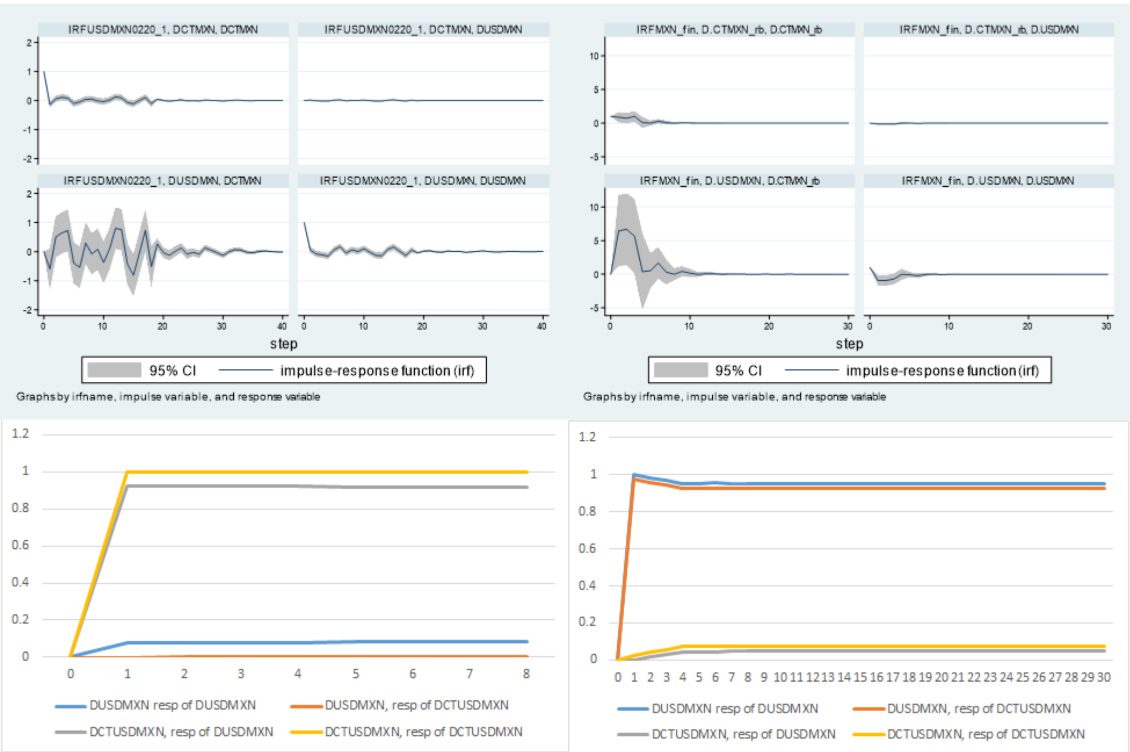
Appendix 17. IRF and variance decomposition results for analysis 1, time-series data from 2002 to 2020 and the financial crisis. Figure is showing results of JPYAUD carry trade impact to JPYAUD spot rate. Both variables have first difference order.



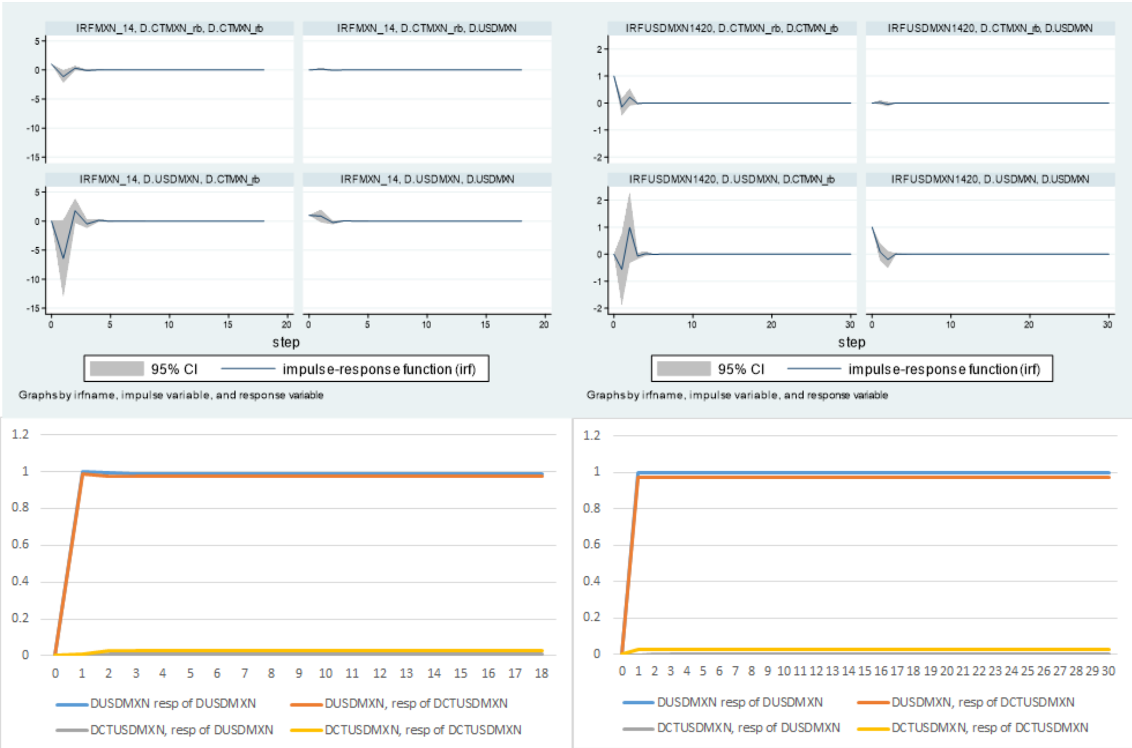
Appendix 18. IRF and variance decomposition results for analysis 1, time-series data of two crisis 2014 and the financial crisis. Figure is showing results of JPYAUD carry trade impact to JPYAUD spot rate. Both variables have first difference order.



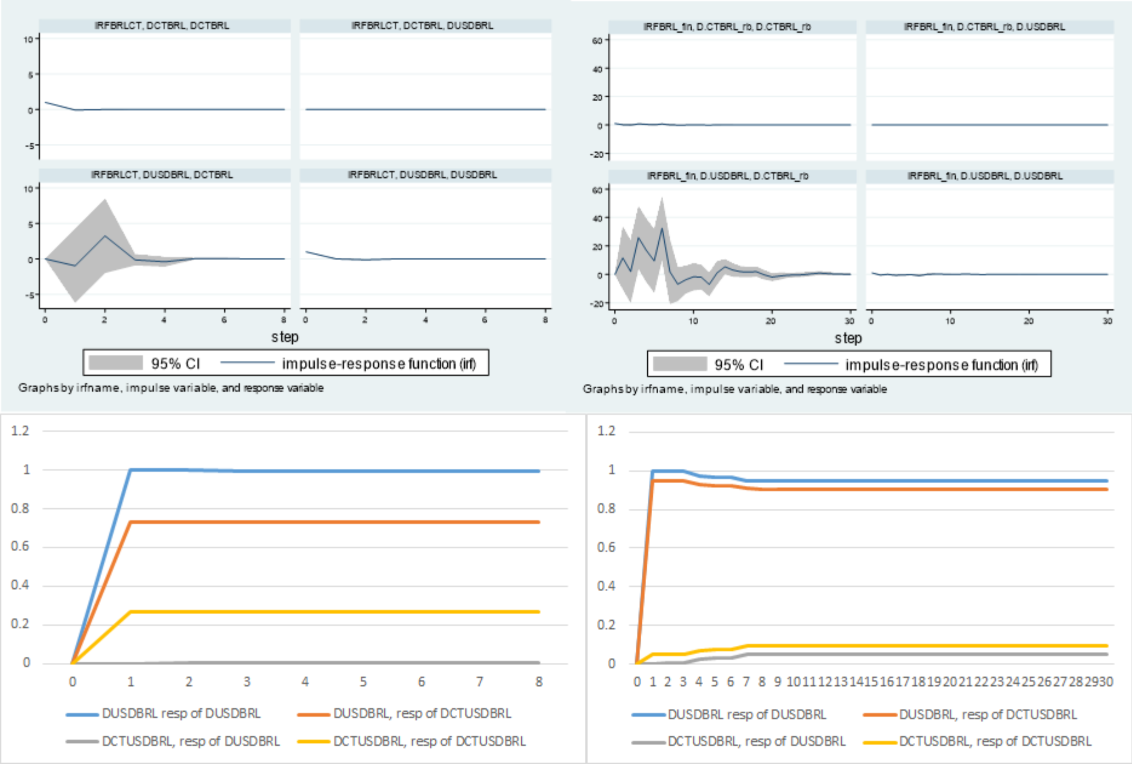
Appendix 19. IRF and variance decomposition results for analysis 1, time-series data from 2002 to 2020 and the financial crisis. Figure is showing results of USDMXN carry trade impact to USDMXN spot rate. Both variables have first difference order



Appendix 20. IRF and variance decomposition results for analysis 1, time-series data of two crisis 2014 and the financial crisis. Figure is showing results of USDMXN carry trade impact to USDMXN spot rate. Both variables have first difference order.



Appendix 21. IRF and variance decomposition results for analysis 1, time-series data of two crisis 2014 and the financial crisis. Figure is showing results of USDBRL carry trade impact to USDBRL spot rate. Both variables have first difference order



Appendix 22. IRF and variance decomposition results for analysis 1, time-series data of two crisis 2014 and the financial crisis. Figure is showing results of USDBRL carry trade impact to USDBRL spot rate. Both variables have first difference order.