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PREFACE OF THE CHAIRMAN OF THE EDITORIAL BOARD

Dear readers,

In the December issue of the Visnyk of the National Bank of Ukraine you can learn about applied research studies on topical issues related to money market regulation, the development of efficient monetary policy instruments by central banks, and ensuring the stability of the financial system. Articles published in the December issue provide insight into specific impacts of vulnerable external markets, internal institutional changes, and other macroeconomic challenges faced by small open economies. The articles included in this issue outline a number of reasonable proposals for methods to identify potential risks in the banking system, to reliably forecast the macroeconomic situation, and specifically to implement inflation targeting regime.

The first article in the issue is entitled Cashless Society and De-Dollarization in Ukraine: What Is Missing From Present Discussions?, coauthored by Marko Skreb and Kostiantyn Khvedchuk. The authors study prerequisites for large-scale usage of cash foreign currency in Ukraine and argue that central banks should focus significant efforts on restoring confidence in the national currency and banking system as a whole. The paper explores global experiences and suggests how to reduce the scale of foreign currency cash usage in Ukraine.

The article entitled Ukrainian Banks' Business Models Clustering: Application of Kohonen Neural Networks, coauthored by Vladyslav Rashkovan and Dmytro Pokidin identifies six business models of Ukrainian banks and demonstrates how they change over the crisis period. Using six major criteria (Profitability, Credit, Liquidity, Concentration, Related Party Lending, and Money Laundering) banks have been designated as safe or risky. The authors create risk maps of each business model and conclude that the method is an efficient default prediction tool, which can be used for the development of an Early Warning System, Supervisory Review, and Evaluation Process. Additionally, it may become an aiding instrument in mergers and acquisitions of banks.

The article entitled Applying FX Interventions as an Additional Instrument Under Inflation Targeting: the Case of Ukraine, coauthored by Anton Grui and Volodymyr Lepushynskyi, looks into the effectiveness of FX interventions conducted by central banks amid implementation of an inflation targeting regime. Using the NBU's Quarterly Projection Model, the authors evaluate the potential effect of FX interventions on key macroeconomic indicators in response to different kinds of shocks. The authors study in detail the issue of achieving monetary policy goals such as low inflation volatility and the accumulation of international reserves. They conclude that the application of FX interventions in the context of inflation targeting may be reasonable.

We hope that the topics, research methods, and conclusions of the published articles will be interesting for you and will spur professional discussions, generate new ideas, and elaborate further proposals. The Editorial Board welcomes all researchers who are interested in cooperation. Authors are invited to submit their fundamental and applied studies for publication in Visnyk of the National Bank of Ukraine.

Best regards ***Dmytro Sologub***

CONTENTS

CASHLESS SOCIETY AND DE-DOLLARIZATION IN UKRAINE. WHAT IS MISSING FROM PRESENT DISCUSSIONS?

Marko Skreb[1]
Canada-IMF Capacity Building Project

Kostiantyn Khvedchuk
National Bank of Ukraine

ABSTRACT

The National Bank of Ukraine stepped on the track to a cashless economy aiming at reforming the financial system, improvement of the transmission mechanism, and reduction of the underground economy and corruption. A substantial part of money in the Ukrainian economy is estimated to be foreign cash in circulation. This article underlines the importance of considering it while conducting monetary policy. Negative consequences of high dollarization and proliferation of cash are emphasized. We discuss measures that are helpful in decreasing usage of cash in general and foreign cash in particular.

JEL Codes: E41, E50

Keywords: cash demand, dollarization, negative mirage, hysteresis, cashless economy

I. INTRODUCTION

"Negative mirage" was first mentioned by Professor Robert Mundell (awarded a Nobel Prize in Economic Sciences in 1999) at his lecture in the Croatian National Bank Conference in 1996, Mundell, (1997). He went on to explain that a mirage is something we see but is not there, like Fata Morgana in the deserts. Economists like to use the term "negative" so we speak about negative growth rate, not a "fall" rate. Thus, a negative mirage is something that is there, but we do not see it. He was referring to GDP in transition economies. In the early to mid-nineties, official statistics would show a deep dive in GDP in transition economies, but reality was not as bad as statistical numbers pointed to. Official statistics do not always capture all economic activity, especially in so-called transition economies, whose structure was changing too rapidly. It is worth noting that statistical omissions in economics are not limited to post-socialist economies. Recently a lot of emerging countries have "increased" their economies by a so-called rebasing of GDP. The most notable example is Nigeria, who increased its GDP by 90% in 2014.[2]

Similar phenomena, when official statistics do not account for the total of a variable, can be found in the monetary sphere as well. The effective money supply in countries is often larger than what monetary statistics captures. We refer in particular to so-called foreign cash/currency in circulation (FCC).[3] There are many countries in the world where not only local currency in circulation (LCC) is used, but FCC as well. That means the amount of effective cash is larger than captured by official statistics and comprises of both LCC and FCC. Ukraine seems to be among such counties. Why is this relevant for policy makers and the economy in general?

The first issue is the propensity of households to use and hoard cash. Rogoff (2016) advocates cash is paid insufficient attention in economic research.[4] Being aware of this, the National Bank of Ukraine (NBU) has recently launched the Cashless Economy Project.[5] This is positive and should be continued. However, discussions should not be limited to LCC only,

[1] Views expressed in this article are the only responsibility of the authors and not of institutions they work for.
[2] More detailed information is posted at the link: http://www.economist.com/news/finance-and-economics/21600734-revised-figures-show-nigeria-africas-largest-economy-step-change
[3] By FCC we mean only cash issued by foreign central banks but circulating in a country. Foreign exchange (FX) is broader and encompasses foreign exchange deposits as well (for example USD deposits in Ukrainian banks).
[4] We use the terms cash, paper currency, and currency in circulation as synonyms in this article.
[5] More detailed information is posted at the link: https://bank.gov.ua/control/en/publish/article?art_id=32495491, and https://bank.gov.ua/doccatalog/document?id=36963478

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the hryvnia, but should include FCC as well. Second is the question of dollarization.[6] Use of foreign exchange (FX) in a country has deep roots and many consequences. Unlike cash, dollarization has attracted considerable interest by researchers abroad, Mecagni et al (2015), Scheiber and Stix (2009), and in Ukraine, Perelygin (2015). A "negative mirage" like FCC is usually omitted from analysis, Zholud et al. (2016). Usually discussions on dollarization are limited to asset or liability dollarization of economic agents (households, businesses, government, etc.) that is measured by official statistics (for example households' FX deposits in banks). Third, the large use of FCC has a number of negative impacts on the economy as will be explained.

The goal of our article is to draw additional attention to economic agents using and holding FCC in a country. Without analyzing FCC more deeply, the discussion on de-dollarization, the drive to cashless economy, as well as overall macroeconomic stability, is incomplete. After discussing why FCC is a problem, we will present some estimates of FCC in Ukraine as well as give some data comparisons with other countries. The last part of our article includes conclusions and gives some policy discussions.

II. WHY IS FCC A PROBLEM?

One may think that FCC is not a serious economic problem and there is no need to focus on it. Putting political issues aside, a large amount of FCC in an economy should be taken seriously and adequately addressed by all economic policy makers.[7] True, if a banking crisis is in full blossom with currency in free fall, this might not be a priority. However, once macroeconomic stability is restored, FCC should be analyzed more thoroughly. The argument is simple. If people hold cash in their portfolios instead of bank deposits, it means that their trust in the banking system is low and/or the financial infrastructure in a country to use cashless modes of payments is inadequate. If they prefer FX to domestic currency (asset dollarization either by holding cash at home or FX deposits in a bank), it means that their trust in the domestic currency is low. The reason for this is usually due to past macroeconomic instability, i.e., high inflation and/or depreciation of the domestic currency. Economic agents try to avoid inflation tax by saving FX instead of domestic currency. Neither phenomenon is new nor restricted to Ukraine or transition economies.[8] Until relatively recently (i.e., after the Global Financial Crisis – (GFC) starting in 2008), policy makers did not pay sufficient attention to dollarization due to the following reasons:

Countries where dollarization was never a problem are typically those whose economic history is not burdened with inflationary periods, currency depreciations, and banking crises. If a small percentage of assets are held as FCC, this indeed should not be a top priority for policy makers.

Countries aspiring to join the European Union (EU) soon claimed that once they became an EU member they will introduce the euro as their currency. So, why bother with de-dollarization if the euro will soon be the official currency? Today we know better. First, EU candidate and other countries in the region might not become members in the medium-term, and second, joining the euro area is not the panacea for economic ills as it once was thought to be. The recent economic history of Greece and other euro area Mediterranean countries is proof of that.

Some countries had a "benign neglect" approach. They admitted that dollarization is there, but it probably does not do much harm and it may even have some benefits, so why bother? Even if risks were perceived, the probability of them materializing was considered low. However, a Black Swan in the form of a GFC resulting in large depreciation of currencies in some transition economies, and especially the strong appreciation of the CHF toward main currencies, means potential risks have materialized. All the negative consequences of neglecting to boost domestic currency became visible and were painful. As a reaction to this, EBRD launched its local currency initiative in May 2010.[9] In Ukraine, it was launched in July 2015.[10] However, FCC remained outside the scope of developing capital markets in local currency.

Finally, there are countries that started programs for de-dollarization, but have given up efforts due to its persistence, like the hysteresis effect, Valev (2005).

As a result of the GFC, de-dollarizing economies came into renewed focus of many researchers and an increased number of articles on de-dollarization were published, Perelygin (2015), Catao et al. (2016), Naceur et al. (2015).

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[6] We will use the terms "dollarization" and "euroization" as synonims in this article.
[7] The end of October's e-declarations in Ukraine have shown (according to media) that political elites hold vast amounts of FX "under the mattress" – FCC (Aslund, 2016).
[8] When discussing other countries, we will focus mostly on transiton economies.
[9] More detailed information is posted at the link: http://www.ebrd.com/what-we-do/sectors-and-topics/local-currency-and-capital-markets.html.
[10] More detailed information is posted at the link: https://bank.gov.ua/control/en/publish/article?art_id=19486492

Dollarization aside, a high share of LCC can be a problem for the economy as well. True, cash has been around for a while since it was described to Westerners by Marco Polo in the XIV century, Rogoff (2016). But it seems that analyzing LCC is considered "old fashioned". It is much more "in" to discuss Bitcoin and block chain technologies than the economic role of cash.[11] Unlike FCC, the amount of LCC (banknotes and coins), can be computed as a "residual". We do not know where it is actually held, under a mattress or used to settle economic transactions, but we know how much is in circulation. Central banks/monetary statistics know how much banknotes are printed (and coins minted) and how much is in their vaults (and banks' vaults). The difference is "in circulation". For relatively weak currencies it is reasonable to assume that most of the amount is held in the country of origin.

But knowing how much FCC is in a country is much more difficult. There are different methods of estimating it, Feige et al. (2002), but none seem to be very precise. For that reason, researchers are not very keen to include FCC in their models and research papers. Some may not even be aware of its relevance in the economy. Emerging and transition economies face a challenge to compute the effective money supply in their countries, including FCC. Ukraine is not alone in this club. This is a big problem, especially in Central, Eastern, and Southeastern Europe, which had its share of macroeconomic instabilities in the past, Schneider and Stix (2009). It is important to elaborate what are the possible negative consequences of FCC which combines the problems of high use of cash and dollarization:

A) A high share of cash (as compared to bank deposits) in an economy is a sign of an underdeveloped financial system and lack of trust in it. It means a low level of financial intermediation as money is not in the form of bank deposits and is not intermediated by banks. This lowers the efficiency of financial markets and the overall economy. If, besides a large amount of domestic banknotes in circulation, there is a significant amount of FCC, the problem is compounded;

B) With FCC, monetary statistics in a country are incomplete, i.e., we may be missing a large part of the effective money supply. This can have serious consequences for policy making. Economic models that use monetary data may not be accurate. If FCC is not taken into account, it may be difficult to explain inflation in a country. A good example is Oomes et al. (2005), where the FCC in Russia included into the model helped to explain relations between inflation and money demand. Furthermore, without measuring FCC holdings of different economic sectors, the balance sheet calculation can be misleading, especially for households;

C) Behavior (partially) of economic agents may differ substantially with a significant amount of FCC in the economy. For example, if a central bank wants to pursue expansionary monetary policy and increases the money supply, economic agents may expect inflation and/or devaluation and may switch to FCC, which may actually decrease demand for domestic currency. The so-called law of unintended economic consequences should not be neglected;

D) Much of monetary policy efficiency relies on the credibility of the domestic central bank. As mentioned already, the existence of FCC corresponds tightly to credibility. So, decreasing FCC should go alongside with improving credibility, though it is difficult to measure;

E) In such a case, the transmission mechanism of monetary policy may not be well understood and may be less efficient than in economies that do not have FCC;

F) If FCC is widely used, then seigniorage from banknotes will go to ECB or the Fed and not to a domestic central bank like the NBU. As usually an excess of revenues over expenditures at central banks is transferred to the Government, wide use of FCC may have negative fiscal implications;[12]

G) Linked to this is loss of tax revenue in the gray and underground economy generated by use of cash in non-registered activities. Tax avoidance (and all illegal activities) is much easier when transactions can be settled with ample FCC in an economy.[13] The biggest euro banknote is about thirty times larger in value than the largest hryvnia banknote, which means that a much large value can be put in a proverbial briefcase;[14]

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[11] The importance of cash is visible in the case of India for example. In November 2016, the Government decided to withdraw (i.e., demonetize) its 500 and 1,000 banknotes. The aim is to fight black market activities. However, the measure, at least after introduction, created a lot of problems for small businesses in particular as there is no alternative. More detailed information is posted at the link: http://www.economist.com/blogs/economist-explains/2016/11/economist-explains-6

[12] For more detailed information on seigniorage, see Rogoff (2016).

[13] Rogoff (2016) devotes a large part of his book to teh use of large denomination banknotes in illegal activities.

[14] In May 2016, the ECB decided that it will not produce Euro 500 banknotes any longer, but printed ones will be valid without limitation. More detailed information is posted at the link: https://www.ecb.europa.eu/press/pr/date/2016/html/pr160504.en.html

H) In some advanced economies, a cash-prone society may undermine monetary policy. Estimates are that around 80% of transactions by volume in Germany are done in cash. In the US, around half of them, Schmidt (2016). If monetary policy operates in a "zero lower bound" environment (a situation that older generations might remember as a Keynesian liquidity trap), this becomes a problem. After the GFC, as central banks started running out of options in their "toolkit" for their expansive monetary policies (once interest rates were close to zero, measures like quantitative easing were introduced), researchers started considering using negative interest rates to stimulate economic agents to spend more and not to save. But the risk of applying negative rates to households' deposits in banks is that they might, instead of paying to banks to keep their money there, change their portfolio composition to cash and keep it at home. If this would happen, negative interest rates would be counterproductive as a measure to stimulate aggregate demand. Therefore, some economists started advocating phasing out cash, which would decrease degrees of freedom for monetary policy in the future. Rogoff (2016) is one of the most vocal advocates of phasing out cash.

Despite all the difficulties in estimating circulation and the stock of foreign cash within the borders of a specific country, taking into account its presumable range and dynamics should help a lot. Therefore, we draw attention to the issue of dollarization, and FCC in particular, and we discuss ways of estimating FCC.

III. FOREIGN CURRENCY IN CIRCULATION IN UKRAINE AND OTHER COUNTRIES

In European economies that have a currency substitution problem, the two mostly used substitute currencies are US dollars and the euro. They are valued for their stability and tradability (network effect). Chinese Renminbi or Japanese Yen may be stable currencies, but not of much use in Europe as banknotes since nobody holds them. So, how big is the use of the euro and dollar outside their territories?

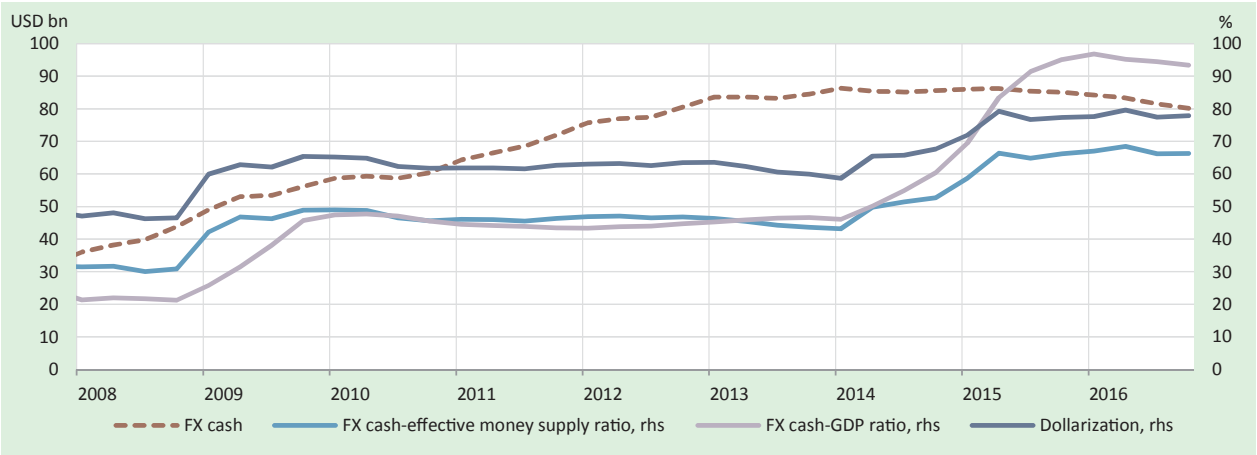
The total value of euro cash in circulation is somewhat larger than one trillion euros. It is estimated that 20-25% of banknotes by value are held outside the euro area, so only ¾ of the total circulate within the euro area. But, how much is in Ukraine, how much in Romania, or even outside Europe can only be guessed. For the US, the total value of paper currency in circulation (outside vaults) is about USD 1.4 trillion. When it comes to estimates of currency held outside US, they vary between 50% and 70% of the total amount. As more recent estimates are focusing on the lower bound, Rogoff (2016), it means that at least USD 700 billion is held outside US. There is even less certainty about how much of this is used by Mexican drug cartels, Russian citizens, or some Asian countries as USD is more global than the euro. One could say the dollar is a globally recognized brand.

Research on FCC is not plentiful. The most comprehensive and systematic work on FCC in Europe is done by the Austrian Central Bank, Scheiber et al. (2009), in their systematic OeNB Euro Survey for eleven countries of Central and South East Europe since 2007. Specifically, it supplies micro data comparable between countries and social groups that give insights into the determinants of euroization. As no systematic surveys are done in Ukraine, estimates can end up with very different results (magnitude of order of several multiples). Below we will try to show some estimates of FCC indicators in Ukraine compared to other countries.

Flows of FX cash from the BoP are our starting point in analyzing the dynamics of dollarization in Ukraine. They are estimated as net cash imported by Ukrainian banks and net cash exports by firms and households, including informal trade, tourism, and cash imported by migrants. Expert estimates are used in assessing informal trade. Volumes of FX cash exported by travelers are calculated as a difference between estimated expenses of tourists and payments made through the banking system. The amount of cash imported by migrants is calculated as a portion of the total sum of remittances that came into Ukraine from migrants through banks and international payment systems. The stock of FX cash is assumed to be accumulated since 1995. Though the approach is often thought to underestimate outflows of cash, results can be considered as the upper bound of estimated FX cash.

Figure 1 shows the amount of FCC estimated to be in Ukraine together with main dollarization indicators of the Ukrainian economy. Against the background of weak financial market and a fixed exchange rate, the Ukrainian economy has accumulated huge amounts of FX cash. Net FX cash inflows were positive until 2014, reflecting the attitude towards FX and lack of trust in the banking system. The recent loss of part of Ukraine's territory, alongside a real income decrease, has led to a switch in the trend. Further macroeconomic stabilization in Ukraine should lead to continuation of the FCC decline tendency.

Figure 1. Dollarization indicators of the Ukrainian economy

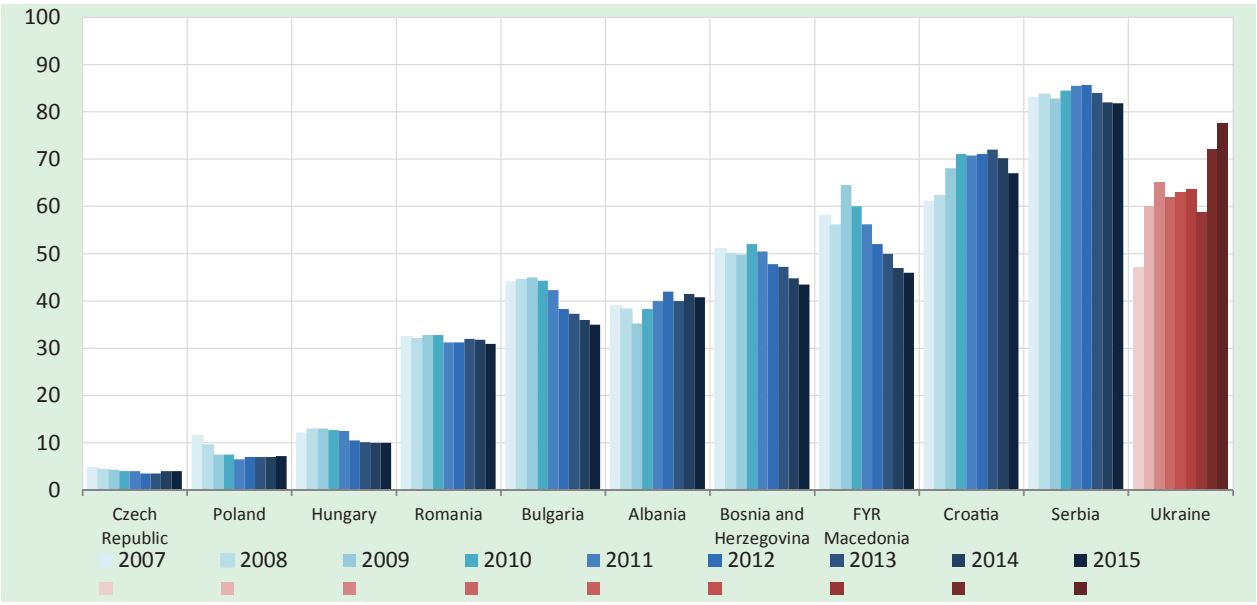


Source: NBU estimates

We can see that the FX cash to effective money supply in Ukraine is about half of it. It is proof that we need to focus additional attention on it in monetary policy.[15] The share of FX to GDP has increased dramatically in Ukraine. This can be explained not just by an increase in the absolute amount of FX estimated in Ukraine, but due to the economic crisis and fall in GDP after 2014, as well as significant depreciation of the UAH against the USD.

Based on estimates that we have for FCC, it turns out that the dollarization index for Ukraine is high and has increased since 2014, which is understandable keeping in mind the significant negative shocks the Ukrainian economy went through. For illustrative purposes, we compared two methodologies. For Ukraine, the estimates are done on basis of the BoP approach mentioned earlier, while other data is taken from the OeNB survey.[16] We are aware that we are comparing "apples and oranges," but the aim is only to have an indication of how high euroization has taken place in Ukraine.

Figure 2. Euroization index of select European countries and the dollarization index of Ukraine, %



Source: OeNB, NBU estimates

[15] The effective money supply is measured as aggregate M3 extended by estimated FCC.
[16] More detailed information is posted at the link: https://www.oenb.at/en/Monetary-Policy/Surveys/OeNB-Euro-Survey/Main-Results/Asset-Euroization.html

Determinants of euroization vary between countries and are highly correlated with the efficiency of past economic governance. Such factors as lack of trust in banks, memories of past banking crises, weak tax enforcement, and underground economic activity are mentioned as the main drivers of both cash preferences and FX demand, Stix (2009). Hikes of the dollarization index of Ukraine are associated with significant devaluations/depreciations of the hryvnia. But even before the GFC, it seemed to be high compared to other developing countries. Although the same factors could reign expanding sympathy to cash, including FCC, researchers conducting studies like the OeNB could help better understand the "negative mirage" of FCC.

IV. CONCLUSIONS AND POLICY DISCUSSION

A) It is important to understand that high usage of FCC in a country is a problem for monetary and economic policy. One should explicitly address it to decrease the costs to the economy and mitigate risks stemming from it. Causes of large use of FCC are deeply rooted, usually in past macro-instabilities. Unfortunately, Ukraine had it all: banking crises, a history of inflation, devaluation and depreciation have repeatedly occurred since independence. The first step in restoring trust in the domestic currency and banking system should be a return to macroeconomic stability. The NBU has done a great job in the last two-plus years by significantly lowering inflation and cleaning up the banking system while upgrading banking regulation and transforming its supervision function into a modern risk-based one. However, this is necessary but not a sufficient condition to resolve or significantly decrease FCC. The main reason for this is the so-called hysteresis effect, Valev (2005).

B) A long term strategy to address FCC in a country is needed. Besides continuation of macroeconomic stability (credibility takes a long time to be build), the first step should be to develop a deeper understanding of the amounts of FCC in the economy and the reasons why households keep it. This could be done by using surveys similar to the ones done by the OeNB.[17] Specific questions as to why people hold cash: LCC and FCC in particular in Ukraine should be included to better understand the motives of Ukrainians. The composition of assets is not only driven by economic motivation but has its causes in social conventions, culture, and simply past behavioral practices. Stix (2011) is an excellent starting point for such surveys. It is only with a better understanding of the amounts of FCC and reasons why economic agents prefer cash to deposits (and foreign to domestic currency) that effective measures can be designed.

Before surveys are conducted, researchers in Ukraine could simply look at their own experiences to comprehend the relevance of FCC in the economy. This can be combined with official statistics on asset and liability dollarization and existing estimates. One could ask oneself questions like: How much FCC do I hold at home? This helps assess the relevance of FCC as a store of value. Is it customary to pay rent, or even buy an apartment, car, or other valuables, in FX? What about smaller transactions like restaurants or other services, can they be settled in euros or dollars? Why are there so many exchange offices in the center of Kyiv even outside of peak tourist season? This can help assess the relevance of FCC as a medium of exchange. How do I express prices of rent for an apartment, in local currency or in dollars? This assesses the relevance of FCC as a unit of account. If answers to those questions are positive, it means that FX has "taken over" all three main functions of money versus the domestic currency.

C) Once macroeconomic stability is reasonably achieved and a better understanding of the role and magnitude of FCC in the economy is understood, policy makers should consider a set of micro-economic regulatory measures that decrease use of cash in general and use of FCC in particular. They have to be aware it is going to be an uphill and complex battle. Restrictive measures can be counterproductive or have unintended consequences. However, some well thought measures could help in the process and we briefly discuss some of them:

- Continue increasing the credibility of the domestic currency (macro stability as mentioned is a primary factor).
- Limiting the amount of cash to settle transactions. A lot of advanced economies do it, like France and Italy. Some big economies do not have such limits, like Germany and Austria.[18] The main motivation is usually anti-money laundering and financing of terrorism. Limiting the amount of cash for a transaction is reasonable, especially if combined with developing a financial infrastructure. In some economies, like Sweden and Finland, merchants are not obliged to take cash. A counter argument is that if one limits domestic cash transactions, agents will move to FCC. But this cannot hold for legal transactions.
- Developing a financial infrastructure for cashless transactions on the whole territory of a country. The lack of bank and ATM/POS networks in a country are often stressed as one of the main reasons for the use of cash (tax avoidance aside).
- Financial literacy is important. Educating the population about the individual and social benefits of a cashless (or at least cash-lite) society that uses local currency, should be done continuously in popular and accessible ways. Similarly, the FX risks need to be elaborated as well.

[17] More detailed information is posted at the link: https://www.oenb.at/en/Monetary-Policy/Surveys/OeNB-Euro-Survey/Main-Results/Asset-Euroization.html and Scheiber and Stix (2009).
[18] More detailed information is posted at the link: http://www.europe-consommateurs.eu/fileadmin/user_upload/euconsommateurs/PDFs/PDF_EN/Limit_for_cash_payments_in_EU.pdf.

In conclusion, we all know that believing a mirage in the desert can be very dangerous. In spite of the fact that we see it, lifesaving water is not there. Similarly, when a "negative mirage" exists in the economy and we do not pay sufficient attention to it, it can lead to serious problems. While a mirage is a natural phenomenon and not much can be done about it, a "negative mirage" is a human error and should be corrected in the best way possible.

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UKRAINIAN BANKS' BUSINESS MODELS CLUSTERING: APPLICATION OF KOHONEN NEURAL NETWORKS

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National Bank of Ukraine

ABSTRACT

This paper clusters and identifies six distinct bank business models using Kohonen Self-Organising Maps. We show how these models transform over the crisis and conclude that some of them are more prone to default. We also analyze the risk profiles of the bank business models and differentiate between safest (valid) and riskiest ones. Specifically, six risk types (Profitability, Credit, Liquidity, Concentration, Related parties lending, and Money Laundering) are used to build risk maps of each business model. The method appears to be an efficient default prediction tool, since a back-testing exercise reveals that defaulted banks consistently find their place in a "risky" region of the map. Finally, we outline several potential fields of application of our model: development of an Early Warning System, Supervisory Review and Evaluation Process, mergers and acquisitions of banks.

JEL Codes: G210, L100, C450

Keywords: neural networks, clustering, SOM, business model, banking

I. INTRODUCTION

As believed by many experts, the recent financial turmoil in Ukraine stemmed from more than a decade of reckless monetary and supervisory policy that allowed huge imbalances to be accumulated. Poor supervision gave rise to the unchecked growth of bad business practices at banks. Related party lending, large assets concentration, and money laundering are among the most pronounced risks of the Ukrainian banking system. Before the crisis, a number of banks had been growing fast, with the market having reached the peak of almost two hundred banks.

By collecting individuals' savings, most banks didn't provide funds to small- and medium-sized businesses. Instead, they mainly served business groups related to banks' owners, shoring up monopolization of the market at best. In the worst scenarios, the banks were used as intermediaries for illegal money laundering schemes.

According to many scholars, business model analysis must become a cornerstone in modern banking supervision.[1] Banking regulators also share this opinion, as the European Central Bank launched the Single Supervisory Review and Evaluation Process (SREP) in which business model analysis plays a key role. Indeed, business model analysis provides the regulator with valuable information on the structure of the financial sector. Knowing the dominant business models and their respective risks aids in the implementation of proper macroprudential policy. It also helps in ensuring proportionality in supervision, as stipulated by SREP.

This paper is fully devoted to identification and research of current Ukrainian banks' business models, how they changed over the crisis period, outlining risk areas, and finding out new possibilities for development. To the best of our knowledge, this is the first work of its kind in Ukraine. The ultimate goal of it is to develop a policy-oriented methodology that would aid in advancing the supervisory practices of the National Bank of Ukraine (NBU).

We did a clustering analysis of the Ukrainian banking industry with the aim of identifying business models. The clustering model we deployed in this paper was a Kohonen Self-Organizing Map (SOM). We identified six business models endemic to the Ukrainian banking system: Households-to-Corporates, Retail, Universal, Corporate, Investment/Wholesale, and Frozen/Undecided. Then, we demonstrated what kind of transformations Ukrainian banking underwent during the financial crisis.

[1] See Ayadi et al. (2015)

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To supplement our findings, we built a risks map based on a set of risk indicators, one developed specifically for Ukrainian market. The map serves as a tool for assessment of each business model as well as for default prediction of an individual bank. We proved the efficiency of this tool by conducting backtesting, which showed that a majority of the defaulted banks lie in some particular (risky) region of the maps.

The vast majority of existing works on the clustering of banks' business models utilize k-means or hierarchical clustering methods.[2] Our paper proposes a SOM as a valid alternative to it. It is not only good in its primary function of dividing data into homogeneous groups, but it also has very nice features for data visualization as well as other functionality such as trajectories analysis, which we deployed in our work as well.

The paper is structured in the following way. In the second section, we propose an overview of some literature on the topic and compare it with our methodology. The third section presents the methodology, data, and software we deployed for the analysis in detail. In the fourth section, we present our most important findings. The fifth section sets out further work on the topic. Finally, the sixth section provides a summary of our study and concluding remarks.

II. LITERATURE OVERVIEW

In recent years, many works on identification and analysis of banking business models emerged in response to increased demand from regulators. In this section, we identify the main tendencies that appear in the literature and discuss their relative pros and cons.

Banks' business models

A business model is something that differentiates businesses within an industry from one another. The choice of a business model ultimately shapes all the essential characteristics of the firm: target clients, regions, products, marketing channels, suppliers, etc. All these features in one way or another find their quantitative representation in the data. Therefore, the problem of business model identification is purely a clustering one. All the works presented below use clustering algorithms to find out which banking business models prevail on the market. Nevertheless, the model, timing, variables, their granularity, and resulting number of clusters varied greatly.

The scholars generally try to keep their models parsimonious, i.e., using a modest number of variables. Ayadi et al. (2014/2015) and Ferstl, Seres (2014) used merely five variables, while overall a common range is from five to eight variables. Halaj, Ochowski (2009), however, stand out from the list using fifteen variables. For business model clustering that is aimed at solving policy related issues, the number of variables should indeed be limited. An increased number of variables commonly results either in an increased number of groups or less homogeneous ones. For macroprudential purposes, we want to see the general picture of the system and the main groups of banks comprising it. If the analysis is on a micro-level, e.g., for the purpose of mergers and acquisitions, we want to see as granular data as possible. In this case, the number of variables must be greater.

Scholars are divided in their approaches towards variable selection and construction. Ayadi et al. (2014/2015), Roengpitya, Tarashev, Tsatsaronis (2014), and Tomkus (2014) use exclusively standardized balance sheet data so that banks' size does not matter. The advantage of this approach is that it is universal since financial statement data is always open sourced. The key assumption here is that all relevant information regarding a bank's business model shows up in its balance sheet ratios, which is not necessarily true. Other authors try to complement data with other characteristics. Halaj, Ochowski (2009) included some product-specific information such as the amount of housing loans and business-specific ones such as assets per employee. The European Central Bank (2016) used information on the proportion of domestic balance sheet exposure. Such information, of course, might be very helpful in achieving the goal of business model identification; however, it is not always openly available.

The European Central Bank (2016), among others, included a size variable in the form of Risk Weighted Assets. In such a way, the authors added another dimensionality to their analysis: they not only differentiate banks by business models, but by their size as well. However, in our study, we try to avoid inclusion of information that could in any way describe the banks' size. We believe that concentration only on the key business ratios could ensure clarity and consistency of results.

The methodology of Ferstl, Seres (2014) strikingly differs from previous ones. The authors made an amalgam of profitability, liquidity, and balance structure variables assuming they all reflect business models. For the reason discussed in the preceding paragraph, we believe that mixing the data that describes long-term business choices with volatile performance or risks indicators is not a good idea. Some business models might indeed correlate with risk level; others might occasionally outperform their peers in terms of profitability. However, this commonly has a temporary nature and depends on the financial cycle. In the long run, such indicators only contribute to noise in the data related to the business model.

[2] See the literature review section for details.

Some of the authors do a post-clustering assessment of the resulting business models. Ayadi R et al. (2014/2015), and Roengpitya, Tarashev, Tsatsaronis (2014) analyzed the performance of business models in terms of their efficiency and riskiness by calculating some standard banking metrics. However, we think that more can be done about the issue. In this paper, we tried to extend the methodology for business model assessment. We made the methodology specifically targeted for Ukraine. However, it is also applicable to other post-soviet economies.

The abovementioned works reveal major strands in the literature on banking business model identification. All the authors agree that this is a clustering problem. To tackle the problem, they try to keep their clustering models parsimonious by keeping the number of variables moderately low. However, they are divided in the choice of the variables: some of them stick to financial statement data only, while others complement their analysis with more granular data. A few scholars went deeper in their assessments of the resulting models, while we believe that there is a lot of undiscovered space here. In our work, we tried to build a comprehensive methodology for both business model identification and their assessment. The methodology is tailored specifically for Ukraine, although it is also can be applied to many other emerging markets.

A SOM and its application in finance[3]

In the previous subsection, we revealed that scholars use clustering algorithms for business model identification. The algorithms they use are either hierarchical or k-means clustering. We propose a SOM as an alternative to them. A SOM is a clustering method based on neural computations. Kohonen (1982) first introduced it in the field of biology. Later on, it became popular in other areas, including economics.

We cannot claim that a SOM is any better than other clustering algorithms. Neither do other scholars researching the topic who often make controversial conclusions about the clustering efficiency of a SOM compared to other algorithms. Abbas (2008) did an experiment and showed that a SOM is better than its peers in almost all instances. Bação, Lobo, Painho (2005) found that a SOM is less prone to local minima than k-means. On the other hand, Mingoti, Lima (2006) showed that a SOM does not outperform hierarchical and k-means clustering, and often turns out inferior. However, we picked a SOM mainly due to its extensive functionality in data visualization. Additionally, it allows performance of a trajectories analysis (see the next paragraph), which we heavily deployed in our study.

There are not many works that apply a SOM to the business model identification problem. To the best of our knowledge, a paper by Vagizova, Luire, Ivasiv (2014) is the only in the field. The authors used a SOM to identify business models of interactions of the banking sector and the real economy of Russian banks. However, there are plenty of applications of SOM in broader economics and finance. Sarlin, Peltonen (2011) built a financial stability map of European banks in their paper aimed to predict financial crises. The authors of this work featured the attractive functionality of a SOM – trajectories analysis, showing how (by what trajectory) some countries moved across the map over time. Zarutska (2012) also used this feature in her analysis of the riskiness of Ukrainian banks.

Summarizing this subsection, one can assert that a SOM has its advantages over classical clustering methods. Although there is no strong evidence that a SOM is more efficient in the division of banks by homogeneous groups, it has an obvious data visualization advantage. Additionally, it allows for conducting a trajectories analysis, which we used in our study. Therefore, we propose it as a valid alternative to hierarchical and k-means algorithms commonly used in business models clustering.

III. METHODOLOGY AND DATA

Brief intro to Self-Organizing Maps

Kohonen SOMs is an algorithm from the Artificial Neural Networks (ANN) family. It is a two-layer neural network consisting of input and output layers. The following is a short theoretical summary of the method. It will be supported with examples specific to this paper, such that the reader can grasp the general idea of the method more easily.

Let $x=\{x_i : i=1,\dots,n\}$ be a set of size n of vectors of banks' variables on the input layer and $w=\{w_j : j=1,\dots,k\}$ be a set of size k of vectors of neurons' weights on the output layer, where $dim(x_i)=dim(w_j)$. In a Kohonen SOM, neurons are located on a two-dimensional grid.

In a SOM, algorithm weights w are typically initialized to have small random values. This, however, may result in the so-called dead-neurons problem – phenomena when some neurons do not ever take part in the learning process due to a high distance from each point from the input data (the essence of the problem will get clearer further). To avoid this problem, the weights are initialized along with two principal eigenvectors that correspond to the two highest eigenvalues of the input data. Such initialization ensures that all the data points are close enough to at least one output layer neuron.

[3] Refer to Bullinaria (2016) for a comprehensive introductory guidance to SOM and neural computation. The text of Deboeck, Kohonen (1998) gives many additional examples of SOM applications in Finance.

After initialization, the vectors *x* on the input layer are matched with *w* to find the closest neuron by the formula $d(x_i,w_j)=(x_i-w_j)'(x_i-w_j)$, which is the squared Euclidian distance between the variables' vector of bank and the weights' vector of neuron *j*. The neuron with the minimum distance is declared the *winning* or the *Best Matching Unit (BMU)*.

Then, the input vectors start being supplied to the model iteratively. The SOM iterative process consists of two phases: *rough* and *fine-tuning*, which differ by learning parameters described below. In our case, the rough phase consisted of 10,000 iterations (*epochs*), and the fine-tuning of another 20,000 epochs. Each time, the neuron weights are updated by the formula $\Delta w_{i,j}=a(t)\, N_{i,j}(t)\,(x_i-w_j)$.

The term *a(t)* is a time (epoch) dependent learning parameter, which determines by how much the weights would be updated. It starts with a moderately large value and then decays as the iteration process continues. In our application, the learning parameter decayed from 0.5 to 0.05 during the rough phase, and from 0.05 to zero in the fine-tuning phase.

The term $N(t)_{i,j}$ is a neighborhood parameter, which adjusts the weights' update according to the distance of the neuron to the BMU. It's defined as follows: $N(t)_{BMU,j}=\exp(-\frac{D^2_{BMU,j}}{2\sigma(t)^2})$, where $D^2_{BMU,j}$ is a map distance between neuron j and BMU. The term *σ(t)* is a radius parameter. By analogy with the learning parameter, *σ(t)* should decay over the epochs. In our case, it starts from 2.5 at the rough phase and decreases to 1, in the fine-tuning phases it is constant at 1.

To keep it simple, the formulas above ensure the following. Once the input vector of banks' variables is fed to the model, the weights of the output layer adjust in a way that the BMU's weights get closer to the input vector the most, while the neighbor neurons adjust by fewer values depending on their distance to the BMU. The farther the neuron from the BMU, the less its adjustment is. In such a way, over many iterations, our two-dimensional map takes on a topological structure, which corresponds to the original highly dimensional data.

Another parametric choice we faced was selection of the map's size. We opted for a 20x15 square, i.e., 300 neurons overall. The map size choice was stipulated by the data sample size.

There are a couple of clustering efficiency criteria we use to assess the quality of the resulting maps: quantization and topological errors. Quantization error is the average distance between each input data vector and its BMU. Topological error is the fraction portion of all input data vectors for which the first and second BMUs are not adjacent.

The software we deployed in this paper is MATLAB and open sourced SOM Toolbox.

Clustering methodology

Our methodology consists of two main blocks. The first is business model clustering and the second is the assessment of the resulting business models. In both cases, we use a SOM: in the first application, we use it to cluster the data; in the second, we use it to build a risk map for the assessment of the riskiness of the business models in whole and of individual banks.

Classifying business models

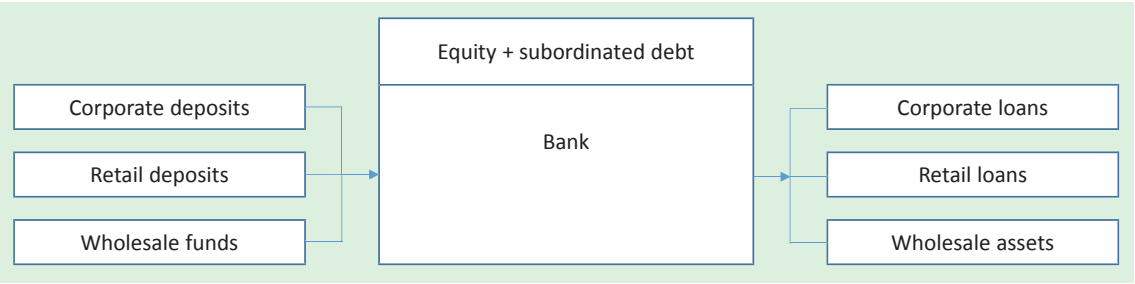
In broad strokes, a bank's business model can be described by answering four general questions:

- Who are a bank's target clients?
- Which products are offered to them?
- Which marketing channels does it deploy (chain of branches, alternative channels, etc.)?
- How does it generate profit (scale, low costs, high tariffs, etc.)?

Our goal for business model identification is to provide an unbiased quantitative view of the balance sheet structure of Ukrainian banks. We believe that the balances of a bank, coupled with some auxiliary indicators, can reveal the underlying business decisions that shape its business model.

The Figure 1 describes what the business model could be. How much equity does bank have, i.e., how leveraged it is? What sort of funds does it attract? What kind of revenue sources (i.e., assets) does it have? Are they classic loans only or some mixture of loans with wholesale assets? All these define the bank as a business.

Figure 1. Business model concept



The data we used was semi-annual, spanning a period of 3.5 years from January 2013 to July of 2016. Thus, a unit of measurement was a bank in a given period. Overall we had 169 banks as of 2014, of them only 93 were left as of mid-2016. This corresponds to 799 observations. The variables that we used to identify business models along with their descriptive statistics are displayed in Table 1.

Table 1. Business model variables descriptive statistics

Variable	*mean*	*sd*	*min*	*max*	*median*
Assets/Bracnhes (UAH)	602 951 772	1 344 209 368	2 212 142	6 499 324 617	102 137 583
Average loans maturity (years)	1.95	1.39	0.00	7.08	1.56
Average loans size (thousands UAH)	5 165.15	11 026.46	0.66	127 528.34	1 476.76
Equity and subordinated banks ratio	0.30	0.22	-0.20	1.00	0.23
Retail assets ratio	0.11	0.16	0.00	0.94	0.05
Retail deposits ratio	0.38	0.20	0.00	0.91	0.40
Loans ratio	0.74	0.21	0.00	1.00	0.79

The Assets/Branches variable shows how intensively the bank uses a chain of branches in its operations. Since we did not want this variable to implicitly represent banks' size, we standardized it by assets value. In the results, the variable shows assets' value per branch. A high value is supposed to indicate a relatively small number of branches.

The average loan maturity is calculated as the weighted average loan maturity in years applied to loan stocks as of a particular date. This indicator reflects the timing horizon in which a bank operates on its product side. The problem with this indicator is that it is calculated from stocks' values. Therefore, it reflects a decision made in the past (probably a distant one). What we instead would like to see is the flow information, i.e., the maturity of newly issued loans for a period. Unfortunately, data limitations did not allow us to construct such a variable.

The same problem applies to the average loan size variable, which was constructed as the overall loans portfolio divided by the number of loans. To tackle the possible problem of outlying values, we first dropped the top decile of each bank's loans. The difference between the mean and median of this variable indicates the presence of outliers from the top side. That means that some banks credit big businesses by issuing large loans.

The equity and subordinated debt ratio shows how leveraged is a bank. The distribution of the variable is centered around 0.23, while the mean is 0.3. As previously stated, this indicates the presence of some very deleveraged banks, which is very uncommon to the banking business.

The retail loans ratio is the proportion of retail loans to revenue generating assets.[4] It reveals the main target clients of the bank. A high value of this variable evidences that a bank serves individuals mainly. If the value is low, a bank orients more on the corporate or wholesale market. Descriptive statistics show that Ukrainian banking has more corporate or wholesale exposures, while there are banks that serve mostly individuals.

[4] Revenue generating assets include loans, interbank exposures, and securities.

The retail deposits ratio is the proportion of retail funding to the sum of overall liabilities minus subordinated debt. It shows to what extent a bank relies on individuals to fund its operations. We can see from descriptive statistics that, despite assets exposure to individuals is on average very low, Ukrainian banks rely much more on them to fund their activities.

Finally, the loans ratio is a the share of loans (excluding interbank) to assets. It shows to what extent a bank is engaged in non-classical banking activities. If the value is low, then a bank has a high interbank or trading exposure. From descriptive statistics, we can see that Ukrainian banking is mostly traditional, having a median value of the variable equal to 0.8.

Note that no qualitative indicator is included in the list above, since we strived to give as objective a result as possible, without the use of subjective qualitative indicators. We also did not explicitly differentiate banks by size since all the ratios are standardized by assets value where applicable.

Also, to provide for equal weighting of all the variables in the SOM algorithm, they were normalized to have a mean of zero and variance of one. We did not want to see outliers in our training sample. Therefore, we replaced outlying values in the sample with the nearest value in a non-outlying range. Generally, we qualified a value as an outlier if it was more than 4 standard deviations away from the median. Appendix 1 contains boxplot graphs of the normalized variables.

After application of a SOM algorithm to the data, we additionally needed to join the output layer neurons into groups, such that we get the resulting clusters (i.e., business models). For this purpose, we applied a k-means algorithm to the neurons' weights.[5] The number of clusters (k's) was determined by an elbow method.[6]

Given the optimal number of clusters, the optimal division is achieved by a bootstrap procedure with 100 iterations. At each iteration, the criterion was constructed using the formula $Cr = \frac{BCSS}{WCSS}$, with BCSS (between clusters sum of squares) and WCSS (within clusters sum of squares). $BCSS=\sum_i (\overline{w}_i-\overline{w})(\overline{w}_i-\overline{w}), WCSS=\sum_i\sum_j(\overline{w}_i-\overline{w}_j)(\overline{w}_i-\overline{w}_j)$, where $\overline{w}$ is the overall sample mean, $\overline{w}_i$ is the cluster i mean, and $\overline{w}_j$ is the cluster j mean. Ultimately, the clustering with maximum *Cr* is selected.

Risk mapping

For the purpose of risk assessment, we propose concentrating on the six types of risks:

1) Profitability risk;
2) Credit risk;
3) Liquidity risk;
4) Concentration risk;
5) Related party lending risk;
6) Money laundering risk.

The first three types of risks come directly from the Basel framework. Profitability risk here partially quantifies the market risk from Basel, as will be explained below. Unfortunately, we could not include operational risk here as we could not find proper quantification of it. We admit that this type of risk might be material and contribute to the severity of the banking crisis.

The remaining three types of risks deal with those problematically specific to Ukraine and many other emerging market countries, namely high concentration, related party lending, and money laundering. The variables that we used to quantify the risks are presented in Table 2.

The time span is the same as business models clustering, so is the unit of measurement and outliers' treatment. However, the frequency this time is higher. We choose quarterly data since risk indicators are usually less stable over time than the ones for business model identification. As a result, the sample size for risk clustering is 1,475.

Our approach to normalization was slightly different too. We did separate normalization for each point of time. The reason for this was the fact that some variables we used for risk clustering experienced structural shifts in means.[7] Therefore, doing so ensured some sort of mean stationarity of the data.

[5] A SOM algorithm is closely related to a k-means one. In fact, application of a k-means algorithm to the output weights of a SOM adds another layer to the neural network in the form of k-mean clusters. Therefore, the overall model may be considered as a three-layer network.
[6] The method was first proposed by Thorndiket (1953).
[7] For example, a real NPL that had been hidden by banks for a long time was revealed with a recent Assets Quality Review.

Table 2. Risk variables descriptive statistics

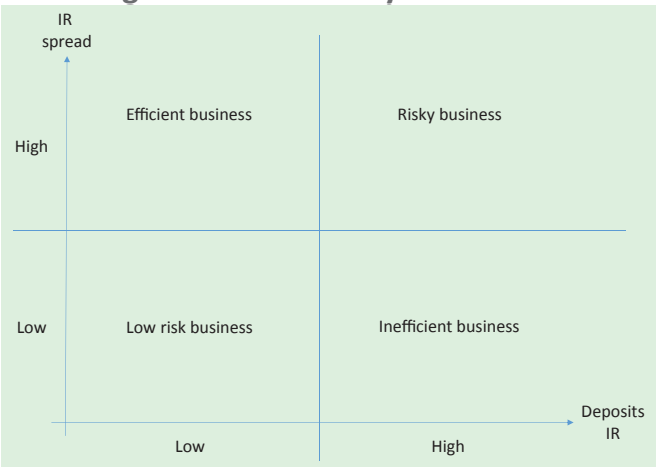
Variables	*mean*	*sd*	*min*	*median*	*max*
Deposits IR	15.36	5.49	0.00	16.34	33.64
IR spread	6.76	7.04	-8.34	5.97	28.33
NIM	0.03	0.03	-0.08	0.02	0.19
NPL ratio	0.13	0.21	0.00	0.04	1.00
NPL coverage	1.10	0.77	0.02	1.00	3.03
Liquid assets ratio	0.09	0.12	0.00	0.05	0.90
Assets concentration	0.49	0.25	0.00	0.49	1.00
Liabilities concentration	0.17	0.16	0.00	0.12	0.84
Unique borrowers ratio	0.36	0.23	0.00	0.34	1.00
Turnover	2.22	2.16	0.01	1.51	10.80

When analyzing profitability of banks, we address their ability to raise funds cheaply and allocate profitably. These imply the efficacy of a bank's target clients, market, regional, and other strategic choices. The variables that aid to quantify this are deposits' interest rate (**Deposits IR**) and interest rate spread (**IR spread**). These indicators deal with the interest rate and interest rate spread risk according to the Basel definition of market risk.[8]

The banking business is deemed efficient when it raises funds at a low interest rate and lends at a higher one (given a reasonable risk profile) and the other way around (see the Figure 2). Nevertheless, if a bank raises expensive funds and lends them with a high spread, it may suggest that the bank may undertake risky projects. From descriptive statistics, you can see that the average deposits interest rate and interest spread are very high, reflecting the high risk profile of the Ukrainian market.

Another useful indicator of profitability is Net Interest Margin (**NIM**). It is the relation of net interest, commission, and trade income to revenue generating assets. The average value of 0.03 is commensurate with the similar figure for developed markets. Therefore, higher risks are not on average compensated for by higher returns on assets.

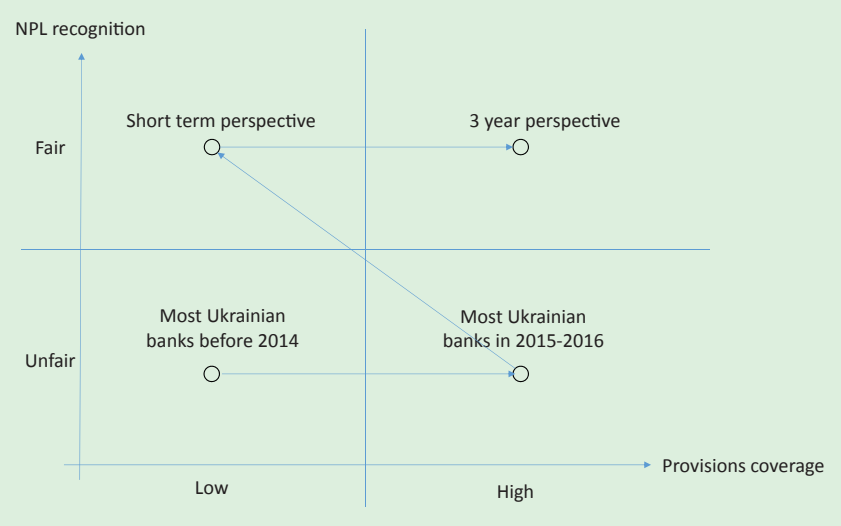
Figure 2. Profitability risk matrix



When dealing with credit risk, an obvious choice was to consider the non-performing loans level (**NPL ratio**) and to check if it is covered with provisions (**NPL coverage**). Dealing with the NPL level is a bit tricky since many banks hide the real level of NPLs by rolling over, restructuring, etc. Hence, we face an issue of fair recognition of NPLs. Before 2014, most banks had been hiding the real level of NPLs and kept too little provisions, as shown in the bottom-left box of Figure 3. An Assets Quality Review and stress test exercise conducted by the NBU from 2015-2016 forced banks to raise their provisioning levels, thereby moving them to the bottom-right box. In the short-term period, banks are expected to show the real NPL level, thus moving themselves to the top left box. Over a three-year period, banks are expected to fully cover these NPL with provisions, thereby appearing in the top-right box. Given the above information, we regarded having abnormally low NPL levels risky in our analysis. To the contrary, having high NPL and little provisions coverage should not always be taken myopically, because, in some occasions, it might signal the willingness of a bank to represent the real picture of its assets and to provision them shortly. The subjectivity of the issue allows us to make inferences only with some degree of confidence and subject them to professional judgment.

[8] See BIS (2016).

Figure 3. NPL and fair recognition issue

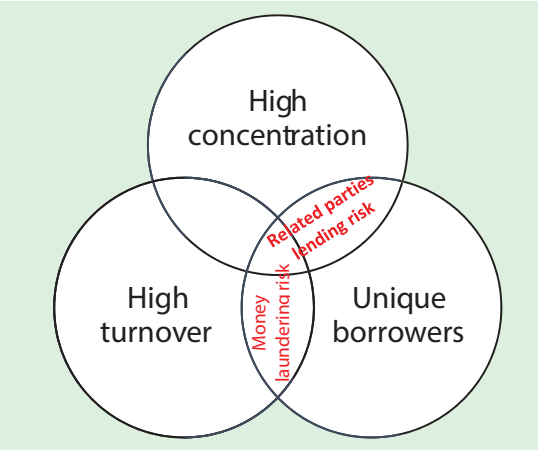


In analyzing Liquidity Risk, we constructed a **liquid assets ratio** indicator. It is essentially the portion of the bank's most liquid assets, which include cash, correspondent accounts with the NBU, deposits with NBU, and government securities that are refinanced by NBU. One can be sure that, in the case of a massive deposits outflow, a bank would certainly be able to survive the increased liquidity pressure of at least the value of this indicator. Unfortunately, there are not many ways to measure liquidity risk yet since such measures as Liquidity Coverage Ratio (LCR) are yet to be developed in the NBU.[9]

Last, but just as important as the previous risks, is the risk of a bank's malpractices. It includes related party lending, endemic to it concentration risk, and money laundering risk. Concentration risk is measured with **assets concentration** and **liabilities concentration** variables. These variables are constructed as the ratio of assets/liabilities that account for >2% of the total assets each.[10] Descriptive statistics show us that assets concentrations risk is more pronounced in Ukrainian banking.

Related lending detracts the banking system from the fulfillment of its primary function – provision of funds to the real sector. Instead, it causes market inequalities, inefficient resource allocation, monopolization, and many resultant issues. More on the destructive impact of related lending is laid out in La Porta, Lopez-de-Silanes, Zamarripa (2001). Identification of such practices is a tough and tricky task. Our approach to this issue is presented in Figure 4.

Figure 4. Banks' malpractice identification approach



[9] In fact, there are three existing liquidity measures in accordance with NBU economic normatives – N4, N5, N6. However, they were proven inefficient in the current application. More details on this can be found in Figures A-C of the Appendix 1, where the signaling ability of some indicators is analyzed.
[10] Liabilities excluded subordinated debt.

Here we incorporate the following logic. A variable of the **unique borrowers ratio** is the portion of large borrowers (>2mln UAH) within a particular bank that have not come across in other banks for a period of the four last years. We assume that if there is a high unique borrowers ratio and a high assets concentration, then the probability that a given bank is engaged in related party lending is greater, ceteris paribus. Here we bear in mind that banks practicing related party lending are most likely to serve some particular business group that is not interested in borrowing from someone else. In addition, many business groups have the practice of creating fictitious companies (so-called Special Purpose Vehicles) that manage financial flows of the business group and will most likely to be a client of only the bank also belonging to this group. Such companies usually do not create any value, have a few of employees, and do not have an office. Therefore, such companies naturally do not even have a chance to get a loan from a bank other than that owned by the business group.

In turn, we assume that a high **Turnover** on some balance sheet accounts[11] coupled with a high ratio of unique borrowers might indicate money laundering practices.

IV. RESULTS

Business models maps

Using the variables and optimal clustering solution from Section 3.1, we conducted a clustering analysis of the Ukrainian banking system. The purpose of this was to identify what types of business models are common for Ukrainian banks and how they transformed over the crisis. We identified six business models: Households-to-Corporates, Retail, Universal, Corporate, Investment/Wholesale, and Frozen/Undecided.

Figure 5 contains a SOM of the business models. It shows the location of each business model on it. From the figure, we can observe how 300 neurons are organized into a two-dimensional grid. Each neuron can contain one bank, several banks, or be empty. The coloring of the map represents different clusters. Neurons to be joined into one group were determined by a k-means clustering algorithm, as explained in Section 3.1.[12]

Figure 5. SOM of business models

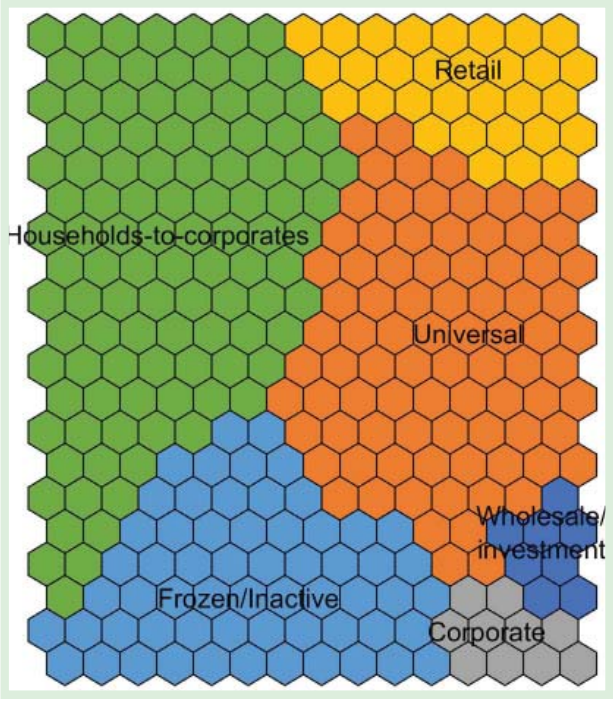
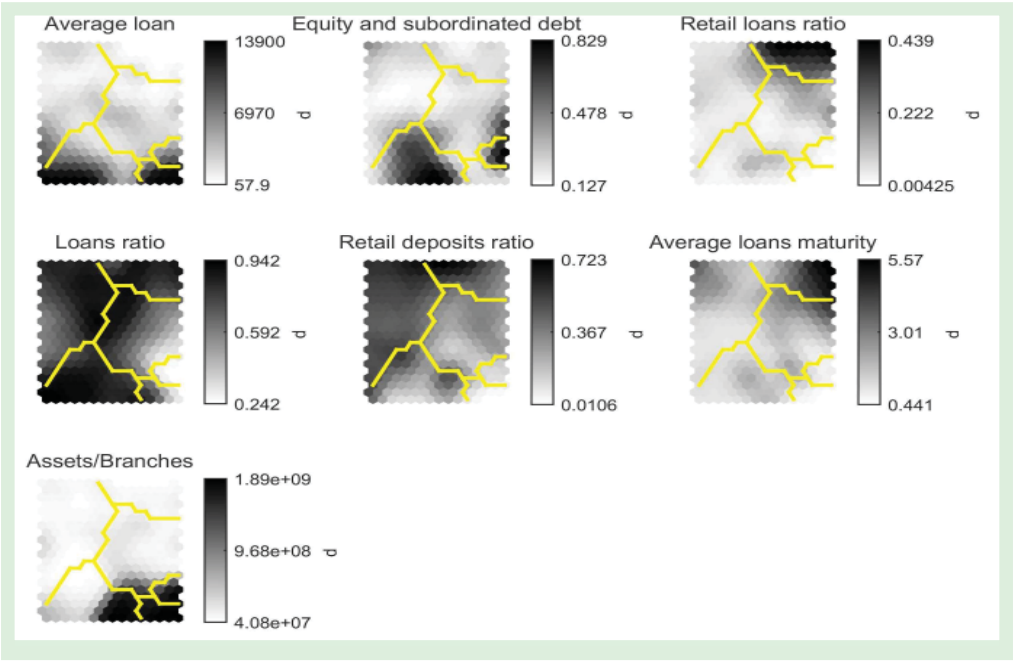


Figure 6 visualizes the variables used in a SOM algorithm. Each little map corresponds to some of the seven variables utilized for the business models clustering. These maps are colored according to the variables' values. The darker the region, the higher a variable's value it has, and hence, the less a variable's value the banks have in that area.

[11] The list of accounts used is the result of an analysis conducted by the authors. This list includes accounts, increased turnover on which could be observed in banks, liquidated by Financial Monitoring Laws. Unfortunately, the authors cannot disclose the list of accounts.
[12] We applied elbow criterion to the map's weights and found the optimal number of clusters - 14. However, this number was unreasonably high and the actual difference in the weights was not very material. Therefore, we expertly joined some clusters and came up with the six. You can find the map divided by these original 14 clusters in Figure N of the Appendix 1.

Figure 6. Components maps



On these maps, you can visually observe characteristics of the determined clusters.[13] For example, you can see that the share of retail loans is much higher in the retail cluster region; also, it has a very high retail deposits ratio, the lowest average loan size, the longest maturity of loans, and the largest number of branches.

The Households-to-Corporate (HTC) has a small portion of retail loans (high fraction of corporate loans) and a large portion of retail deposits. In other words, the banks from this cluster stream households' funds to corporates. It is not a bad business model per se. However, in Ukraine, it is highly over-represented and accounted for about half of the banking system before the crisis. In addition, due to its characteristics, this cluster bears the risk of related party lending, although this point will be disclosed in the risk clustering section.

A mix of loans and wholesale assets characterizes the universal cluster. Loans are issued to both retail and corporate clusters. The retail deposits ratio is high, but not much high as in the HTC and retail clusters.

The Frozen/Undecided segment is quite diverse in assets and liabilities structure. The feature that is common to this segment is very high equity and subordinated debt share, reaching up to 90%. It indicates that the banks from this group do not fulfill one of the main function of a banking institution (financial intermediation) since they do not attract deposits. This might happen for several reasons: the bank is young and not yet scaled up in its operations; the bank is inactive; the bank is undecided as to its business model; or the bank is engaged in activities not typical to traditional banking.

The Corporate segment does not have retail loans and deposits – it serves only corporates. In addition, it has the largest average loan and shortest loans' maturity: there is no surprise in it since enterprises naturally take larger loans than individuals do. Moreover, corporates in Ukraine take loans mainly to finance operational activities. Therefore, loans are mostly short-term. Finally, since the cluster does not serve individuals, it does not need branches, which is reflected on the Assets/Branches variable's map.

The Wholesale/Investment banks are extremely uncommon in Ukraine. There had been just five such banks before the crisis. The cluster is similar to Corporate; however, it has the lowest fraction of loans among all clusters. Therefore, the majority of its operations are wholesale.

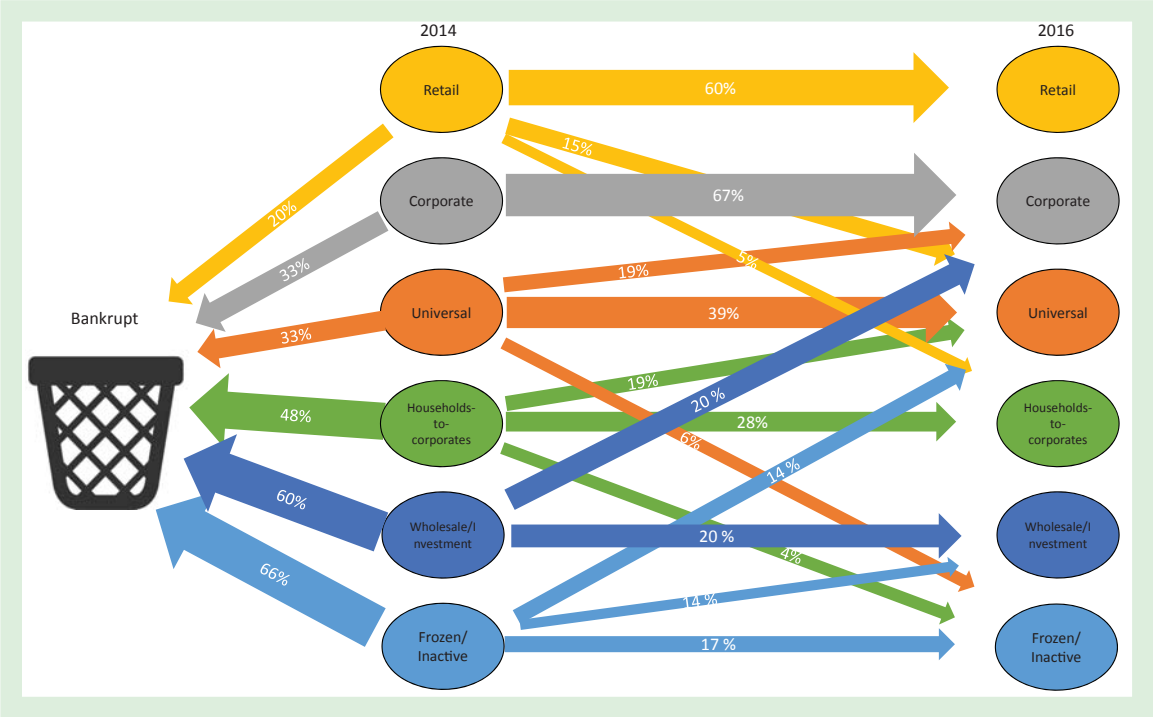
The quantization error for a business models SOM is 0.8, and the topological error is 1.75%, which is low enough for the map to be considered accurate. An optimal clustering solution has a Cr value of 0.37.

Banks migration from clusters over time is illustrated in Figure 7. It seems that the HTC and Frozen/Undecided segments were more prone to defaults over the crisis. Investment/Wholesale also has very high default rate, however, taking into account the very low number of its constituents, the absolute number of defaulted banks in this cluster is not material.[14] Universal, Corporate, and, especially, Retail segments have relatively low default rates. Therefore, they might be considered relatively safe from this perspective.

[13] Appendix 2 contains descriptive statistics of the identified clusters.
[14] Refer to the tabular representation of Figure 7 in Appendix 2.

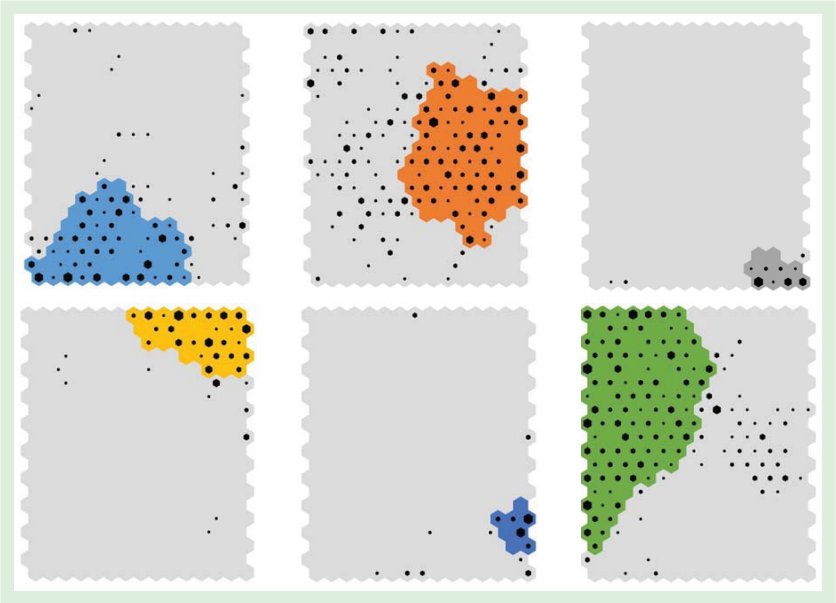
Ayadi et al. (2015) also conducted a migration analysis among clusters in their regular *Banking business models monitor. Europe.* In Europe, the clusters behave quite stably. If we consider only the banks that survived the crisis in Ukraine, we would observe a similar picture in Ukraine.

Figure 7. Visualization of banks' migrations among models



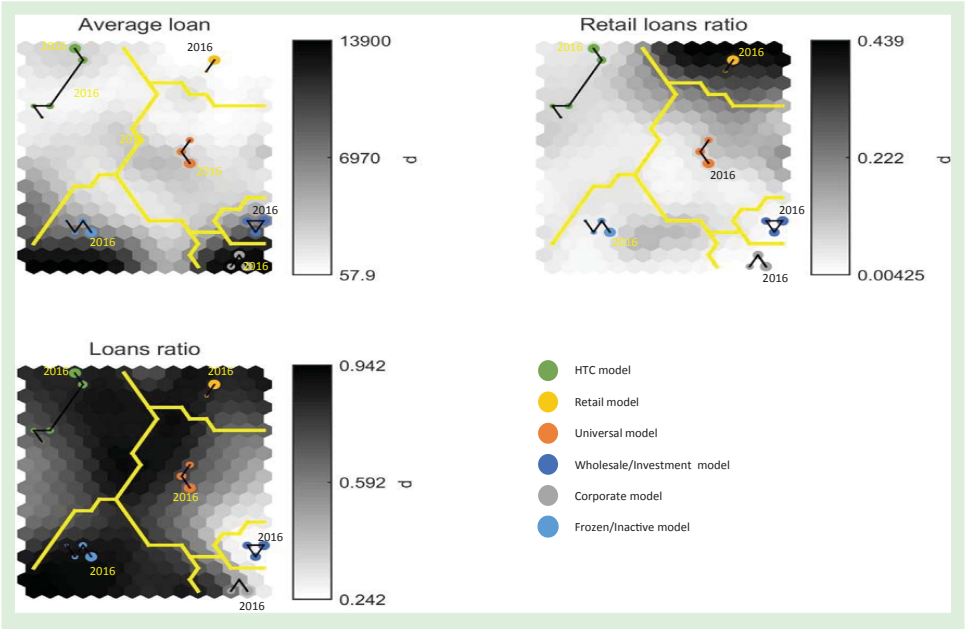
Another important feature of business models is the stability of their constituents, which is illustrated in Figure 8. The black dots there indicate the locations of banks that appeared at least once in the respective cluster over the studied period. It is seen that all groups, except Universal, are quite stable. Universal, though, has its constituents very scattered over the map. Therefore, this cluster can be deemed as a transition cluster. For example, if a bank decides to change its business model from a Retail to a Corporate one, it would certainly start changing its assets structure by reducing its retail loans ratio. But, it would not happen instantly. Hence, during the transition period, the bank would appear in the Universal segment, which is characterized by diversity of assets.

Figure 8. Banking constituents' stability



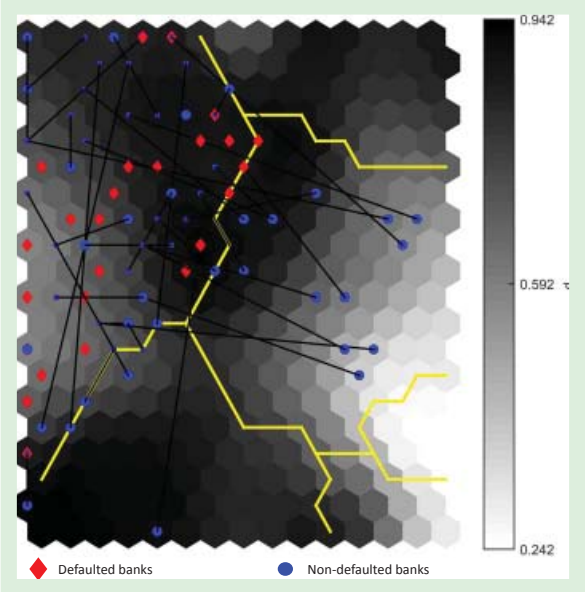
A SOM provides very useful functionality called trajectory analysis. Trajectory analysis tracks the movement of some units (for example, a bank or a cluster centroid) on the map over time. It allows visual observation of the changes undergone by that unit over time. Figure 9 shows the movement of cluster centroids starting from the beginning of 2014 on three variable's maps.[15] We can see that for nearly all clusters the average loan has increased, which is natural due to drastic depreciation and inflation that occurred in Ukraine during the crisis. However, the retail loans ratio increased exclusively in the Retail cluster, while in others, this indicator either decreased or remained unchanged. In a way, the Retail cluster reinforced its authenticity, which we believe is a good sign.

Figure 9. Trajectories of cluster centers on the business models map



Considering the Loans ratio, we can observe that the HTC segment somewhat got rid of its wholesale assets. There are a couple of reasons for that, namely the disappearance of the Ukrainian interbank market and high default rates of HTC banks that were engaged in wholesale operations. Figure 10 illustrates the trajectories of HTC banks on the Loans ratio map. Red diamonds are the banks that went bankrupt. We can see that a majority of banks located in the light region of the cluster either went bankrupt or moved out of the region.

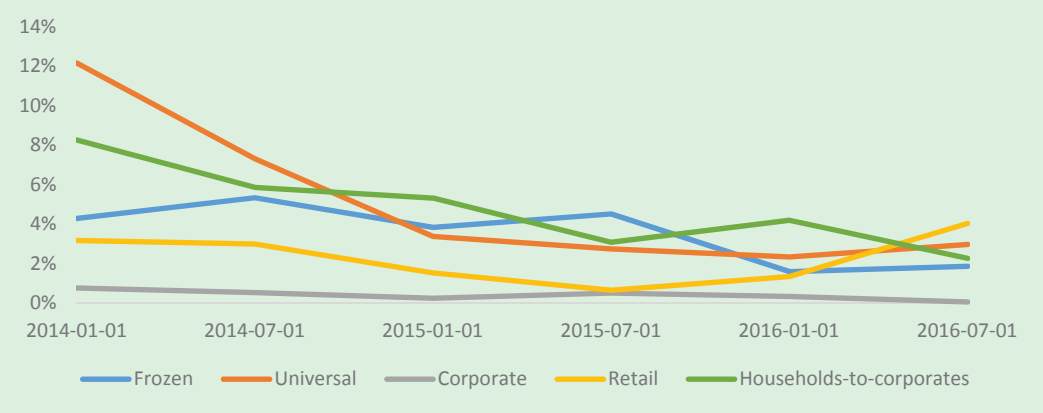
Figure 10. Trajectories of HTC banks on the Loans ratio map



[15] Similar figure for all variables maps is in Appendix 1 (Figure O).

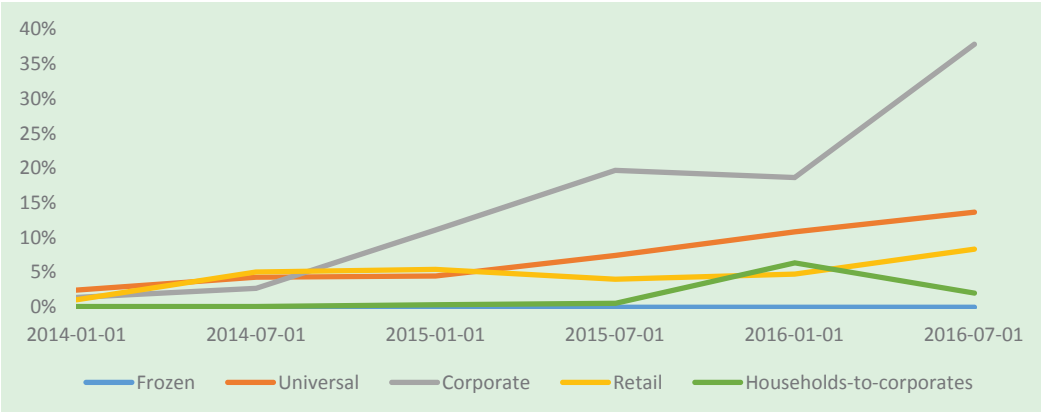
Before the crisis, banks had relied heavily on the interbank market to fund their short-term liquidity gaps; other banks had been ready to stream their free resources to them. However, with the onset of liquidity pressure in 2014, a decrease in overall lending, and a loss of trust within the banking system, this market naturally vanished. Therefore, the portion of the local interbank market in assets approached zero. Figure 11 shows that the HTC and Universal segments were active participants in the interbank lending market. Now the fraction of local interbank lending for each cluster is diminutive. This led the HTC cluster centroid to the top of the business model map in Figure 9, where the ratio of loans is relatively high.

Figure 11. The portion of local interbank lending by clusters



On the other hand, Figure 9 also tells us that the Universal and Corporate clusters reduced its loans share. The reason for this is illustrated in Figure 12. We see that the portion of government securities in assets soared dramatically with the onset of the crisis for the segments mentioned above. This phenomenon can be easily explained by the risk aversion of the clusters. Economic turbulence made the real sector very risky. As a result, these clusters seemed to prefer to invest in relatively safe government securities instead.

Figure 12. The portion of government securities by clusters



Business models clustering identified six distinct business models of Ukrainian banking system. Banks that went bankrupt were not equally spread among business models with HTC and Frozen/Undecided clusters accounting for more than 70% of all defaulted banks. We also showed that the clusters are relatively stable, except Universal one, which carries a bit of each cluster's characteristics, therefore can be regarded as a transfer point for banks switching between business models. Retail cluster reinforced its authenticity by accumulating retail loans fraction in its assets. The engagement in wholesale operations changed oppositely for HTC cluster and Corporate and Universal ones. The former reduced its wholesale assets fraction mainly due to the disappearance of the local interbank market, where it used to be the dominant player. Universal and Corporate clusters invested heavily in the government securities thus having accumulated wholesale assets fraction compared to the pre-crisis period. This was presumably dictated by risk aversion of the clusters.

Risks maps

Using variables from the section 3.2.2 we constructed a risks map, which you can find in Figure F of the Appendix 1. However, for the sake of visualization advantage, we transformed it somewhat by merging some of the map's weights (variables) using the logic of the section 3.2.2. In a way, we came up with six-dimensional weight map: each for a particular risk type. To be precise, we applied the following transformations[16]:

- Concentration risk=(Assets Concentration + Liabilities Concentration)/2;
- Related parties lending risk=(Assets Concentration + Unique borrowers Concentration)/2;
- Laundering risk=(Assets Concentration + Turnover)/2;
- Liquidity risk=(Deposits IR-Liquid Assets Fraction)/2;
- Profitability risk=(–IR spread – NIM)/2;
- Credit Risk=(|NPL level|–NPL coverage)/2.

As a result, we can visually illustrate six risk types with the maps in Figure 13. The darker the region on the maps, the more risk of particular type bear the bank located in that region. It can be easily seen that the top half of the mast overall is riskier than the bottom one: it is highly concentrated and has signs of related parties lending; it also has liquidity problems; the left flank of it bears the risk of money laundering; the top right corner has very high credit risk.

Figure 13. Risks map

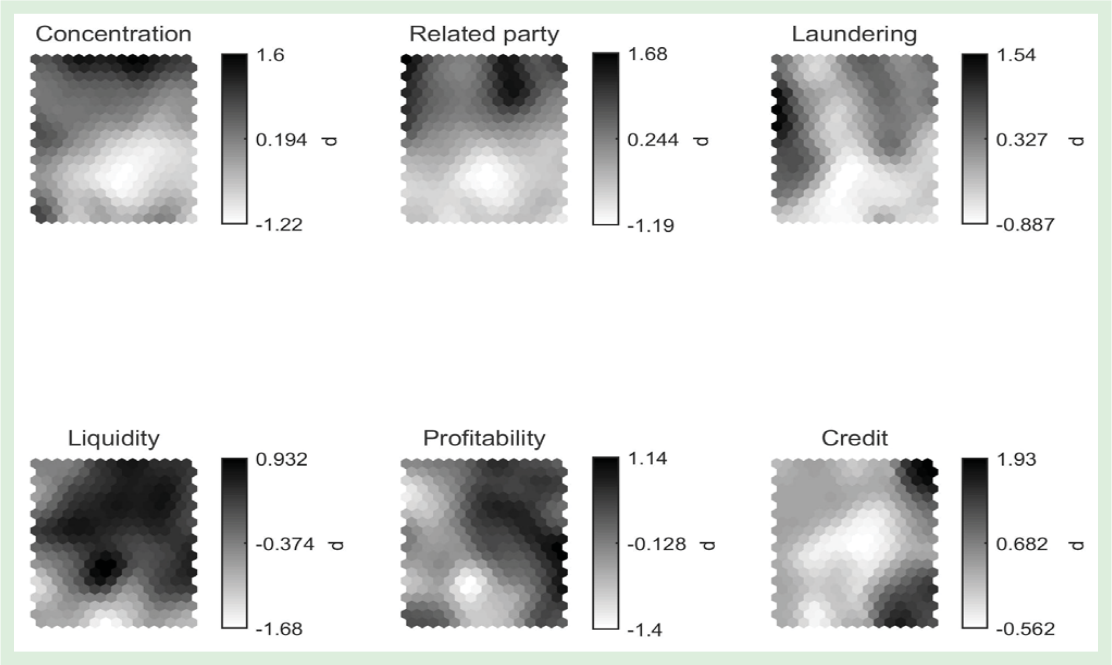
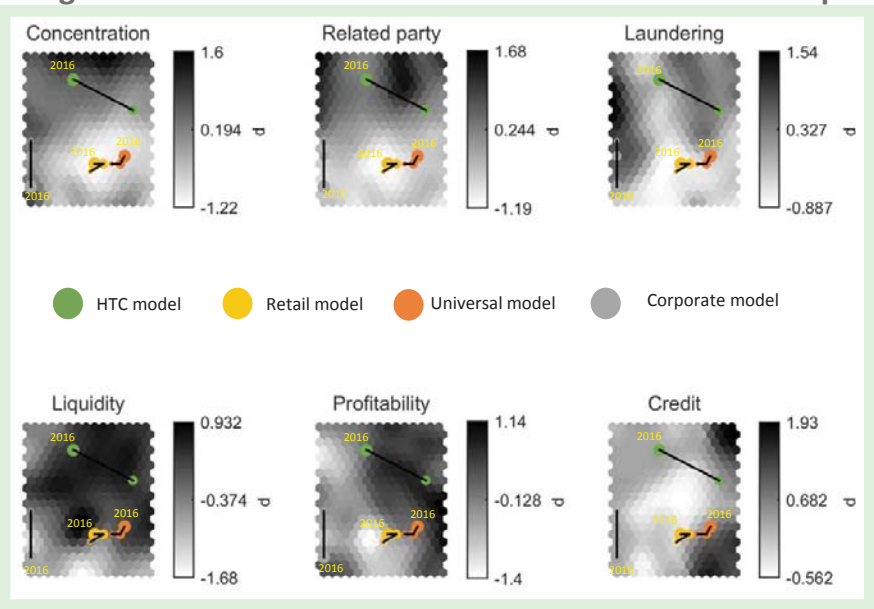


Figure 14 contains trajectories of business models' means on the risks map. It shows how business models looked at the beginning of 2014 and now in terms of riskiness. We disregarded Frozen/Undecided and Investment/Wholesale clusters due to their negligible size in the banking system and concentrated our attention on the HTC, Retail, Universal, and Corporate segments. There is no surprise that the HTC model is located at the top part of the map given its default rates. The model is highly concentrated, not very profitable, and has signs of related party lending. These risks, along with liquidity ones, are the major issues for this model. The Retail, Corporate, and Universal models are in the bottom part of the map. The Retail model seems to have the safest risk profile. The Universal model bears a bit of profitability and credit risk, while the Corporate model is somewhat concentrated.

Unfortunately, the risk profile of the HTC business model has not changed much over the crisis. It is seen that the model moved to the region with more concentration and credit risk. The Retail model remained in the safest area. The Universal cluster on average also has not changed its risk profile much, however its liquidity position slightly deteriorated. Regarding the Corporate model, we can see that it moved out of the region with high money laundering risk. It is natural because some of the banks from this segment were liquidated under the Financial Monitoring Law. Thus, we can reasonably assume that the remaining banks do not practice any illegal activity. The banks also enhanced their liquidity positions due to investments in liquid government securities. On the other hand, profitability deteriorated slightly.

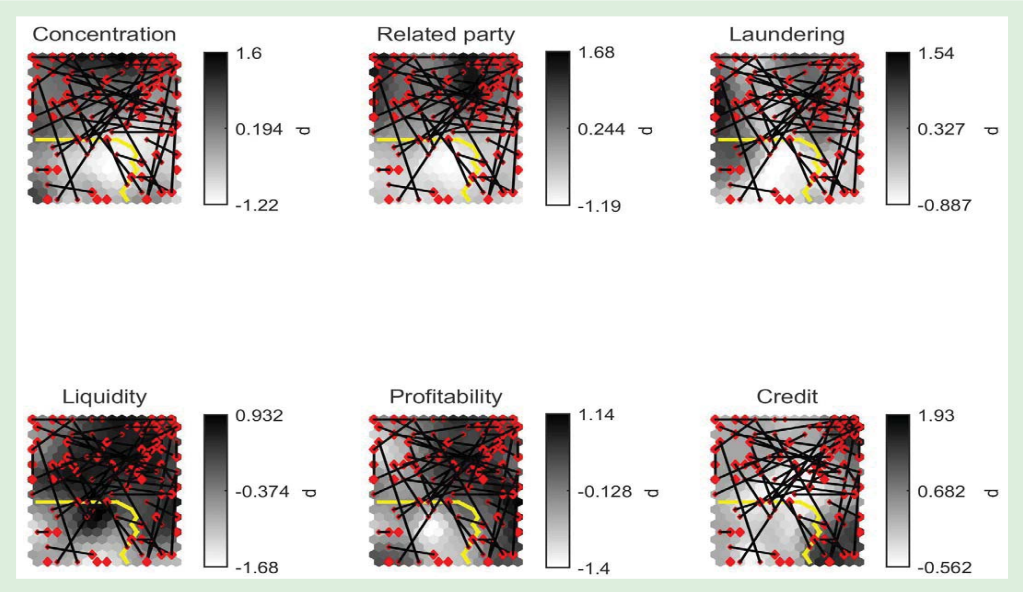
[16] While reading the formulas, keep in mind that all the variable, and hence maps' weights, were normalized around zero. This makes the interpretation of the NPL level taken to the modulus in the sixth formula clearer: not only a high NPL level was considered risky by us, but an unusually low (below average, i.e., zero) as well.

Figure 14. Business models' movement on the risks map



Now, we are in a position to perform backtesting on our risks map with the use of actual data on banks' defaults. Figure 15 illustrates trajectories of the banks defaulted over the crisis from the beginning of 2014 until the last quarter of their existence. The circumscribed region in the bottom left region is considered the safest one, this is supported by the fact that only 8% of the defaulted banks were located there in the last quarter before their bankruptcy. There are also many instances when a bank had been located in the safe region and then moved out of it right before its bankruptcy. Based on the map, we can conclude that the region that is most densely populated with defaulted banks is the top right corner. The area holds each of the six types of risks to some extent.

Figure 15. Trajectories of defaulted banks[17]

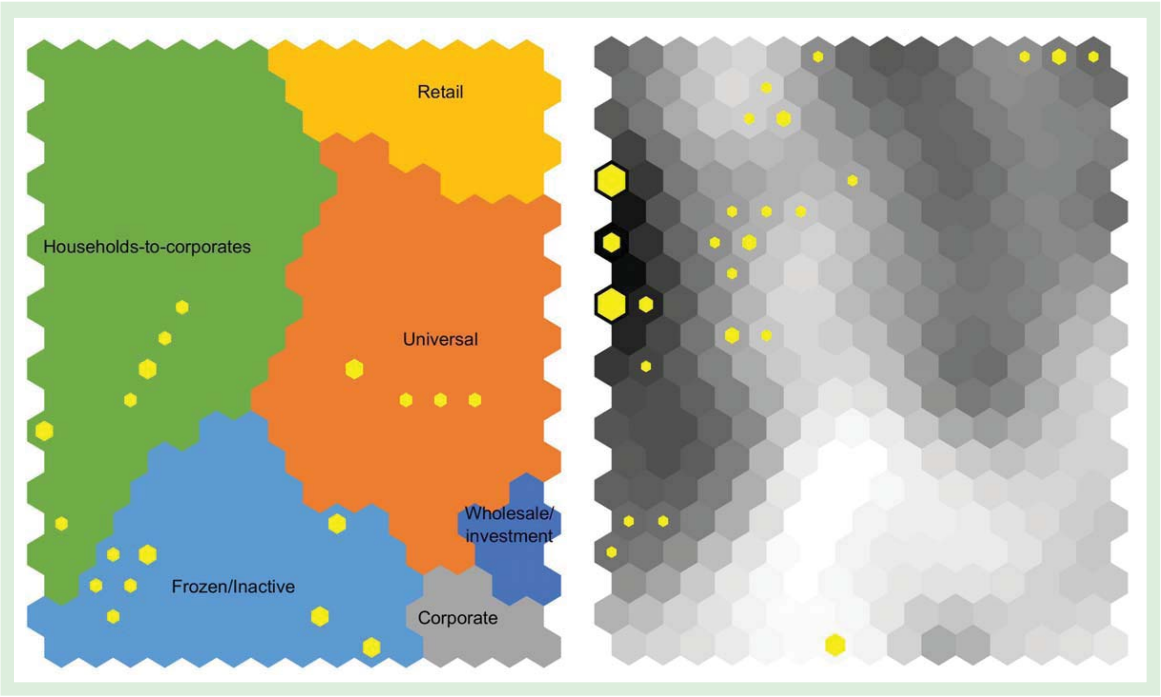


We can also test our hypothesis regarding identification of money laundering banks. Figure 16 shows the locations of money laundering banks on the business models map a) and on the laundering risk map b). On the business models map, the majority of these kinds of banks are expectantly located in the Frozen/Undecided business model or nearby it. On the laundering map, they lie mainly in the darkest region. This also confirms our hypothesis that high accounts turnover, coupled with a high unique borrowers concentration, may indicate illegal banking practices.

[17] Figures H-M of the Appendix 1 contain the trajectories of individual bank by business models.

Figure 16. Money laundering banks location

a)BM map **b) Laundering map**



In this section, we proved that the risk indicators we constructed turned out to be quite informative in terms of default prediction. The risks map built based on them illustrated that 92% of the defaulted banks were located in a particular map's region that we consider risky. On the other hand, there is a relatively safe region, which contains only 8% of the defaulted banks. In addition, we confirmed our initial hypothesis that if the bank has high accounts turnover and a large unique borrowers concentration, then it is likely to be engaged in money laundering schemes. Such banks were mainly located in the Frozen/Undecided cluster.

V. FURTHER RESEARCH

The previous section exhibited the great potential for SOM clustering in an analysis of the banking sector. However, some issues can be explored in more detail during further research. In particular, despite the risk maps showing a good signaling ability, this part of the analysis cannot yet be considered as fully comprehensive because of the complexity of the topic. For example, the analysis of such an important risk as liquidity risk and development of its measures requires much time and effort. This work is yet to be done within the NBU and well beyond the scope of this paper. In the meantime, we have just one measure of liquidity risk (Liquid Assets Ratio), which is proven to be informative retrospectively.

Risk mapping is not an attempt to create an Early Warning System since the time horizon of the risk mapping is much longer than an EWS must have. It does not preclude one from using the current methodology for the creation of such a system. Given the undeniable visualization advantages of the technique, it may appear as a very lucrative option. In this context, a trajectories analysis would be a very useful tool. If, for example, a regulator observes that it gradually approaches a map's "risky" region, this should become a clear warning signal.

Another fertile field for SOM usage might be banks' mergers and acquisitions. A bank seeking a partner for a merger or acquisition can outline key indicators that describe a desired profile of the target. Then, a SOM could be built based on these indicators. An analysis of the map can help identify the region that contains the most suitable targets.

In addition, the subject of our work might fit well in the SREP, which the NBU plans to develop. As prescribed by the European Banking Authority (2014), banks' categorization, business models, and strategic risks analysis are essential parts of the SREP. All the topics were disclosed in our methodology.

VI. CONCLUSIONS

In this paper, we developed a methodology and conducted a clustering analysis based on Kohonen neural networks to identify banking business models that prevail in Ukraine. We outlined six distinct business models: HTC, Retail, Universal, Corporate, Investment/Wholesale, and Frozen/Undecided.

Then, we showed how these models transformed as a result of the banking crisis. We showed that more than half of HTC and Frozen/Undecided models' constituents went bankrupt. This indicated that these models by default were riskier. We also revealed that some of the models had opposite changes in wholesale assets portfolios: while the HTC segment reduced its wholesale ratio due to the disappearance of the local interbank market, the Corporate and Universal segments accumulated the ratio due to increased investments in government securities. The latter happened presumably due to the risk aversion of the clusters' constituents. In addition, we showed that the Retail cluster is considered relatively safe due to its transparent and market-oriented business model: during the crisis it not only had the lowest default rate but additionally accumulated its retail loans ratio, thereby reinforcing its authenticity.

To complement our analysis, we constructed a risk map based on a set of risk indicators of six types: Profitability, Credit, Liquidity, Concentration, Related party lending, and Money laundering. It confirmed our previous findings regarding the riskiness of the HTC model and safeness of the Retail one. Then we conducted backtesting, which proved the efficiency of the proposed risk indicators: a majority of defaulted banks were located in some map's "risky" region before their bankruptcy. Hence, the presented SOM tool can be considered efficient in default prediction and other supervisory purposes.

Finally, we outlined a field for further research. In particular, in our plans is an improvement in the risk assessment methodology as new quantitative indicators of risks, such as LCR, come to life. Additionally, we gave some examples of where our methodology and method could also be applied. Particularly, in our opinion, such fields as EWS, SREP, or M&A are potentially good spheres to apply a SOM clustering approach.

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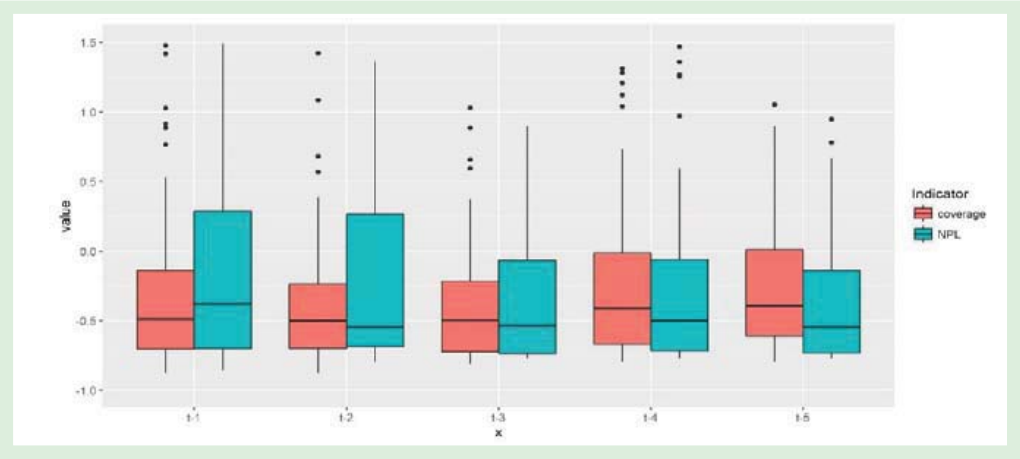
Appendix 1. Figures

Figure A. Signalling ability of NPL level and provision coverage*



* Horizontal axis – quartes to default. Values are standartized such that non-defaulted banks have a value of zero. Therefore, the locations of bars are deviations of defaulted banks' indicators from non-defaulted ones.

Figure B. Signaling ability of the NBU's major economic normatives

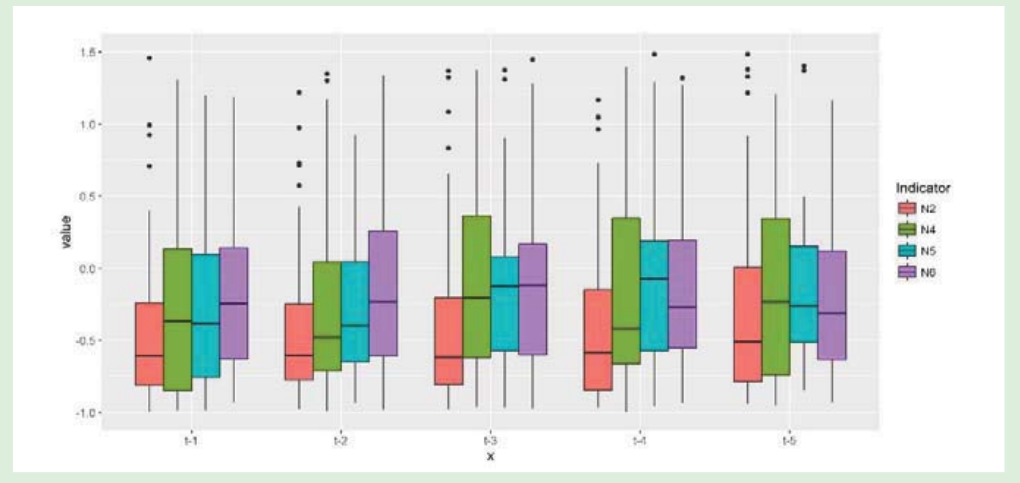


Figure C. Signaling ability of interest rates and spreads

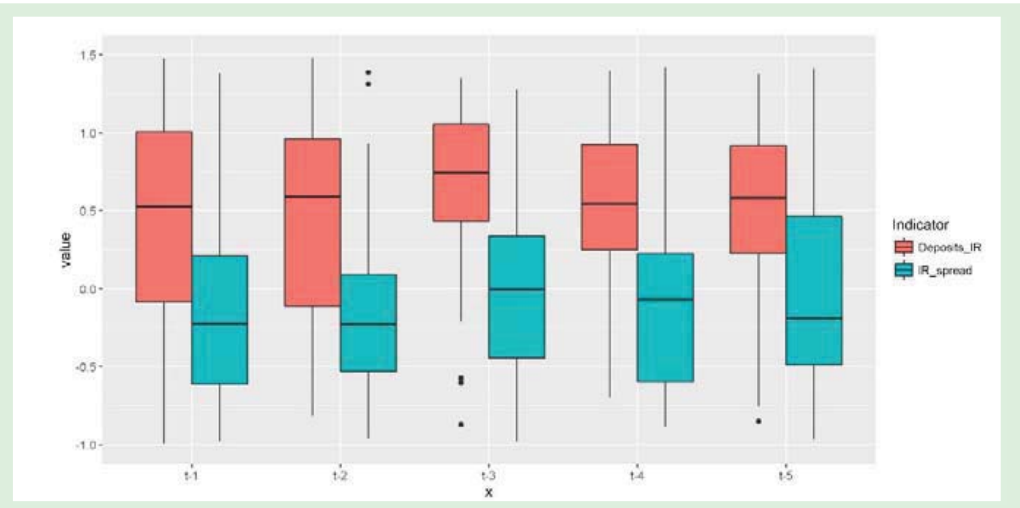


Figure D. Boxplots of normalized business models' variables

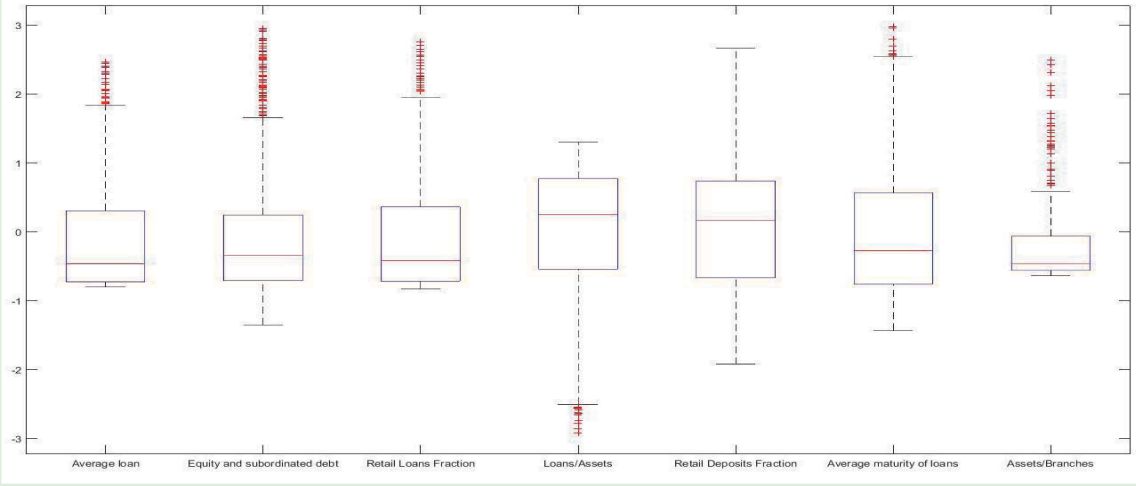


Figure E. Boxplots of normalized risk variables

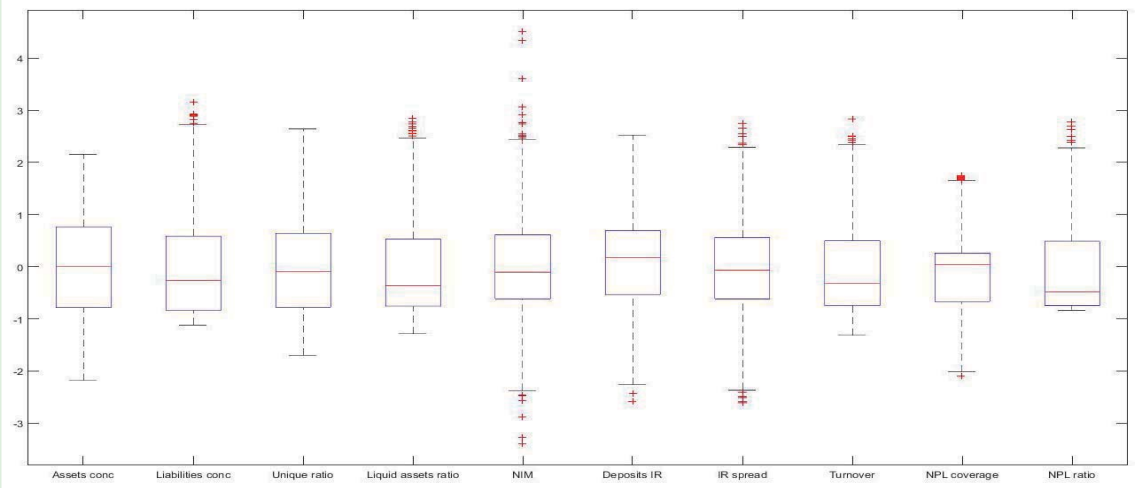


Figure F. Original risks map

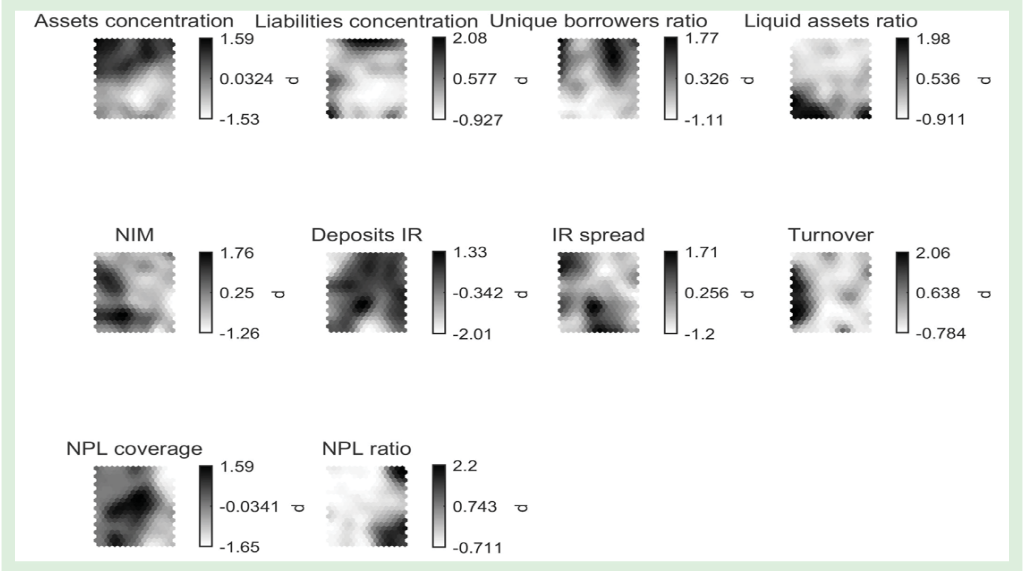


Figure G. Ownership structure by clusters as of mid-2016

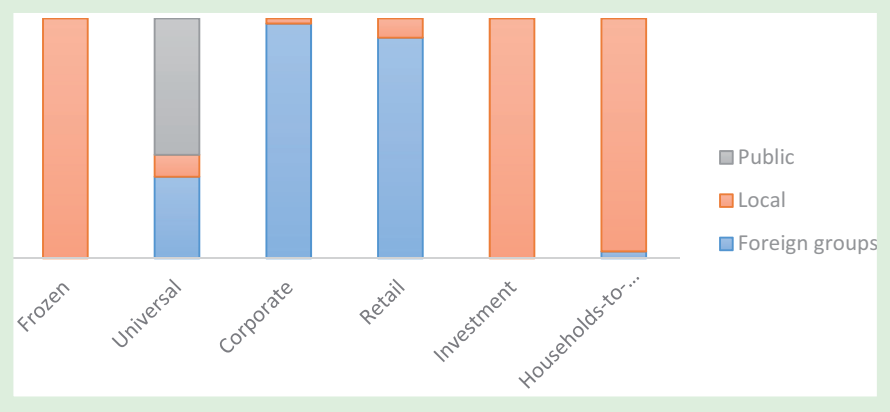


Figure H. HTC banks' trajectories on risks map

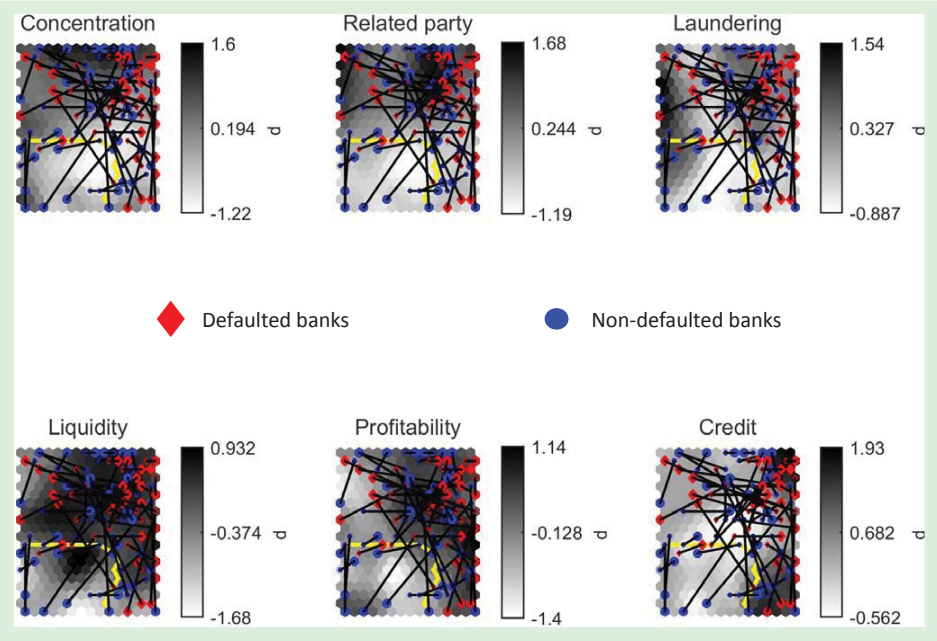


Figure I. Frozen/Undecided banks' trajectories on risks map

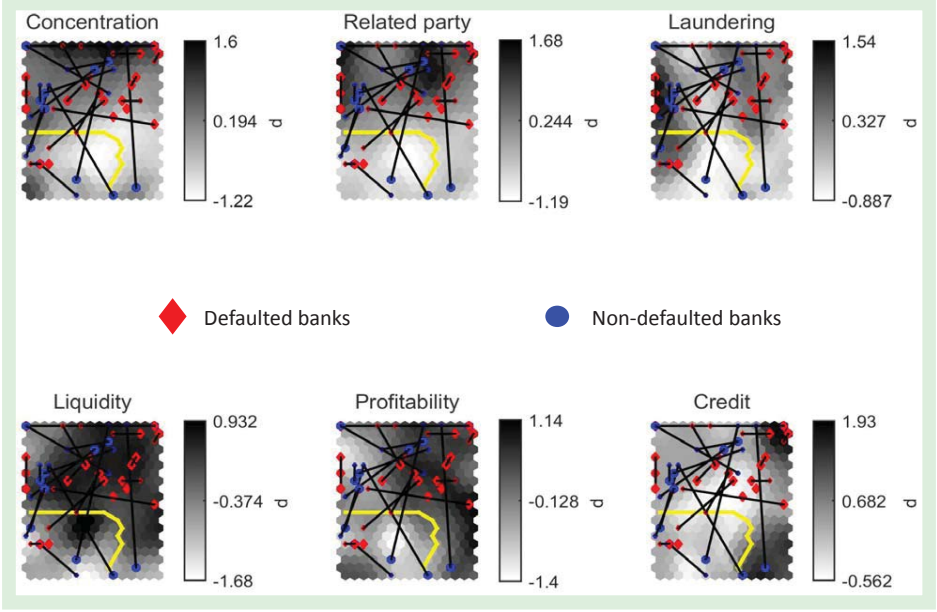


Figure J. Universal banks' trajectories on risks map

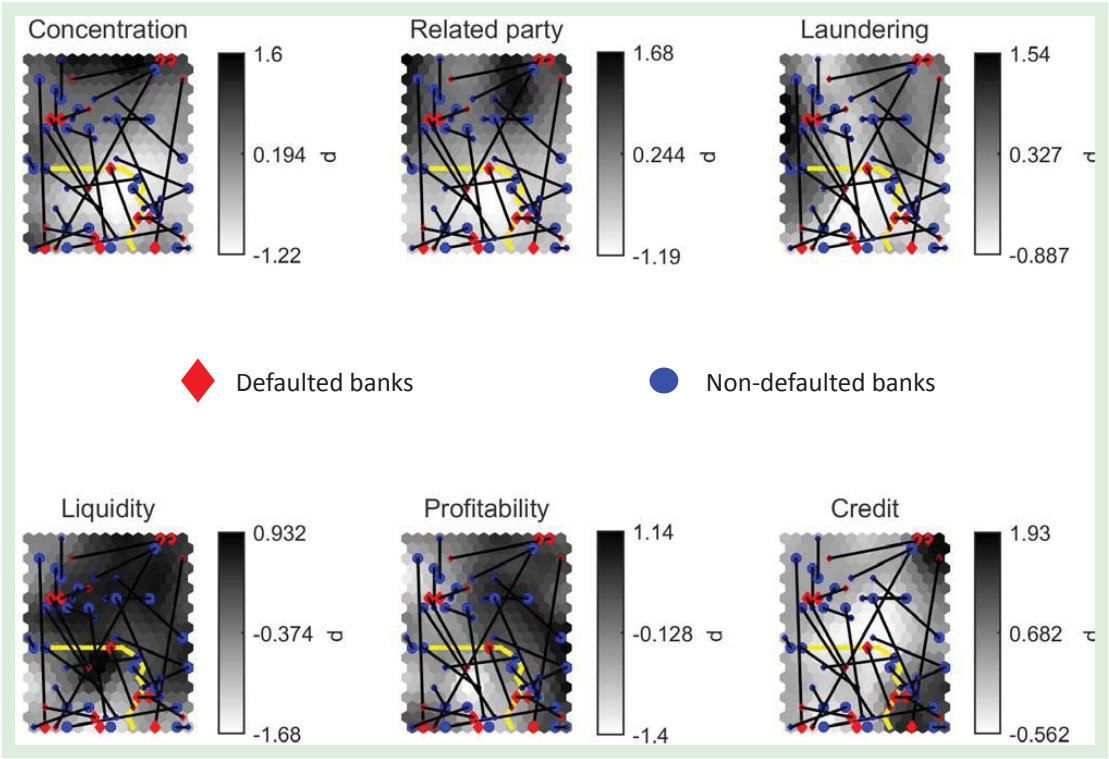


Figure K. Corporate banks' trajectories on risks map

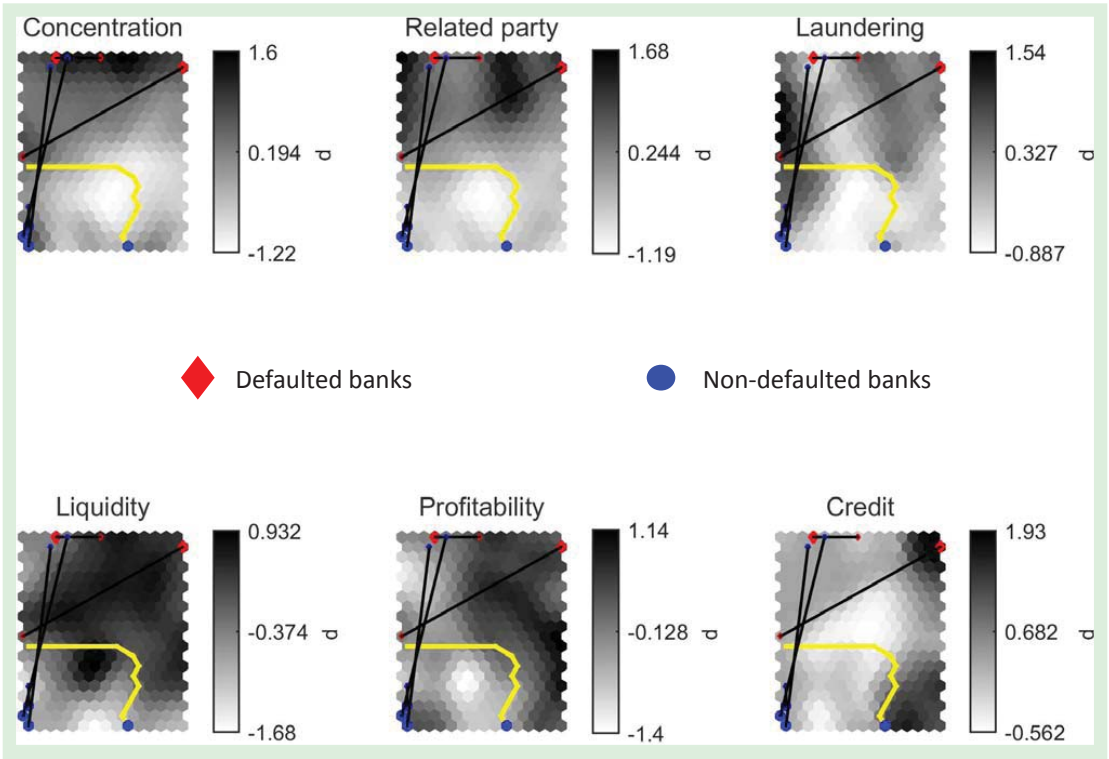


Figure L. Investments/Wholesale banks' trajectories on risks map

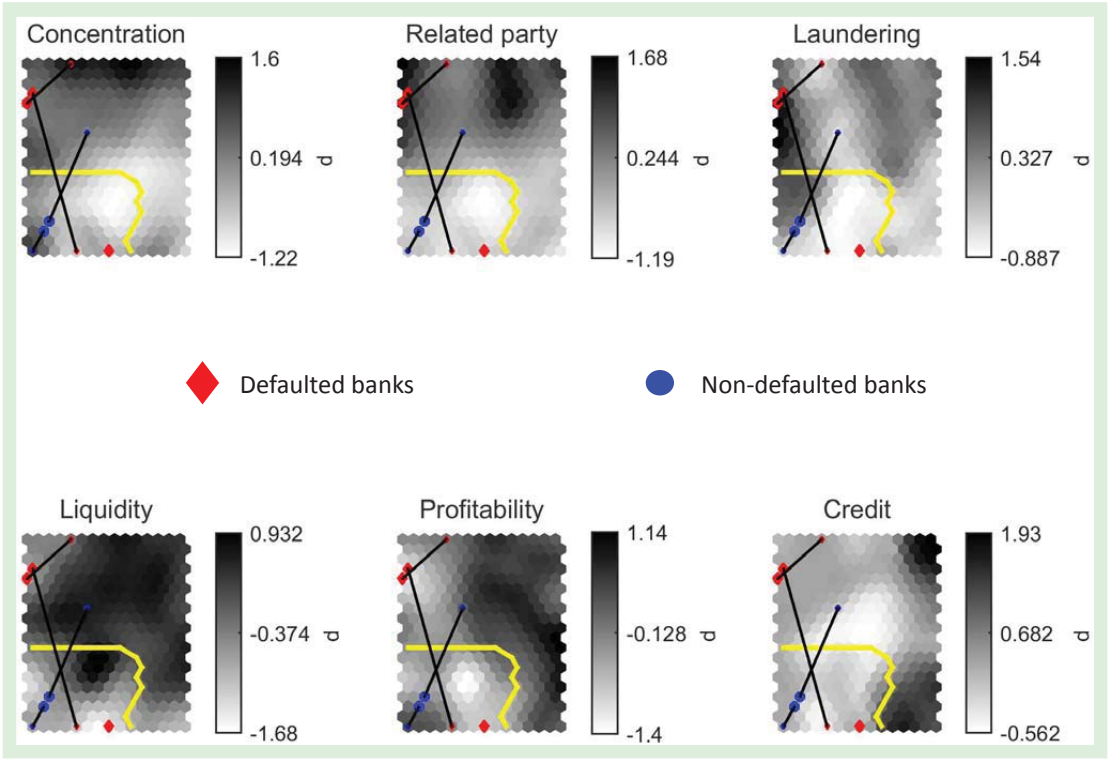


Figure M. Retail banks' trajectories on risks map

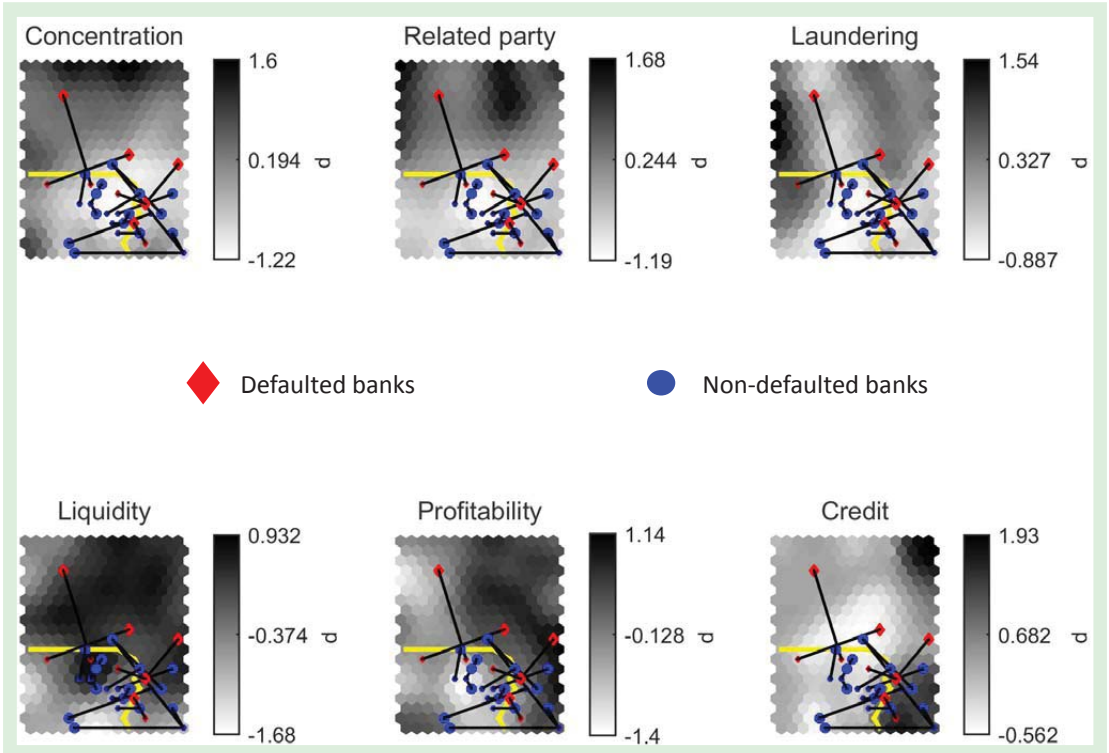
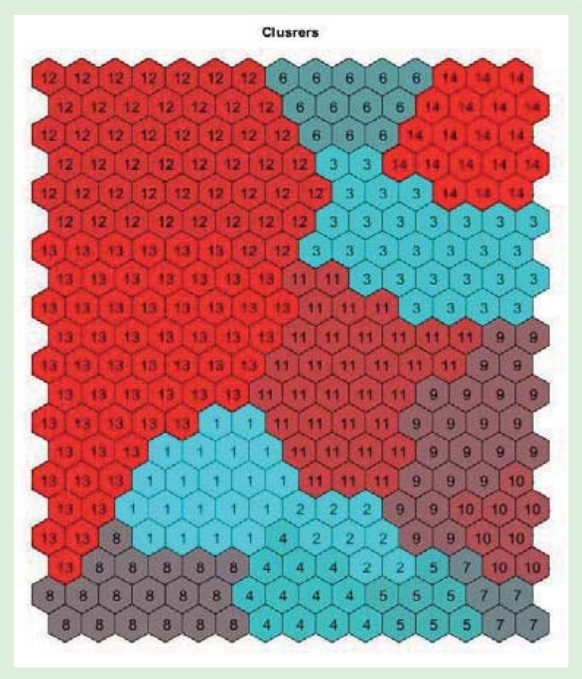
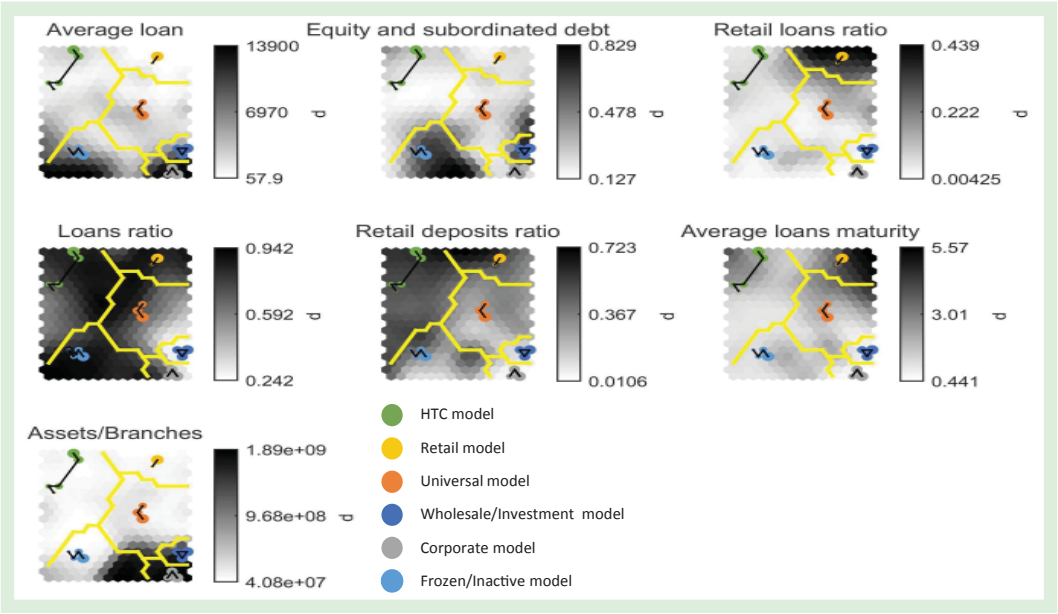


Figure N. Original clusters of the business models map*



*As you can see, we expertly joined some of the clusters: clusters 6 and 14 are the Retail model; cluster 3, 9, and 11are the Universal model; clusters 12 and 13 are the HTC model; clusters 1, 2, 4, and 8 are the Frozen/Undecided model; clusters 5 and 7 are the Corporate model; and cluster 10 is the Investment/Wholesale model.

Figure O. Business models' centroids movements on the business models map



Appendix 2. Tables

Table A. Descriptive statistics by business models over time

Clusters	Variables	1.1.2014					7.1.2016				
		mean	sd	max	median	min	mean	sd	max	median	min
Corporate	Retail deposits ratio	0.02	0.03	0.07	0.00	0.00	0.01	0.01	0.02	0.00	0.00
	Retail assets ratio	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Loans ratio	0.63	0.30	0.90	0.72	0.16	0.45	0.29	0.82	0.29	0.16
	Equity and subordinated banks ratio	0.16	0.07	0.30	0.13	0.12	0.22	0.07	0.32	0.20	0.15
	Average loans size (thousands UAH)	13 397.7	1 539.0	14 556.0	14 149.2	11 038.8	14 556.0	0.0	14 556.0	14 556.0	14 556.0
	Average loans maturity (years)	0.59	0.32	1.06	0.61	0.07	0.42	0.12	0.55	0.45	0.25
	Assets/Bracnhes (UAH)	1 849 826 287	110 921 749	1 895 109 902	1 895 109 902	1 623 408 216	1 895 109 902	0	1 895 109 902	1 895 109 902	1 895 109 902
Frozen/Undecided	Retail deposits ratio	0.41	0.19	0.87	0.45	0.00	0.34	0.24	0.84	0.32	0.00
	Retail assets ratio	0.07	0.09	0.39	0.03	0.00	0.05	0.10	0.40	0.02	0.00
	Loans ratio	0.86	0.12	1.00	0.90	0.57	0.88	0.14	1.00	0.94	0.54
	Equity and subordinated banks ratio	0.41	0.25	0.87	0.35	0.10	0.62	0.23	0.92	0.66	0.20
	Average loans size (thousands UAH)	6 004.90	5 476.50	14 556.01	5 219.54	48.80	7 692.84	5 518.38	14 556.01	6 907.83	539.60
	Average loans maturity (years)	1.25	0.73	3.02	1.04	0.35	1.33	0.67	2.60	1.21	0.48
	Assets/Bracnhes (UAH)	877 840 137	817 760 092	1 895 109 902	543 254 739	2 272 634	584 917 205	742 758 024	1 895 109 902	202 027 212	9 032 576
HTC	Retail deposits ratio	0.50	0.09	0.76	0.48	0.25	0.52	0.09	0.71	0.55	0.30
	Retail assets ratio	0.07	0.06	0.23	0.06	0.00	0.05	0.06	0.25	0.04	0.00
	Loans ratio	0.78	0.13	1.00	0.80	0.43	0.79	0.10	0.95	0.78	0.56
	Equity and subordinated banks ratio	0.18	0.07	0.41	0.16	0.08	0.26	0.14	0.71	0.26	0.08
	Average loans size (thousands UAH)	2 256.63	2 326.73	9 606.47	1 416.43	24.06	2 435.27	2 095.32	6 832.79	1 536.91	27.61
	Average loans maturity (years)	1.52	0.71	3.38	1.42	0.53	1.70	0.92	4.36	1.44	0.67
	Assets/Bracnhes (UAH)	143 364 968	197 503 788	932 301 122	70 491 584	13 862 860	85 951 467	75 960 799	330 881 069	60 984 865	10 286 533
Investment/Wholesale	Retail deposits ratio	0.15	0.18	0.43	0.16	0.00	0.05	0.03	0.08	0.05	0.03
	Retail assets ratio	0.01	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Loans ratio	0.21	0.09	0.37	0.16	0.16	0.33	0.10	0.40	0.33	0.25
	Equity and subordinated banks ratio	0.87	0.07	0.92	0.89	0.76	0.79	0.19	0.92	0.79	0.66
	Average loans size (thousands UAH)	10 595.22	5 749.26	14 556.01	14 556.01	1 956.17	1 074.45	755.46	1 608.64	1 074.45	540.26
	Average loans maturity (years)	1.34	0.67	1.97	1.42	0.29	0.15	0.18	0.27	0.15	0.02
	Assets/Bracnhes (UAH)	1 895 109 902	0	1 895 109 902	1 895 109 902	1 895 109 902	1 895 109 902	0	1 895 109 902	1 895 109 902	1 895 109 902
Retail	Retail deposits ratio	0.52	0.13	0.78	0.55	0.23	0.54	0.20	0.85	0.49	0.18
	Retail assets ratio	0.37	0.08	0.45	0.37	0.23	0.40	0.07	0.45	0.45	0.30
	Loans ratio	0.82	0.10	0.96	0.85	0.61	0.78	0.13	0.98	0.81	0.58
	Equity and subordinated banks ratio	0.20	0.06	0.28	0.20	0.10	0.21	0.15	0.59	0.16	0.02
	Average loans size (thousands UAH)	228.69	435.78	1 824.09	80.16	1.26	659.59	1 751.60	6 412.57	46.89	6.02
	Average loans maturity (years)	3.83	1.37	5.95	4.30	0.86	3.77	1.71	5.95	3.41	1.01
	Assets/Bracnhes (UAH)	95 693 262	142 406 621	656 114 208	55 712 310	10 905 967	95 265 551	71 837 636	260 219 890	81 476 473	19 114 667
Universal	Retail deposits ratio	0.27	0.13	0.59	0.27	0.02	0.25	0.12	0.54	0.25	0.01
	Retail assets ratio	0.11	0.09	0.30	0.10	0.00	0.08	0.08	0.26	0.04	0.00
	Loans ratio	0.58	0.21	0.93	0.63	0.16	0.63	0.21	0.97	0.64	0.23
	Equity and subordinated banks ratio	0.29	0.17	0.85	0.24	0.11	0.28	0.19	0.77	0.24	0.06
	Average loans size (thousands UAH)	2 354.81	2 487.22	9 210.24	1 691.69	9.07	1 768.14	2 022.20	6 223.23	686.55	27.11
	Average loans maturity (years)	2.08	1.14	4.45	2.00	0.39	2.26	1.40	5.95	2.09	0.42
	Assets/Bracnhes (UAH)	292 484 931	439 611 352	1 895 109 902	105 461 727	5 172 013	247 916 068	348 235 662	1 895 109 902	154 129 279	6 406 940

Table B. Migration of banks across business models*

As of 1h of 2016 / As of 2014	Frozen/ Inactive	Universal	Corporate	Retail	Investment/ Wholesale	Households-to-corporates	Went bankrupt	Total
Frozen/ Inactive	6	5	0	0	1	0	23	35
Universal	2	14	0	1	0	7	12	36
Corporate	0	0	4	0	0	0	2	6
Retail	0	3	0	12	0	1	4	20
Investment/ Wholesale	0	0	1	0	1	0	3	5
Households-to-corporates	3	13	0	0	0	19	32	67
Total	11	35	5	13	2	27	76	169

*The number of banks that participated in the analysis is slightly less than official number of the factual number of banks. We consider some banking institutions outliers, therefore their inclusion might have distorted the output of the model.

APPLYING FOREIGN EXCHANGE INTERVENTIONS AS AN ADDITIONAL INSTRUMENT UNDER INFLATION TARGETING: THE CASE OF UKRAINE

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ABSTRACT

This study examines applying foreign exchange interventions under Inflation Targeting regime in an emerging market economy. For this purpose, we employ the Quarterly Projection Model of the National Bank of Ukraine and simulate different policy responses to various macroeconomic shocks. We discuss monetary policy objectives, which are low inflation volatility and accumulation of international reserves, and conclude that monetary policy could benefit from using interventions in addition to the key policy rate. We advise on particular policy reactions (with or without FX intervention) in case of different macroeconomic shocks.

JEL Codes: E17, E52, E58, F31

Keywords: foreign exchange interventions, inflation targeting, monetary policy, macroeconomic models

I. INTRODUCTION

In the 1990s, it was widely believed that a central bank under a "pure" inflation targeting (IT) regime should not have any foreign exchange (FX) interventions in its toolkit. The rationale for this was quite clear: there is a risk that manipulating an exchange rate could undermine credibility to the declared nominal anchor, i.e., an inflation target. In fact, the emergence of IT can be considered as a response to the negative experience of using an exchange rate as a nominal anchor, which in many cases resulted in accumulation of macroeconomic imbalances and loss of credibility.

At the same time, the benefits of using FX interventions were doubtful in developed economies, which were first to adopt IT. The macroeconomic effect of intervention on foreign exchange market was believed to be eliminated because advanced economies used to have open capital accounts and developed financial markets. Thus, any central banks' manipulation with an exchange rate would be offset by capital flows. However, this conventional wisdom has changed after several emerging market economies successfully implemented IT with a specific role for FX interventions.

After the eruption of the global financial crisis in 2008-09, the possibility and even necessity of taking into account exchange rate movements for emerging market economies with IT became obvious. FX interventions could help smooth the devastating effect of excessive exchange rate volatility and speculative capital flows on small open economies. If done prudently, they could enhance the credibility of the IT regime by stabilizing expectations. FX interventions can have prolonged effects on macroeconomic variables given some of their specific features.

The National Bank of Ukraine (NBU) has committed to an IT regime with a floating exchange rate in its monetary policy strategy for 2016-2020 (NBU, 2015). The difference between "floating" and "free floating" exchange rate regimes is that the former presumes a possibility for a central bank to intervene frequently on the FX market (although without having explicit exchange rate targets), IMF (2014).

[1] The views expressed in this paper are those of the authors and do not necessarily represent the position of the National Bank of Ukraine.

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The NBU declares 3 tasks for using FX interventions which are quite common for emerging market economies with IT: 1) FX reserve accumulation; 2) the smooth functioning of the foreign exchange market; and 3) supporting the transmission of the key interest rate as the main policy instrument.

The question of an optimal mix of monetary instruments available for the NBU (a policy interest rate and FX interventions) to achieve price stability and abovementioned tasks is of current importance. The literature on the role of the exchange rate in IT is abundant. However, research on the optimal monetary policy reaction using such a policy mix in response to different types of shocks is scarce.

Thus, the purpose of this paper is to develop an analytical framework that allows advising on the optimal reaction of the NBU using an interest rate and FX interventions in response to different shocks with a view to achieve price stability and other relevant tasks.

The rest of the paper proceeds as follows: a brief overview of the literature on the role of exchange rate and FX interventions under an IT framework is presented in Section 2; Section 3 provides an overview of specific features of Ukraine's economy that motivates having FX interventions in the NBU`s toolkit; Section 4 gives a brief overview of the framework the NBU is applying to perform sterilized FX interventions; methods of analysis, results, and policy implications can be found in Sections 5 and 6; and then followed by conclusions in Section 7.

II. BRIEF LITERATURE SURVEY

Foreign exchange interventions used to be an undoubted instrument for central banks until the early 1970s under the Bretton Woods system of fixed exchange rates, which was an agreement among the United States, Canada, Western Europe, Australia, and Japan. Since that time, there have been major changes in the way they are considered by economists.

After an abandonment of the Bretton Woods system and a move to managed floating, interventions initially increased in scale, but appeared to be successful only temporarily. In the early 1980s, their effectiveness was questioned by both government officials and economists. However, after the Plaza Accord in 1985 and then the Louvre Accord in 1987, the impact of interventions began to be reassessed. The literature until 1993 is devoted to developed countries (namely G-7) and is well examined by Edison (1993).[2] We rely heavily on this paper in our pre-1993 literature review.

Most of the studies consider sterilized interventions and look for economically significant (predictable, sizable, and lasting) effects on the exchange rate. Non-sterilized interventions are not considered. They affect the monetary base, thus generally leading to significant effects on the exchange rate. Hereinafter we regard only sterilized interventions.

The literature measures the effectiveness of interventions through two different channels: portfolio based and signaling. The former arises since the relative supply of foreign and domestic currency assets changes after an intervention occurs. A less abundant asset becomes more pricy. On the other hand, the exchange rate is not affected under perfect capital mobility or in case both assets are perfect substitutes (i.e., uncovered interest parity holds). Advanced economies have massive markets where even huge interventions cannot really change the relative allocation of assets, which creates reasons to be skeptical about the quantitative effect of this channel. Indeed, pre-1993 literature suggests that sterilized interventions do not permanently amend the exchange rate.

From the other perspective, the current exchange rate is affected through the signaling or expectation channel if the market alters its expectations about the future exchange rate. A central bank possesses better information about the fundamentals (at least future monetary policy), thus interventions may become a signal about future exchange rate developments. Some studies suggest that they are a useful tool for signaling official views on foreign-exchange markets, but only effective when supported by the reshaping of other macroeconomic policies. Still, most empirical evidence testifies that interventions are able to influence exchange rates through the signaling channel, though temporarily.

Another important topic in pre-1993 literature is motivation for interventions. The first incentive is the desire to smooth short-term fluctuations in exchange rates. Secondly, sometimes central banks "lean against the wind," not allowing the nominal exchange rate to deviate far from anticipated target level. Moreover, studies of Germany and Japan reveal asymmetry in the countries' reaction rules during the period from 1973 to 1987. The Bank of Japan showed relatively stronger resistance to appreciation of the yen, whilst the Bundesbank exhibited relatively stronger resistance to depreciation of the deutsche mark.

Many studies are concerned about profitability of interventions. However, it is agreed that profitability is not a suitable assessment of effectiveness since both profitable intervention may be non-stabilizing and stabilizing interventions may be unprofitable.

[2] The G-7 (Group of Seven) countries are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

Edison (1993) concludes that it is possible to explain the motivation for FX interventions, but there is little empirical evidence for sizable and long-lasting effects.

In 1991, the first IT regime was adopted by New Zealand, and now there are about 30 countries that use it, with Ukraine among them. Therefore, the second part of the literature review is devoted to managing the exchange rate under IT.

A central bank under IT commits to an explicit inflation target, which is generally associated with a flexible exchange rate. Masson et al. (1997) indicates the absence of an obligation to any other anchors like an exchange rate to be an important premise for adopting an IT framework. Indeed, a central bank with more than one anchor puts itself at risk of sending conflicting signals about its objectives. Thus, managing exchange rates may disrupt the credibility of a commitment to an inflation target.

However, Ostry et al. (2016) claim that the argument above was used just to prevent countries that are not going to allow for exchange rate flexibility from adopting IT. Furthermore, they reveal that disregarding exchange rate volatility can become costly in countries with mismatches in domestic balance sheets and high exchange rate pass-through. This comes in line with findings by Stone et al. (2009), which investigate the role of the exchange rate in emerging market economies, particularly during the 2008-09 period of financial turmoil, and argue that responding to exchange rate deviations from its medium-term equilibrium produces better economic outcomes. Both studies agree that the exchange rate is a more important policy instrument for emerging markets under IT than for their advanced economy counterparts with massive markets and mobile capital.

The interest rate is a textbook instrument for IT, thus its adjustment might be the first response to exchange rate volatility. In fact, Mohanty and Klau (2005), in their study of Latin America, as well as Ostry et al. (2016) for a wide range of countries, conclude that central banks in emerging economies under IT often implicitly account for exchange rate movements in their interest rate reaction functions (aka the Taylor Rule). Such regimes are often called "Dirty" IT with hybrid policy rules.

Many papers present models with hybrid policy rules, e.g., Roger et al. (2009) or Garcia et al. (2011). Their simulations reveal that advanced economies with broad financial markets do not gain much from including the exchange rate into the interest rate reaction function. On the other hand, more vulnerable emerging economies can benefit in terms of less volatile inflation and output. Yet these studies do not cover the role that interventions can play.

Svensson (1999) suggests no room for an impact from sterilized interventions under uncovered interest parity. However, given not perfectly mobile capital and comparably low stocks of assets, they become a powerful instrument. Thus, along with being in more need for a managed exchange rate, emerging market economies are actually more eligible for possessing FX interventions as an additional policy tool.

Ostry et al. (2016) regard emerging economies as being best characterized by having two targets (inflation and exchange rate) and two instruments (interest rate and FX interventions). They highlight the importance of interventions as a tool against abrupt though temporary changes in capital movements. In contrast, the interest rate is best to deal with persistent shocks. Generally speaking, interventions can act symmetrically against both capital inflows and outflows, though the only crucial difference is that a central bank may eventually run out of reserves in the face of outflows.

The "two targets, two instruments" idea is not rejected by Gersl and Holub (2006), who investigate the Czech Republic's experience since 1998 and find some evidence for the significant effect of interventions on the exchange rate.

Benes et al. (2015) model FX interventions as an additional tool along with the Taylor Rule. They show that such a framework helps to shield the economy against shocks to international financial conditions, but may fail to provide needed exchange rate adjustments, e.g., in response to shocks to terms of trade.

Bayoumi and Saborowski (2014) examine the impact of interventions on the current account and agree on their ineffectiveness for advanced economies. On the other hand, foreign currency buyouts are a source for the current account surplus and undervalued exchange rates in some emerging markets. The study claims controls on capital movements to reconcile these facts. Authors find evidence that, in the absence of capital controls, the potential effect of sterilized interventions on the current account is fully offset by private money movements, thus adjustments in the capital account. For countries with major restrictions, each additional dollar in reserves brings about 50 cents to the current account. The effect is mostly compensated by opposite adjustments in the current account of the United States – the prevailing supplier of reserve currency with the most liquid bond markets.

All in all, sterilized interventions are consistent with an IT framework for emerging market economies. They may be a supplement to the interest rate in reacting to temporary shocks, mitigating abrupt capital movements, and fighting exchange rate volatility. However, as the economy achieves asset substitutability and higher capital mobility, a central bank must rely more and more on the interest rate as an instrument to influence the exchange rate.

III. MOTIVATION BEHIND HAVING FX INTERVENTIONS IN THE NBU`S TOOLKIT

In this framework, sterilized FX interventions could serve as an additional policy instrument to enhance the influence of the key interest rate on the economy and pursue other tasks of monetary policy. Of course such tasks of FX interventions need to be considered only if they enhance the credibility of the IT regime. Here we consider the motivation for FX interventions for the NBU and their consistency with achievement of inflation targets.

International reserves of the NBU are below optimal level

The NBU has the task of international reserves accumulation, which is a part of the Extended Fund Facility (EFF) agreement with the IMF. In the medium-term prospective, this task is reinforcing the IT regime and its credibility. If Ukraine had an adequate level of international reserves, it would be more resistant to external shocks. Thus, both the ability of the NBU to achieve its inflation targets and the overall credibility of the IT regime would increase. However, in the short-term period, achievement of inflation targets and accumulation of reserves could be conflicting. Yet the Law On the NBU gives strict priority to price stability among other tasks. So it resolves possible policy inconsistencies.

Pass-Through from the Exchange Rate to Inflation is nonlinear

The price responsiveness to exchange rate movements of different sizes is nonlinear in Ukraine. Farina (2016) provides evidence that prices are sensitive to small and extremely large changes, but the pass-through effect is insignificant if exchange rate movements are moderate.

That motivates the NBU to smooth the volatility to some optimal levels while avoiding pegging the exchange rate. That is crucial not only for achieving the targets, but for gaining credibility as well. On one hand, some FX volatility stimulates adequate perception of risks related to unhedged FX positions of economic agents. On the other hand, excessively high exchange rate volatility negatively affects both the investment climate and financial stability.

In this regard, the credibility issue needs to be mentioned. The NBU is a beginner in IT and inflation used to be very volatile in the past. In this context, the credibility of the NBU is less than full. Large volatility could undermine efforts to build it.

Among IT countries, the exchange rate volatility is fluctuating in a range of 2-15%, spiking in times of crisis, (Inflation report of the NBU, 2016).

Countries with the experience of using IT and flexible exchange rate usually do not have a need to intervene too frequently on the FX market to smooth volatility. Usually their developed FX markets have a higher potential to find balance by themselves. That reduces the propensity to high volatility. Edwards (2006) noted that volatility under a floating exchange rate is diminishing if IT is applied. That will also be true for Ukraine in the future. However, the FX market is currently shallow and the frequent presence of the NBU is justified with a view to balance it.

Weak transmission of interest rates to prices

Countries with less developed financial systems logically used to have less effective interest rate transmission to the inflation and real variables. But the situation in Ukraine seems to be even more complicated, because financial system has been just rebooted via clean-up reforms. Real sector is overindebted as the loans-to-GDP ratio reached 40% in 2015 and is the highest among peers (Financial stability Report of the NBU, 2016). That hampers the ability of the real sector to receive new loans.

The private securities market is in a rudimentary state. Of course there are positive signs of development as the Ministry of Finance started to place Government bonds on the market in 2016. The yield curve on these instruments is now reacting quite well to changes in the key policy rate. Still, sometimes (especially in time of distress) a change in the interest rate per se could have no appropriate effect on inflation.

Thus, the economic effects of the interest rate could be intensified in some cases through interventions. If short-term fluctuations of the exchange rate are threatening the achievement of the inflation target, monetary policy needs to react. Primarily, such a reaction should be done via interest rate adjustment. But, if the interest rate could not effectively influence the exchange rate in the desired direction, supportive interventions could be justified.

These motives for interventions are considered by the NBU Monetary policy strategy for 2016-2020 as it defines three tasks of using FX interventions: 1) FX reserve accumulation; 2) smooth functioning of the FX market; and 3) supporting the transmission of the key interest rate as the main policy instrument (NBU, 2015).

However, there can be other quite beneficial outcomes of using FX interventions in Ukraine's case.

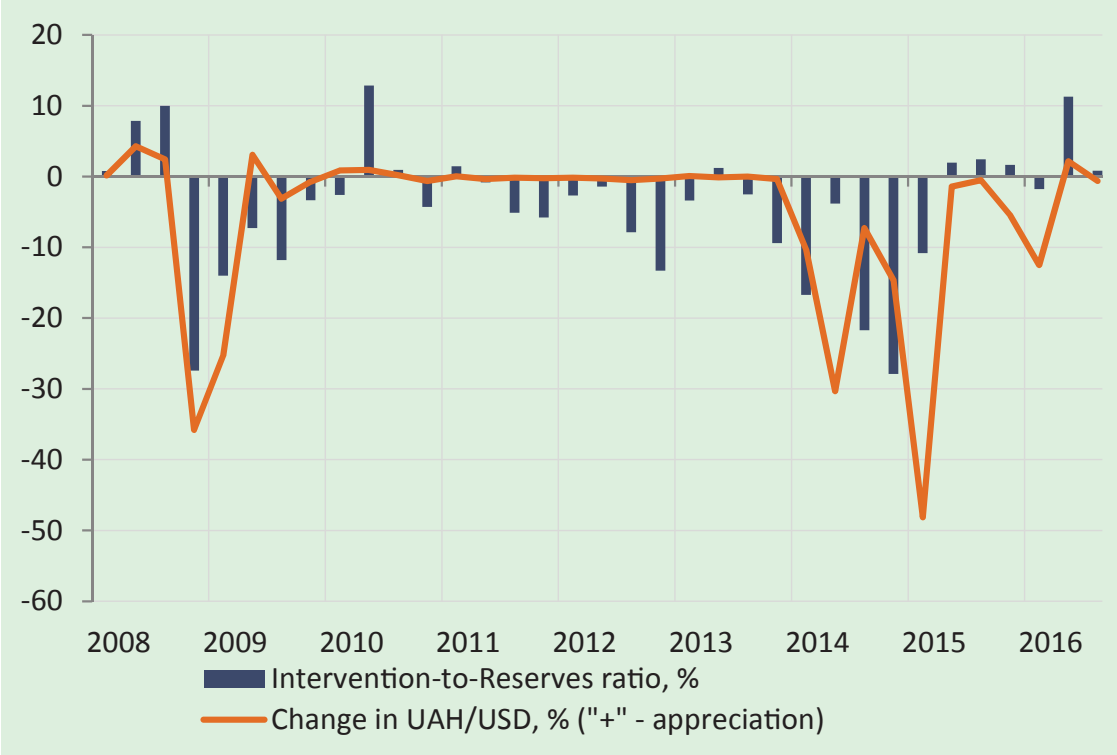
IV. THE NBU`S FRAMEWORK FOR STERILIZED INTERVENTIONS

In the past, the stability of the exchange rate was the central point of the monetary policy in Ukraine. Naturally, FX interventions were intensely used for protecting a certain level of the exchange rate. During the last years of exercising such a pegged regime, the NBU was mostly selling foreign currency, which summed up into a dashing decrease in the FX reserves on the background of an overpriced hryvnia. Thus, in February 2014 when international reserves were depleted to critical levels, the NBU had no other option but to adopt a floating exchange rate, which in turn is a prerequisite for IT.

The NBU declared the interest rate as its main policy tool. A remarkable step was made in April 2016 when new monetary policy implementation framework was adopted, which is common for IT central banks. The NBU determines a single policy rate for its main liquidity-injecting or liquidity-absorbing operations. From that time, decisions on the key policy rate have had a significant effect on market rates and actually define the policy stance.

The design of monetary policy instruments allows the NBU to steer interbank market interest rates as well as perform special tasks of FX interventions. The NBU performs both buyer and seller roles in order to smooth the volatility of the exchange rate. Given that there is the task of accumulation of international reserves, the NBU is a net buyer on the FX market. Because of this task on international reserves accumulation, since mid-2015 the NBU reacts with FX interventions only gradually when the exchange rate is depreciating but more actively when it is appreciating (Figure 1).

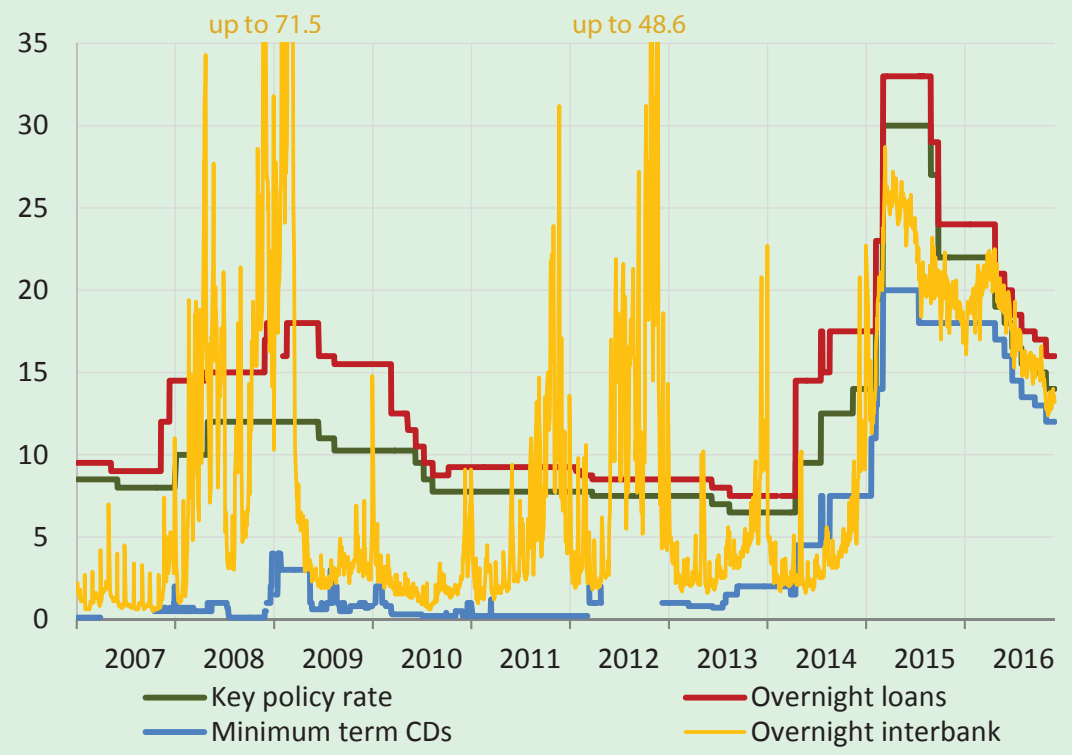
Figure 1. NBU`s FX interventions and UAH/USD exchange rate



These operations create a surplus of liquidity in the banking system. In such conditions, central banks can implement independent monetary policy through sterilization operations. Benes et al. (2015) defines sterilized interventions as FX interventions that 1) keep market interest rates unchanged or 2) do not change the level of reserve money.

The NBU defines the key interest rate as its main instrument, so the first definition is applicable in this case. Ukrainian banks use excess liquidity to buy NBU's certificates of deposits with remuneration equal to the key interest rate. The NBU is performing the role of a debtor of last resort and, hence, manages to steer interbank interest rates close to its key policy rate. The NBU started to perform such active interest rate policy in 2015 with some updates that increased its efficiency in 2016 (Figure 2).

Figure 2. NBU's Policy Rates and interbank market rates , % pa



Actually, this setup gives the NBU two separate instruments: the key interest rate for achieving inflation targets and FX interventions for smoothing exchange rate volatility and accumulation of FX reserves.

It is worth noting that such practice dramatically differs from the past experience of the NBU (up to 2014). Under a fixed exchange rate, negative shocks had been absorbed through FX sales and liquidity shortages with interbank interest rate hikes (Figures 1 and 2). The volumes of FX sales reflected not only attempts to prevent the exchange rate from depreciating, but also direct operations with state energy company Naftogaz for gas imports. These operations were discontinued in mid-2015 when reforms in the energy sector allowed Naftogaz to settle its contracts by itself.

For the purposes of this research, we ignore operations of the NBU with the Government related to exchanging its funds into foreign currency or vice versa. Such operations do not have direct implications for the markets. One could argue that without having the ability to exchange funds with the NBU, the Government would be pushed to enter the market for those purposes. Given that the FX market in Ukraine is shallow and there is the need to accumulate international reserves, the NBU would have to react with interventions. Thus, the overall impact on the FX market and economy would be eliminated.

V. MODEL AND METHOD

We dedicate this section to presenting the main features of the NBU's Quarterly Projection Model (QPM), which is conventionally used for analysis of the core macroeconomic dynamics in the Ukrainian economy. In this paper, we use it to simulate macroeconomic responses (so-called Impulse Response Functions) to different shocks, including policy ones. Ideally no policy decision must be implemented without modeling its anticipated outcomes. Hypothetically, such a decision could be done on a judgmental basis, but only modeling can provide consistent and comprehensive views on how a set of variables in policy focus react to a particular action or shock. Moreover, Impulse Response Functions (IRF) reveal the possible reactions to risks and are therefore able to help in dealing with uncertainty.

The QPM by no means is able to produce any short-term forecasts, which is a job reserved for other approaches. Instead, it investigates key macroeconomic linkages, "tells the story behind them," provides a framework for policymaking, and analyzes the way it influences the economy and inflation.

The QPM is a "gaps" model. It captures the general dynamic equilibrium of the economy and estimates deviations from it. The latter are called gaps. Their developments are explained, particularly what are the contributors and how they fade out with time.

Glossary

y_t	GDP in logs*100
$\overline{y}_t$	Potential GDP, a sustainable long run level that generates no inflationary pressure
$\hat{y}_t$	GDP gap, scale is built so that it is measured in percent deviations from the potential
s_t	UAH per USD exchange rate, growth means depreciation in domestic currency
s_{t+1}^{exp}	Expectations about the future exchange rate
$\overline{z}_t$	REER trend, accounts for inflation in main trading partners, growth means depreciation
$\hat{z}_t$	Real effective exchange rate (REER) gap
$\overline{r}_t$	Real interest rate trend, aka real natural interest rate
$\hat{r}_t$	Real interest rate gap
$\widehat{w}_t$	Real wage gap
$\hat{y}_t^W$	World output gap, weighted GDP gap of main trading partners
$\widehat{tot}_t$	Terms of trade gap, weighted ratio of main export and import prices
f_t	Fiscal impulse
π_t^{core}	Core inflation, i.e. headline except regulated prices as well as prices for fuel and raw foods
π_t^{food}	Price changes in foods, annualized quarter-over-quarter percent changes
π_{t+1}^{exp}	One quarter ahead inflation expectations
$\pi 4_t$	Year-over-year inflation
π_t^T	Targeted inflation
π_t^W	Weighted average for main trade partners (world) inflation
π_t^{WT}	World inflation target
i_t^T	Key interest rate
i_t	Interbank interest rate
i_t^W	World interest rate
$prem_t$	Sovereign risk premium for Ukraine
tb_t	Trade balance, % of GDP
$\varepsilon_{i,t}$	Different kinds of shocks

Main equations

$$y_t = \overline{y}_t + \hat{y}_t \quad (1)$$

$$\hat{y}_t = \alpha_1 \hat{y}_{t-1} + \beta_1 \hat{y}_{t+1} + \gamma_1 \hat{z}_{t-1} - \delta_1 \hat{r}_{t-1} + \theta_1 \hat{w}_t + \vartheta_1 \hat{y}_t^W + \mu_1 \widehat{tot}_t + \rho_1 f_t + \varepsilon_{1,t} \quad (2)$$

$$\pi_t^{core} = \alpha_2 \pi_{t-1}^{core} + \beta_2 \pi_{t+1} + \gamma_2 (\pi_{t-1}^W + \Delta s_{t-1} - \Delta \overline{z}_{t-1}) + \delta_2 \hat{y}_t + \theta_2 \hat{z}_{t-1} + \vartheta_2 \hat{w}_t + \mu_2 (\pi_t^{food} - \pi_t^T) + \varepsilon_{2,t} \quad (3)$$

$$i_t^T = \alpha_3 i_{t-1}^T + (1-\alpha_3)(\overline{r}_t + \pi_{t+1}^T + \beta_3 (\pi 4_{t+3}^{exp} - \pi_{t+3}^T) + \gamma_3 \hat{y}_t) + \varepsilon_{3,t} \quad (4)$$

$$s_t = \alpha_4 s_{t+1}^{exp} + (1-\alpha_4)\left(s_{t-1} + 2(\Delta \overline{z}_t + \pi_t^T - \pi_t^{WT})/4\right) + (i_t^W - i_t + prem_t)/4 + \varepsilon_{4,t} \quad (5)$$

$$tb_t = \alpha_5 tb_{t-1} - \beta_5 \hat{y}_t + \gamma_5 \hat{y}_t^W + \delta_5 \hat{z}_t + \theta_5 \widehat{tot}_t + \varepsilon_{5,t} \quad (6)$$

Equation (1) is a simple identity. It reveals the relationship between the GDP level, its potential, and gap. We think of gap as a cyclical deviation from potential output. In economic terms it stands for a measure of relative demand. Negative numbers indicate depressed demand, while positive ones evidence in favor of an "overheated" economy. The concept is defined and equations are constructed so that the GDP gap typically gravitates to zero on the medium-term horizon of a simulation. The output in turn approaches its potential.

Equation (2) models the developments of the GDP gap. Its behavior is quite complex and depends on many factors. Among them in order as they appear in the equation are expectations about future economic activity and the effects from the real effective exchange rate and the real interest rate that both contribute to the monetary policy stance, world demand, terms of trade, wages, and fiscal impulse.

Foremost, expectations about future economic activity are constructed as a weighted sum of model forecast and lagged value. This is the way to model adaptive expectations. Next we introduce several additional gap terms. A positive REER gap, which means that the real exchange rate is depreciated against its equilibrium trend, makes exports relatively cheaper and contributes positively to the GDP gap. A real interest rate above its trend stimulates savings, but depresses domestic demand. A gap in real wages represents slack in the labor market.

Ukraine is a small open economy, thus its output depends on external conditions. They are modeled with the world output gap, i.e., relative demand from main trade partners, and the terms of trade deviation from its long-term level.

Last but not least is fiscal impulse. Both budget expenditures and revenues react to the economy's business cycles. The fiscal impulse distills fiscal policy from these cyclical movements and reveals whether it is truly expansionary or contractionary.

Equation (3) models the behavior of core CPI, though other inflation components are modeled in a similar fashion. The core component has the highest weight. Moreover, its example is the most illustrative since core inflation is deeply linked with domestic demand, unlike other CPI parts that depend highly on exogenous factors. Headline inflation is a weighted sum of its components. We must mention that headline inflation is targeted by the NBU.

The equation utilizes an expectations-augmented version of the Phillips curve. Expectations are again adaptive, however, now the lagged value of core inflation is combined with a model forecast of the headline one. This is to provide a link with administratively regulated and other goods in the consumer basket, thus capturing the bargaining power of workers.

The second term represents imported inflation. It considers both changes in prices of main trade partner countries and changes in the exchange rate. Changes in REER equilibrium trend allow accounting for contributions from different price movements in tradable and non-tradable goods according to the Balassa-Samuelson effect. Later we describe the effect in depth. Imported inflation is assumed to impact with a one quarter delay.

Core inflation is modeled to depend on real marginal costs, thus having a pro-cyclical reaction to a combination of GDP gap and real wage gap, i.e., general economic activity and the labor market in particular. Moreover, REER deviation from its equilibrium is modeled to be at least partially compensated for by change in prices.

Finally, the equation incorporates what we call "fried potatoes effect." It suggests that movements in costs for raw foods should be reflected in core inflation, since it comprises prices for processed foods.

Equation (4) models a key interest rate reaction function in the form of a modified Taylor Rule. The lagged value represents persistence in the decision-making of the NBU, while the second term gives some glance to its active rule. In a steady state, the rate approaches its neutral level, which is the sum of the real natural interest rate and targeted inflation. From a policy point of view, neutrality means that GDP will grow at its potential rate and inflation will be stable.

The key interest rate actively reacts if y-o-y inflation projected three quarters ahead deviates from its target. Similarly, it reacts to the stance of the economy. In particular, it rises in response to a positive GDP gap, which means an "overheated" economy and is a clear inflationary prerequisite.

There is no exchange rate in the Taylor Rule, thus we do not expect the NBU to adjust the key interest rate in response to exchange rate movements per se.

Notice that the interest rate in equation (5) is not the key policy rate. Instead, it is the interbank rate, which fluctuates around the key policy one in autoregressive fashion.

Equation (5) is based around the Uncovered Interest Parity (UIP) condition. This is embodied in the last term of the equation, while the first and the second terms represent the expected movements in the exchange rate and the effect from NBU interventions on the currency market (we discuss them in the next paragraph). Indeed, in the absence of interventions and stable expected exchange rate, the world interest rate and the domestic one will differ only on the value of the sovereign risk premium. For example, this premium surged for Ukraine both in 2009 and 2015. Generally, international investors act to equalize returns on their investments in different currencies with amendments for anticipated risks.

The first term in equation (5) is the model forecast of the exchange rate one-quarter ahead. The second term represents interventions in the following way. The lagged value of the exchange rate is complemented with a double change in its medium-term target, thus summing up in a targeted value. The relative weight between the model forecast and targeted value defines how heavily the NBU intervenes, mitigates exchange rate volatility, and anchors market expectations.

We consider such a framework as the best way to model sterilized FX interventions for the NBU. Under sterilization, we mean that the interest rate is set independently of exchange rate movements. The interest rate is defined in equation (4) in the Taylor Rule without special reference to the exchange rate. But, of course, there is indirect influence from FX interventions on the interest rate through responses of inflation and an output gap to the exchange rate dynamic. But by those effects, we actually want to track the combined use of both instruments: the interest rate and FX interventions.

The medium-term target is not a real target per se, but rather reflects the idea behind the Balassa-Samuelson effect. It states that the difference in domestic and world inflation targets does not strictly lead to exchange rate re-evaluation, but instead is compensated for by productivity growth, which is well proxied by changes in the real effective exchange rate (REER) trend. Due to this effect, inflation rates in developing countries can be higher as long as they come along with higher productivity growth. The exchange rate is modeled to be stable in the long-run equilibrium for Ukraine.

Equation (6) explores the developments of the trade balance. Firstly, the lagged term represents overlapping contracts. Next, the trade balance depends on both domestic and external demand. The former increases a deficit, while the latter contributes to a surplus. Further, the trade balance gets improved with depreciated REER, which stimulates foreign demand for domestic goods, as well as favorable terms of trade that make exported goods relatively more valuable.

The trade balance is essentially the net export that is a part of GDP. Thus, it is modeled similarly to the GDP gap with a bit of a loop, since increased domestic demand worsens the trade balance.

Calibration

The mechanism that transforms the set of equations into a model of the Ukrainian economy is the parameter values, which are presented in the following tables. The parameters were not statistically estimated, but rather calibrated, with a view to comply with economic theory and provide sound model properties. We also evaluated how well the model performs on the historical horizon, while accounting for macroeconomic structural breaks as well.[3]

Equation (1)

α_1	β_1	γ_1	δ_1	θ_1	ϑ_1	μ_1	ρ_1
0.30	0.20	0.06	0.04	0.07	0.5	0.07	0.2

[3] For more discussion on calibration, one may refer to Benes et al. (2003).

Equation (2)

α_2	β_2	γ_2	δ_2	θ_2	ϑ_2	μ_2
0.40	0.50	0.10	0.30	0.10	0.10	0.09

Equation (3)

α_3	β_3	γ_3
0.70	1.20	0.40

Equation (4)

α_2	
0.20	with interventions
0.70	without interventions

Equation (5)

α_5	β_5	γ_5	δ_5	θ_5
0.50	0.25	0.25	0.30	0.20

VI. RESULTS OF ANALYSIS AND POLICY IMPLICATIONS

To illustrate how FX intervention can be beneficial in achieving the NBU`s goals, we considered several cases with different shocks:

1. Aggregate demand shock;
2. Aggregate supply shock;
3. Risk premium shock;
4. Foreign interest rate shock – inflow of "hot" capital;
5. Terms of trade shock.

In all cases, shocks lead to a deviation of the inflation from the targeted level. The task here is to choose the optimal combination of the NBU`s instruments as a reaction to a each shock. Such combinations include: reaction with policy interest rate only or interest rate supplemented by FX interventions. In case of exchange rate shock (inflow of "hot" capital), a capital control tool is considered in addition.

IT is a flexible regime that needs to take into account not only stabilization of inflation (thus limiting its volatility), but stabilization of the real economy, Svensson (2009). Therefore, the NBU has flexibility in the timing of bringing inflation to the target in order to minimize output losses.

Additionally, policy reaction needs to take into account the limited amount of international reserves and the task of the NBU to accumulate them.

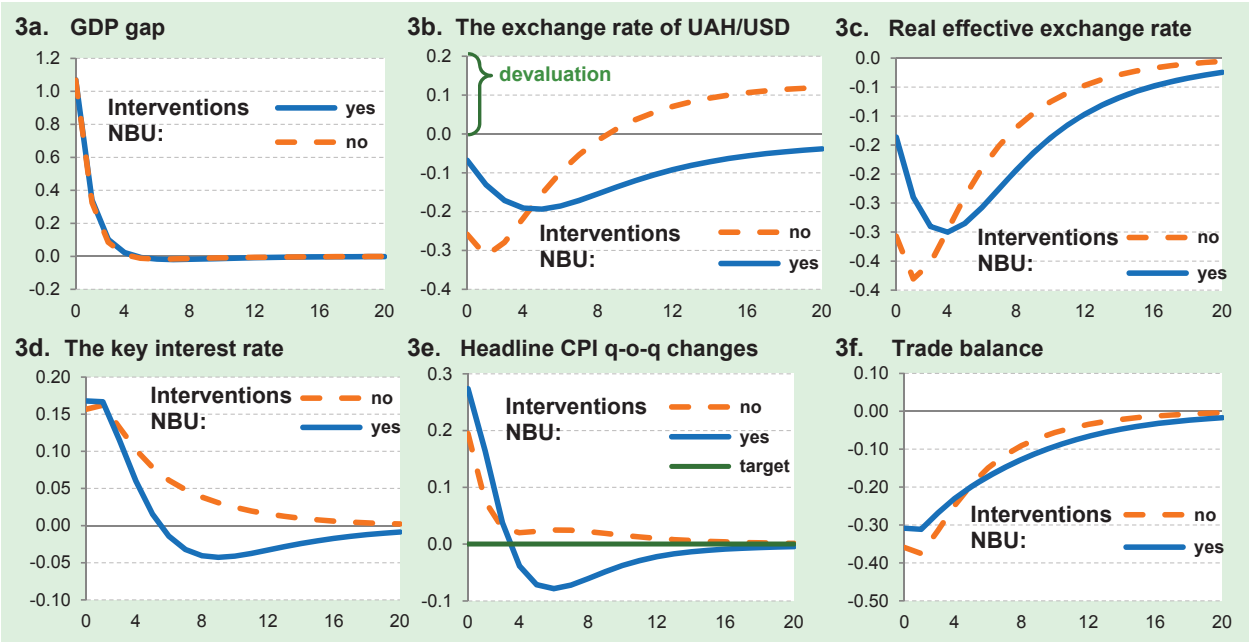
Aggregate demand shock

The cause of a shock can vary, e.g., fiscal expansion or expectations driven by a rush in the consumer market. It is designed as a positive change in output gap that lasts for one quarter and then gradually dies out back to potential (Figure 3a).

Exceeding demand causes acceleration of inflation, so the NBU needs to react using its policy rate in both scenarios. An increased interest rate appreciates both nominal and real exchange rates in the short-run. However, the NBU introduces FX interventions in scenario 2 and restrains the exchange rate from excessive appreciation (blue line, Figures 3b, 3c). Appreciated REER generates additional demand for imports. It depresses trade balance, which leads to exchange rate depreciation in the medium-run. In scenario 2, the NBU intervenes again. This time the purpose is to reduce depreciation.

In scenario 1, the NBU does not use FX interventions, and a more long lasting reaction with the policy rate is needed to mitigate the inflation outbreak (Figure 3d). Inflation reaches its target without excessive volatility (orange dashed line, Figure 3e).

Figure 3. Aggregate demand shock under different policy responses



Policy implications. Monetary policy after an aggregate demand shock is a bit tricky and has to account for a trade-off between more volatile inflation and a more volatile exchange rate. The NBU probably needs to react to domestic demand shocks using only the key policy rate. The advantages of such an approach are less volatile inflation, a slightly faster narrowing of the trade deficit (Figure 3f), and saving international reserves. In scenario when interventions are used together with the policy rate, inflation is more volatile, which could negatively affect the IT regime's credibility while international reserves are just being "eaten up."

Aggregate supply shock

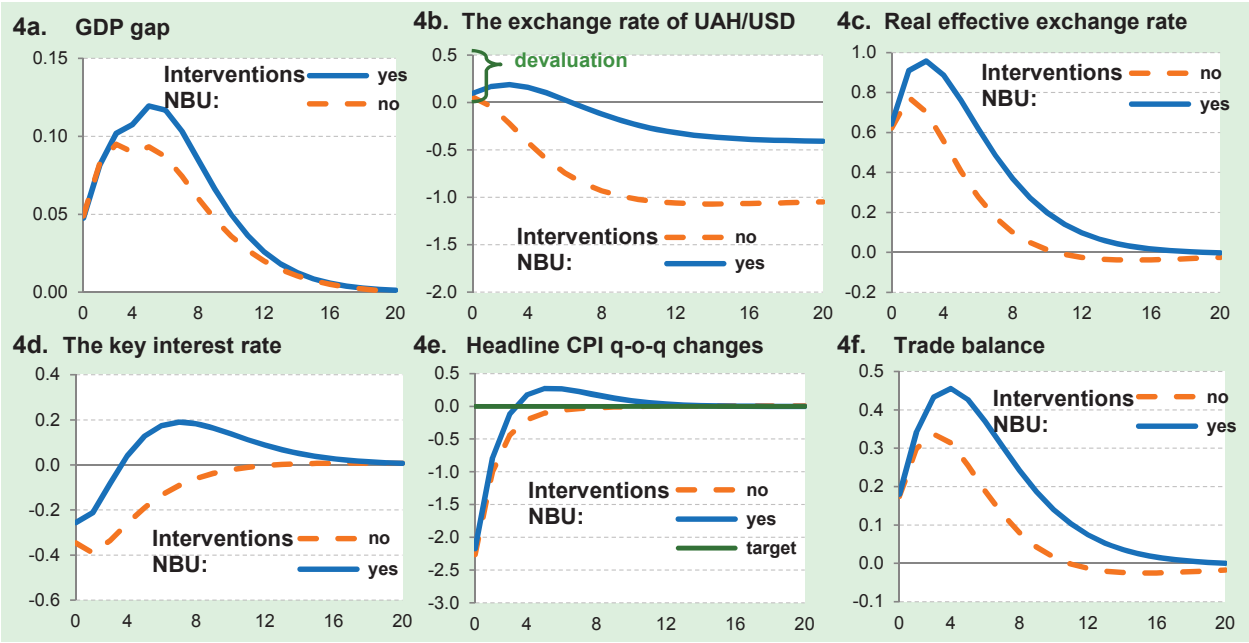
This kind of indignation is commonly modeled as a drop in prices, which takes the form of a negative shock to residual in the Phillips curve. A decrease in prices leads to depreciation in REER (Figure 4c), thus improving the competitiveness of domestic producers, stimulating net exports, and leading to medium-term nominal exchange rate appreciation (Figure 4b). An improved trade balance (Figure 4f) also contributes to higher aggregate demand and "overheats" the economy (Figure 4a).

However, reactions of all the variables differ in two policy scenarios. In scenario 1 (orange dashed line) the NBU does not intervene on the FX market, thus allowing nominal exchange rate to appreciate swiftly. In scenario 2 (blue line) the NBU purchases foreign currency from the market and constrains appreciation.

Both scenarios make the NBU react to deflationary pressure with a lowered policy rate (Figure 4d). But in scenario 2, the initial decrease is less significant and the NBU even needs to increase the policy rate after some time because of an "overheated" economy.

In scenario 2, the output gap is larger on the simulation horizon because of a more pronounced REER undervaluation, which stimulates external demand. Inflation quickly returns to its target and even slightly overshoots it (Figure 4e). Finally it approaches the target as a result of increased policy rate. In contrast, inflation approaches its target more gradually in the first scenario.

Figure 4. Aggregate supply shock under different policy responses



Policy implications. All in all, FX interventions after a favorable supply shock may restrict exchange rate appreciation and contribute to a trade balance improvement. Taking into account the need to accumulate international reserves, the NBU might consider such a scenario as an opportunity to take advantage and buy FX from the market. An additional benefit of such a policy is higher GDP growth. Given the open Ukrainian economy, slowing the pace of nominal exchange rate appreciation provides more significant stimulus for GDP growth in comparison with a decreased policy rate. However, the policy rate can be effective in counteracting some inflation pressure, which could arise due to an "overheated" economy.

Risk premium shock

Ukraine is an emerging market economy with low credit ratings. Moreover, its international reserves are below the composite metric of reserve adequacy, IMF (2016). Thus, investor's sentiments can change very quickly as a reaction to domestic developments or global shifts in risk attitudes.

This kind of shock models an abrupt, albeit temporary, increase in sovereign risk premium, which indicates a lack of credibility in the country, e.g., during crises. In particular, Ukraine's risk premium peaked in both years 2008 and 2014.

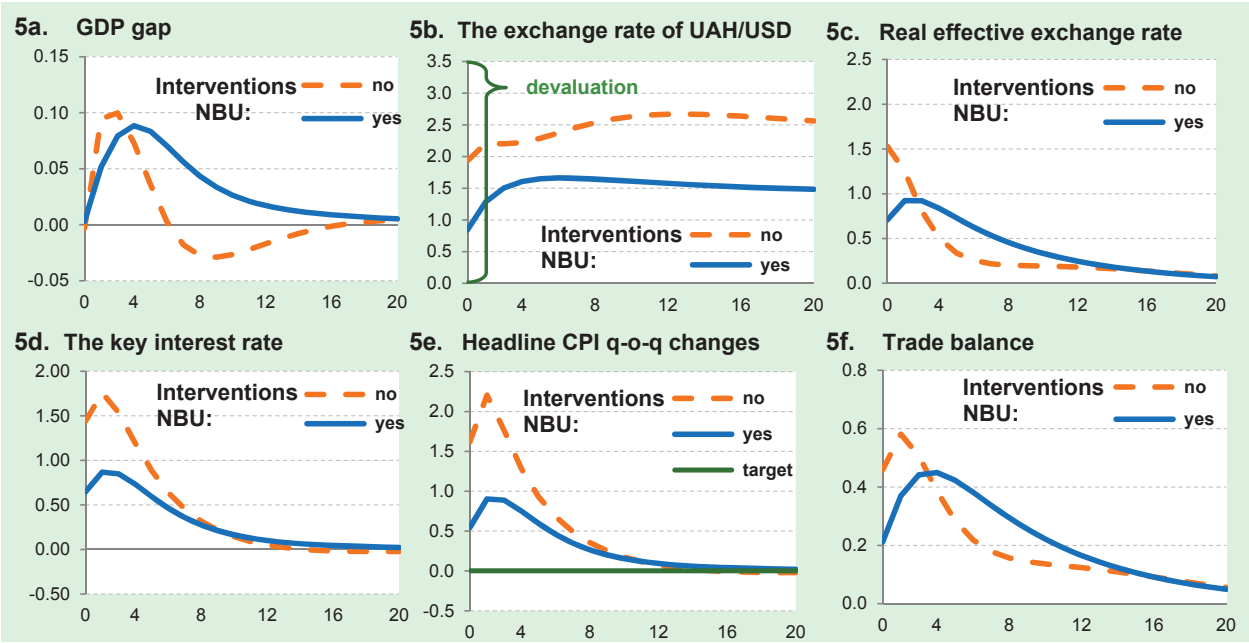
A higher risk premium leads to sharp capital outflows and consequently devalued domestic currency (Figure 5b). In scenario 1 (orange dashed line), the NBU doesn't intervene on the FX market and allows the exchange rate to depreciate significantly. In scenario 2, the NBU intervenes on the FX market, which allows a smooth depreciation (blue line). As we discussed in Section III, the pass-through from the exchange rate to inflation depends on the scale of exchange rate changes. In scenario 1, a sharp depreciation of the exchange rate leads to a significant inflation hike (Figure 5e), though it declines quickly as a result of the temporary nature of the increase in the risk premium as well as the surged policy rate (Figure 5d). In scenarios with FX interventions, smoother devaluation leads to more modest increases in inflation.

Due to the stickiness in price responses, disturbances in the nominal exchange rate are to a high extent transferred into the real exchange rate (Figure 5c). Devalued REER in turn stimulates external demand for domestic goods, improving both the trade balance and contributing to a positive output gap (Figures 5a, 5f). With interventions, the stimulus is less abrupt but more lasting. Moreover, the cumulative effects are higher.

The shock in risk premium creates two sources of inflationary pressure. The first acts through a positive output gap. The second comes along with a devalued REER and increased prices for imported goods.

The NBU immediately increases the key interest rate with a view to resist an inflationary outbreak. This helps to restrain aggregate demand and attract more foreign capital. The need for tight monetary policy lasts a bit longer with interventions since inflationary pressure is more enduring.

Figure 5. Risk premium shock under different policy responses



Policy implications. In case of risk premium shocks related to investors' sentiments, the NBU needs to react with a policy rate hike combined with FX interventions with an aim to mitigate the pace of depreciation. A smooth adjustment of the exchange rate helps to preserve confidence and limit the pass-through to prices. As a result, the increase in inflation is less dramatic and less volatile. Among the other positive outcomes of such a policy are longer benefits for the economy and trade balance because of a slower REER appreciation after the shock.

Foreign interest rate shock – inflow of "hot" capital

Here we consider a situation with conflicting policy goals that arrive after short-term capital inflows. The latter are caused by deviations from the UIP condition in terms of increased differences between domestic and foreign interest rates or expectations of exchange rate appreciation. The shock is modeled as a drop in foreign interest rates.

Such inflows force the exchange rate to appreciate and put pressure on interest rates to decline. However, they are unstable and are thus able to quickly reverse and cause undesirable volatility of the exchange rate, interest rates, and inflation.

In a "classical" case, an IT central bank could lower interest rates while allowing the exchange rate to appreciate. That would demotivate further capital inflows and prevent disinflationary pressure. But if inflation is already high for whatever reason (e.g., fiscal expansion, global environment), the central bank could be unable to lower interest rates. At the same time appreciation caused by "hot" speculative inflows could have a damaging effect on the domestic real sector.

Cases when central banks in emerging economies were facing these described challenges are not rare. In Ukraine's case, such episodes happened several times, e.g., in 2005 when the NBU needed to adjust the fixed exchange rate to a new revalued level.

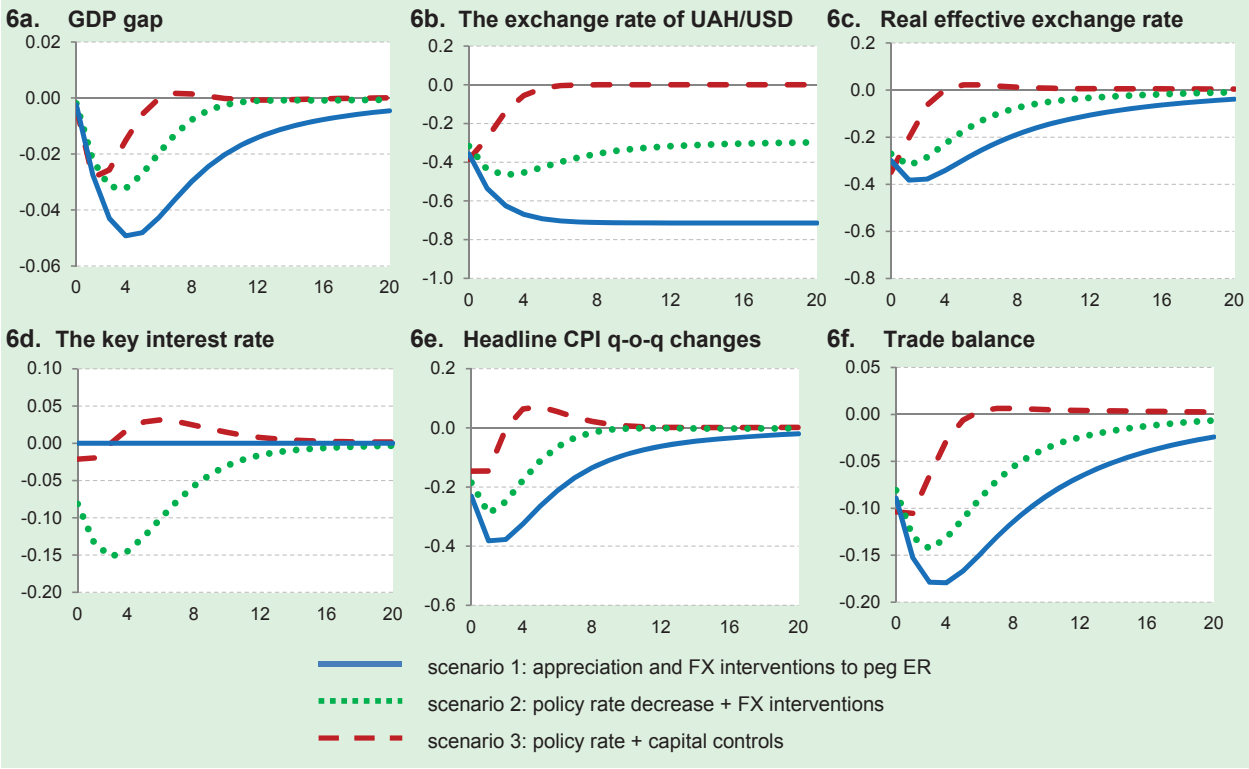
Such policy is replicated in scenario 1 when, after abrupt revaluation, the exchange rate remains stable due to FX interventions (blue line, Figure 6b). The NBU is not lowering the policy rate (Figure 6d).

In the scenario 2, the NBU lowers the policy rate (green dotted line, Figure 6d) and allows moderate appreciation of the exchange rate using FX interventions (Figure 6b). A lower interest rate demotivates capital inflow, thus appreciation pressure is less significant.

In scenario 3, the NBU uses a capital control tool as well as two other instruments with the intention of containing short-term capital inflows. The effect of a capital control tool is modeled as an increase in the risk premium. International experience suggests a variety of such tools that allows managing composition of capital flows: reserve requirements, taxation, special licensing requirements, and outright limits or bans (Ostry et al., 2016).

In this case and after initial appreciation, the exchange rate depreciates to the previous level (red dashed line, Figure 6b). The initially lowered policy rate needs to be increased (Figure 6d) as depreciation of the exchange rate creates some inflationary pressure (Figure 6e).

Figure 6. Foreign interest rate shock under different policy responses



In scenario 1 (Figure 6e), deflation is the most significant and prolonged as the effect from appreciation intensifies due to an increase in the real interest rate as the nominal rate remains stable.

In scenario 2 (Figure 6e), lowering the policy rate by the NBU helps to bring inflation back to its target faster in comparison with scenario 1.

Loss of real growth is the most significant in scenario 1 (Figure 6a) because of appreciation of the exchange rate and tight monetary policy. This policy mix is the most harmful for the trade balance (Figure 6f) as well.

Scenario 3 is optimal from the position of GDP loss minimization. The negative effect on trade balance also vanishes quickly in this scenario.

Policy implications. In the case of "hot" capital inflows, the most appropriate monetary policy needs to include a combination of policy rate reaction, interventions, and application of capital control tools. Such a policy mix allows for avoiding a damaging effect on the real sector and limits excessive volatility of output, the exchange rate, and inflation.

However, monetary policy is a short-term solution to a problem. The conflict of goals in this case emerges because of existing imbalances in fiscal or financial sectors. For the persistent reduction of risks related to speculative capital, other policies (e.g., fiscal, macroprudential) need to react.

Terms of trade shock

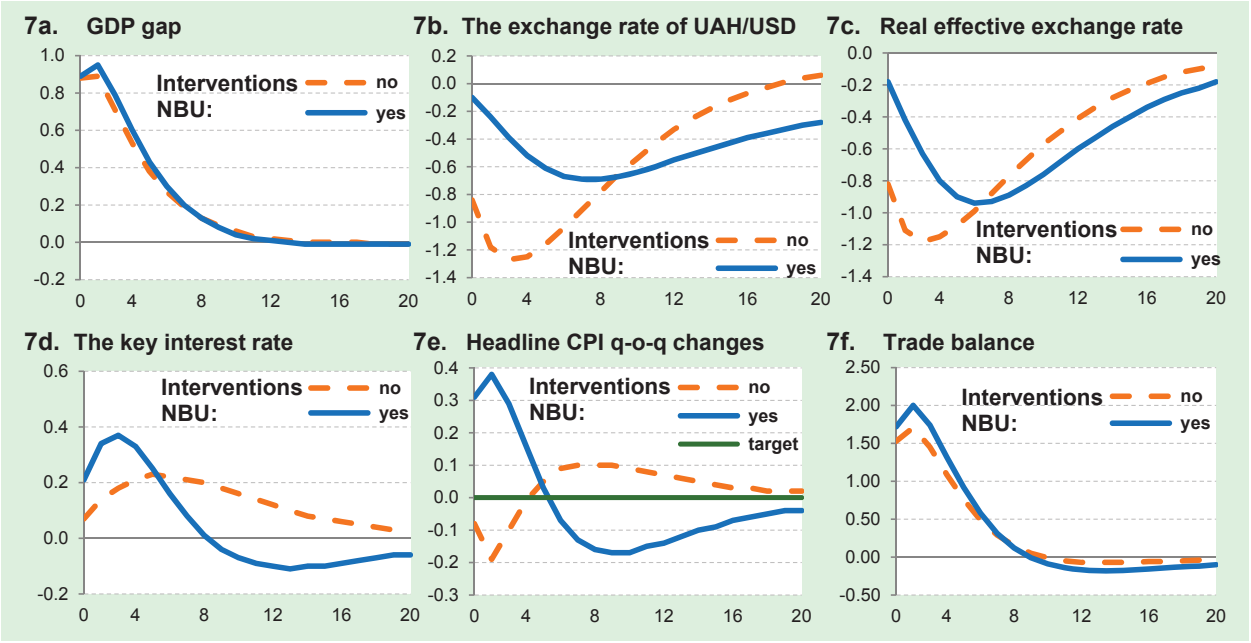
As an open price taking economy with a lot of trade in raw commodities, Ukraine is exposed to the impact from developments on commodity markets. We model terms of trade shock as a 10 percent increase in the ratio of an export deflator over an import deflator. This may come through a surge in world prices for wheat or some ferrous metals, which are the main exported goods.

This kind of shock immediately improves trade balance (Figure 7f), thus leading to both nominal exchange rate appreciation (Figure 7b) and opening a positive GDP gap (Figure 7a). The NBU reacts to the economy "overheating" with an interest rate increase (Figure 7d), though the reaction is delayed under the scenario without FX interventions (orange dashed line).

The reason for the mentioned delay lies in a disinflation hike (Figure 7d) caused by appreciation of the exchange rate. If the NBU applies interventions and conducts FX buy-outs (blue line), the appreciation is less pronounced and outweighed by the inflationary pressure from excessive demand. Increased inflation enforces a sharper interest rate response, which may end up being over-reactionary against the background of prolonged currency appreciation.

It is important to notice that the shock is modeled as a temporary one. Moreover, appreciated currency stimulates domestic demand, which in turn reverses trade balance into deficit. These movements eventually return the exchange rate to its pre-shock level. However, interventions might reduce exchange rate volatility.

Figure 7. Terms of trade shock under different policy responses



Policy implications. In the event of a favorable shock to terms of trade, the monetary policy response must consider the overall macroeconomic context. If inflation is suppressed (e.g., due to low domestic demand), the NBU is able to replenish its international reserves and permit some inflation. In the contrasting case of an already "overheated" economy, the right decision is probably to allow exchange rate appreciation with a view to mitigate inflation.

If inflation is close to the target, FX interventions are yet advised. They might mitigate exchange rate volatility, which is also beneficial for the anchoring of inflation expectations.

Volatility under different policy responses

Simulations showed that different shocks require different policy responses. The main reasoning behind FX interventions was that they help to smooth exchange rate volatility. However, under IT it is more important to mitigate volatility of inflation and, under a flexible version of IT, the volatility of the GDP gap. Sometimes it is not the case with application of FX interventions as an additional tool. We formalize that finding by construction of unconditional standard deviations of the model variables, which arise in response to each particular shock.[4] Table 1 summarizes.

[4] For more discussion on unconditional standard deviations, one may refer to Benes et al. (2015).

Table 1. Macroeconomic volatility under different policy responses

	GDP gap	*ΔER UAH/USD*	*REER gap*	*Key interest rate*	*CPI q-o-q changes*	*Trade balance*
Aggregate demand shock						
Without Interventions	1	1	1	1	1	1
With Interventions	1.0	0.4	1.0	0.9	1.6	0.9
Aggregate supply shock						
With Interventions	1.2	0.5	1.5	0.8	0.9	1.5
Risk premium shock						
With Interventions	0.5	0.4	0.6	1.1	0.7	0.7
Foreign interest rate shock						
With Interventions	0.7	0.5	0.7	1.8	0.9	0.8
Terms of trade shock						
With Interventions	1.1	0.3	0.9	1.2	2.1	1.2

Similarly to IRF, we examine one shock at time. Each column represents how big the standard deviation will be of a variable should the shock in heading be the only source of volatility in the economy. For comparison purposes, we normalize the results with respect to the case without interventions. Thus, a lower than unity number indicates that interventions are able to mitigate volatility.

Indeed, the exchange rate enjoys sufficiently lower volatility for all kinds of shocks under interventions. However, inflation volatility is mitigated only for three of them: aggregate supply, risk premium, and foreign interest rate. Applying interventions after these shocks would strictly come in line with IT. Moreover, in cases of the latter two, more stable GDP growth would be ensured as well.

Applying FX interventions after aggregate demand or terms of trade shocks could surge inflation volatility and does not create benefits for bringing down the volatility of output. From this prospective, FX interventions are not recommended in case of such shocks. However, this volatility analysis does not take into account the importance of international reserve accumulation, which is crucial for price stability in the medium- to long-term perspective. Thus, as mentioned before, the final decision needs to be based on an assessment of the situation before a shock hit the economy.

VII. CONCLUSIONS

A central bank operating under an IT regime in a developed economy often relies solely on the policy interest rate as a monetary instrument. However, research and experience in recent years shows that flexible IT can benefit from using FX interventions as a supplementary tool in emerging economies. Here we consider using FX interventions in the context of a floating exchange regime, so the central bank does not seek any particular level for the exchange rate or oppose the dominant trend on the FX market.

In this research, we show the cases when the monetary policy of the NBU can benefit from using FX interventions in combination with the policy interest rate.

For the purposes of our analysis, we simulate macroeconomic responses to different shocks in the NBU's QPM. Different monetary policy scenarios are considered as a reaction to a shock. The optimal scenario is advised on the basis of achieving goals that can enhance the credibility of the IT regime. They are inflation stabilization, accumulation of international reserves, safeguarding competitiveness of the real sector, and smoothing undue volatility of the exchange rate.

On the basis of the analysis, we discovered that there is no universal policy advice. Sometimes trade-offs emerge. The use of FX interventions needs to be considered on the basis of the nature of the specific shock. Such an approach allows the avoidance of conflict among monetary policy goals and enhances the credibility of the IT.

In the case of shocks to supply, the risk premium, and "hot" capital flows, the monetary policy could definitely benefit from using FX interventions in addition to the key policy rate. This policy-mix brings down the volatility of inflation in addition to smoother volatility of the exchange rate, which is essential for expectations in dollarized countries. In that way, the IT regime could gain greater credibility.

Moreover, if such shocks are leading to currency appreciation pressure, the NBU needs to use the opportunity and accumulate international reserves. A decrease in the policy interest rate needs to be moderate while easing of monetary policy can be achieved by slowing the pace of exchange rate appreciation. That supports the exporting sector and economic growth in the best way for a small open economy like the Ukrainian one.

In case of shocks related to credibility issues (e.g., risk premium) the NBU needs to react more harshly using both its policy interest rate and FX interventions that are needed to smooth depreciation, but not avoid it.

In the case of a shock related to "hot" capital inflows, some kind of capital control tool needs to be implemented in addition to the interest rate and FX interventions. Such a combination allows for minimizing volatility of inflation and output losses.

In case of aggregate demand or terms of trade shocks, the trade-off for policy choice arises as using FX interventions is accompanied by a higher volatility of inflation. However, there is no doubt that in case of depreciation pressure on the national currency the NBU needs to refrain from using FX interventions (except marginal use for smoothing the functioning the FX market), allow the exchange rate to play the role of shock absorber, and save international reserves, which are a scarce resource.

If there is an appreciation pressure, the NBU has to make a policy decision between less volatile inflation and output or accumulation of international reserves and a temporary increase of output. In this case, the overall macroeconomic situation needs to be taken into account.

If inflation is already suppressed when the shock happens (e.g., due to low domestic demand), the NBU is able to replenish its international reserves and permit some inflation. In the contrasting case of an already "overheated" economy, the right decision is probably to allow exchange rate appreciation with a view to mitigate inflation.

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