CURRENCY CRISES IN GEORGIA: A MULTIVARIATE LOGIT MODEL

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Abstract
After the collapse of the Bretton Woods system, developing countries, including Georgia, experienced several currency crises followed by severe recessions and deteriorated macroeconomic stability. This creates incentives for policymakers to predict currency crises in a timely manner, and avoid them or mitigate their negative consequences. This paper aims to identify episodes of the currency crisis in a panel of the Post-Soviet countries (to create evidence for Georgia), and access predicting power of the various economic, structural and institutional variables. Based on the different versions of the foreign exchange market pressure indices and their critical values, we identified three periods of the currency crisis: 2008-2009, 2015-2017 and 2020 years (with multiple episodes of the crisis). Among the reasons behind these episodes of currency crises, we can highlight: global financial crisis, monetary expansion of the United States, reduced crude oil and commodity prices, armed conflicts between countries in the region, political instability and imposed sanctions, and COVID-19 pandemic. Early warning indicators were chosen based on desk research of the theoretical models, and meta-analysis of the empirical papers. The optimal forecast horizon is 1 year and predicting ability of indicators are assessed employing multivariate logit model. One-year lag of the annual export growth, crude oil price and credit to GDP ratio are significantly correlated with the probability of currency crisis. These early warning indicators have an ability to collectively predict currency crises one year prior. The results of the multivariate logit model are robust under different specifications of the model. In contrast to the theoretical foundation, the lag value of the crude oil prices is positively correlated with the probability of the currency crisis, but narrowing the predicting corridor changes the sign of the correlation coefficient from positive to negative. The most reliable specification of the models successfully predicts 34% of the crisis episodes. Moreover, the model has low Quadratic Probability Score (QPS) and Logarithmic Probability Score (LPS), indicating high level of reliability of the model's outcomes.

Keywords: *Currency crisis; exchange rate; leading indicators; logit model; economic forecasting*.

JEL Classification: *E47, F31, O24, F62.*

I. INTRODUCTION

Before the collapse of the Gold Standard and Bretton Woods systems, currency crises were quite rare events. There were several leading currencies all around the world, and international monetary systems experienced major fluctuations only due to large-scale events, such as the Great Depression (during 1930s) and World War II (1939-1945). However, after the collapse of the Bretton Woods system, the most of the countries in the world abandoned the existing monetary arrangement and switched to the fiat money system, where fiat money is a government-issued currency backed by the reserves of commodities (e.g. gold) and / or internationally convertible currencies (e.g. USD, EURO, etc.). Hence, governments gained greater control over the economy of the country, and the stability of the exchange rate depends on the economic and political situation of a specific country.

In addition, globalization and increasing economic integration of countries that increases transmission of various negative economic shocks between them, makes it even more difficult to ensure exchange rate stability, which creates problems related to achieving the goal of sustaining price stability (especially for the countries with the high level of import-dependency), and maintaining debt burden in a low level for the unhedged borrowers - economic agents having income in a national currency and liabilities in a foreign currency (currency mismatch). As a result, currency crises became more frequent in the late 20th century, and even several global level crises occurred in the beginning of the 21st century.

Currency crises are mostly followed by severe recessions (e.g. currency crises in the transition economies during 1990s were followed by decline of GDP on average by 6.5% yearly), high and sometimes even uncontrolled inflation (e.g. the average annual inflation rate in transition economies, Latin American and Asian countries even reached to 40% during 1997-1998 currency crises), increased fragility of the financial system and even banking crises in the worst case scenario (due to currency mismatch and increased debt burden for unhedged borrowers), problems in terms of sustainability of the public debt (as big portion of the external public debt in the developing countries are denominated in a foreign currency – "Original Sin"), deteriorated external trade, reduced foreign direct investment, etc. (Blaszkiewicz and Paczyński, 2001).

Moreover, policymakers are often conservative with their monetary policy intervening in a foreign exchange market (especially, increasing monetary policy rates that have a negative impact on GDP) to avoid currency crises, sometimes even if it is not necessary (when there is a false signal of the currency crisis). For example, during the 1998 in Ukraine and Russia, central banks have sold around 40% of the central bank's reserves, and increased interest rate differentials even to 12% (Jakubiak, 2000).

The study of early warning systems of the currency crises is quite relevant for the Post-Soviet countries, since the monetary system of almost all these countries collapsed in the early 1990s (after collapse of the Soviet Union), and there were multiple episodes of the currency crises in 1997-1998 (series of devaluations of national currencies in the region), 2008-2009 (global financial crises and armed conflict between Russia and Georgia), 2015-2017 (sharp decline of the oil prices, financial crisis in Russia, difficult political processes in the region: conflicts, and economic and political sanctions), and 2020 (COVID-19 pandemic and armed conflict between Armenia and Azerbaijan). In addition, less diversified trade and close integration of the countries in the region, makes the contagion effect of the currency crisis particularly important. Therefore, it is key for policymakers to predict currency crises in a timely manner and mitigate the negative impact of them on the macroeconomic stability.

This article aims at assessing predicting power of the economic indicators estimating multinomial logit models for Georgia (based on the panel of the Post-Soviet countries). For this purpose, we identified episodes of the currency crises, chose appropriate early warning indicator, and assessed predicting power of them one year prior to the crisis.

II. PRACTICAL MODEL FOR EARLY WARNING SYSTEMS OF CURRENCY CRISES

In general, currency crisis is defined as an abnormally large change in the national currency over a short period of time, resulting in the partial or complete loss of the medium of exchange and store of value functions of the national currency (Burnside, Eichenbaum and Rebelo, 2007, pg. 1). Nevertheless, this definition is mostly valid for fixed exchange rate regimes, while many countries (including Georgia) prefer a floating exchange rate regime over the fixed one. Hence, the most common definition of the crisis states that currency crisis is a situation, when speculative attacks lead to a sharp devaluation / depreciation of the exchange rate and / or a significant reduction of the Central Bank's (CB) international reserves.

This paper introduces definition of the currency crisis based on the Exchange Market Pressure Index (EMP), which consists of three main components (Eichengreen, Rose and Wyplosz, 1996):

1. Monthly percentage change of the nominal exchange rate. The rationale behind employing USD exchange rate is that it is widely used in the international economic relations in Post-Soviet countries: international trade, remittances, tourism, foreign direct investment (FDI), and public and private external debt. These countries are also characterized by high level of deposit and loan dollarization;
2. Deviation of the domestic nominal interest rates from the foreign nominal interest rates. Theoretically, domestic interest rates should be equal to the foreign interest rates under fixed exchange rate regime. In the context of the inflation targeting regime, changing the nominal interest rates on the refinance loans (e.g. changing monetary policy rate in case of Georgia) are considered as the main instrument of the monetary policy of central banks;
3. Monthly percentage change of the CB's international reserves. CB's often employ foreign exchange market interventions to provide necessary liquidity (FX resources) to the commercial banks, and manage economic agent's expectations about exchange rate and inflation.

Then, components are weighted by their standard deviations. The formula has the following form:

$$EMP = \frac{1}{\sigma_{\%\Delta e}} \%\Delta e + \frac{1}{\sigma_{(i-i^*)}} (i - i^*) - \frac{1}{\sigma_{\%\Delta res}} \%\Delta res \quad (1)$$

Where $\%\Delta e$ is a monthly percentage change of domestic exchange rate with respect to USD (1 USD = e domestic currency); i - domestic nominal interest rate (monetary policy rates, refinance rates, money market interest rates or deposit rates for domestic currency depending on the availability of the data for each country); i^* - the effective federal funds rate in the U.S.; $\%\Delta res$ - monthly percentage change of the CB's foreign currency reserves; and $\sigma_{\%\Delta e}$, $\sigma_{(i-i^*)}$ and $\sigma_{\%\Delta res}$ are corresponding standard deviations of components.

In the second version of the EMP index, the nominal USD exchange rate is substituted by the nominal effective exchange rate, which makes it possible to consider not only the USD exchange rate but also the dynamics of the exchange rates of the major partner countries. For example, Georgia's main trading partner countries are its neighbors (Turkey, Russia, Armenia and Azerbaijan) and EU countries. The third and fourth versions of the EMP index represent modification of the previous two versions, removing the component of the nominal interest rate differential due to data availability and reliability issues related to this indicator.

In the next stage, we determined criteria for the currency crises and defined corresponding binary variables. There is no explicit methodology of choosing critical value of the EMP index, but after assuming the distribution of the index being quite close to the normal distribution and the probability of a currency crisis is 5%, critical value of the indicators will be deviation from its mean by 1.645 standard deviations (this criterion will be common to all versions of the EMP index). Hence, binary variable of the currency crisis will take the following values:

$$Currency\ Crisis = \begin{cases} 1, & when\ EMP \geq \mu + 1.645 * \sigma_{EMP} \\ 0, & otherwise \end{cases} \quad (2)$$

where μ and σ_{EMP} are the mean and standard deviation of EMP index, respectively (Avetisyan, 2017).

In the context of building early warning systems of the currency crisis, the choice of the early warning indicators is based on the economic theories and country experiences presented in analytical papers. In theory, there are three generation models describing determinants of the currency crises. The first-generation models (speculative attack models) pay special emphasis on the currency crises caused by speculative attacks arising from the inconsistency of the fiscal and monetary policy with the fixed exchange rate regimes (the best described by Mundell's (1963) theory of "impossible trinity") (Krugman, 1979; Flood and Garber, 1984; Flood and Marion, 1999). The second-generation models (multiple equilibrium models) recognize the self-fulfilling nature of the currency crisis – reaching multiple equilibrium under uncertainty (Obstfeld, 1996; Morris and Shin, 1995; Copeland, 2008). The third-generation models (financial crisis models) describe linkages between banking and currency crises, and consider contagion effect as one of the most important reasons behind the crisis (Gerlach and Smets, 1994; Chang and Velasco, 1998; Kaminsky and Reinhart, 1999).

Avetisyan (2017) conducted meta-analysis of 86 research papers and described leading indicators relevant for most of these studies. Based on this analysis, we have chosen a group of variables that can potentially predict crisis in a timely manner: 1) Real exchange rate, which successfully predicts episodes of the currency crisis in more than 65% of the papers. An overvalued national currency has a negative impact on the competitiveness of a country, export of goods and services, economic growth, and financial stability. 2) International reserves, which successfully predicts crises in more than 51% of the works. Deteriorated external statistics (due to exogenous negative external shocks) puts pressure on the exchange rate, often leading to a reduction of the international reserves, and further diminishes CB's ability to safeguard the national currency from speculative attacks. 3) Broad money (M2) to international reserves, which predicted crises in almost 42% of the research papers. The M2 aggregate is considered as a financial resource that could potentially be converted into a more stable currency when economic agents expect depreciation of the local currency (determines the potential volume of the speculative attack). 4) Domestic credit growth, which is considered as a predictor of the currency crisis in more than 38% of the works. Rapidly growing domestic credit (with inappropriate supervision, liberalization of financial system and / or high level of capital mobility) might cause indebtedness of economic agents, which might be particularly dangerous for the countries with high levels of financial dollarization. 5) Current account deficit and export growth, which is represented as a leading indicator in 33% and 28% of the research papers, respectively. Current account deficit and export growth are considered as one of the most important fundamental factors determining demand, supply and equilibrium in the foreign exchange market (particularly important for the small open economies). The other important sources of foreign currency inflow / outflow are service export (especially for the tourism dependent countries), remittances and foreign direct investment. Deteriorated export statistics might indicate lost competitiveness of local firms. 6) Real GDP growth and budget deficit, which are considered as a forecast indicator of the currency crisis in 28% and 21% of the papers, respectively. In general, a country is prone to a currency crisis when the domestic economy does not grow adequately (real GDP growth falls behind the potential growth of GDP). A persistent budget deficit might be associated with unhealthy government policy and financed by debt monetization leading to the loss of the international reserves, and currency crisis. 7) Inflation, which is considered as an early warning indicator in 20% of the works. Rapidly increasing price level is associated with high level of interest rates, and problems in the banking system.

In addition, there are the wide range of macroeconomic, structural and institutional variables predicting the currency crises: crude oil prices, short-term foreign debt, change in asset prices, loan and deposit dollarization, etc. (indicators are chosen based on the theoretical foundations described before as well as country context and data availability). This paper aims to evaluate predicting power of the abovementioned indicators.

There are various models predicting currency crises, and studying predicting ability of different indicators. The most common of them are probit/logit econometric models (Eichengreen, Rose and Wyplosz, 1996; Demirgüç-Kunt and Detragiache, 1998) and signaling modeling techniques (Kaminsky, Lizondo and Reinhart, 1998). This paper will employ the multivariate logit model, which uses classic econometric assessment technique, by linking the probability of the currency crisis to the vector of explanatory variables, and studying the extent of marginal contribution of each variable in predicting the crises. The main advantage of this method is that it accesses predicting power of explanatory variables controlling the other indicators (taking into consideration possible multicollinearity and testing statistical significance of each variable). While the potential

disadvantages are limited number of explanatory variables that could be accessed within a single model, necessity of stationarity of the variables (when variables have unit root, mathematical transformations are necessary, and indicators become hard to interpret), and sometimes impossibility to address the issue of intersection between factors, etc. (Avetisyan, 2017).

The process of accessing predicting power of the various indicators is done by basing upon the panel data. The panel option incorporates Post-Soviet countries, with a total of 9 countries, including Georgia (Lithuania, Latvia and Estonia are excluded from the panel due to having notably different monetary system then the other countries by having euro as a national currency, as well as Tajikistan, Turkmenistan, and Uzbekistan due to the lack of data for the most of the indicators). The choice of the panel is determined by the need to explore a specific region with a group of homogenous countries all of them having Soviet background and consideration to make useful conclusions about Georgia. Since the most data was not possible to obtain on a monthly basis, the database covers quarterly series for the period 2003-2020. The data was obtained by IMF's International Financial Statistics, World Bank's World Development Indicators and databases retrieved from the national statistics offices and central banks of the countries included in a panel.

Before estimating the multinomial logit model, we accessed stationarity of the independent variables based on the unit roots test developed by Im, Pesaran and Shin (1997), and all the forecasting indicators turned out to be stationary and can be employed in the logit model without further transformation. Furthermore, there is no significantly high correlation between explanatory variables to create multicollinearity problem in a model. All the explanatory variables in the model are presented by a one-year lag (forecast horizon is a one year). Based on the theoretical justification and the results of the Hausman's test, we have selected a fixed effect estimation technique that allows us to control for time-invariant unobserved individual characteristics that can be correlated with the observed independent variables. We have used robust standard errors to allow for the presence of heteroskedasticity. The goodness-of-fit of the most suitable model is assessed based on the Quadratic Probability Score (QPS), the Logarithmic Probability Score (LPS) (Diebold and Rudebusch, 1989) and Noise-to-Signal Ratio (Kaminsky, Lizondo and Reinhart, 1998).

III. MULTINOMIAL LOGIT MODEL AS A TOOL FOR PREDICTING CURRENCY CRISES IN GEORGIA

Based on the various versions of the EMP index, it is possible to distinguish three periods of the currency crises: 1) 2008-2009; 2) 2015-2017; and 3) 2020. There were 87 cases of the currency crisis identified in the discussion period, which included the following episodes for each country: Armenia (2009, 2014-2015), Azerbaijan (2015-2016), Belarus (2011-2012, 2015), Georgia (2008-2009, 2015, 2016-2017, 2020), Kazakhstan (2009, 2015-2016, 2020), Kyrgyz Republic (2008-2009, 2014-2015, 2020), Moldova (2009, 2014-2015), Russia (2008-2009, 2014-2015), and Ukraine (2008-2009, 2014-2015).

The first episodes of the currency crises were mostly driven by the 2008 global financial crisis causing considerable negative real shocks in the global level associated with capital outflow from developing to developed countries, and notably reduced crude oil and commodity prices in the world market (Post-Soviet countries tend to be dependent on the export of the crude oil and commodities). The second episodes of the currency crises were caused by combination of regional and country specific factors, such as prolonged expansionary monetary policy of the Federal Reserve System (FED), notable decline in crude oil, agriculture goods and metal prices in the world market, armed conflicts between Russia and Ukraine, imposition of diplomatic, political and economic sanctions on Russia by the EU, the United States, Canada, Australia, japan and others (Dabrowski, 2016). The third episodes of the currency crises were mostly related to the COVID-19 pandemic in 2020, sharp decline of the crude oil prices in the world market and armed conflict between Armenia and Azerbaijan.

The following section presents results of the multivariate logit model described in the previous section. After building different models including various combinations of explanatory variables, 10 leading indicators were chosen: annual growth rate of export (EXPORT), crude oil prices (OIL PRICE), annual growth rate of the trade deficit (TRADE DEFICIT), credit to GDP ratio (CREDIT to GDP), liquidity coefficient (LIQUIDITY), annual growth rate of credit (CREDIT), annual change of consumer price index (INFLATION), broad money (M2) to the official international reserves (M2 to RESERVES), monthly change of terms of trade (TERMS of TRADE), and annual real GDP growth (GDP GROWTH), and 4 different models were built. The results of the multivariate logit model are presented in the table below.

In all the model specifications, the one-year lag value of the annual growth rate of export, crude oil prices and credit to GDP ratio are significantly related to the probability of the currency crisis. Hence, these variables can successfully predict the crises one year prior and the results are robust under different specifications of regression (different combination of variables, different approaches of panel data analysis: random effect model, probit model and models with robust standard errors). In all four models, low annual growth rate of export is clearly associated with a higher probability of a currency crisis, confirming that deteriorated external trade has

been a major source of the currency crisis in the discussion period. Furthermore, higher trade deficit appears to worsen stability of the exchange rate, but this variable is significant only at two of the specifications (after including inflation and M2 to the official international reserves in the model) and only at 10% confidence level. The later finding is not robust under models employing different definitions of the currency crisis.

Credit to GDP ratio is highly significant in all the specifications and has the expected sign, confirming the vulnerability of the foreign exchange market to rapid credit growth (exceeding economic growth and together with inappropriate supervision of the central bank) leading to indebtedness of economic agents, credit bubbles and distress of the financial market.

In contrast to the theoretical foundations, the one period lag of crude oil prices is positively correlated with the probability of the currency crisis. However, narrowing down the forecast horizon, the sign of the correlation coefficient between crude oil price and the likelihood of the currency crisis is changing from positive to negative. This could be explained by the fact that decline of the crude oil prices usually coincides with the currency crisis. Hence, factors that explain the dynamic of the crude oil prices can successfully predict currency crises. The finding of the analysis is robust even after including lag value of the dependent variable, which only slightly improves reliability of the model.

Table 1 – Results of the Fixed Effect Logit Model

Dependent Variable: Binary Variable of Currency Crisis

	Model 1	**Model 2**	**Model 3**	**Model 4**
EXPORT	-1.23** (-2.47)	-1.35*** (-2.61)	-1.26** (-2.37)	-1.33** (-2.23)
OIL PRICE	0.03*** (6.72)	0.03*** (6.68)	0.03*** (6.12)	0.03*** (6.12)
TRADE DEFICIT	0.12 (1.59)	0.12 (1.59)	0.13* (1.81)	0.13* (1.80)
CREDIT to GDP	1.27*** (4.14)	1.31*** (4.22)	1.16*** (3.55)	1.20*** (3.63)
LIQUIDITY		0.23 (0.08)	-0.75 (-0.25)	-0.86 (-0.29)
CREDIT		3.00 (1.36)	4.01 (1.63)	3.71 (1.49)
INFLATION			1.33 (0.91)	1.37 (0.93)
M2 to RESERVES			-0.21 (-1.34)	-0.22 (-1.35)
TERMS of TRADE				-0.01 (-0.87)
GDP GROWTH				0.61 (0.35)
Number of Observations	594	594	594	594
Akaike Information Criterion (AIC)	378.35	379.27	380.69	383.81
Bayesian Information Criterion (BIC)	395.90	405.59	415.79	427.68
Model's χ^2	83.10***	86.18***	88.76***	89.65***
Log likelihood	-185.18	-183.64	-182.35	-181.90

Note: The dependent variable takes the value one if there is a crisis and value of zero otherwise. Z statistics are in parentheses. Coefficients represent marginal effects. One, two, and three asterisks indicate significance levels of 10%, 5%, and 1%, respectively.

All four models presented in the table are jointly significant, while the most parsimonious model (Model 1) has the best goodness-of-fit measures (including Akaike and Bayesian information criteria as well as log likelihood ratio). Therefore, reliability of the forecast models will be assessed for the first model. The model successfully predicts 22 cases of the currency crisis one year prior the crisis, which is about 34% of the total number of crises. This number significantly increases when we narrow down the forecast horizon to 6 months, but this period usually is not enough for policymakers to avoid currency crises or notably mitigate negative consequences of it (Kaminsky and Reinhart, 1999). Furthermore, the model's Noise-to-Signal Ratio is considerably below 1 (Kaminsky, 1999), which means that the model has predictive properties. However, despite having quite low Type II errors (i.e. "false signals" - model predicted crises, while there has been no crisis), type I errors take relatively high value (i.e. "missed crises" – model failed to predict crisis). Hence, the conditional probability of the currency crisis is about 0.54. The Quadratic Probability Score (QPS) and the Logarithmic Probability Score (LPS) are taking quite low values that again indicates reliability of the forecasting model (see table 2).

Table 2 – Goodness-of-fit Measures of the Model

Successfully Predicted Currency Crises (A)	22
The Number of Inaccurate Signals - "False Signals" (B)	19
Cases of Crisis that Could not be Predicted – "Missed Crises" (C)	65
Tranquil Periods (D)	488
Noise-to-Signal Ratio	0.148
Type I Errors	0.747
Type II Errors	0.037
Conditional Probability of Crisis A/(A+B)	0.537
The Share of Successfully Predicted crises in total number of crises	0.338
Quadratic Probability Score (QPS) $[0, 2]$, where 0 represents a perfect forecast	0.2757
Logarithmic Probability Score (LPS) $[0, \infty)$, where 0 represents a perfect forecast	0.5679

Source: authors' calculations based on the first logit model.

IV. CONCLUSIONS

There is a consensus among economists that early warning systems of the currency crises, despite being complex, can not provide absolutely accurate predictions of the currency crises. However, studying predicting power of different indicators and building early warning systems makes it possible for policymakers to timely intervene in a foreign exchange market, and avoid or at least mitigate negative consequences of the currency crises or substantial exchange rate pressure. Concluding remarks of this paper can be summarized as follow:

- Based on the various versions of the EMP index, there were three periods of the currency crises: 1) 2008-2009; 2) 2015-2017; and 3) 2020.
- Currency crises episodes in 2008-2009 were driven by considerable negative real shocks in the global level associated with capital outflow from developing to developed countries, and notably reduced crude oil and commodity prices in the world market.
- Currency crises in 2015-2017 were caused by prolonged expansionary monetary policy of the Federal Reserve System (FED), notable decline in crude oil, agriculture goods and metal prices in the world market, armed conflicts between Russia and Ukraine, imposition of diplomatic, political and economic sanctions on Russia by most of the advanced economies.
- Currency crisis in 2020 was mostly related to the COVID-19 pandemic in 2020, sharp decline of the crude oil prices in the world market and armed conflict between Armenia and Azerbaijan.
- The one-year lag value of the annual growth rate of export, crude oil prices and credit to GDP ratio are significantly related to the probability of the currency crisis.
- Low annual growth rate of export is clearly associated with a higher probability of a currency crisis, while higher trade deficit appears to worsen stability of the exchange rate, but this variable is significant only two of the specifications and at 10% confidence level. Credit to GDP ratio is highly significant in all the specifications and has the expected sign.
- The one period lag of crude oil prices is positively correlated with the probability of the currency crisis - decline of the crude oil prices usually coincides with the currency crisis. Hence, factors that explain.
- The best specification of the multivariate logit model successfully predicts 22 cases of the currency crisis one year prior, which is about 34% of the total number of crises.
- The model's noise-to-signal ratio is considerably below 1, which means that the model has predictive properties. Despite having quite low Type II errors, type I errors take relatively high value.

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