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Assessing Georgia's External Vulnerability

by Valida Pantsulaia, Salome Tvalodze and Zviad Zedginidze

საქართველოს ეროვნული ბანკი
National Bank of Georgia

Assessing Georgia's External Vulnerability[1]

Valida Pantsulaia,[2‡] Salome Tvalodze[‡] and Zviad Zedginidze[⁑]

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Abstract

Small open economies with persistent current account deficit and financial dollarization like Georgia are especially vulnerable to external shocks. Therefore, developing an Early Warning System can play an important role in identifying external vulnerability. How can we detect the build-up of external risks in Georgia? We take this question and employ a three-step approach to create a tool for detecting rising vulnerabilities, designed for Georgia's economic circumstances. The first step identifies historical periods of increased external vulnerability in Georgia using the Exchange Market Pressure (EMP) index. The second step determines some of the best indicators that capture rising external imbalances individually. Finally, these indicators are aggregated into a single composite - External Vulnerability Index (EVI), which proves to be helpful in detecting rising external vulnerabilities in the country.

JEL Codes: E58, E61, G01, C13

Keywords: external vulnerability; exchange market pressure; early warning indicators; signalling approach

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[2] *Corresponding author*: Valida Pantsulaia, National Bank of Georgia, Senior Specialist of Macrofinancial Modelling and Analysis Division (e-mail: vpantsulaia@nbg.gov.ge)

‡ Macrofinancial Modelling and Analysis Division; National Bank of Georgia

⁑ Advisor to the executive director; International Monetary Fund

Content

I. Introduction

Georgia is a small open economy, which makes it vulnerable to external shocks. High level of dollarization coupled with current account deficit and dependence on international flows makes Georgia vulnerable to developments in foreign sector, especially in major trading partners and neighboring countries. While external vulnerability of the Georgian economy is comparable to that of CIS countries, it is relatively high compared to emerging market economies (Financial Stability Report, NBG, 2019). This study aims to detect rising imbalances, which make Georgia more exposed to external developments and as a result may lead to crises. While it is impossible to predict exogenous shocks, it is possible to timely detect the buildup of imbalances, which amplify the adverse effects of such shocks. Developing an Early Warning System (EWS) in the form of External Vulnerability Index (EVI) can play an important role in mitigating the risks stemming from the external sector.

Following the Global Financial Crisis (GFC), the International Monetary Fund (IMF), along with various central banks, has been actively involved in improving the surveillance and early warning systems to increase the resilience of the financial system (Pasricha, 2013). This led to the development of an EVI, which combines individual indicators in an attempt to detect rising imbalances in the external sector. The main objective of this study is to develop an external vulnerability index for Georgia, which will be used for early detection of rising external pressure. The study is divided into three steps. The first step identifies historical periods of increased currency pressure in Georgia using Exchange Market Pressure (EMP) index. After defining these periods, the study determines individual external sector indicators that are best able to capture rising external imbalance. Results indicate that variables related to external debt, FDI, reserves position, trade balance and current account balance are the most informative indicators for external vulnerability analysis in Georgia. Finally, these indicators are combined into a single EVI, which will be a useful tool for detecting the buildup of external risks.

It should be noted that this is the first study of its nature conducted in Georgia. Additionally, existing international studies are either devoted to discussing EMP index or constructing an EVI. While a few papers are attempting to do both (Supriyadi, 2014), our study goes further by addressing potential issues related to the normality assumption of the EMP index. Moreover, considering more specifications of both EVI and EMP indices allows us to analyze the external sector vulnerability of a country better.

II. Exchange Market Pressure, EMP

Alternative Methods for Deriving EMP: Literature Review

The use of EMP as an indicator of currency vulnerability was pioneered by Girton and Roper in 1977. Since then, the index has been widely adopted and modified to better capture the periods of increased currency pressure. EMP measures not only the actual depreciation of the exchange rate, but also the policy response, notably increase in interest rate and decrease in international reserves. This way it becomes possible to detect not only the periods of successful attacks on currency (leading to exchange rate depreciation), but also the periods where speculative pressure on currency existed but was averted through interventions (MacFarlane, 2010). The goal of EMP index is to formally define such periods of increased exchange pressure and use it as a benchmark for evaluating the performance of Georgia's external vulnerability index.

The initial specification of the EMP index only included depreciation of exchange rate and change in international reserves. Eichengreen, Rose and Wyplosz (1996) were the first to introduce the change in interest rate to the formula and since then, most of the studies use all three components to construct the EMP index. Increase in interest rate, similar to the decrease in international reserves, can be indicative of the central bank's attempt to counteract currency depreciation.

By the end of the 90s, several attempts were made to improve the performance of EMP index by Sachs et al. (1996) and Kaminsky et al. (1998). The quest for modifying the index continues. While there is a general agreement about the three components of EMP, the major discussion is about how to weigh and aggregate them. Over time, three methods emerged for weighting the EMP index: precision weighting, model-based and elasticity-based.

The most commonly used method is precision weighting, which means weighting each component by inverse of its historical standard deviation. As a result, series with larger volatility end up with smaller weight in the EMP index. Lack of economic interpretation behind such weighting system and cross-country comparability problems of the resulting EMP index were cited as major reasons for dropping the weights all together (Li et al., 2006). Such an approach, however, increases sensitivity of EMP index to its most volatile component (which is usually change in reserves), decreasing the relative importance of other two variables.

Roper, in collaboration with Turnovsky worked on an alternative model-based approach for obtaining weights in 1980. This method was further developed by Weymark (1995). It relies on IS-LM stochastic framework and derives weights based on estimated parameters from the model. The main drawback of this approach is that it is based on various assumptions about the relationship between different variables in IS-LM framework. This model-based approach has been criticized by economists (Eichengreen et al., 1995) as random walk forecast outperforms structural models of exchange rate determination up to one year (McFarlane, 2010). Thus, they concluded that the weights based on structural models do not necessarily improve the performance of EMP index.

The third method was suggested in a series of papers by Weymark (1995, 1997, 1998), which based weights on elasticity of exchange rate to change in reserves (Li et al., 2006). However, the major concern with this method is how to properly estimate such elasticities.

All three methods for estimating weights (precision weighting, model-based and elasticity-based) have their respective drawbacks. Despite the lack of economic interpretation of precision weights, using inverse of standard deviation allows us to account for volatility differences of EMP components. Additionally, since our study does not aim to conduct a cross-country comparison of EMP indices, lack of comparability is not really an issue. This study will look at several specifications of the EMP index for Georgia all based on precision weighting method. Adoption of model- and elasticity-based methods and their comparison with the chosen methodology could be the subject of subsequent research.

EMP Index for Georgia: different specifications

The weight specification and composition of EMP index differ across the studies even for precision-based weighting method. To avoid reliance on a single version of EMP index, alternative representations were adopted and compared.

As outlined before, the three variables participating in EMP index are exchange rate, international reserves and interest rate. Exchange rate shows the price of US$ 1 in GEL; interest rate represents monetary policy rate for Georgia, while international reserves are composed of official reserve assets excluding gold. The data for Georgia's EMP index were obtained from the National Bank of Georgia. The index is constructed so that the rise in EMP index indicates increasing vulnerability of the domestic currency.

The first version of the exchange market pressure index is based on Eichengreen et al. (1996). This specification uses the United States as a country of reference and looks at reserve and interest rate changes in the base country (Georgia) relative to the United States. The index has the following form:

$$EMP_t = \frac{1}{\sigma_e}\frac{\Delta e_t}{e_t} - \frac{1}{\sigma_r}\left(\frac{\Delta \underline{r}_t}{\underline{r}_t} - \frac{\Delta \underline{r}_{US_t}}{\underline{r}_{US_t}}\right) + \frac{1}{\sigma_i}\left(\Delta\left(i_t - i_{US_t}\right)\right)$$

where

EMP_t - exchange market pressure at period t;
e_t - USD to GEL exchange rate at time t;
$\underline{r}_t$ - ratio of international reserves to money base in Georgia at period t;
$\underline{r}_{US(t)}$ - the same ratio for the United States;
i_t - monetary policy rate in Georgia;
i_{USt} - federal funds rate in the United States;
σ_e - the standard deviation of the relative change in USD to GEL exchange rate;

σ_r - standard deviation of the difference between the relative changes in the ratio of international reserves to money base in Georgia vs. the United States;
σ_i - the standard deviation of the interest rate differential.

As decrease in reserves implies negative pressure on exchange rate, this component enters the equation with a negative sign. As for the nominal exchange rate change and change in differential, these variables enter the EMP with a positive sign, as their increase indicates rising pressure on the exchange rate.

This formula was later modified by Sachs et al. (1996):

$$EMP_t = \left[\frac{\frac{1}{\sigma_e}}{\left(\left(\frac{1}{\sigma_e}\right) + \left(\frac{1}{\sigma_r}\right) + \left(\frac{1}{\sigma_i}\right)\right)}\right]\frac{\Delta e_t}{e_t} - \left[\frac{\frac{1}{\sigma_r}}{\left(\left(\frac{1}{\sigma_e}\right) + \left(\frac{1}{\sigma_r}\right) + \left(\frac{1}{\sigma_i}\right)\right)}\right]\frac{\Delta r_t}{r_t} + \left[\frac{\frac{1}{\sigma_i}}{\left(\left(\frac{1}{\sigma_e}\right) + \left(\frac{1}{\sigma_r}\right) + \left(\frac{1}{\sigma_i}\right)\right)}\right]\Delta i_t$$

The resulting formula includes the same e_t and i_t variables; however, instead of using the ratio of reserves to monetary base, it uses r_t which is simply international reserves (excluding gold) in period t. As for other variables, σ_e refers to standard deviation of the rate of change in the exchange rate; σ_r is the standard deviation of the rate of change in reserves; and σ_i is standard deviation of the change in nominal interest rate.

Another commonly used variation of EMP was suggested by Kaminsky et al. (1998):

$$EMP_t = \frac{\Delta e_t}{e_t} - \frac{\sigma_e}{\sigma_r}\left(\frac{\Delta r_t}{r_t}\right) + \frac{\sigma_e}{\sigma_i}\Delta i_t$$

where the variables have the same interpretation as in the case of Sachs et al. (1996), the only difference is in the weighting method.

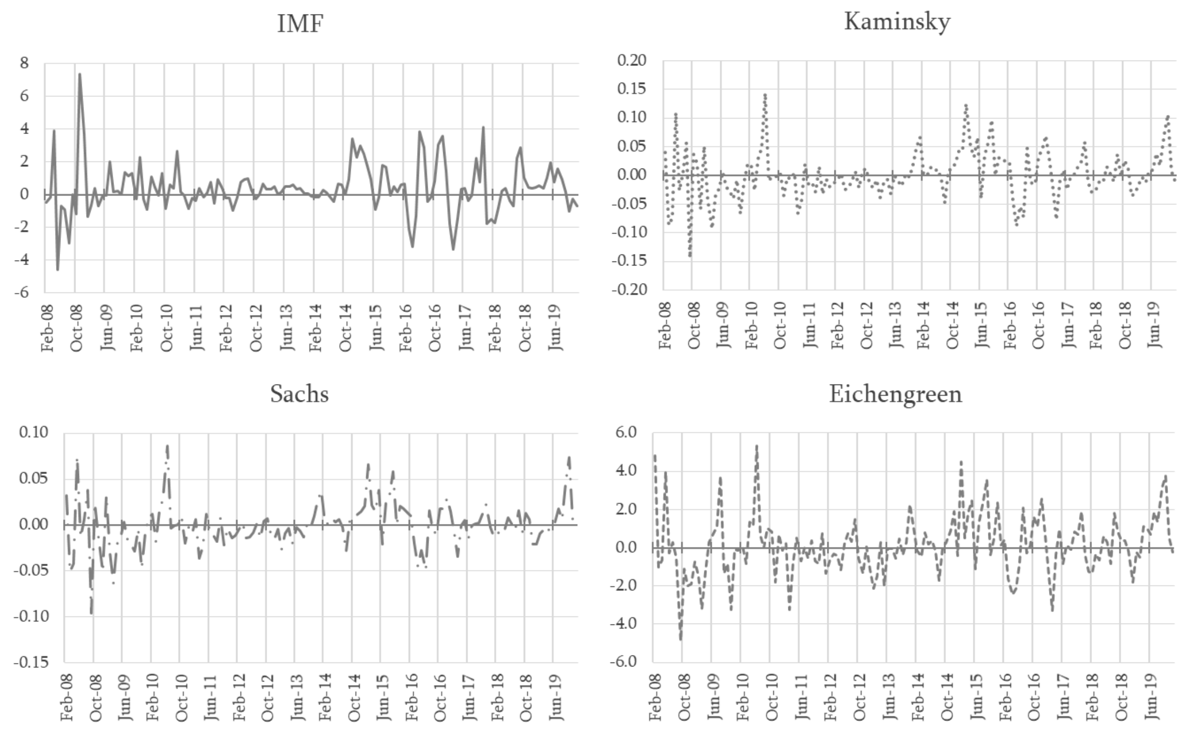
The International Monetary Fund (IMF) also developed its own version of the EMP index in 2007. This version does not include interest rates and instead of using reserves, it focuses on the net foreign assets (NFA).

$$EMP_t = \frac{1}{\sigma_{\Delta\%_{r_t}}}\Delta\%r_t + \frac{1}{\sigma_{\Delta res_t}}\Delta res_t$$

where the first variable $\Delta\%r_t$ is the percentage change in exchange rate of GEL to USD and the second component Δres_t is the change in net foreign assets by monetary base $(NFA_t – NFA_{t-1})/MB_{t-1}$. Finally, $\sigma_{\Delta\%_{r_t}}$ and $\sigma_{\Delta res_t}$ are the standard deviations of these variables respectively.

EMP series based on these four specifications were calculated for Georgia using monthly data from February 2008 to December 2019. Prior to 2008, the monetary policy rate was based on the 7-day certificate of deposit. In 2008, the NBG introduced a refinancing instrument for conducting the monetary policy operations, thus using monetary policy rate data before 2008 would not be consistent. The resulting EMP series are presented on Figure II.1 below.

Figure II.1 EMP Indices for Georgia



Source: Authors' calculations

Visual inspection of the indices reveals that Sachs, Kaminsky and Eichengreen-based indices have a similar pattern across the time; however, Eichengreen has a larger variance, which is the result of using a country of reference in the equation.

Despite similarities between these indices, there are also notable differences, like the absence of a prominent peak in 2010 in IMF series. This could be explained by the fact that the IMF-based EMP index includes only two variables (reserves and exchange rate) and does not capture the changes in monetary policy rate, which could be the contributing factor to the peak in other versions of the EMP.

Identifying Vulnerability Periods - Threshold Estimation

After constructing four specifications of EMP index, it is important to determine the threshold beyond which currency vulnerability is considered to be elevated. Earlier studies mainly use a threshold of 1.5 standard deviation from the mean value of EMP index to identify the periods of elevated exchange pressure (Heinz and Rusinova, 2015). According to these authors, the values in the right tail (beyond the 1.5 standard deviation threshold from the mean) indicate the periods of high vulnerability. This approach, however, has been criticized as it assumes it assumes that the EMP index is normally distributed. Studies like Pozo and Amuedo-Dorantes (2003) and Heinz and Rusinova (2015) have shown that the EMP index has fat tails, and as a result, threshold calculation based on normal distribution underestimates the incidence of periods with extreme values. Pozo and Amuedo-Dorantes (2003) demonstrated that using extreme value method improves the identification of high vulnerability periods by taking into account the fat tails of EMP index.

Previous research demonstrates that the normality of EMP index varies across countries. For example, Heinz and Rusinova (2015) found that while EMP index in Russia and Turkey are characterized by very heavy tails, Romania and Latvia are intermediate cases, while EMP index for Poland shows no evidence of fat tails. The paper concludes that while tail events in individual countries in Central and Eastern Europe are not frequent, they happen more often when we start questioning the normality of EMP index's distribution.

To test the normality of EMP series, MacFarlane (2010) uses Q-Q plot, while Heinz and Rusinova (2015) evaluates histogram, skewness, kurtosis, and Jarque-Bera statistics of the EMP index. All these statistical tests were used to evaluate the normality of the EMP index for Georgia. Descriptive statistics, Q-Q plots and histograms, and the results of Jarque-Bera normality test for all four specifications are presented in the Appendix I.

Distributions with heavy tails usually curve off in the extremities in the Q-Q plot. Visual inspection of the endpoints of Q-Q plots suggests that the EMP index under IMF, Sachs and Kaminsky specifications has fat tails. The results are less conclusive for Eichengreen based EMP index, which visually resembles a normal distribution. All specifications demonstrate positive skewness and excess kurtosis. The Jarque-Bera statistic also rejects the null hypothesis of normal distribution for these series. Thus, overall tests confirm that the EMP index for Georgia is not normally distributed and has fat tails. In sum, rule of thumb measure from previous studies - a threshold of 1.5 standard deviation from the mean - would significantly underestimate the true number of extreme pressure events and thus is not useful.

An alternative way of determining EMP threshold beyond which we observe high vulnerability is through Hill estimator. The calculation is based on EMP series and uses the following formula:

$$\gamma(k) = \frac{1}{k}\sum_{j=1}^{k}\{(lnx_{n-j+1}) - (lnx_{n-k})\}$$

where lnx is the log value of the EMP index in a particular period and k is the number of tail observations included in the analysis. As shown by Huisman et al. (2001) k equal to half of the full data (n/2) produces robust results and allows us to determine the threshold. Once gamma ($\gamma(k)$) values are calculated for different values of k, we use it to construct a Hill plot which is used to determine the number of periods of extreme exchange vulnerability.

Threshold estimation requires that the data be stationary. This was confirmed using Dickey-Fuller unit root test (Appendix II).

The first point where the Hill plot starts to stabilize determines the threshold and the number of periods with increased exchange pressure in a country in a given timeframe. Hill plot graphs gamma $\gamma(k)$ series for different values of k ranging from 1 to ($\frac{n}{2}$). By doing that we are trying to identify a cut-off point where the estimated parameter ($\gamma(k)$) becomes independent of marginal changes in k (Heinz and Rusinova, 2015).

Based on Hill plot analysis (Appendix III) we have determined the cut-off point and the number of periods with extreme exchange pressure for different specifications of EMP index (Table II.1). The results are highly comparable, indicating consistency across the specifications.

Table II.1 Number of Extreme EMP Periods

Specification	Number of extreme EMP periods (k)
IMF	28
Eichengreen	24
Sachs	21
Kaminsky	21

Source: Authors' calculations

To verify the robustness of our results, we decided to employ the recursive least squares method. While there exist other statistical ways for selecting optimal k (Danielsson et al. 2001), they can only be applied to large samples. Since our sample size is not large enough, we adopted a recursive least squares method for verifying the threshold. This method derives recursive residuals and plots them against the bandwidth of plus and minus two standard errors (Pozo, 2003). The resulting graph is used to determine the robustness of threshold identified from Hill plots. More details about this method and corresponding graphs can be found in Appendix IV.

The recursive residuals verify that stabilization of gamma ($\gamma(k)$) happens at around 30 for IMF based EMP, around 25 for Eichengreen based EMP and around 20 for Kaminsky, and around 20 for Sachs. Thus, our selection of threshold seems appropriate and we can proceed with identification of the periods of increased currency vulnerability in Georgia based on all four indices.

Results: High Vulnerability Periods for Georgia

Threshold estimation allowed us to identify the periods of high vulnerability in Georgia under four different specifications of EMP index. The periods of high exchange pressure determined for each specification are presented in Table II.2. Colored cells indicate that there were signs of increased vulnerability in a given month according to that particular specification of EMP index. The analysis covers a period from January 2008 to December 2019.

Table II.2 High Vulnerability Periods for Georgia under four specifications of EMP

	2008 M01	2008 M02	2008 M03	2008 M04	2008 M05	2008 M06	2008 M07	2008 M08	2008 M09	2008 M10	2008 M11	2008 M12	2009 M01	2009 M02	2009 M03	2009 M04	2009 M05	2009 M06	2009 M07	2009 M08	2009 M09	2009 M10	2009 M11	2009 M12
IMF																								
Eichengreen																								
Sachs																								
Kaminsky																								
	2010 M01	2010 M02	2010 M03	2010 M04	2010 M05	2010 M06	2010 M07	2010 M08	2010 M09	2010 M10	2010 M11	2010 M12	2011 M01	2011 M02	2011 M03	2011 M04	2011 M05	2011 M06	2011 M07	2011 M08	2011 M09	2011 M10	2011 M11	2011 M12
IMF																								
Eichengreen																								
Sachs																								
Kaminsky																								
	2012 M01	2012 M02	2012 M03	2012 M04	2012 M05	2012 M06	2012 M07	2012 M08	2012 M09	2012 M10	2012 M11	2012 M12	2013 M01	2013 M02	2013 M03	2013 M04	2013 M05	2013 M06	2013 M07	2013 M08	2013 M09	2013 M10	2013 M11	2013 M12
IMF																								
Eichengreen																								
Sachs																								
Kaminsky																								
	2014 M01	2014 M02	2014 M03	2014 M04	2014 M05	2014 M06	2014 M07	2014 M08	2014 M09	2014 M10	2014 M11	2014 M12	2015 M01	2015 M02	2015 M03	2015 M04	2015 M05	2015 M06	2015 M07	2015 M08	2015 M09	2015 M10	2015 M11	2015 M12
IMF																								
Eichengreen																								
Sachs																								
Kaminsky																								
	2016 M01	2016 M02	2016 M03	2016 M04	2016 M05	2016 M06	2016 M07	2016 M08	2016 M09	2016 M10	2016 M11	2016 M12	2017 M01	2017 M02	2017 M03	2017 M04	2017 M05	2017 M06	2017 M07	2017 M08	2017 M09	2017 M10	2017 M11	2017 M12
IMF																								
Eichengreen																								
Sachs																								
Kaminsky																								
	2018 m01	2018 m02	2018 m03	2018 m04	2018 m05	2018 m06	2018 m07	2018 m08	2018 m09	2018 m10	2018 m11	2018 m12	2019 m01	2019 m02	2019 m03	2019 m04	2019 m05	2019 m06	2019 m07	2019 m08	2019 m09	2019 m10	2019 m11	2019 m12
IMF																								
Eichengreen																								
Sachs																								
Kaminsky																								

Source: Authors' calculations

IMF-based EMP index signals a crisis one or two months ahead. This could be related to the fact that it is the only index, which incorporates changes in reserves and interest rates relative to another country (United States) and thus, captures foreign market developments earlier than the other versions. However, we are not interested in EMP's ability to forecast a crisis. The goal of the EMP index is to define the periods of increased vulnerability when they occur; thus, getting signals earlier than the actual crisis is not an advantage of IMF-based EMP index. The other three specifications of EMP index are more consistent with each other about the crisis periods in 2008-2019.

To be robust in determining the periods of high exchange vulnerability, we applied two criteria: first, at least two out of four specifications of EMP index need indicate the presence of a crisis, and second: the signal should last for at least two consecutive months or have at most one month gap between the signals.

Based on the above set criteria, 20 out of 143 months indicate high exchange vulnerability that constitutes approximately 13.9% of all observations. This share of 'crisis months' is comparable to the results from other studies (Heinz and Rusinova, 2015).

According to the analysis, we managed to identify 8 quarters of high exchange vulnerability in Georgia. These periods include August-October 2008, May-June 2010, December 2013 -January 2014, January – September 2015 and September-October 2019.

- The August-October 2008 episode is related to global financial crises and war with Russia. The August War and GFC had a negative impact on the country's growth and decreased FDI. The August war was followed by a decrease in confidence in domestic currency and financial stability. It created demand for liquid sources which resulted in loosening of monetary policy and decrease in the level of official reserve assets. To maintain financial stability and address liquidity needs, the NBG adopted lending of last resort facility. By September 2008, the situation in the banking sector stabilized. In October 2008, the level of official reserve assets decreased once again, contributing to an increasing EMP index.

- The May-June 2010 episode is related to decrease in capital inflows and appreciation of the US dollar worldwide, which contributed to depreciation of the GEL. As GEL depreciated against USD, the level of reserves decreased and in June 2010, the Monetary Policy Committee decided to increase monetary policy rate by 125 basis points. The increase in monetary policy rate also reflected rising pressure on inflation. The NBG intervened multiple times over these two months, selling USD in the currency auction. All of this contributed to increasing the EMP index.

- The December 2013 -January 2014 episode is related to taper tantrum, which changed the risk aversion for all emerging markets. Over the uncertainty of capital flows and risk sentiment in international capital markets Gel nominal effective exchange rate depreciated by 5.3% over this period, which influenced consumer prices and thus, inflation forecast. Reserves also decreased in this period, contributing to an increasing EMP index.

- The January – September 2015 episode is related to oil price shock and global appreciation of the USD which left Georgia's neighboring countries in a grim situation. Economic activity declined in Ukraine, Russia and Armenia. Decreasing oil prices had a negative effect on Azerbaijan as well. Crisis in Russia decreased trade, remittances, and tourism flows in Georgia. The regional economic and geopolitical developments significantly affected Georgian economy in 2015. Monetary policy was tightened - policy rate steadily increased to 8 percent by end-2015 from 4 percent in the start of the year. At first, the policy rate was increased because of inflationary concerns of the currency depreciation. Subsequently, interest rate was further increased because of the second round effects of the shock to inflation. In fact, GEL continued depreciating and the monetary policy rate kept increasing. Overall, this period saw a decrease in exports, and growth of remittances and tourism growth, all of which had a negative effect on Georgian economy and currency.

- The September-October 2019 episode is related to Russian ban on travel. Over the fear of reduced tourism related FX inflow and possibility that ban would be extended to merchandise trade to Russia, Georgia again found its currency significantly depreciating against the US dollar. Currency depreciation translated into rising inflation and led the National Bank to raise the monetary policy rate two times in September from 6.5% to 7.5% and once again in October to 8.5%. This was supplemented by a decrease in foreign reserves, increasing the EMP index.

Overview shows that threshold analysis for EMP index adequately identified high vulnerability periods for Georgia. Thus, we can proceed with estimation of EVI, which will alert the authorities about the future episodes of rising external imbalances.

III. External Vulnerability Index, EVI

Literature Overview

Following the global financial crisis, the IMF, along with various central banks, has improved the surveillance and Early Warning Systems (EWS) to increase the resilience of the financial system (Pasricha, 2013). Existing vulnerabilities have been categorized into five major groups, including the financial sector, private-nonfinancial sector, sovereign sector, external sector and asset markets (Lee et al., 2017). While imbalances in all five sectors are important for the holistic analysis of the country's vulnerability level, external sector imbalances have become especially prominent in leading to currency crises in Emerging Markets and Developing Economies (EMDE).

Data shows that EMDEs often rely on external financing to cover current account deficit and maturing debt. The dependence on external financing makes them vulnerable to any increase in risk premia in international markets, whether a broad-based change in risk aversion for all EMDEs or a country specific development (Lee et al., 2018). As a result, adverse developments can have a significant negative effect on the financial stability of EMDEs. While not every shock leads to financial crisis or stress, presence of vulnerabilities can significantly increase their likelihood. Thus, timely detection of external sector imbalances becomes extremely important.

Analysis of external vulnerability indicators has become especially prominent following the Mexican and Asian crises (Berg et al, 2005). Studies like Kaminsky et al. (1998), IMF (2000), Bussiere and Mulder (1999), Berg et al. (2005) evaluated the performance of dozens of vulnerability indicators that could play a role in timely detection of rising imbalances. The study of external vulnerabilities, particularly in EMDEs, gained additional interest after the global financial crisis (Supriyadi (2014), Dahlhaus and Lam (2018)).

After individual assessment of external vulnerability indicators, economists attempted aggregating the best-performing ones into a single external vulnerability index that would track the level of vulnerability in a given country. To evaluate the early warning properties of the resulting composite index, two approaches have been commonly used: signaling approach and discrete method. Each method aims at assessing the probability of crisis using different approaches. However, since one of the major studies evaluating leading indicators of currency crisis (Kaminsky, 1999) uses signaling approach, we decided to also adopt this methodology. Thus, this study will evaluate performance of individual indicators, construct an aggregated external vulnerability index for Georgia, and evaluate its performance using signaling approach.

Selecting Indicators

In this study, we construct an external vulnerability index as a tool, which alerts the authorities about rising imbalances in Georgia's financial sector. EVI needs to act as an early warning system and capture the periods of high vulnerability. To do that, EVI is composed of vulnerability indicators that can signal external imbalances in a timely manner. According to Lee et al. (2017), external sector vulnerabilities elevate early before the onset of the financial crisis, making them useful in alerting policy makers about entering in stress.

To construct EVI we have to select relevant indicators. For Georgia we examined 28 quarterly external sector indicators from 2007 to 2019. The potential variables are based on previous external vulnerability studies, including Pasricha et al. (2013), Frankel et al. (2011), Lee et al. (2017), OECD (2008), etc. The most extensive list of potential indicators was developed by Frankel et al. (2011), which conducted a large-scale literature review about EVIs. That study showed that reserves (relative to GDP, M2, short-term debt, 12m change) were the most significant indicators for assessing a country's vulnerability, followed by credit growth, current account/GDP, trade balance/GDP, etc. The full list of the candidate external vulnerability indicators that are considered in this study is presented in Table III.1.

Table III.1. List of Potential Indicators for EVI

Potential Indicators	
Public sector net external debt/GDP	Reserves position/Broad money
Net external debt/GDP	Reserves position/Base money
Short run external debt/Gross external debt	Change in reserves position/Moving average of imports
External debt/Exports	Change in exports
Short run external debt/GDP	Exports/Imports
FC external debt/External debt	Trade balance/GDP
Short run external debt/reserves	Portfolio investment/External debt
Change in gross external debt	Reserves position/Moving average of imports
Public sector debt/Tax revenue	Reserves position/GDP
Debt service payment/Exports	Growth of reserves
Debt service payment/GDP	Current account balance/GDP
FDI inflows/GDP	FDI/Total external debt
Change in imports	FDI/GDP
Reserves position/Short run external debt	FDI outflows/GDP

Composite EVI for Georgia

After compiling the data for the potential indicators, we used a signaling method to determine the most informative variables for rising external vulnerability. Since we are concerned with early detection of vulnerabilities, we observe the behavior of the indicators up to 8 quarters prior to the actual crisis. Best performing indicators were aggregated to derive an external vulnerability index for Georgia.

Signaling approach minimizes the occurrence of two types of errors: failure to predict a crisis (false negative) and issuing a false signal for a crisis that does not occur (false positive).

According to this methodology, if the indicator passes a certain threshold, it issues a signal indicating a crisis. Following the signal, if the crisis truly occurs within the next 8 quarters, the signal is labelled as "true"; however, if the crisis does not happen within that period, the signal is labelled as "false". Accordingly, there are four possible outcomes, presented in Table III.2, one can expect from a signaling approach:

1. Indicator signals a crisis and stress episode follows within next 8 quarters (true positive)
2. Indicator signals a crisis and stress episode doesn't follow (false positive)
3. Indicator doesn't signal a crisis but stress episode follows (false negative)
4. Indicator doesn't signal a crisis and stress episode doesn't follow (true negative)

Table III.2. Signaling Approach Matrix

	EMP indicates crisis	EMP doesn't indicate crisis
Indicator signals crisis	True positive (A)	False positive (B)
Indicator doesn't signal crisis	False negative (C)	True negative (D)

The signaling approach chooses the best indicator by minimizing the number of false negative and false positive signals. More specifically, it minimizes the noise to signal ratio (NTS), which is a ratio of share of false positives given no crisis and the share of true positives given a crisis (Kaminsky et al., 1998):

$$\text{NTS ratio} = B/(B+D) \;/\; A/(A+C) = \text{Type II} \;/\; (1 - \text{Type I})$$

Minimization of NTS implies a threshold level, beyond which the indicator signals rising vulnerability. Following Kaminsky (1998), the threshold level was identified using a grid of reference percentiles (between 10 and 20 percent) for each indicator[3]. The resulting NTS ratios for all 28 variables are presented in Table III.3 below.

[3] For variables for which left tail values increase the probability of a crisis, the threshold is below the mean of the indicator. For variables for which right tail values increase the probability of a crisis, the threshold is above the mean.

Table III.3. Indicator and Corresponding NTS Ratio

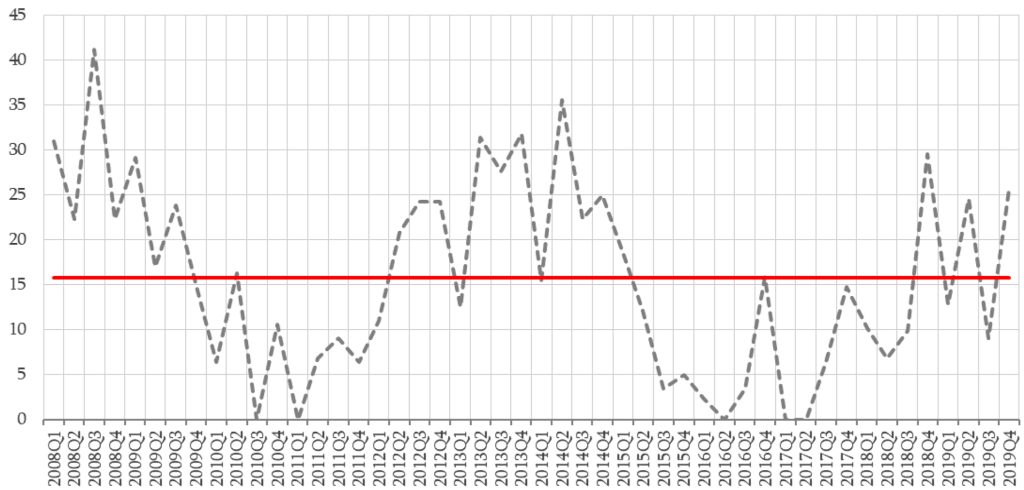
Indicator	Lowest NTS	Indicator	Lowest NTS
Public sector net external debt/GDP	3.96	Reserves position/Moving average of imports	0.20
Net external debt/GDP	10.57	Reserves position/GDP	0.18
Short run external debt/Gross external debt	0.17	Growth of reserves	0.29
External debt/Exports	1.32	Current account balance/GDP	0.37
Short run external debt/GDP	0.75	FDI/Total external debt	0.26
FC external debt/ External debt	0.66	FDI/GDP	0.18
Short run external debt/reserves	1.13	FDI inflows/GDP	0.15
Change in gross external debt	0.52	Reserves position/Broad money	0.29
Public sector debt/Tax revenue	1.32	Reserves position/Base money	0.33
Debt service payment/Exports	0.29	Change in reserves position/Moving average of imports	0.33
Debt service payment/GDP	0.29	Change in exports	0.44
FDI outflows/GDP	0.66	Exports/Imports	0.29
Change in imports	0.75	Trade balance/GDP	0.33
Reserves position/ST external debt	1.32	Portfolio investment/External debt	0.29

Source: Authors' calculations

The NTS ratio is informative only if it is below one. Value greater than one signals that the variable performs worse than a coin flip and is worthless for crisis detection. Thus, six variables were automatically eliminated. While the NTS ratio below one is informative, we use more stringent criteria for variable selection and construct EVI only using the variables with NTS ratio below 0.5. Based on this criteria, 17 variables qualified for inclusion. Results indicate that variables related to external debt, FDI, reserves position, trade balance and CA balance are the most important indicators for external vulnerability analysis in Georgia.

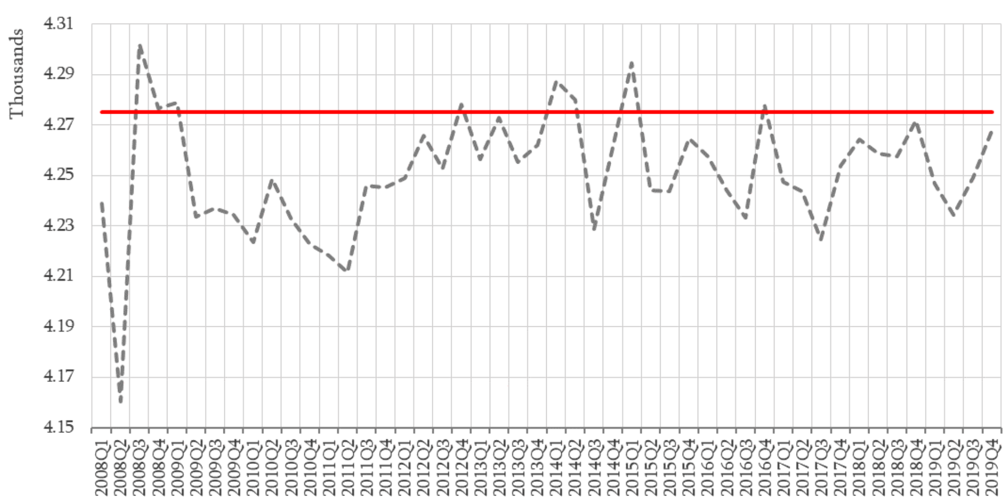
Having determined the most informative variables, the next step is aggregation, which can be done in multiple ways. This research uses both Kaminsky and OECD methods for aggregation. Kaminsky's method sums weighted signals (1 for crisis, 0 for no crisis) for each indicator where weights are based on determined NTS ratios. OECD's additive aggregation method weighs and sums normalized indicators. Weights are once again based on NTS ratios (OECD, 2008). The resulting indices are presented below.

Figure III.1. Composite EVI for Georgia using Kaminsky method



Source: Authors' calculations

Figure III.2. Composite EVI for Georgia using OECD method

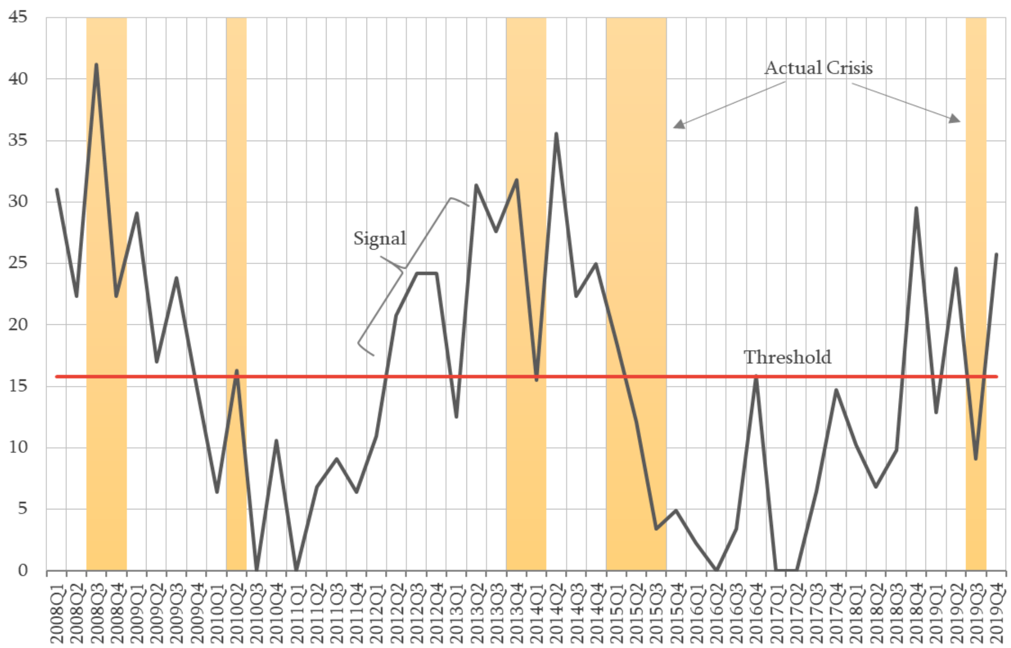


Source: Authors' calculations

After constructing the EVI for Georgia using two weighting methodologies, we need to determine the threshold level beyond which it indicates periods of increased vulnerability. To do that, we once again used a signaling approach that was applied for determining thresholds for individual indicators. The resulting threshold levels are indicated in Figures III.1 and III.2 as a red line. The values above the threshold signal the periods of increased external vulnerability in Georgia up to two years prior to the actual crisis. It should be noted that the composite index based on the Kaminsky method is not very smooth as it aggregates the weighted binary signal (1 for crisis, 0 for no crisis) for each indicator in each period.

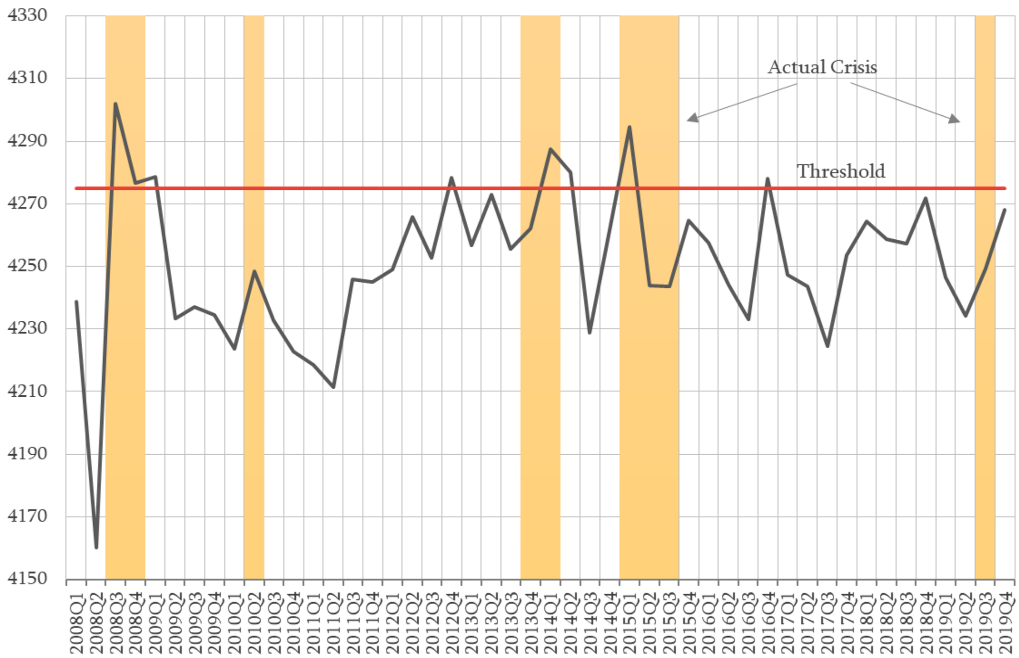
To evaluate the performance of Kaminsky- and OECD-based external vulnerability indices, we graphed each EVI along with the actual crisis periods, which were determined using the EMP index. These crisis periods are marked in yellow in Figures III.3 and III.4. After that, we evaluate the performance of each EVI prior to the crisis. If an indicator exceeds the threshold level in a given quarter and a crisis truly occurs within the next 2 years, that signal is considered to be correct.

Figure III.3. Actual Crisis versus Composite EVI using Kaminsky method



Source: Authors' calculations

Figure III.4. Actual Crisis versus Composite EVI using OECD method



Source: Authors' calculations

Figures III.3 and III.4 show that both indicators capture the five stress episodes indicated in yellow. EVI based on Kaminsky method, however, starts issuing a signal earlier and lasts for a longer (Figure III.3), while OECD methodology based EVI issues signal shortly before or exactly during the crisis period (see Figure III.4). All issued signals occur within 2 years prior to the crisis and both EVIs capture all the crisis periods (except for Q3 2019, which OECD-based EVI failed to identify). The number of false signals was extremely low for both EVI specifications. There was only one period (Q4 2016) when both indices signaled a false crisis, which was not identified using the EMP index. Even though different specifications of EMP index did indicate the rising external imbalance in Q4 2016, the signal failed to satisfy the criteria used for defining a crisis (at least two out of four specifications of EMP index need indicate the presence of a crisis and the signal should last for at least two consecutive months or have at most one month gap between the signals).

Overall, while both indices are informative, EVI based on the Kaminsky method seems to have the early warning properties and persistence that we are looking for in the external vulnerability index. As a result, it can be a highly informative and useful tool for assessing the external vulnerability of Georgia.

IV. Conclusion

The goal of this paper was twofold: first, to define the periods of high vulnerability in Georgia using an EMP index and second, to construct an external vulnerability index, which would be able to capture these crisis periods with sufficient timeliness and accuracy. Crisis periods were identified using several specifications of EMP index; the results from different versions of the index were comparable, indicating consistency across the four versions. External Vulnerability Index was constructed based on two methods (Kaminsky, OECD) and the comparison has shown that they are comparable, however, OECD-based EVI sends shorter signals closer to the crisis (Figure III.4), while Kaminsky-based EVI sends longer-lasting signal at least one quarter prior to the crisis (Figure III.3). The comparison of EMP series with EVI demonstrated that both external vulnerability indices adequately capture the crisis periods with minimal instances of false positive or false negative signals. Unfortunately, we were limited in our sample size and could not extend the analysis prior to 2008 due to data limitations. However, future data will help us test the performance of the resulting EVI against the upcoming periods of increased external vulnerability and refine it as needed.

Overall, the existence of such external vulnerability index aids in timely detection of rising imbalances in the external sector and can act as an early warning system for policymakers. The results indicate that Kaminsky-based EVI successfully captures crisis periods and can be adopted for external sector analysis in Georgia.

Appendix

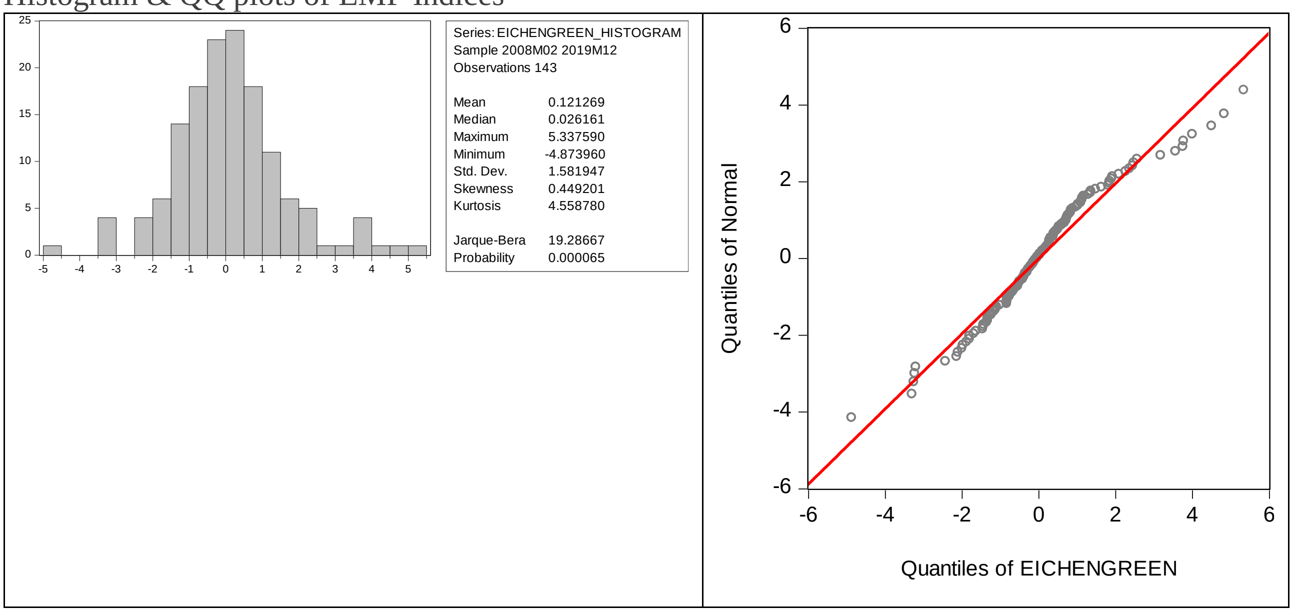
Appendix I

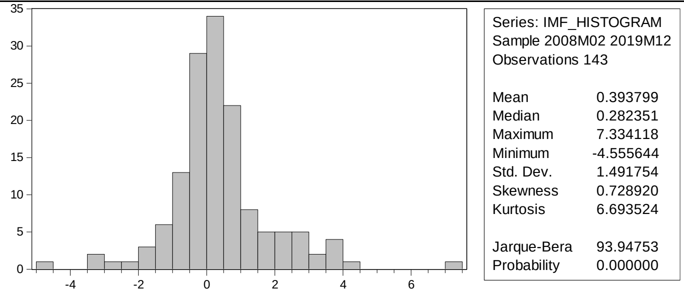
Description of EMP Indices

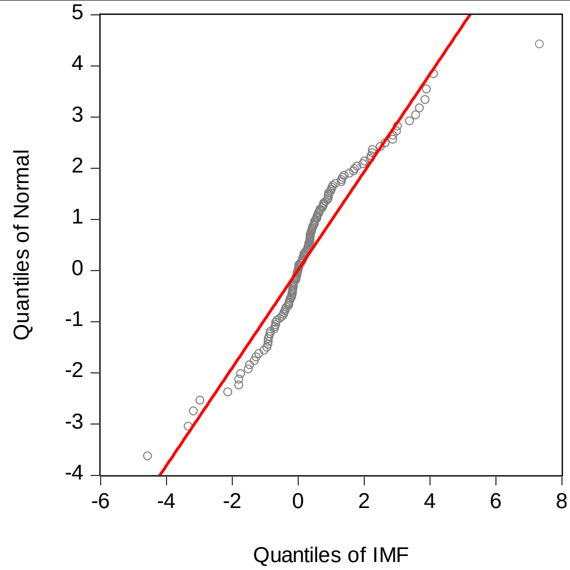
The descriptive statistics, along with the corresponding graphs, test whether the four specifications of EMP index are normally distributed. The table below shows skewness, kurtosis and Jarque-Bera statistics for all specifications. The graphs below show histograms and corresponding QQ plots of the series.

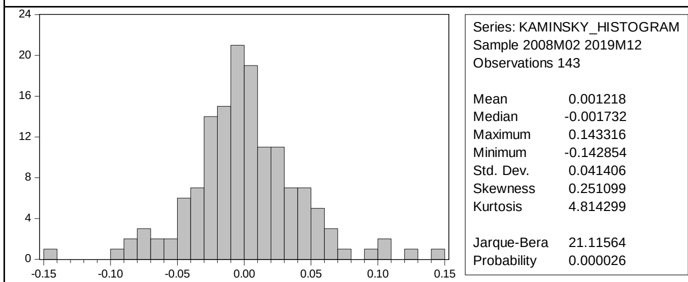
	Skewness	**Kurtosis**	**Jarque-Bera**
Eichengreen	0.449	4.558	19.28***
IMF	0.728	6.693	93.94***
Kaminsky	0.192	5.696	44.206***
Sachs	0.192	5.696	44.206***

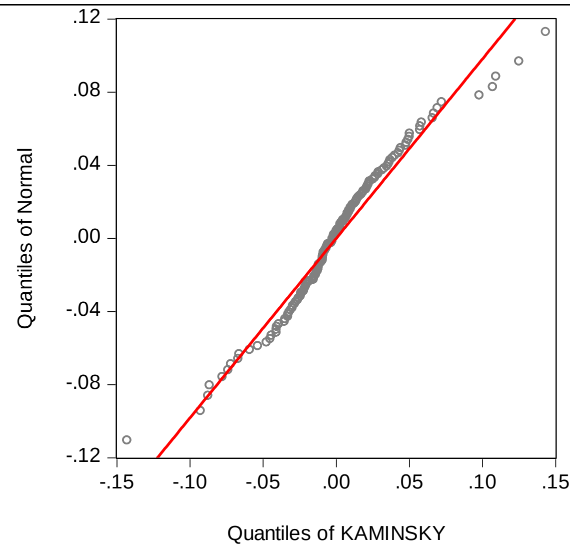
Histogram & QQ plots of EMP Indices

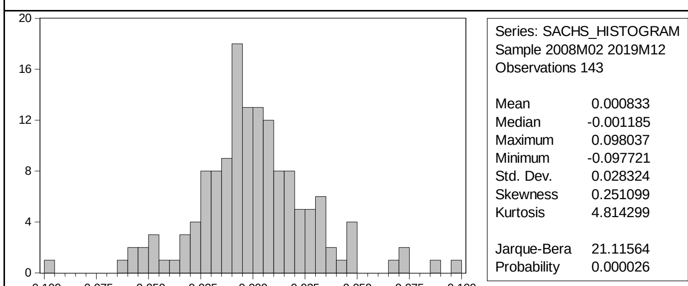


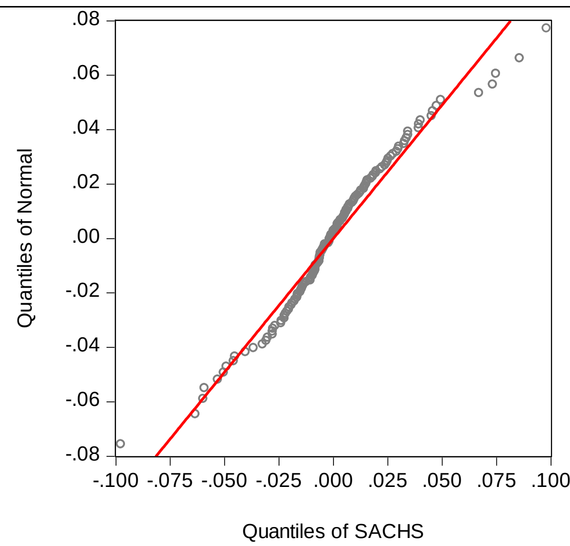

Series: IMF_HISTOGRAM
Sample 2008M02 2019M12
Observations 143
Mean 0.393799
Median 0.282351
Maximum 7.334118
Minimum -4.555644
Std. Dev. 1.491754
Skewness 0.728920
Kurtosis 6.693524
Jarque-Bera 93.94753
Probability 0.000000


Quantiles of Normal
Quantiles of IMF


Series: KAMINSKY_HISTOGRAM
Sample 2008M02 2019M12
Observations 143
Mean 0.001218
Median -0.001732
Maximum 0.143316
Minimum -0.142854
Std. Dev. 0.041406
Skewness 0.251099
Kurtosis 4.814299
Jarque-Bera 21.11564
Probability 0.000026


Quantiles of Normal
Quantiles of KAMINSKY


Series: SACHS_HISTOGRAM
Sample 2008M02 2019M12
Observations 143
Mean 0.000833
Median -0.001185
Maximum 0.098037
Minimum -0.097721
Std. Dev. 0.028324
Skewness 0.251099
Kurtosis 4.814299
Jarque-Bera 21.11564
Probability 0.000026


Quantiles of Normal
Quantiles of SACHS

Appendix II

Threshold estimation requires that the EMP series be stationary. This was confirmed using the Dickey-Fuller unit root test.

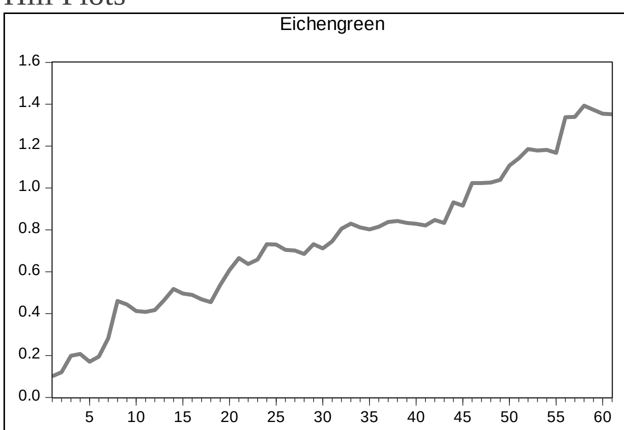
EMP specification	p-value	Dickey-Fuller statistic
Sachs	0.0000	-9.611180
Kaminsky	0.0000	-9.611180
Eichengreen	0.0000	-9.267121
IMF	0.0000	-8.080761

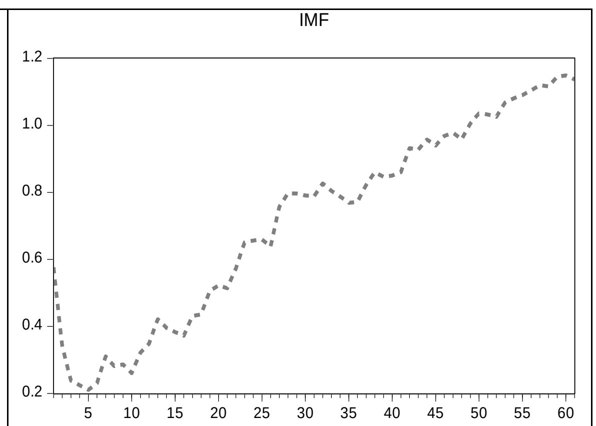
Appendix III

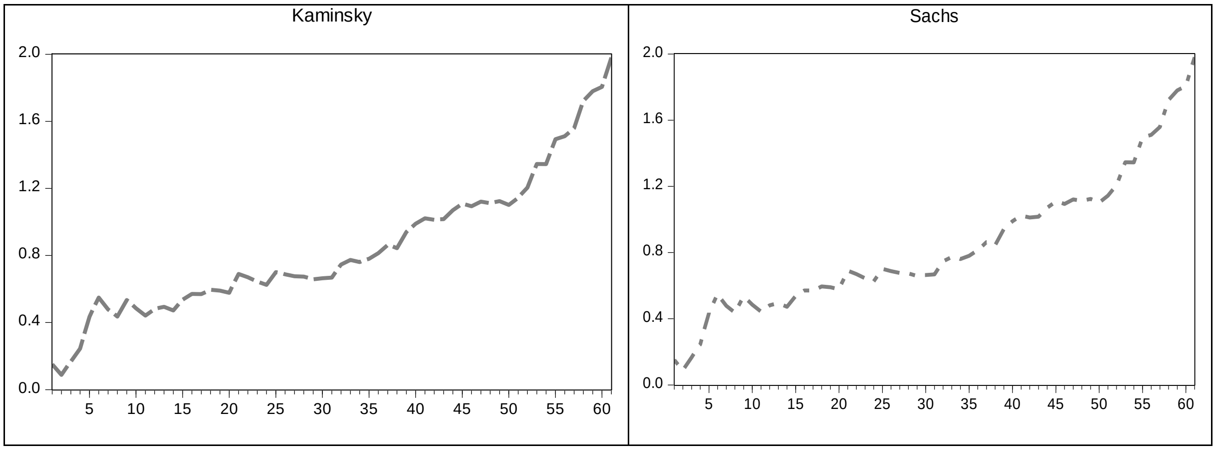
Hill estimator: method and results

The first step is arranging the EMP values so that $x_{(i-1)}<x_{(i)}$ for i=2,….,n. Thus, x(n) becomes the largest EMP observed over the years, followed by x(n-1) and so on in a decreasing order. k is a predefined number of tail observations used to calculate Hill estimator. As shown by Huisman et al. (2001) k equal to half of the full data (n/2) produces robust results. So, gamma is calculated for a range of values for k from 1 to n/2.

Hill Plots



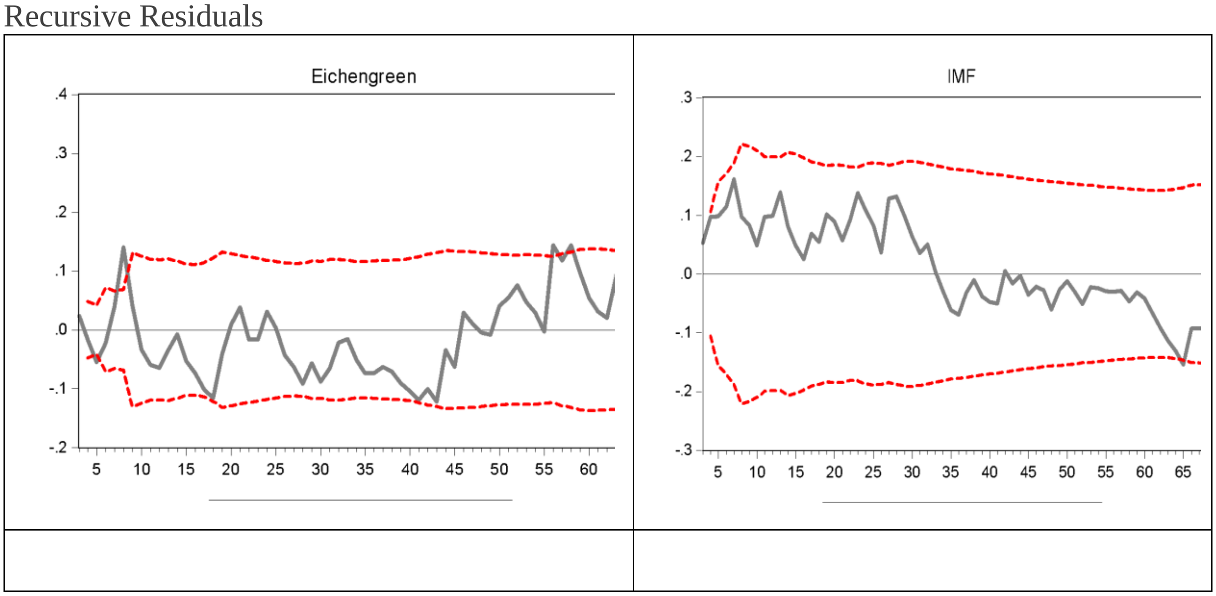


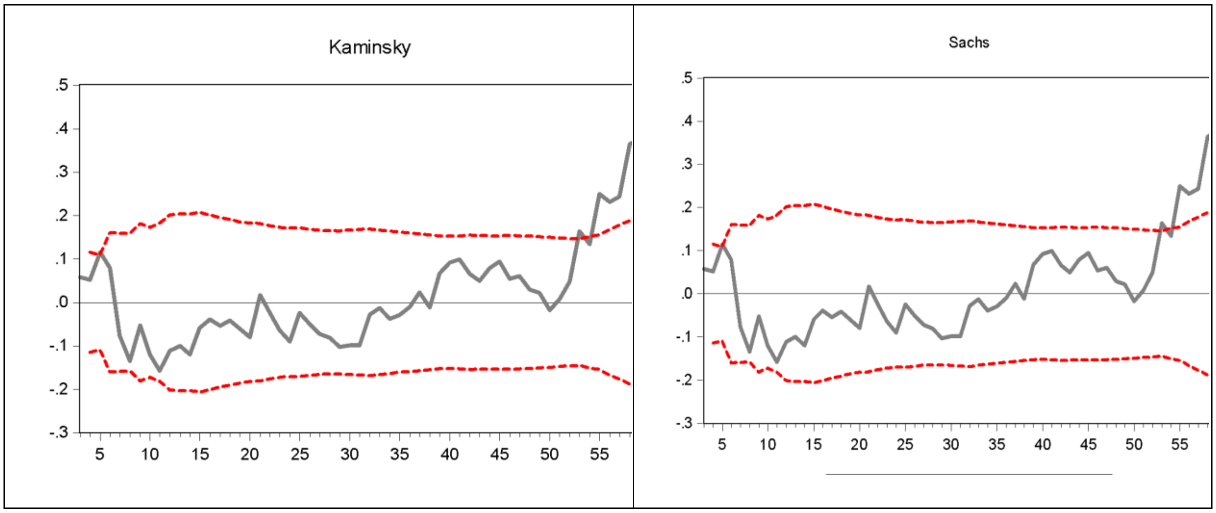


Appendix IV

To verify the threshold derived from Hill plots we employ recursive least squares method. This is done by regressing the Hill estimator on a constant and time. We add one observation at a time and obtain a one step ahead forecast for gamma. Using these forecasted and actual values, forecast errors (recursive residuals) are derived and plotted against the bandwidth of plus and minus two standard errors (Pozo 2003). To account for heteroskedasticity Pontines (2004) and McFarlane (2010) use weighted least squares while we decided to use heteroskedasticity robust standard errors for deriving the recursive residuals.

Recursive Residuals




Kaminsky
.5
.4
.3
.2
.1
.0
-.1
-.2
-.3
5
10
15
20
25
30
35
40
45
50
55
Sachs
.5
.4
.3
.2
.1
.0
-.1
-.2
-.3
5
10
15
20
25
30
35
40
45
50
55

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National Bank of Georgia
Macroeconomic Research Division
Sanapiro st. #2, 0114, Tbilisi, Georgia
Phone: +995 32 2406531
www.nbg.gov.ge
Email: research@nbg.gov.ge

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