

CENTRAL BANK OF THE REPUBLIC OF ARMENIA

FINANCIAL STABILITY REPORT

2012

2013

This Financial Stability Report presents an assessment of potential risks that could threaten the stability of financial system of the Republic of Armenia as well as the capacity of the financial system to absorb such risks.

More detailed information on Armenia's macroeconomic environment and financial system analyses is available in the Central Bank's periodicals, such as *Annual Report of the Central Bank*, *Status Report on Monetary Policy Implementation* and *Armenian Financial System: Development, Regulation, Supervision*.

The data published in this report are as of 15.04.2013

The Central Bank of the Republic of Armenia
Vazgen Sargsyan 6, Yerevan 0010
Phone: (374 10) 58 38 41
Fax: (374 10) 52 38 52
Internet website: www.cba.am

TABLE OF CONTENTS

Preface	5
1. Developments in World Economy	9
1.1. Macroeconomic Environment	9
1.2. International Financial Markets	12
2. Developments in Macroeconomic Environment in Armenia	17
2.1. Macroeconomic Developments	17
2.2. Foreign Trade	20
2.3. Net Factor Incomes and Remittances	21
2.4. Household Incomes and Debt Burden	22
2.5. Real Estate Prices	24
3. Financial Market Stability in Armenia	27
3.1. Money and Capital Markets	27
3.2. Foreign Exchange Market	30
4. Financial Institution Stability in Armenia	32
4.1. Commercial Banks	32
4.1.1. <i>Financial intermediation; concentration</i>	33
4.1.2. <i>Credit risk</i>	34
4.1.3. <i>Liquidity risk</i>	36
4.1.4. <i>Market risks</i>	38
4.1.5. <i>Capital adequacy and profitability</i>	40
4.2. Credit Organizations	41
4.3. Securities Market Participants	43
4.4. Insurance Companies	44
5. Financial Market Infrastructures Stability	47
5.1. Interbank Payments via Electronic Payment System of Central Bank	47
5.2. Securities Accounting System	51
5.3. Payment Systems Oversight	52
5.4. Guaranty of Deposits	53
5.5. Credit Registry and ACRA Credit Bureau	54
ANALYSES AND RESEARCH	
Hayk Avetisyan - Early Warning Systems for Predicting Currency Crises in Armenia	57
Charts	141
Tables	144
Glossary of terms	145
Abbreviations	147

Financial stability can be characterized as concurrence of financial and macroeconomic conditions when the financial system i.e. financial institutions, markets and market infrastructures are capable to withstand the probable shocks and instability, in this way minimizing the probability of interruption of intermediation function.

In defining the financial stability, what is taken into consideration is that financial instability can emerge as a result of interruption of internal functions of the financial system as well as unfavorable developments in domestic and world economies, credit risk issues connected with major borrowers and lenders, shifts in economic policies and infrastructures.

Maintaining the financial stability presumes the efforts for the identification of main risk sources, poor-managed financial risks, ineffective asset pricing and finally implementation of the policy as appropriate.

PREFACE

The Financial Stability Report of the Central Bank of the Republic of Armenia is prepared on a semiannual basis. It contains a broad assessment of risks that could threaten the stability of financial system as well as the capacity of financial system to withstand such risks. Through publishing of information concerning a variety of reviews on financial stability, the Central Bank seeks to bring interested parties' attention to those risks and events that could undermine financial stability of the Republic of Armenia as well as provide an opportunity to debate on how to minimize such risks.

One of the tasks of the Central Bank is to maintain the stability and functionality of the financial system of Armenia. The primary objective of the Central Bank is price stability in the country. Serious disruptions in the financial sector may create impediments to effective implementation of monetary policy. Contrariwise, the monetary and macroeconomic stability contributes to the minimization of risks threatening financial stability. The financial sector plays an important role in overall economic system, and the financial sector needs to maintain continuity and sustainability of processes thus contributing to the organic growth of the entire economy.

The Central Bank carries out an ongoing monitoring and analysis of financial stability for early disclosure of any changes and variations that could threaten financial stability. The report refers to the risks revealed in macro-environment and financial sector and their influence on the developments in all sectors of the economy and financial system.

Risks affecting financial stability of Armenia can emerge in the domestic economy, external economy and the financial sector itself. In this sense, the main preconditions for financial stability are:

- a domestic and external macroeconomic environment with sustainable development whereby households and companies would be creditworthy enough,
- an effective financial system with risks that are prudent and manageable,
- efficient financial infrastructures with operational continuity to the benefit of functioning of the financial system.

As presented in this report, risks that can potentially undermine financial stability of Armenia derive from:

- developments in world economy,
- developments in macroeconomic environment in Armenia,
- developments in financial market in Armenia,
- financial institutions of Armenia, and
- financial infrastructures of Armenia.

The report addresses the risks revealed in those areas and attempts to measure their possible impact on the developments in the economy on the whole and all parts of the financial sector. The report mainly focuses on the risks to the banking sector and development trends: the role the sector plays in overall financial system is vital as assets of commercial banks account for more than 90 percent of entire financial system assets. The banking sector as a principal pillar to the financial system of today determines overall financial stability and development trends.

ABSTRACT

A suite of risks threatening financial stability has not changed notably compared to the previous year

Major risks deriving from the external sector and affecting the financial stability as well as the uncertainties associated with further developments persisted this year, too. The world prices of industrial commodities and the continuous inflow of remittances and growing domestic demand have contributed to the growth of GDP, exports and incomes, which positively affected the financial stability. At the same time, the banking system continued the practice of active lending, keeping the existing risks at a manageable level.

In 2012 uncertainties in global economy persisted and determined various patterns of developments in commodities markets

The global economic recovery continued in spite of more downside risks to the economic growth. In advanced economies the sovereign and private debt burden persisted at high levels, limiting the state's ability to intervene and hindering the growth of demand and preventing the economy from reviving further.

Growth in commodity prices was observed mainly at the beginning of the year. Then the rising of prices, in fact, slowed down due to weak private demand and a slow recovery in world economic growth. Compared with the previous year, the highest level of prices was observed in the wheat market owing to the expected volume of the crop.

Monetary authorities further implemented moderate monetary policies

During the year, the suppression of inflation went off the agenda of the monetary authorities in developed and developing countries, giving way to the core task of recovery and future growth of the economy. Both the developed and developing countries kept on implementing moderate monetary policy almost throughout the year.

Monetary authorities have embarked on a number of economic stimulation programs to achieve economic recovery

The U.S. Federal Reserve System has launched the third phase of the program "quantitative easing", the European Central Bank has carried out bond purchases in the secondary market, and the Bank of Japan had its own program of quantitative easing at the end of the year. These measures paved a way to further accelerate economic growth, although a breakthrough is not expected yet.

The economic recovery in main trade partners of Armenia – Russia and some EU countries – has not slowed down expressively, and this has positively affected foreign trade and household incomes of the Armenian economy (for details, see the section “Development of World Economy”).

Developments in partner countries positively affected the domestic economy

Economic growth in Armenia in 2012 reached 7.2 percent. Growth was reported in all sectors of the economy, including construction which saw increased volumes of household-financed construction.

Developments in the domestic economy were encouraging

Despite diverse patterns of developments in the global economy, Armenia posted bigger volumes in private transfers, factor income, and foreign trade turnover. This has contributed to the growth of incomes in the economy, and thus strengthening the financial stability of companies and households (for details, see the section “Developments in the Macroeconomic Environment in Armenia”).

Increased incomes in the economy provided for a higher credibility potential

During 2012, while maintaining low inflation environment, the Central Bank left the monetary policy rate unchanged. Weak external inflationary environment as well as lower prices of agricultural products on the back of growth trends in agriculture prompted the annual inflation rate to rest within the target level. According to December data, the 12-month inflation was 3.2 percent (for more details, see the section “Development in the Macroeconomic Environment in Armenia”).

No significant inflationary pressures were observed during the year

With strong credit growth reported during the year, the capital adequacy ratio has dropped. However, the banking system of Armenia has maintained the capital adequacy and liquidity levels above the regulatory requirements, whilst keeping market risks manageable. The financial system performed at a profit plus a reported increase in profitability of the banking system during the year.

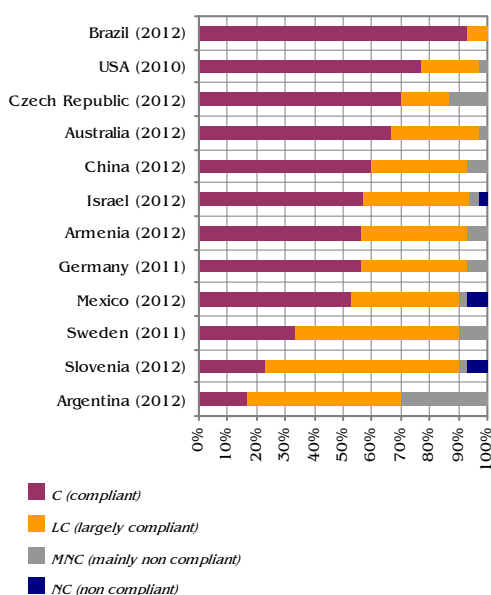
Favorable developments in the domestic economy boosted up credit market

The risks in the financial system remained manageable throughout the year, without creating a threat in the financial stability point of view (for details, see the sections “Financial Institution Stability in Armenia” and “Financial Market Infrastructures Stability in Armenia”).

Results of FSAP¹ for Armenia in 2012

The Basel Committee on Banking Supervision has developed the “Core Principles for Effective Banking Supervision” that establish international standards for regulation and supervision². The FSAP team consisting of experts from the World Bank and the International Monetary Fund is called to assess the compliance of the financial systems of different countries with the above principles. The FSAP assessed the financial system of the Republic of Armenia in 2001, 2005 and 2012. Compared with the assessment carried out in 2005, the assessment in 2012 pointed to the significant improvements and progress in the field of regulation and supervision of the financial system. In particular, according to the recent assessment, the financial sector of the Republic of Armenia **meets these requirements by nearly 93 percent** at the level described as compliant or largely compliant. In the 2005 assessment of Armenia, the country’s financial sector met these requirements by 67 percent only, whether at levels compliant or largely compliant.

FSAP comparative evaluation among selected countries



Source: IMF.

Main FSAP team conclusions

- The Central Bank has a sufficient level of independence, transparency and pool of resources
- Strong regulatory and supervisory frameworks are in place
- The banking sector maintains sufficient levels of capital adequacy and liquidity
- A versatile supervisory framework is in place
- A concept of crisis management has been introduced, which allowed the Central Bank to respond effectively to the crisis in 2009
- There has been significant progress in the monitoring of systemic risks by the Central Bank;
- The results of solvency stress-tests suggest that the banking sector of the Republic of Armenia is resilient enough to withstand the shocks

Key FSAP recommendations

- Improvement of the risk management process: bring in full compliance with Pillar 2, in-depth guidance, a need for chief risks manager, improve regulation in the field of credit, market and operational risks
- Implementation of consolidated supervision
- Development of the Institute of Actuaries: introduce Actuarial Standards, the Code of Ethics
- Improved measures to combat insurance fraud, launch legislative amendments aimed at protecting interests of the policyholder under life insurance contracts, improve bankruptcy procedures: in the event of bankruptcy, satisfy the policyholder claims in the first place by the use of assets adequate to technical reserves
- Strengthening the regulatory framework and expanding the Central Bank competence in the field of applying measures of sanction: provide for a possibility to appoint administration in the absence of grounds for insolvency

¹ FSAP = Financial Sector Assessment program.

² Core Principles for Effective Banking Supervision, 2006 (revised in September 2012).

1. DEVELOPMENTS IN WORLD ECONOMY ¹

1.1. MACROECONOMIC ENVIRONMENT

Preliminary results of review of global economic development for 2012 suggest that most probable risks have materialized, which was clearly reflected in the slowing economic growth. Particularly problematic was the first half of the year, whereas the second half, especially the end of the year, was marked with some positive trends.

The global economic recovery continued at a slower pace, and major risks were alarming throughout the year

Despite the fact that a large-scale program of the ECB to provide liquidity had relaxed the tension, further developments were unfolded in an adverse path. In general, the first half of the year was characterized by the deterioration of the situation in countries with debt problems, downgrades in their international rating, noticeable slowdown in economic growth in developing countries, as well as increased level of distrust and pessimism toward future.

At the end of the year, however, changed patterns of economic slowdown in developing countries, and solid measures by international organizations and public authorities have contributed to the creation of positive mood and eased the tension in global financial markets.

According to IMF estimates, the global economic growth in 2012 was 3.2 percent (in 2011, 3.9 percent). In developed countries, growth remained low, 1.3 percent, while in developing countries it has shown a downward trend, 5.1 percent.

In 2012 world economic growth was slower than in the previous year²

IMF revisions of the 2012-2013 estimation of world economic growth outlook

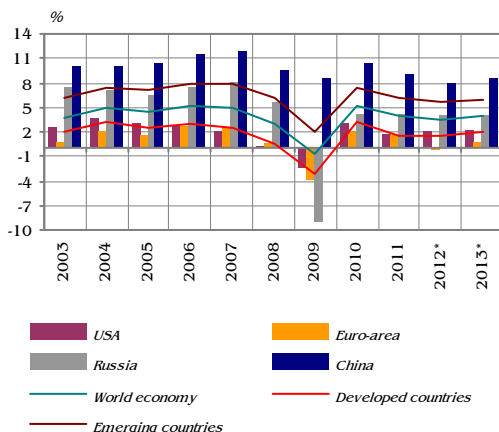
Indicator (economic growth)	2011 assessment as of 30.01.12	2012 forecast as of 30.01.12	2012 forecast as of 30.04.12	2012 forecast as of 30.06.12	2012 forecast as of 30.11.12	2012 assessment as of 30.01.13	2013 forecast as of 30.01.13
World economy	3.9	3.3	3.6	3.3	3.3	3.2	3.5
Developed countries	1.6	1.2	1.4	1.3	1.3	1.3	1.4
USA	1.8	1.8	2.1	2.0	2.2	2.3	2.0
Euro-area	1.4	-0.5	-0.3	-0.3	-0.4	-0.4	-0.2
Emerging countries	6.3	5.4	5.7	5.3	5.3	5.1	5.5
CIS	4.9	3.7	4.1	4.1	4.0	3.6	3.8
Russia	4.3	3.3	4.0	4.0	3.7	3.6	3.7
China	9.3	8.2	8.2	8.0	7.8	7.8	8.2

¹ Sources: IMF, World Bank, Economist Intelligence Unit, Financial Times, Bloomberg, P&G, the Institute of International Finance, etc.

² All IMF predictions and estimates are from the World Economic Outlook Update 2013 January.

The developments were more troublesome in the first half of the year

Regional growth rates



* Hereafter all indicators marked with asterisk are IMF estimates (2013 January):

Source: IMF, WEO data base.

Developments were relatively positive in the second half of the year

The year started with encouraging optimism as a result of the ECB's anti-crisis measures, but a set of developments further deepened the atmosphere of mistrust.

Debt problems in European countries continued to determine the tightness in financial markets and the gloomy prospects of reaching reasonable solution thereto urged the rating agencies to consider downgrades for some countries.

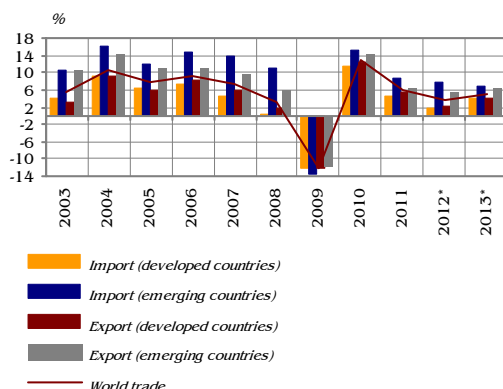
Fragile economic growth and existing uncertainties in developed countries began to affect the economic activity in developing countries through both the financial system and world trade. Especially prominent were the problems transmitted through trade. In particular, economic growth slowdown in China was determined by lower export volumes. In 2012 China's economic growth was only 7.8 percent, the lowest level in the post-crisis period. Similar trends were seen in major developing countries.

Economic conditions in the world economy began improving from the third quarter. This time too, the positivity came from emerging economies where the trend decline in economic activity has changed, as well as the U.S. economy where economic growth was higher than expected. At the same time, the measures taken by the governments and international financial institutions at the end of the year had a positive impact on the world's financial markets.

Despite these positive developments, the problems in European countries are still disturbing, and the economic downturn in Japan continued.

The declining global trade trend has stopped at the end of the year

Annual growth rate of world trade



Source: IMF.

Developments in commodity markets were mostly in line with global economic development trends³

In the year under review there was further a trend decline observed in world trade due to the slow recovery of the global economy and persisting uncertainties.

The growth of world trade of goods and services in 2012 amounted to 2.8 percent (5.9 percent in the previous year). The reason for the low growth was the slowing economic growth in developing countries and the use of protectionism. However, a bunch of indicators can suggest about formation of a trend of recovery of the global economy by the end of the year.

The beginning of the year was marked by the rise in international prices of basic commodities, driven by developments typical to selected product markets. However, since the second quarter, prices in almost all markets have dropped and remained basically at the same level until the end of the year.

³ Main stock exchange commodity price short-term forecasts, according to the IMF and Economic Intelligence Unit:
<http://www.imf.org/external/pubs/ft/weo/2013/update/01/>
<http://gfs.eiu.com/Article.aspx?articleType=cf&articleId=560297240&secId=0>

In the first quarter of 2012 oil prices jumped due to the embargo on export of Iranian oil. However, the trend of rising oil prices continued through a downward path as geopolitical risks weakened and uncertainties about future development of the world economy grew. Based on the annual data, the average price for crude oil was USD 112.1 per barrel, remaining at the level of the previous year.

In the short term it is expected that the average energy prices would remain at the same level, although there are dual-sided risks associated with geopolitical developments and supply-side factors.

At the beginning of the year, on the back of improved expectations on a global scale, there was an increase in prices of base metals, which, however, was offset in the coming months due to the tendency of weakening economic growth in developing countries. In particular, the average copper price was USD 8,000 per ton, which is a 10.0 percent decline in relation to the previous year's average.

In the short run, all other things being equal, considerable volatilities in world prices of base metals will not be expected.

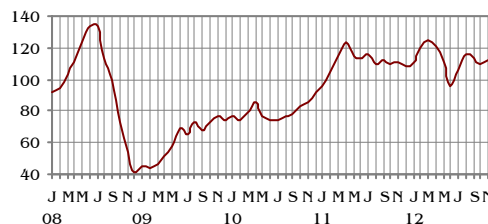
The dynamics of world wheat prices during the year was somewhat different from the trend of the prices of other goods. Earlier this year, in anticipation of rich harvest, prices remained fairly low – at the level which had been observable at the end of the previous year. In the second half of the year, however, prices went up due to expectation of humble crops for the marketing year 2012/2013. In 2012 the average wheat price was USD 8.7 per bushel, staying unchanged in relation to the previous year's level.

Considerable volatilities in gold prices in 2012 were not observed, although uncertainty about the prospects for further recovery and sustainable development of the world economy led to keeping prices of gold – as a safe haven asset – at high levels. The average gold price in 2012 was USD 1,676 per troy ounce, up from the previous year's figure by 6.5 percent.

In the short term, with persisted concerns about the continued instability of the world economy, the gold price is expected to remain high.

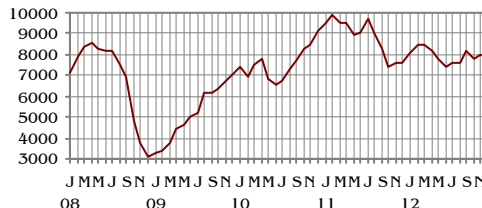
World oil price was especially sensitive to geopolitical developments

Brent oil prices
(USD per barrel)

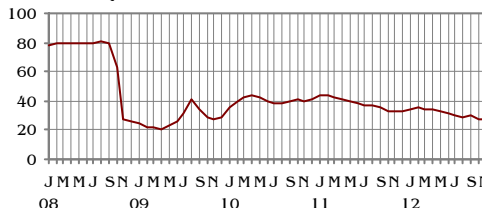


The copper price trended mainly owing to the demand in developing countries

Copper prices
(USD per ton)

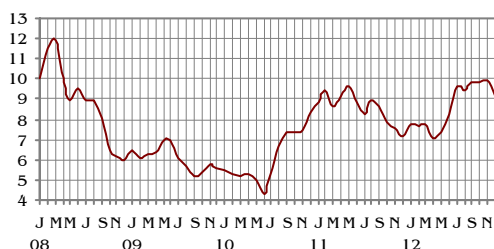


Molibdenum prices
(1000 USD per ton)

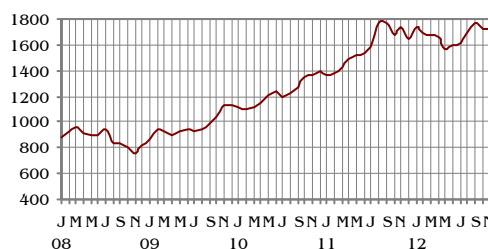


The wheat price has started to grow in the second half of the year

Wheat prices
(USD per bushel)



Gold prices
(USD per troy oz)



Source: Bloomberg Data Vane House.

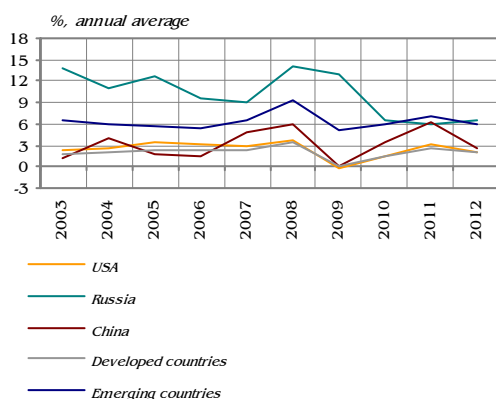
A weak inflationary environment came in with prices of main commodities not so high

In 2012 inflationary pressures in developed and developing countries were not strong. According to IMF estimates, the annual inflation rate in developed countries was 2.0 percent and 6.1 percent in developing countries. As such, either indicator proved lower compared to the previous year.

A weak inflationary environment and unsteady economic growth determined the pace of stimulating monetary policy in major countries

Competent authorities in many countries have shown unprecedented activity in 2012 by stimulating economic growth not only through low interest rates, but also by a series of programs of quantitative easing.

Inflation in selected countries



The U.S. Fed launched the third phase of quantitative easing, while keeping the policy rate at the same level helped push the unemployment rate down to 6.5 percent. The European Central Bank has expressed willingness to buy government bonds in the secondary market as much as would be required to stabilize the financial situation in the Eurozone. The Central Bank of Japan appeared with its own program of quantitative easing. It should be noted that the overall balance of the major central banks (the U.S. Fed, the ECB, the Bank of Japan and the Bank of England) has increased over the last 4 years up to USD 7 trillion from USD 4 trillion.

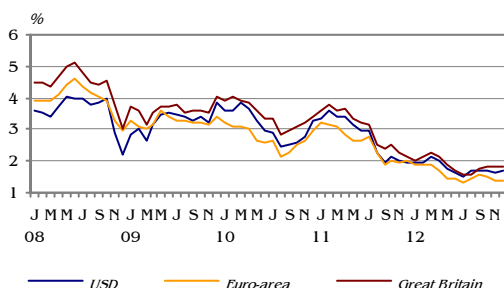
These programs not only resulted in some improvement and increased confidence by the end of the year, but also helped to create a corridor for some further acceleration of economic growth.

1.2. INTERNATIONAL FINANCIAL MARKETS

In global financial markets fundamental tightness persisted during the year, somewhat having eased at the end of the year

In 2012, fundamental tightness and atmosphere of mistrust were dominant in international financial markets. Despite significant and ongoing efforts of Europe's competent authorities, the Eurozone debt crisis remains the main risk in the financial stability point of view. The situation in international financial markets was even more worrying especially during the first half of the year due to fears of Greece attempting to leave the euro zone as a result of political controversies in that country and the growing concerns about the stability of the banking system in Spain. In the second half of the year the tension somewhat eased and certain encouraging developments gave way to optimism. Improvement was mainly due to measures adopted by governments and intergovernmental bodies, which had a positive impact on the situation in the troubled countries and has triggered a wave of optimistic expectations in the financial markets.

10-year government bond yield



Low-risk countries saw historically lowest yields on treasury bills

In the face of unstable situation in the Eurozone especially in the first half of the year, investors preferred the least risky assets; this brought about a "run" of capital mainly into the U.S. and Japanese government bonds. These flows in turn have resulted in historically low interest rates on government funding and created appreciation pressures for

their currencies. In the second half of the year, and especially by end-year, the yield on government bonds of troubled countries has declined substantially. The narrowed spread of government bonds of troubled countries in Europe and the German bonds points to the improvement of the situation (for example, the spread of government bonds of Greece and Germany was 946 basis points by the end of the year whereas in March it was as high as 4680 basis points).

Unsteady economic growth patterns and the atmosphere of uncertainty during the year led many central banks to show unprecedented activity. In addition to the major developed and developing countries, the commitment to reducing interest rates up until the end of the year was prevailing in other countries as well, including Poland, Hungary, Brazil, India, Australia, Israel.

In the second half of the year the ECB cut mid-year interest rate policy by 0.25 pp to a 0.75 percent level. Reducing the policy rate and maintaining it further at the same level was attributable to existing structural problems, unstable economic situation and weak inflationary pressures. The Federal Reserve also left the interest rates unchanged, announcing that this would provide for a secure subsidence of the unemployment rate down to 6.5 percent.

Concomitant with diverse developments in connection with debt problems in the Eurozone countries, the currencies performed volatile, too. The U.S. dollar weakened against the euro at the beginning and end of the year, but from April to August it had considerably appreciated owing to deterioration of uncertainty in the euro area and positive macroeconomic developments in the United States.

Unstable economic growth of developed countries during the year led to a slowdown in the economic growth of developing countries, and currencies of some of the key emerging countries incurred depreciation pressures, as a result. This trend, however, has changed in the last quarter of the year.

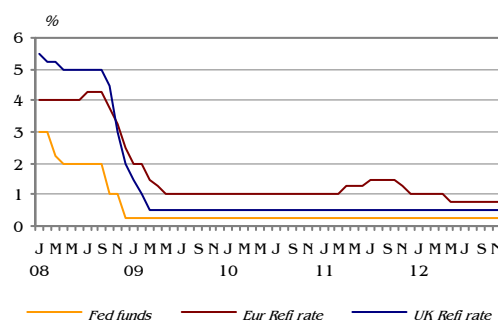
Stock indexes in developed and developing countries have shown little volatility, concomitant with developments in economies, having risen to some extent compared with the average trend reported in the previous year.

Low levels of benchmark interest rates and low risk appetite globally have brought about a declining trend in interbank rates.

The flow of capital to developing countries began increasing significantly in the second half of 2012, although there was a slight weakening of this trend in comparison with the previous year. At the heart of regained flows were unsteady environment in developed economies on the one hand and high level of interest rates in developing countries

The central banks of almost all countries implemented a moderate monetary policy

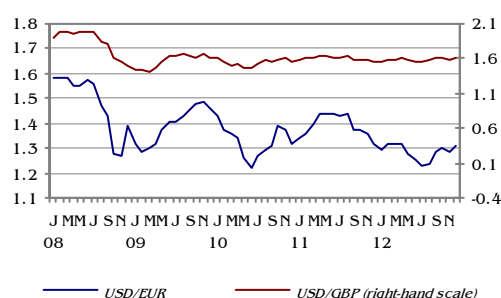
Central banks' policy rates



Source: Bloomberg Data Vane House.

Main currencies were volatile, and only changed their patterns at the end of the year

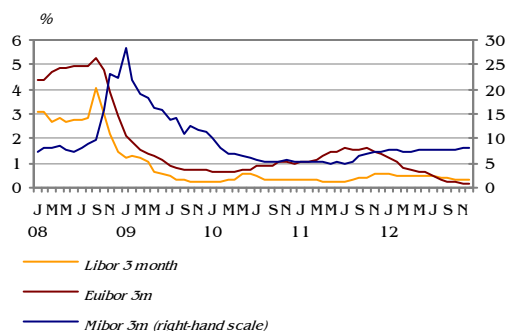
USD exchange rate versus EUR and GBP



Source: ECB.

The stock exchange indices and base interest rates paced in line with developments in international arena

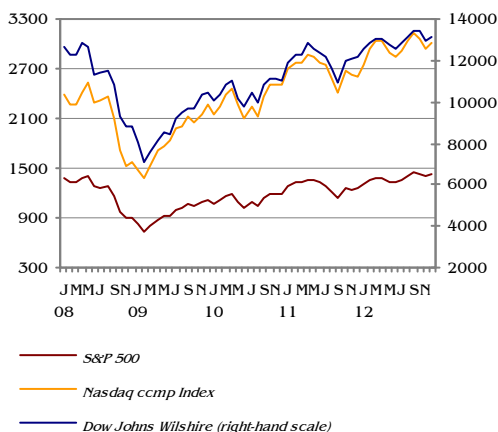
Interbank interest rates



Source: Bloomberg Data Vane House.

Trends of recovering capital inflow to developing countries were observed

Stock exchange indices



All major sectors of the economy posted growth

Trends were positive in the labor market and with regard to household incomes

Foreign trade indicators lagged behind the previous year's respective indicators

on the other. According to the International Institute of Finance, in 2012 the private capital flows to developing countries amounted to 6.8 percent of their GDP. As forecasts suggest, in 2013-2014 that indicator is going to rise to 7.4 percent of GDP (in the pre-crisis period it made up 8 percent of GDP).

Box 2

Economic developments in Russia *

In 2012 the Russian economy posted 3.4 percent y-o-y growth, losing to the relevant indicator of the previous reference period (4.3 percent in 2011). The year 2012 was prominent in that investment and consumer demand have declined in the face of adverse developments in the global economy hence reduced external demand. Unfavorable weather also affected negatively the economic activity, resulting in the loss of part of the crops and increased food prices. The performance of most macroeconomic indicators has deteriorated starting from the second half of the year in part owing to strong data reported for the second half of 2011 (base effect).

Industry reported an annual growth of 2.6 percent, with the main contribution came from processing industry. Based on the data for the period January-November 2012 construction and trade subsectors posted, respectively, 13.6 percent and 49.3 percent rises in financial income. By the end of the year, however, the growth rates in these subsectors have decelerated. The slowing of trade turnover was mainly attributable to strong data reported for the mid of the year while reduced investments in construction pointed to the unsound growth patterns in this subsector.

Preliminary data show that there has been 10.0 percent increase of household income, with real disposable income having grown steadily during the year by 5.3 percent y-o-y. In the meantime, real wage growth has been a mere 0.3 percent compared with the previous year's indicator, which is mostly explained by an impressive wage growth of 26.3 percent reported in the previous year. It should be noted that for the first time since 1999 the economy posted the lowest unemployment rate, i.e. 5.3 percent in 2012.

Generally, the situation in the labor market can be characterized as stabilized, mainly fostered by continued economic recovery and coordinated public policy to shore up the employment.

The slowdown in global economic growth rates has caused reduction of the demand for a number of Russian energy resources. As a result, export value had decreased since the beginning of the year. The aforementioned factors have also pushed down economic growth rates in Russia, with a trend pattern of declining import value. The growth of export in 2012 was 1.7 percent and the growth of import, 3.6 percent (the relevant indicators in the previous year were 30.3 percent and 30.2 percent).

** Among trade partners for Armenia, economic developments in the European Union and Russia are presented. The developments in the EU are described in the section "Developments in World Economy" and the developments in Russia are provided in this box for a thorough analytics concerning the major impulses coming from this country and the channels of transmission.*

In January-April, in view of developments on a global landscape, the domestic market saw an oversupply of foreign currency, which contributed to the strengthening of the ruble exchange rate. In May and June, in the face of declining energy prices and the deterioration of the situation in the Euro-area, growth in demand for foreign currency has weakened the Russian ruble. In the second half of the year, owing to developments in the Euro area and fluctuations in energy prices, the Russian ruble also behaved unstable, going a path of gradual strengthening by the end of the year, however.

During 2012, the net outflow of capital further reduced to USD 56.8 billion, according to preliminary data (USD 80.5 billion in the previous year). In 2013 somewhat a lower capital outflow (of USD 10-15 billion) is predicted.

The annual inflation was 6.6 percent (6.1 percent in the previous year). The inflation rate has accelerated in the second half of the year mostly due to insufficient levels of harvest and rising international wheat prices.

Dynamics of monetary indicators in 2012 was attributable to the slowing of economic activity, prices which remained at the previous year's level and persisting trend of private capital outflow. Given inflationary developments and the level of economic activity, the Bank of Russia raised the refinancing rate by 0.25 percent to 8.25 percent.

In 2012 assets of the banking sector grew by 18.9 percent. As well as lending volumes increased by 12.7 percent. The share of bad loans in total loan portfolio has not changed, 4.6 percent in total.

In 2012 aggregate profit of financial institutions grew by 19.3 percent y-o-y.

* Data are from the report "Monitoring the Results of Socio-Economic Development of the Russian Federation in 2012" published by the Russian Ministry of Economic Development.
http://www.economy.gov.ru/minec/activity/sections/macro/monitoring/doc20130206_004.

International developments and energy prices determined the ruble's volatile performance

Inflation accelerated in the second half of the year, and the Russian Central Bank tightened monetary conditions to some extent

The banking system indicators posted growth in the main

SUMMARY

In 2012, in the face of severe volatility in international markets and persisting challenges, the recovery of the global economy was still slow and sluggish.

The debt problems in the Eurozone have not been tackled for a final political solution, although the competent authorities of major countries were extremely active by applying certain monetary tools, the global unemployment rate has not decreased noticeably. Developing countries experienced a slowdown in economic growth trends whilst the developments in the commodity markets were diverse.

Despite the above developments, some of the positive trends and events at the end of year have created preconditions for optimism ahead in 2013⁴.

⁴ "Global Prospects and Policy Challenges", Meetings of G-20 Finance Ministers and Central Bank Governors, February 15-16, 2013, Moscow.

Other things being equal, in the absence of new shocks (such as in Cyprus⁵) in the short term it is expected that:

- low interest rates in developed countries will slowly promote lending activities thus reducing the risks to financial stability;
- recovery of economic activity in developing countries and the influx of capital may lead to a sharp increase in demand for loans and relaxed credit conditions, in which case tightening of monetary conditions and macro-prudential policies would be possible;
- expansionary monetary policies will continue to support economic recovery, which in the short term is likely to proceed at a slow pace;
- the global trade will show signs of recovery; and
- inflationary pressures in the global economy will mostly be moderate.

The main risks in 2013 are:

1. poor effectiveness of the main measures by the competent authorities of the Euro-area in the short run, while in the medium and long run, the most relevant factors will be a protracted period of stagnation and weak economic growth, which may be determined by still high debt burden of the private sector of Euro-periphery countries;
2. unstable financial position not only in the Eurozone but also in the United States and Japan are another major risk to the global economy in the short run;
3. lower-than-expected economic growth of developing countries in the short run can cause a reduction in investment, capital flows, and, therefore, potential GDP.

Weak demand due to low growth in the European economies and the possibility of lower prices of base metals as a result of unsteady economic growth are among the major risks which may be transmitted from the external environment.

Another aspect of influence is the Russian economy as the developments in the economy of this country may affect both Armenia's tradable sector and inflow of remittances and factor income.

⁵ Following negotiations in March of 2013 between the Government of Cyprus and the ECB to take measures to prevent a possible collapse of the economy of Cyprus it was decided to provide financial assistance to Cyprus only after the government will introduce 7-10% tax on bank deposits in Cyprus. The decision triggered a wave of discontent and galvanized pessimism elsewhere in the world. Although the project has not received support from the parliament of the country, it however has become a powerful impetus for the outflow of deposits and loss of confidence. At this stage, the ECB agreed to provide aid to Cyprus in the amount of EUR 10 billion, provided that Cyprus will fulfill some of the conditions. To save the economy from collapse an additional EUR 7 billion will be needed. The Bank of Cyprus has set restrictions on cash withdrawals from the accounts and their removal from the country (on April 2, these restrictions were eased to certain extent).

2. DEVELOPMENTS IN MACROECONOMIC ENVIRONMENT IN ARMENIA⁶

2.1. MACROECONOMIC DEVELOPMENTS

Fragile growth of the world economy in 2012 and the tightness in financial markets did not have a significant impact on the recovery of the domestic economy, although the risks associated with the unstable growth of the world economy were further among key risks that have potential impact on the growth of the domestic economy and financial stability.

Recovery of the domestic economy continued on the back of increased inflow of funds and export, household income growth and private demand amidst persisting international prices of oil products and base metals.

Economic growth in Armenia in 2012 was 7.2%. As in the previous year, economic growth reported this year was mainly due to the growth of industry, agriculture and service sectors.

During the year, the growth of value added in industry was high enough, 5.7 percent. Growth was recorded in ore and mining and processing industry and energy subsectors. The growth in ore and mining is attributable to world metals prices persisting at a stable level while the growth of the processing industry is mainly due to the lack of sharp fluctuations in private demand in both key partner countries and the domestic economy.

In 2012 the growth in the agricultural sector remained strong, 9.3 percent, mostly owing to favorable weather conditions and the measures taken by the government for improvements in the field of agriculture.

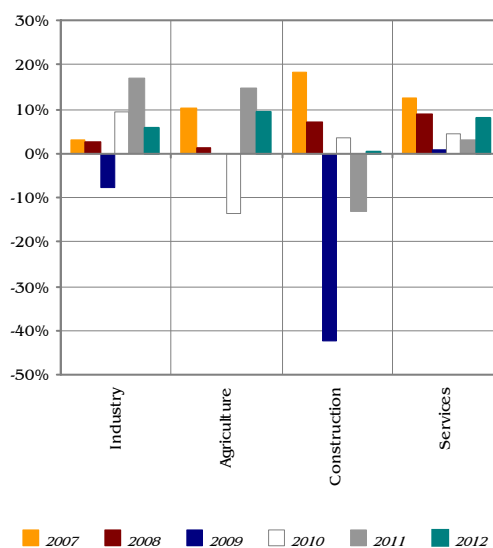
In the construction sector, the growth was small, 0.5 percent y-o-y. The growth was driven by increased volumes of household-funded construction as well as construction carried out by the use of credit disbursed by KfW Bank and the European Bank for Reconstruction and Development for improving infrastructure in agriculture.

Growth in services in 2012 was 8.0 percent y-o-y, driven by increased volumes in retail and wholesale trade⁷. This, in fact, points to the continuous recovery in private demand and household income.

With the revitalization of private investment in 2013 and due to the growth in industry and services, the economic growth will be in the range of 4.7 – 5.7 percent, according to the recent forecasts by the Central Bank.

In 2012 the domestic economy posted growth driven by increased output in the branches, which has positively affected company credibility

Economic growth rate, by sector



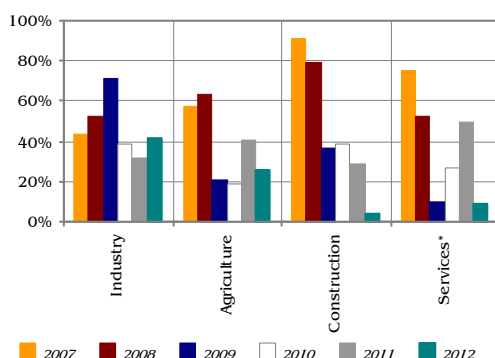
Source: National Statistics Service of Armenia.

⁶ For details on the developments in Armenia's macroeconomic environment, see the quarterly publication *Inflation Report 2012 (Status Report on Implementation of Monetary Policy Program, Q1, 2013 and Status Report on Implementation of Monetary Policy Program, Q4, 2012)*.

⁷ Including Financial Intermediate Services Indirectly Measured (FISISM).

Positive developments in the economy were concurrent with the growth in credit market

Growth of lending to main sectors of economy



Source: Central Bank of Armenia.

Total loan portfolio and lending terms were readjusted, according to the survey of credit market participants

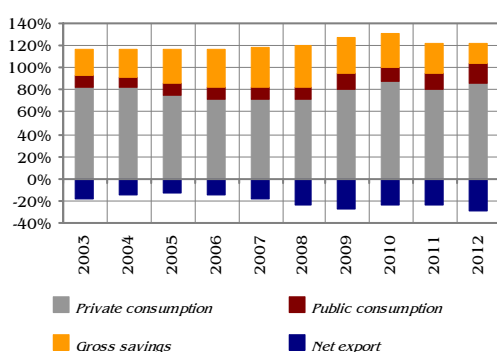
In 2012 the credit market remained active in the light of revived economic environment and positive expectations. Naturally, strong credit growth led to growth in almost all sectors of the economy and the growth in private consumption of households, stimulating, respectively, aggregate supply and aggregate demand. In 2012 the credit growth of the banking system was 26.9 percent, and the share of non-performing loans to total loans has increased by 0.2 percent to 3.5 percent by year-end. Compared with the overall quality of the loan portfolio, somewhat risky were consumer loans and loans provided to the catering subsector. However, these loans do not pose much of a threat to financial stability, as they are attributed as being small size with relatively short durations.

According to the Central Bank surveys⁸ conducted among commercial banks and credit organizations during the year, these organizations placed the main focus on reducing large credit portfolios in favor of lending to small, medium and diversified businesses. There was some recovery on the part of the mortgage loans, associated with an increased number of transactions in the real estate market.

Banks made revision to the lending policy: the lending terms and interest rate of loans in particular were revised. At the same time, to maintain market position, more flexible lending instruments that would best meet the needs of customers were developed.

The annual performance of composite indices were different⁹

GDP expenditure components
(share in GDP)



Source: National Statistics Service of Armenia.

Growth of private consumption continued during the year while investment climate was not active in general

According to surveys conducted over the four quarters of 2012, composite indices trended differently. In particular, the decline in the index of economic activity was observed only in the first quarter, and for the next three quarters it showed continuous improvement. Both, the actual and the expectation sub-indices posted rises mainly owing to reported growth in industry and services and particularly in construction at the end of the year. This in turn points to the revitalization of the economy.

The index of business activity rose in the first half of the year, and in the second half it began showing a declining trend. Construction, despite a reported slight increase, was recognized during the year a sector not preferable in terms of business activity.

By expenditure components of GDP, the highest growth was observed in private consumption, with an annual real growth of 10.0% percent. This has been attributable to some growth in household incomes and revived economic activity as a result of recovering inflows of private transfers, growth in loans, consumer confidence, as well as low prices. Unlike the reported growth in private consumption, public

⁸ The results of quarterly survey "The Terms of Lending Provided by Banks and Credit Institutions in Armenia" conducted by the Central Bank in 2012.

⁹ Economic Activity Indicator and Business Climate Index built by the Central Bank and based on quarterly surveys.

consumption has declined by 5.2 percent, mainly as a consequence of the policy steered to reduce the state budget deficit. Investment environment was not proactive during the year: there were marked reductions in both government investment and private investment. The government investment declined at the highest rate, 25.7 percent, which again was a result of the policy to reduce the state budget deficit. The annual decline in private investment was 5.4 percent due mainly developments in the construction sector.

In 2012, relative to the end of the previous year, the public debt has grown by 4.8 percent and reached USD 3738.3 million. The foreign debt to GDP ratio was an estimated 37.6 percent, representing a slight increase in relation to the previous year. The other debt sustainability indicators posted increases though Armenia remains a country with a low debt burden.

Foreign public debt has grown and debt sustainability indicators reported a slight increase

Some changes were observed in the structure of external debt. In 2012, the share of concessional loans kept on reducing, albeit slowly, which had reached 55.5 percent of total public debt. The share of loans with floating interest rate declined to some extent, making up 36.6 percent of total public credit.

Qualitative public debt indicators of the Republic of Armenia

Indicator	2005	2006	2007	2008	2009	2010	2011	2012
Debt/GDP (limit 50%)	22.3%	18.2%	14.0%	13.6%	35.7%	34.2%	36.4%	37.6%
Debt/Export	78% (less indebted)	80% (less indebted)	82% (less indebted)	90% (less indebted)	227% (moderately indebted)	182.1% (moderately indebted)	154.0% (moderately indebted)	150.0% (less indebted)
Debt service/Export	4.6% (less indebted)	4.2% (less indebted)	2.9% (less indebted)	3.1% (less indebted)	6% (less indebted)	5.0% (less indebted)	4.2% (less indebted)	9.9% (less indebted)
Interest/Export	0.9% (less indebted)	0.7% (less indebted)	0.6% (less indebted)	0.7% (less indebted)	2.0% (less indebted)	2.4% (less indebted)	2.1% (less indebted)	2.3% (less indebted)

Source: Ministry of Finance of RA, <http://www.minfin.am/main.php?lang=1&mode=ppreports&iseng=1&isarm=1>.

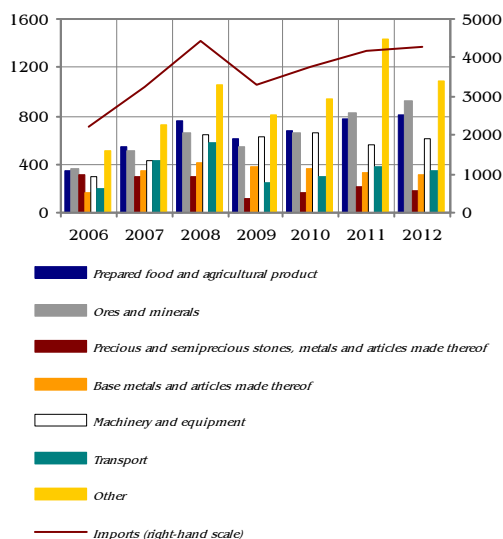
Encouraging developments in the domestic economy in 2012 contributed positively to the state budget. According to the Republic of Armenia National Statistics Service data, there has been a reported increase in collection of revenues during the reporting period: budget revenues have grown by nearly 7.4 percent y-o-y and budget expenditures, by 2.0 percent. As a result, the budget deficit has further reduced by 43.3 percent¹⁰. Attributable to surpassing revenues over expenditures as well as further economic growth, the budget deficit has amounted to 1.5 percent of GDP (2.8 percent of GDP in 2011), according to the year's results. The growth of tax revenues has been relatively high owing to better tax administration and economic activity. In the expenditures structure, almost all expenditures items posted increases.

The state budget deficit kept on reducing

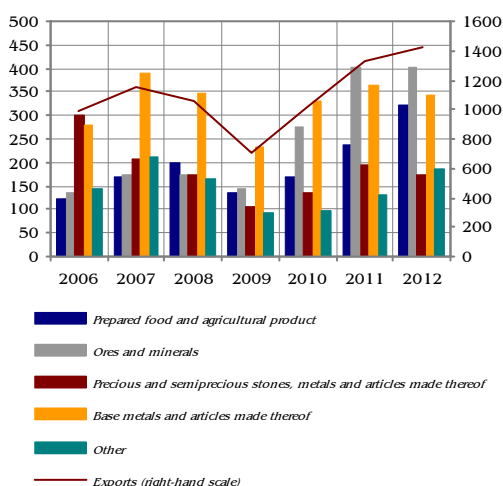
¹⁰ This includes working capital of project implementation units that perform using sources of external funding.

Inflationary pressures were weak during the year

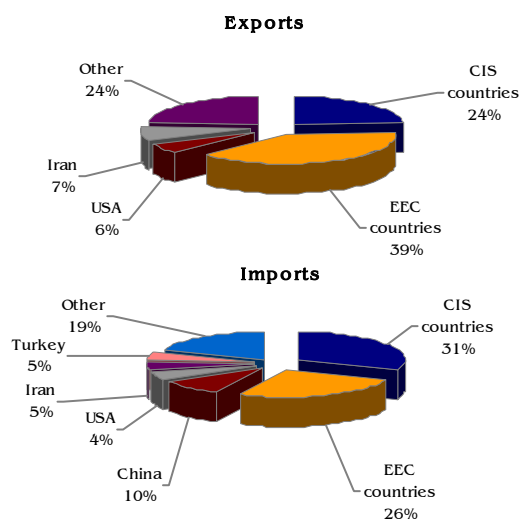
Armenia's imports by commodity groups
(mln USD)



Armenia's exports by commodity groups
(mln USD)



Armenia's foreign trade, by country, as of 31.12.2012



Sources: Central Bank of Armenia.

The domestic economy saw generally a weak inflation environment determined by a low level of world prices of basic food and commodities and agricultural products. In December, therefore, the 12-month inflation was within the target, 3.2 percent¹¹.

2.2. FOREIGN TRADE¹²

On the back of developments in global and domestic economies, the current account deficit has remained almost unchanged in relation to the previous year, and increased item "Incomes and current transfers" has been the main contribution to the deficit funding.

Annual real growth of imports of goods and services in 2012 has been low, amounting to 2.5 percent, and the dollar increase in imports was 2.2 percent, which was due mainly to increased economic activity in the domestic economy and household incomes.

There has been a notable increase of import volumes in such items as "chemical products", "products of vegetable origin", "products of prepared food" and "ores and minerals".

Annual growth of exports of goods and services in real terms amounted to 7.3 percent, and the dollar growth, 3.5 percent. The main contribution to the growth of export came from items such as "products of prepared food", "transport means", "produce of vegetable origin" and "textile products". High export growth was driven by a reported high growth in the industry.

With the dollar value shifts in imports and exports mentioned above, the trade balance deficit has stayed almost unchanged in relation to the previous year and amounted to USD 2838.7 million.

In terms of geographic distribution of external trade, major concentrations remain, and the composition of the main partner countries did not change much, either. In the exports structure, the share of CIS has grown by 3.4 pp while the share of the EU countries has reduced notably by 6.3 pp. The change in shares of other partner countries was negligible. Export remains concentrated by geography and by commodity, which means that vulnerability of ore mining and food production sub-branches will increase in the event of possible shocks in any particular country of export or elsewhere in the global economy.

In terms of imports, the EU countries and CIS, which together constitute 57.7 percent share, remain the main trade partners to Armenia.

¹¹ See details in the publication *Inflation Report, Q4, 2012*.

¹² Real y-o-y growths of export and import are the Central Bank estimates.

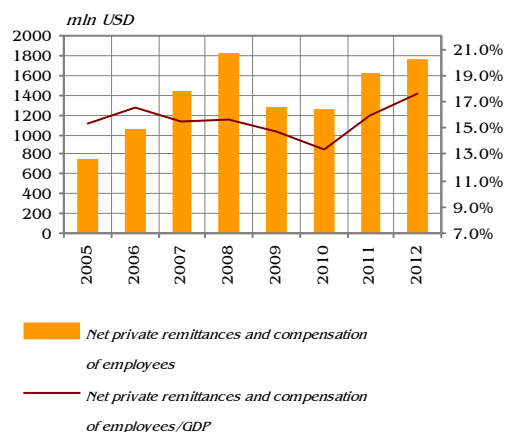
2.3. NET FACTOR INCOMES AND REMITTANCES

Private transfers and seasonal worker income are an important part of disposable income of households in Armenia. In 2012, the growth of net private transfers and net seasonal worker income was 11.7 percent and 6.8 percent, respectively¹³. As a result, in comparison with other countries in the region, the ratio of non-commercial remittances to GDP remains high, which points to the importance of remittances in terms of maintaining financial stability of households. In 2012, as compared to the year 2011, the ratio of net private transfers and seasonal worker income to GDP grew by 1.7 pp, reaching 17.6 percent; the ratio however has risen by a mere 0.4 pp, if changes in the exchange rate are excluded. In the period under review net inflow of non-commercial transfers of individuals via the banking system has increased, having surpassed the pre-crisis level for the first time since 2009. Compared with the previous year, the inflows have increased by 8.8 percent to USD 1,395.0 million.

The prevailing part of inflow of non-commercial remittances of individuals via the banking system (85.6 percent) came from Russia, (3.9 percent from the U.S.A.). This increases Armenia's dependence on economic developments in Russia, leaving it more vulnerable to external economic shocks. In the period under review the growth in remittances to Armenia was driven by positive developments reported in the economy of Russia, the construction and service sectors, in particular (the two sectors altogether employ more than 67.9 percent of the Republic of Armenia citizens authorized to work in Russia in the first half of the year)¹⁴. However, by the end of the year, there has been a slowdown in trade and construction in Russia (see Box 2 "Economic Development of the Russian Federation"), which, other things being equal, may serve a reason for the decline in inflows of seasonal worker income. According to the Central Bank forecasts in the context of evaluations of international institutions about the Russian economy, the growth rate of inflow of non-commercial remittances by individuals in 2013 will amount to 7-9 percent, which may have a positive impact on the economic activity¹⁵.

The year saw remittances grow, which positively affected the household incomes

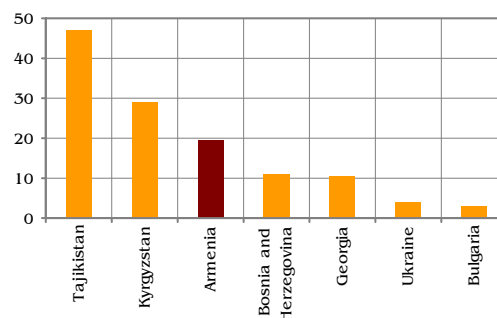
Net private remittances and compensation of employees



Source: Central Bank of Armenia.

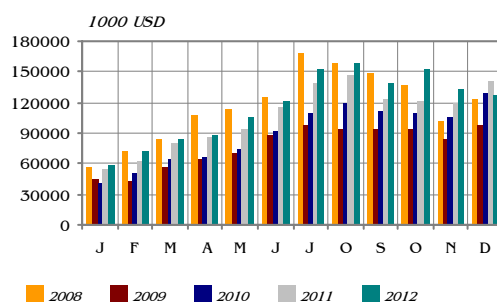
A bulk of non-commercial remittances of individuals via the banking system is from Russia; this increases the dependence on economic developments in that country

Money transfers-to-GDP ratio in different countries in 2011



* In the chart under money transfers the WB includes private transfers and overseas workers' compensation.

Transfers of natural persons through the banking system



¹³ Balance of Payments of the Republic of Armenia according to the 5th edition of the Balance of Payments Manual, <https://www.cba.am/am/SitePages/statexternalsector.aspx>.

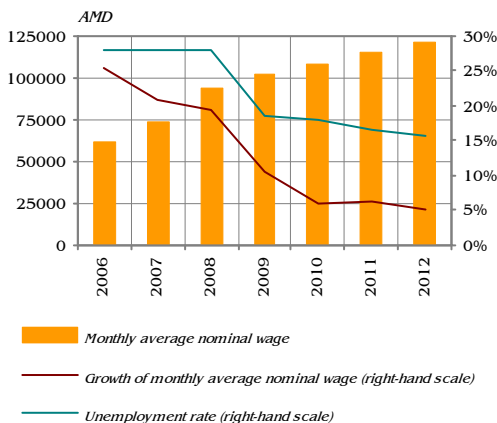
¹⁴ State Migration Service of the Republic of Armenia Ministry of Territorial Administration :// www.smsmta.am/

¹⁵ See details in the publication Inflation Report, Q4, 2012.

2.4. HOUSEHOLD INCOMES AND DEBT BURDEN

The developments in the labor market, too, positively affected the household incomes

Nominal average wage

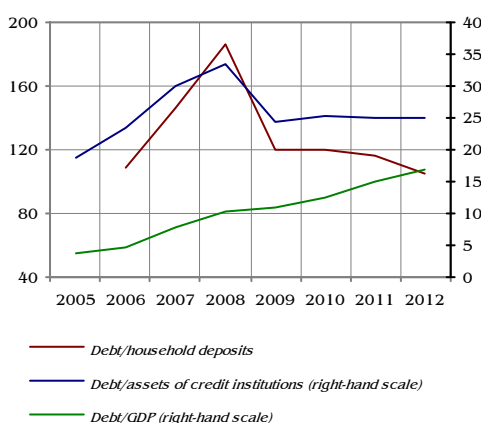


Source: National Statistics Service of Armenia.

During the year the labor market saw improvements in the area of employment and wages. These developments can promote further growth of household lending, as well as the households' ability to perform their obligations on a timely basis. According to the Republic of Armenia National Statistics Service data, in 2012 the average nominal wage rose by 5.1 percent, which is however below the previous year's figure. Given the average annual inflation rate (of 2.6 percent), real wages have grown as well, by 2.5 percent, yet this growth is inferior to last year's respective figure, too. Wage growth was observed in both the private and public sectors due to both productivity growth and increased demand for labor. The demand for labor has increased mainly due to an increase in output in the industry and services. As a result, the unemployment rate for the year has dropped by 0.8 pp and amounted to 15.7 percent by year-end¹⁶. The economy still faced with the problem of persons in search of work more than one year, which may limit their possibility of finding an appropriate work. In anticipation of economic growth in 2013 a further increase of the demand for labor is forecast, which would be concomitant with the growth of both employment rate and nominal and real wages¹⁷. However, the proportion of the population with low wages remains high, leaving a negative impact on the ability of households to use financial services.

The banking system saw more household savings during the year

Households' debt burden indicators



Source: Central Bank of Armenia.

The growth of household income had an impact on the level of their savings. In particular, in the period under review households deposits in banks has grown by 32.0 percent and accounted for 67.2 percent of total deposits¹⁸. As a result, bank deposits of households further remain the most important source of financing by banks. Strengthened public confidence as a result of measures to improve the financial literacy and boost income growth may facilitate further deposit growth.

In the structure of bank deposits, foreign currency deposits continue holding a large proportion (69.0 percent), and this may limit commercial banks' ability to investing funds in dram-denominated assets. However, surpassing growth of dram deposits during the year contributed to a 1.8 percent increase of their share, which may serve a solution to the above problem.

Somewhat faster growth of household debt in comparison with GDP growth has pushed the debt to GDP ratio up to amount to 16.8 percent. Given that the debt burden of households in Armenia stands below the respective indicators in countries of Eastern Europe, it is considered

¹⁶ From now on, the unemployment rate is the level of unemployment as published by the NSS (see "Socio-economic situation of the Republic of Armenia in January-February 2013")

http://www.armstat.am/file/article/sv_02_13a_141.pdf.

¹⁷ See details in the publication Inflation Report, Q4, 2012.

¹⁸ Loans and deposits of resident households were considered.

that a further increase of the debt burden on the back of economic activity and real incomes would not pose essential threats to financial stability.

The ratio of debt to savings has dropped by 11.0 pp, owing to the surpassing growth of household deposits and amounted to 105.4 percent.

The liabilities to financial institutions make up the prevailing part of the debt burden of households, which is approximately 90 percent. In 2012, as compared with the end of 2011, there has been a 19.5 percent increase in liabilities of households to financial institutions. Though the liabilities to credit organizations and pawnshops are growing rapidly, they are much lower in the total financial liabilities, accounting for only 14.6 percent of financial liabilities.

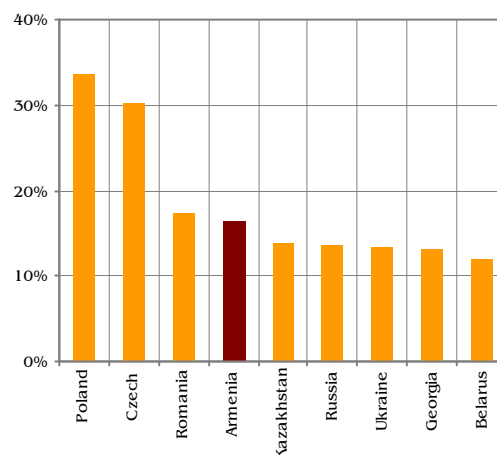
In the area of household lending, the highest activity was observed for consumer credit, which reported as high as 38.5 percent growth during 2012. The growth of all types of loans, with the exception of car loans, has contributed to the growth of consumer credit. Results of surveys²⁰ of the Central Bank showed that consumer credits remain a highly desirable area of business for financial institutions. Strong banking competition in this area during the year has brought about worthy facilitations, new and attractive loan products as well as the timing for decision-making was reduced.

In the period under review mortgage lending has grown by 19.0 percent (or AMD 23.2 billion), which is still 6.6 pp lower from the same indicator in the previous reference period. The growth of mortgage lending was driven mainly by mortgage loans for the purchase of real estate, which had an estimated growth of AMD 17.6 billion. Strong demand for mortgage loans as well as the expectations of banks and credit organizations regarding the growth of the mortgage portfolio serves good evidence that the Armenian mortgage market has a potential to expand²¹. Activities of the credit organization involved in refinancing the program *Home for the Youth* and activities of the National Mortgage Company bolster the development of the domestic mortgage market. The central institutional goal, of course, is to make sure refinanced credit facilities for the purchase of property are increasingly accessible. By the end of the year the volume of loans refinanced by the National Mortgage Company was 17.9 percent of the total loan portfolio.

In the period under review interest rates of both consumer loans and mortgage loans have slightly dropped, each by up to 0.7 pp.

Growing household incomes were concurrent with moderate growth of debt burden¹⁹

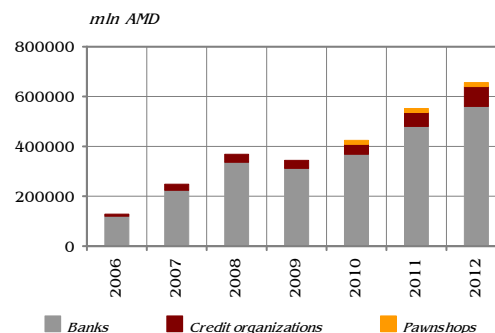
Households' financial liabilities/GDP



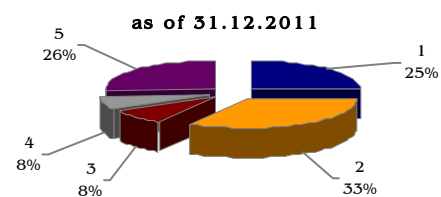
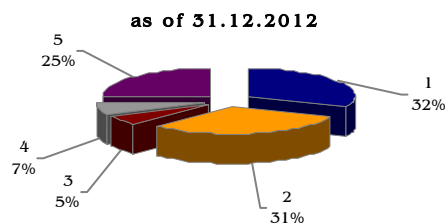
Source: Countries Central Banks.

The volumes of household lending have grown owing to both consumer and mortgage loans

Structure of household liabilities



Consumer loan portfolio of banks and credit organizations



1. Card loans, 2. Gold-backed loans, 3. Car loans, 4. Home appliance loans, 5. Other consumer loans

Source: Central Bank of Armenia.

¹⁹ The aggregate sum of household liabilities to banks, credit organizations and pawnshops.

²⁰ Source: results of the quarterly survey of the Central Bank Terms of Lending by Banks and Credit Organizations in Armenia, Q4, 2012.

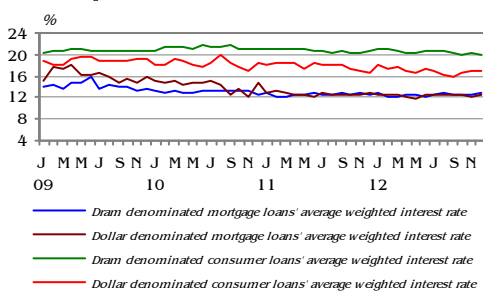
²¹ Source: results of the quarterly survey of the Central Bank Terms of Lending by Banks and Credit Organizations in Armenia, Q4, 2012.

mln AMD

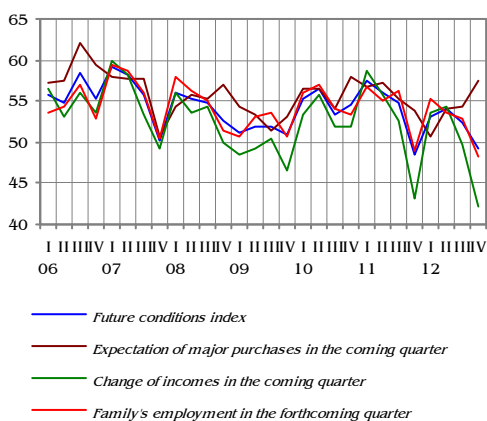
Period	Consumer loan portfolio (mln AMD)	Mortgage loan portfolio (mln AMD)	Total (mln AMD)
01.01.08	~120,000	~30,000	~150,000
01.07.08	~140,000	~40,000	~180,000
01.01.09	~180,000	~60,000	~240,000
01.07.09	~160,000	~80,000	~240,000
01.01.10	~140,000	~80,000	~220,000
01.07.10	~140,000	~90,000	~230,000
01.01.11	~160,000	~100,000	~260,000
01.07.11	~180,000	~120,000	~300,000
01.01.12	~220,000	~140,000	~360,000
01.07.12	~260,000	~160,000	~420,000
01.01.13	~300,000	~150,000	~450,000

■ Mortgage loan portfolio of banks and credit organizations
■ Consumer loan portfolio of banks and credit organizations

Average weighted interest rate of loans of natural persons



Future conditions index and its components



The components of the index of consumer confidence – sub-indices of current and future conditions – are a source for indirect assessment of expectations of economic standing and incomes of people²². The survey of the fourth quarter showed that among current conditions sub-indices only the household sub-index of current economic conditions has risen compared to the previous quarter, although it is still below in relation to the other sub-indices. In the meantime though, only the household sub-index of major purchases posted some improvement.

Although the volume of loans provided to households in 2012 has increased, the share of non-performing loans in the total consumer and mortgage credit portfolios of both banks and credit organizations remained almost unchanged, at 3.3 percent and 4.5 percent, respectively. This positive circumstance is attributable to the reported increment in household incomes. The share of non-performing loans is relatively high on the part of mortgages in foreign currency, which points to the existence of credit risk derived from foreign exchange risks. The quality of the loan portfolio can also be influenced by the fact that most households are middle-income borrowers who are able to perform their contractual obligations in time.

The continuous rise in real estate prices and high growth in construction observable up until the first quarter of 2008 has enhanced the role of the real estate market for the country's financial stability. The development of the real estate market may directly and indirectly affect the stability of the financial system since investment in real estate is an alternative to financial investments on the one hand, and the credit shall be secured by real estate on the other. Consequently, sharp fluctuations in the real estate market may adversely affect both the financial stability of households and financial institutions.

During the second half of 2012 prices for apartments in multi-apartment homes in Yerevan kept on rising, which helped mitigate the deflation reported in the first half of the year and come closer to the 2011 level of prices in a one-year perspective. The highest prices for apartments were reported in administrative districts Shengavit and Nor Nork of Yerevan, which was due to increased demand for relatively cheap apartments. Market prices for apartments in regions of Armenia trended differently but were, in general, 3.5 percent higher compared to the previous year. Prices for apartments

24

again remain the highest in towns Tsaghkadzor, Abovyan and Vagharshapat.

In view of changes in real estate prices and their possible impact on sustainable functioning of the financial sector, banks were further cautious with the loan to value ratio, mostly keeping it within the 60-80 percent range. Under such circumstances, in a financial stability point of view, risks deriving from real estate price fluctuations were not significant (see details in *Market risk of commercial banks* section).

In 2012 the number of transactions of purchase and sale of apartments in multi-apartment homes in Yerevan dropped by 9.1 percent. During the reporting period the number of real-estate transactions has declined, and the share of purchase and sale of apartments in the total sales of real estate remained the same, as a result. In Armenia, the number of sales and purchases of apartments are concentrated in Yerevan, and the number of mortgage loans originated for property purchases was roughly the same in the regions of the country. An indirect measure of the activity of real estate market may come from the number of pledges, which has declined by 16.3 percent in the period under period. However, the volumes of loans secured by collateral continued growing due to additional lending backed by property already mortgaged.

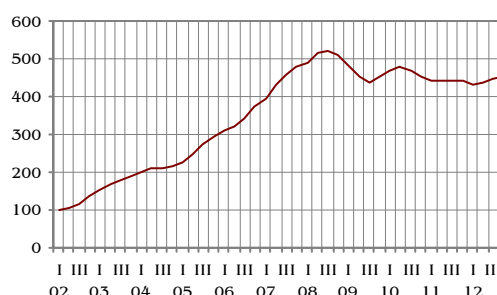
In the period under review the volume of homes commissioned to operate has contracted. This was explained by the reduction in the volume of construction funded by organizations. The business of organizations is largely concentrated in the city of Yerevan, which is why the said decline was so considerable in Yerevan. In 2012, first time after two years of contraction, there was an increase in the volume of household-funded construction of homes commissioned to operate.

Although the volume of homes commissioned to operate has declined the market saw an increase in construction related to real estate, suggesting that there is chance for the revitalization of the real estate market. From the point of view of stimulating supply, making loans to the construction of residential and non-residential buildings is important. Such lending has also grown during the year and at the end of the year it amounted to AMD 87.4 billion.

Mortgage lending remains an important part of the demand for real estate. Further expanding of the mortgage market and ongoing reforms in the real estate market can foster the growth of household incomes. According to surveys²³ of the Central Bank, credit institutions are expecting further strengthening of demand for mortgage

Real estate price movements were not significant during the year

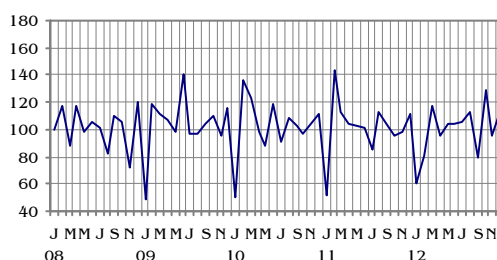
Average apartment price index in Yerevan (sq m)



Source: State Committee of Real Estate Cadastre at the Government of Armenia.

The number of home purchase and sale transactions has reduced

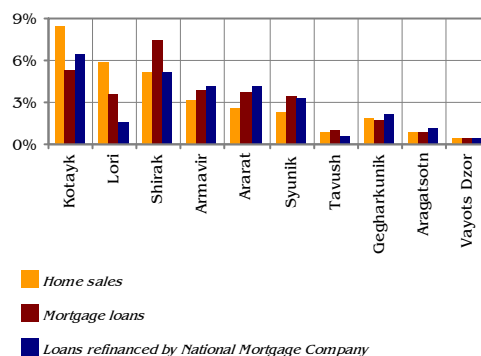
Real estate transactions index



Source: State Committee of Real Estate Cadastre at the Government of Armenia.

Reduced supply of homes commissioned to operate halted further price drop

Home sales and mortgage loans by region, 2012

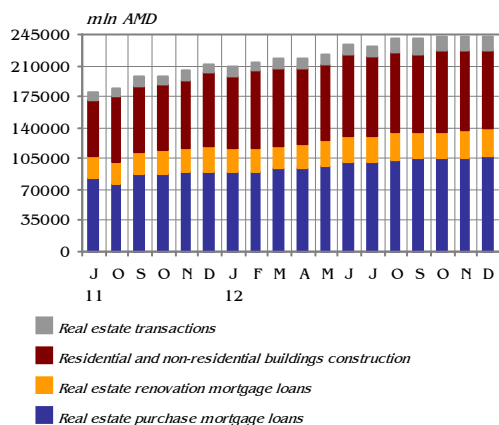


Source: Central Bank of Armenia, National Mortgage Company.

²³ Source: results of the quarterly survey of the Central Bank Terms of Lending by Banks and Credit Organizations in Armenia, Q4, 2012.

Part of demand for real estate continues to be driven by mortgage credits

Volume of loans to real estate market



loans, which can also have a positive impact on the real estate market.

Dwelling house operation by sources of financing

<i>Source of financing</i>	Operated residential apartments in 2012 (sq m)	Share in total	Percentage change to 2011
Total, o/w :	233360	100%	-52.6%
state budget	35018	15.0%	21.3%
resources from organizations	61367	26.3%	-82.0%
household funds	133212	57.1%	7.6%

Source: the National Statistics service of Armenia,
http://www.armstat.am/file/article/shin_12_2012.pdf

SUMMARY

The recovery of economic growth due to internal and external developments as was observed during the previous year continued in 2012, too, at a faster pace though.

The level of international prices of industrial products as well as global demand growth, wider inflow of private transfers and increased lending all further contributed to the economic recovery.

The growth of private transfers, factor income and nominal wages had a positive impact on the real incomes of households and, consequently, on their credibility. The increased outputs in sectors of the economy and the growth of exports have, in turn, boosted creditworthiness of companies thus having left a positive impact on the financial stability.

Price developments in domestic and external markets and implemented monetary policy have led to a minor inflationary environment, contributing to a better credibility of businesses.

In a world without new shocks in the global economy on the one hand and fostered private investment and sustained growth in domestic industry and services on the other, the Central Bank anticipates a reasonable level of economic growth and financial stability.

3. FINANCIAL MARKET STABILITY IN ARMENIA

3.1. MONEY AND CAPITAL MARKETS

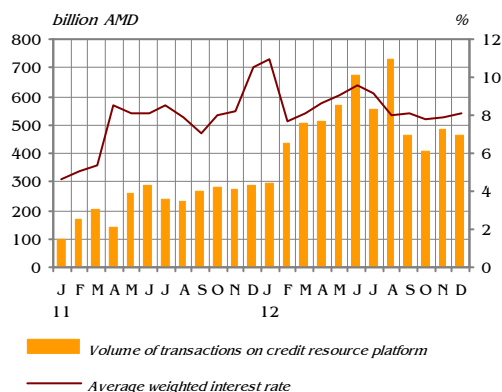
In 2012 the Central Bank left the refinancing rate unchanged, at an 8 percent level. Behind this policy were the following factors: with the 12-month inflation on a down-sloping path recently and generally a non-inflationary environment, the Central Bank believed there was less likelihood of the inflation environment to expand again and the refinancing rate then applicable could help tame the inflation within the target. The other consideration was that in May-June the dram exchange rate had depreciated, which already meant easier monetary conditions, and further relaxing through lower interest rates was no longer required; and finally the 12-month inflation had all the time in the first half been within the confidence band for core inflation.

In the second half of the year the inflation rate gradually increased, approaching the target figure of 4 percent, which was mainly driven by the growth of food prices. Despite this, and with the prospect of persisting weak inflationary environment and future developments in the domestic and external sectors, the Central Bank continued implementing a neutral monetary policy by leaving the policy rate unchanged.

In 2012 the sales turnover on the interbank credit resource platform almost doubled, with average monthly traded volumes of AMD 507 billion. The volumes of transactions on the interbank repo market have not changed.

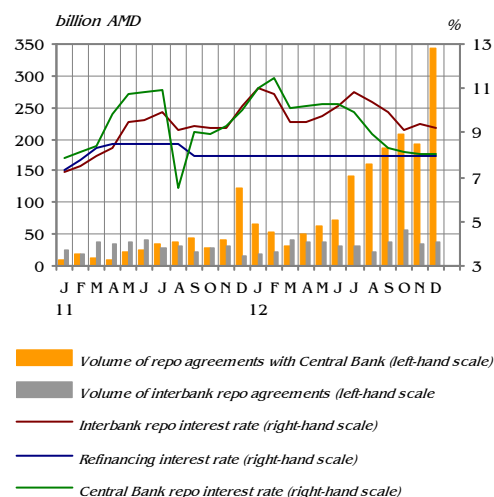
The volumes of repo transactions entered into with the Central Bank during the year have increased significantly due to an increased demand for dram resources. As for interest rates in these markets, it should be noted that they remained almost unchanged, according to annual results.

Volume of transactions on credit resource platform and average weighted interest rate



In 2012 the Central Bank left the refinancing rate unchanged

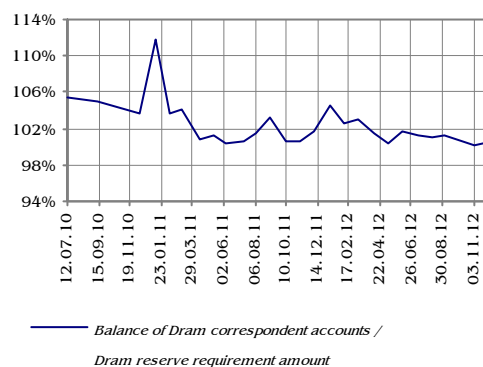
Repo agreements and repo interest rates



Source: Central Bank of Armenia.

Interbank money market was proactive during the year

Dram correspondent accounts of commercial banks with Central Bank and dram reserve requirement ratio

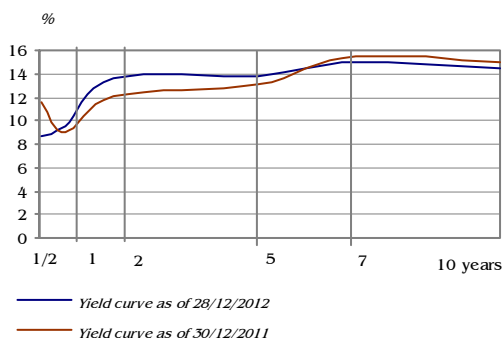


Source: Central bank of Armenia.

Excess liquidity of correspondent accounts of commercial banks with the Central Bank is low

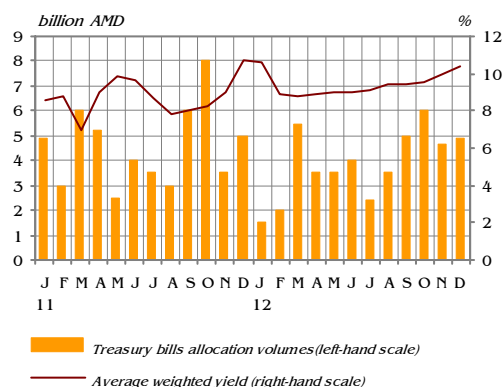
The yield of treasury bills has grown mainly in the medium-term segment

Government bond yield curves



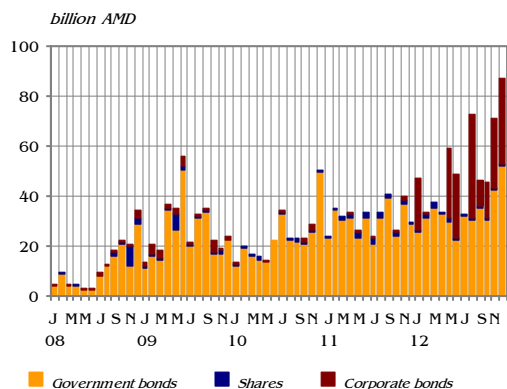
Source: Central Bank of Armenia.

Treasury bills allocation volumes and average weighted yield



Source: Central Bank of Armenia.

Securities trades by investment service providers



Source: Central Bank of Armenia.

Commercial banks' dram excess liquidity with the Central Bank has been low throughout the first half of 2012, owing to the change in reserve requirement (changing the currency of reserves for attracted foreign exchange funds to Armenian dram) in 2012.

The review of yield curves shows that in the secondary market of securities yields have grown mainly in the mid-term segment. Convexity of the curve has not changed much, making up 0.285, which points to the unbroken spread in short-term and long-term interest rates.

As of end-2012, the average maturity (duration) of government bonds outstanding ranged 967 days, and the ratio of Average Modified Duration (D_M) calculated to evaluate interest rate risk was 2.33 for government bonds outstanding.

Modified duration of outstanding government securities as of 31.12.2012 for different maturity groups

D_M	up to 6 months	from 6 months to 1 year	1-2 years	2-5 years	5-7 years	7-10 years
	0.21	0.69	1.17	2.26	3.35	5.29

Source: Central Bank of Armenia.

Modified duration of available-for-sale and trading government securities of commercial banks as of 31.12.2012 and probable profit/loss in case of 1% change in yield for different maturity groups

	up to 6 months	from 6 months to 1 year	1-2 years	2-5 years	5-7 years	Total
Trading government securities (million AMD)	21076.65	12574.24	18709.17	39117.50	13366.24	104843.80
Share in total portfolio	20.10%	11.99%	17.84%	37.31%	12.75%	100%
D_M	0.24	0.69	1.29	2.63	5.28	2.08
Price change +/- (million AMD)	51.29	87.87	239.94	1078.08	805.26	2262.45

Source: Central Bank of Armenia.

In case of 1 percent increase of the yield on government securities, the potential loss in commercial banks' portfolio of government securities could reach AMD 2.3 billion. As such, most loss is likely to come from revaluation of medium-term and long-term securities due to higher sensitivity of government securities to the interest rate change.

During 2012 average variance for yields on transactions performed in secondary markets of government bonds has increased by 0.33 against the previous year and reached 2.83. Average variance for interest rates in repo market (excluding repo transactions with the Central Bank) has decreased by 0.19 and amounted to 1.00.

Operations in securities markets (including repo transactions but excluding operations with the Central Bank) carried out by investment service providers²⁴ have grown by 4.5 percent compared to the same period of the previous year and amounted to AMD 2 trillion 433 billion. Transactions involving securities trades constituted 25.4 percent of the above said operations, which represents a 9.1 pp increase in relation to the same period of the previous year.

In 2012 the government securities market liquidity²⁵ performed in a less volatile manner. However, the liquidity indicator trended more volatile in the second half of the year. So, the standard deviation of the government securities market liquidity reached 2.7 versus 3.0 recorded in the same period of the previous year.

The share of trades in long-term and medium-term securities amounted to 44.5 percent and 42.9 percent, respectively, of total transactions involving government securities trades. The share of short-term securities made up 12.6 percent.

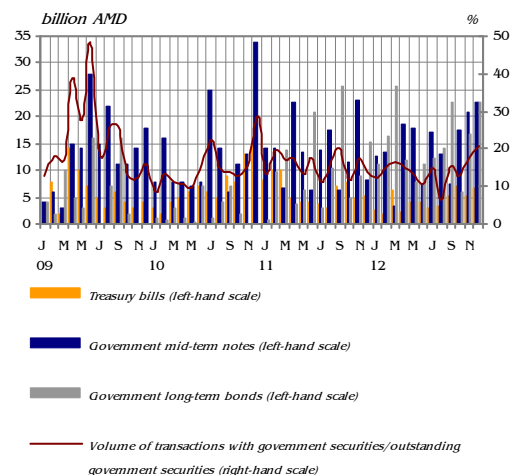
In 2012, relative to 2011, the volume of repo transactions (excluding operations with the Central Bank) carried out by investment service providers has reduced by 7.0 percent and amounted to AMD 1 trillion 813 billion. Again, operations with government securities accounted for the largest share, 98.6 percent, of repo transactions. Repo transactions with corporate bonds constituted 1.3 percent total transactions executed.

In 2012 the total volume of securities trades and repo operations in regulated market amounted to AMD 5.9 billion, with repo operations accounting for 15.7 percent in total.

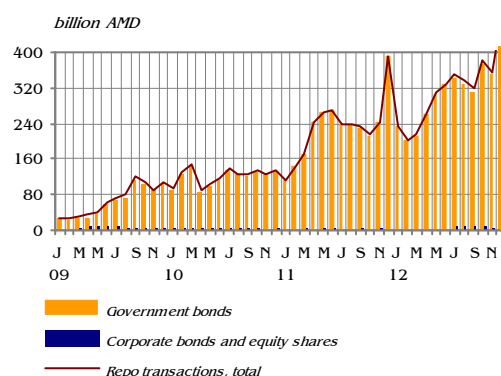
Investment service providers' share of transactions on securities trades in the regulated market is still small, a mere 0.8 percent, which limits the influence of operational risks in the regulated market on financial stability. In the reporting period, the structure of transactions with securities trades in

Securities trades by investment service providers has increased but repo operations contracted

Volume of transactions with government securities and volume of transactions with government securities / outstanding government securities ratio



Repo transactions by investment service providers



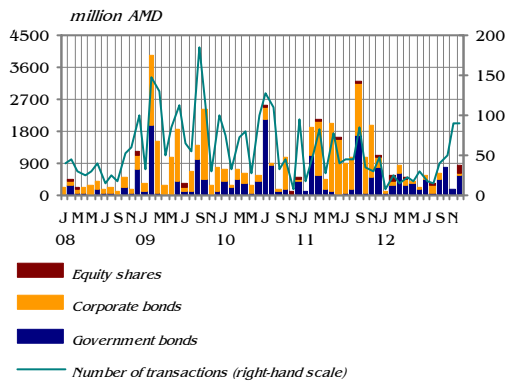
Source: Central Bank of Armenia.

In the regulated market the volumes of repo operations have decreased

²⁴ As of 31.12.2012, investment service providers included 22 commercial banks and 9 investment companies.

²⁵ The liquidity of government securities market is calculated as ratio between an amount of monthly trade transactions executed by investment service providers in the secondary market of government bonds and an amount of government bonds outstanding.

Securities trades at regulated market of securities



In 2012 concentration of reporting issuers by capitalization has reduced

the regulated market was as follows: the share of transactions with government securities accounted for 70.3 percent in total stock exchange turnover; the transactions with corporate bonds and with equity shares constituted 21.8 percent and 7.9 percent, respectively.

In 2012 the securities market gross turnover to GDP ratio²⁶ reached 15.4 percent compared to the previous year's respective ratio of 9.9 percent. The securities market capitalization to GDP ratio²⁷ was 1.3 percent, dropped by 0.1 pp against the previous year, which was due to reduced capitalization at one of the lead issuers on the regulated market. As of December 31, 2012, the ratio of concentration by capitalization with leaders out of 14 reporting issuers admitted to trading on a regulated market was on a downward path.

The 3 and 5 largest share issuer concentration by capitalization, 2008 - 2012(%)

Period	Capitalization at the 3 largest companies (%)	Capitalization at the 5 largest companies (%)
31.12.2008	89.2	99.2
31.12.2009	83.7	98.2
31.12.2010	80.1	94.7
31.12.2011	83.8	96.6
31.12.2012	78.8	96.2

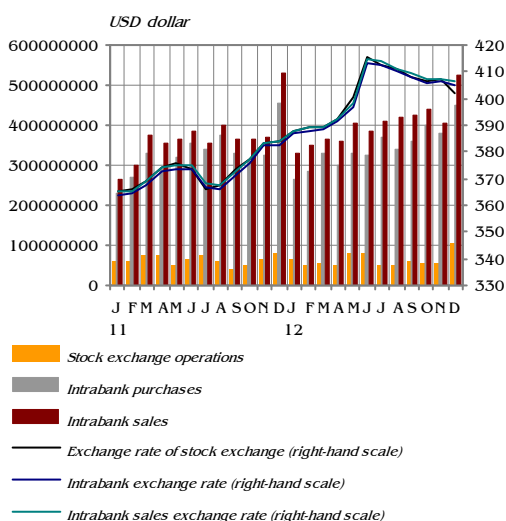
3.2. FOREIGN EXCHANGE MARKET

In the domestic foreign exchange market in 2012 the Armenian dram tended to depreciate. The average market exchange rate of AMD to USD was 401.8, depreciating by 7.3 percent against the previous year. The average market exchange rates of AMD to EUR was 516.4, appreciating by 0.5 percent; and the exchange rate of AMD to RUB was 12.9, depreciating by 1.9 percent.

In 2012 the average nominal effective exchange rate has depreciated by 2.8 percent and real effective exchange rate, by 4.1 percent, in relation to the previous year²⁸.

The volume of stock market turnover in the foreign exchange market in yearly terms have not changed much,

Volumes of operations in Armenian foreign exchange market and exchange rates



Source: Central Bank of Armenia.

²⁶ The ratio of aggregate securities trades by investment service providers to GDP.

²⁷ The ratio of market price of listed securities to GDP.

²⁸ When reviewing the dram exchange rate behavior as well as Armenia's competitiveness in external sector, the nominal effective exchange rate and real effective exchange rate are also considered and shall be computed using the weights the main 12 trade partners to Armenia (Eurozone, Russia, Ukraine, South Korea, Bulgaria, Switzerland, Iran, the USA, Turkey, Georgia, Japan and China) have in foreign trade turnover.

and averaged around USD 126 million. Gain of the banking sector from foreign exchange transactions during the year amounted to AMD 14.6 billion.

SUMMARY

In a low inflationary environment, the Central Bank has left the refinancing rate unchanged in the course of the first half of 2012. In the second half, given the rise in food prices, the Central Bank continued implementing a neutral monetary policy, again without having to change the policy rate.

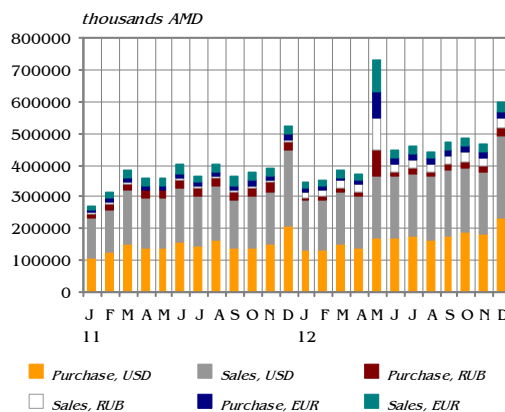
The interbank money market demonstrated sufficient activity during the year.

Transactions with government bonds prevailed in trades with securities and repo transactions by investment service providers and the transactions on regulated market.

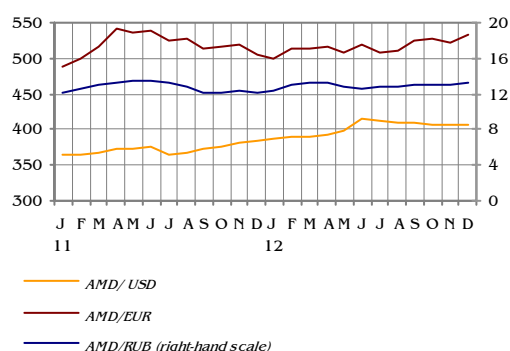
The developments in the domestic foreign exchange market were mainly on a depreciation path, with the annual average market exchange rate having depreciated by 7.30 percent to AMD 401.77.

Despite the reported growth and reduced volatility in the financial market of Armenia, the choice of market tools remains limited while capitalization and integration to global markets low. In 2012 the developments in the financial markets did not have a material impact on financial stability.

Transactions at exchange market by currencies



Exchange rates in exchange market of Armenia

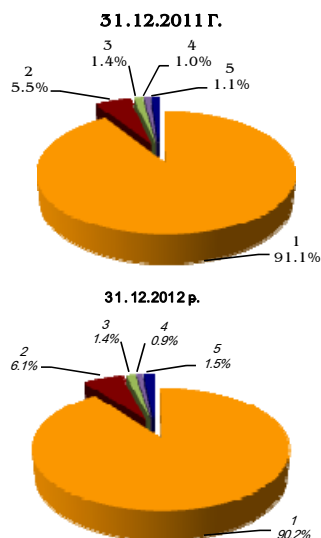


Source: Central Bank of Armenia.

4. FINANCIAL INSTITUTION STABILITY IN ARMENIA

Banking institutions remain prevailing in the financial sector

Financial system assets, by financial institutions



1. Banks, 2. Credit organizations, 3. Insurance companies, 4. Investment service providers, 5. Other financial institutions

Source: Central Bank of Armenia.

The financial system assets to GDP ratio has increased by 8.7 pp to 68.7 percent. The Armenian banking system²⁹ holds 90.2 percent of the financial system assets. Therefore, from the financial stability point of view, assessing and disclosing risks pertaining to the banking activities is rather important. Insurance companies, securities market participants and other financial organizations are small enough in comparison with the banking system, so their potential impact on financial stability in Armenian financial system is estimated to be minor.

During 2012 banks were highly active in the credit market owing to continued recovery in the real sector of the economy and increased remittances. Measures by the Government to stimulate lending to companies as well as international credit disbursement projects all promoted active lending.

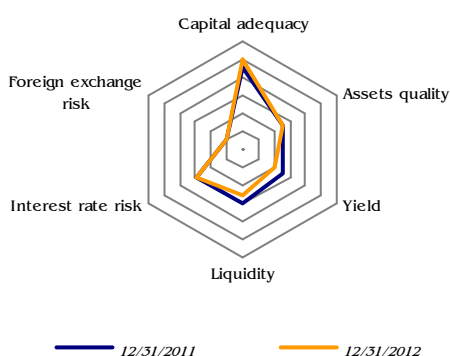
In the reporting period banks further branched out, broadened the spectrum of services by providing more quality services. These developments helped to increase accessibility to banking products and improve banking culture. The increase in demand for insurance services rendered facilitated the growth of that sector.

4.1. COMMERCIAL BANKS

Banking System Stability Map

A banking system stability map³⁰ has been designed to illustrate the behavior of the banking system stability. It denotes how values in the set of indicators of banking risks have changed relative to previous periods.

Banking system stability map



In the stability map in the fourth quarter 2012, relative to the previous year's fourth quarter, no significant shifts have taken place: there were some positive shifts in earnings and liquidity ratios and some minor alterations in the capital adequacy ratio, mostly owing to increased volumes of lending (see details in subsections *Credit risk*, *Liquidity risk*, *Market risk*, *Capital adequacy* and *Earnings*).

²⁹ This refers to the 21 commercial banks functioning in Armenia.

³⁰ The banking system stability map contains indicators denoting capital adequacy, assets quality, liquidity, profitability, interest rate risk and foreign exchange risk. Before usage, these indicators were measured on a 1 to 10 scale basis and calculated in accordance with the IMF methodology. On the map, note that away from the center signifies higher risks, and nearer to the center signifies lower risks. The banking system stability map shall not be interpreted as an eventual reflection of the level of financial stability, rather it provides a picture whether the level of risks involved has increased or decreased.

4.1.1. Financial intermediation; concentration

Over 2012 a rapid growth of the banking system assets has been reported in line with the nominal GDP growth, thus pushing the banking system assets to GDP ratio up by 8.1 pp to have reached 62.2 percent at the end of the year. Similarly, the banking system loans to GDP ratio has increased by 7.1 pp and amounted to 38.6 percent.

The bank-attracted deposits to GDP ratio has also increased, by 3.9 pp, and reached 28.4 percent at the end of the year, and the broad money to GDP ratio has grown by 4.2 percent and made up 33.8 percent at the end of the year.

Although in the period 2006-2012 the financial intermediation has grown, the current level of financial intermediation remains below the levels reported in banking systems of countries in Eastern Europe.

Relative to the start of the year, the share of non-resident participation in the statutory capital of the banking sector has grown by 0.7 pp to 73.3 percent at the end of the year. The growth was mainly attributable to two banks which had added to their statutory capital a total of AMD 9 billion from external sources.

During the year total capital of the banking sector has grown by 10.3 percent (AMD 37.6 billion); and total assets, by 19.5 percent (AMD 403.9 billion). The capital to assets ratio (the leverage ratio) has dropped by 1.3 pp to 16.2 percent.

The Herfindahl-Hirschman Concentration Index

Indicators	31.12.09	31.12.10	31.12.11	31.12.12
Total assets	0.0701	0.0670	0.0671	0.0683
Total liabilities	0.0748	0.0787	0.0692	0.0705
Total capital	0.0617	0.0646	0.0622	0.0618

Source: Central Bank of Armenia.

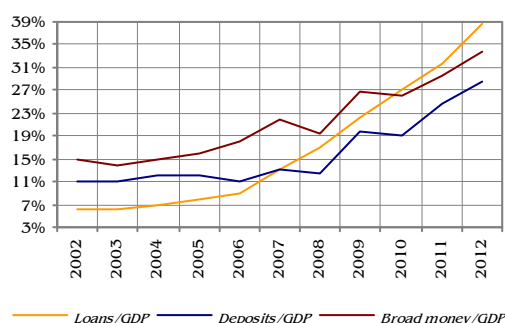
The Herfindahl-Hirschman Index of Concentration³¹ for some balance sheet items (assets, liabilities, capital, loans, and deposits) of the banking system signifies a low level of system concentration, which limits the likelihood of the impact of risk concentration on the financial stability.

Relative to the beginning of the year, the share of assets and liabilities of 4 largest banks out of 22 in Armenia has increased by 1.7 pp and 1.9 pp to have reached 39.3

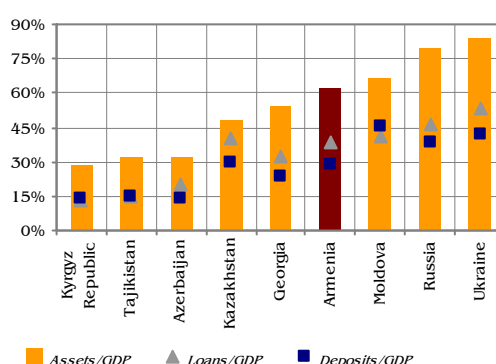
³¹ The Herfindahl-Hirschman Concentration Index varies between 0 and 1, characterizing the level of concentration (values near to 0 denote lower concentration).

Financial intermediation kept on strengthening

Financial intermediation

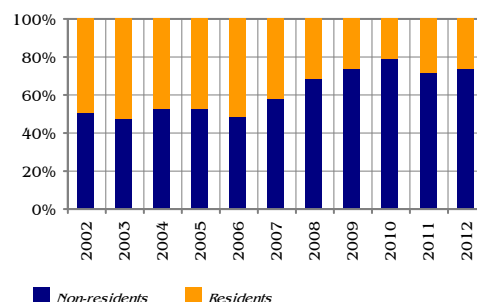


Banking Intermediation in 2012



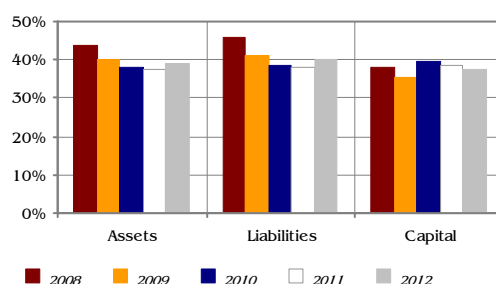
Source: national (central) banks and national statistics services.

Foreign participation in Armenia's banking capital



Source: Central Bank of Armenia.

Share of 4 largest bank assets, liabilities and capital in total banking system



Source: Central Bank of Armenia.

percent and 39.9 percent, respectively, at the end of the reporting period. Contrariwise, the share of capital of these 4 largest banks has contracted by 0.2 pp to 37.3 percent.

4.1.2. Credit risk

In 2012 loans provided to the economy³² grew by 26.9 percent and amounted to AMD 1 trillion 536.3 billion (38.6 of GDP) at the end of the year. Compared with other countries, the growth of loans in Armenia is similar to Georgia, Russia, Kazakhstan (Chart “Annual growth of credit investments”).

During the year the growth rate of lending outpaced the growth rate of total assets by 7.4 pp. As a result, the share of loans in total assets has increased by 3.6 pp to 62.0 percent at the end of the year.

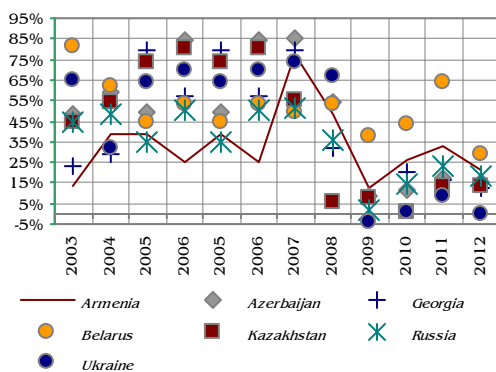
Relative to the beginning of the year, the share of non-performing loans (classified as “watched”, “substandard”, and “doubtful”) has grown by 0.2 pp and constituted 3.5 percent of total loan portfolio. Compared with other countries, the share of non-performing loans lags behind the respective indicators reported in Russia, Ukraine, Kazakhstan and Belarus. In terms of sectoral distribution of credit investments, the share of non-performing assets was relatively high among loans provided to catering and other areas of service, transport and communications, as well as agriculture, having reached 6.1 percent, 5.5 percent and 5.3 percent, respectively.

As calculated by the IMF methodology³³, the share of non-performing loans and receivables in total has grown by 1.3 pp and amounted to 6.1 percent at the end of the year.

In 2012 commercial banks were again active in lending to companies: the share of loans granted to them in the total loan portfolio has increased by 0.7 pp. As a result, by the end of this year, the share of loans to companies and natural persons has been 60.7 percent and 39.3 percent, respectively.

In the reporting period the economy saw loan investment growing in all sectors, except for loans provided to *financial services* and *communications* sub-sector (with loan investment reduced by 14.8 percent and 6.8 percent, respectively). Largest increases were reported in industry, consumer and catering services loan portfolios, by 39.1 percent, 35.9 percent and 32.9 percent, respectively. It

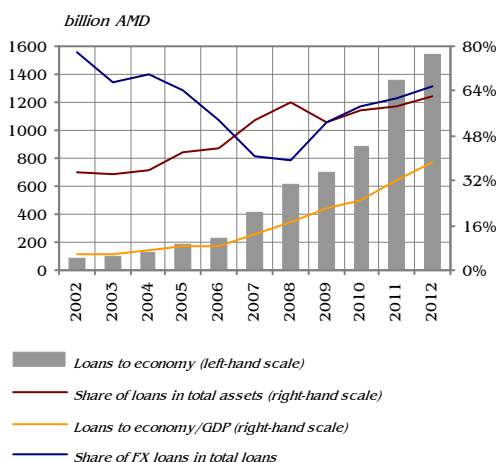
Annual growth of loan portfolio



Source: IMF.

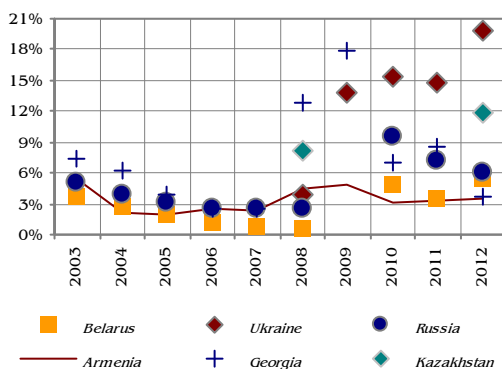
Loan investment trended upward whilst no change has been reported in the loan portfolio in terms of quality

Volume of loans to the economy



Source: Central Bank of Armenia.

Share of non-performing loans in total loan portfolio



Source: IMF.

³² Loans provided to resident and non-resident sectors are inclusive.

³³ According to the IMF methodology, the share of non-performing loans in total loan portfolio is calculated as the ratio of loans classified as “watched”, “substandard”, and “doubtful” to total loans.

should be noted that since 2007 there has been a trend of continuous growth in the share of loans to the industry. In the total loan portfolio, *industry, trade* and *consumer* loans again held large shares, 23.4 percent, 20.1 percent and 18.5 percent, respectively.

As of end-year, as loan investments by the sectors of economy demonstrate, the Herfindahl-Hirschman Concentration Index remained the same, 0.11, which points to the moderate concentration of loans. That indicator based on banks' average was again 0.16, reducing just a notch of 0.01, which is an evidence of high sectoral concentration of loans provided by some banks.

In total loan portfolio, the share of loans made to large borrowers remained unchanged, 25.3 percent, at the end of the year.

In 2012, relative to 2011, the ratio of net provisioning against assets losses to total assets and average total assets has fallen by 0.2 pp to make up 0.9 percent.

The results of credit risk stress-scenarios³⁵ show that potential loss of the banking sector has increased to a certain extent compared to the results of the same scenarios at the start of the year, which is mainly determined by faster growing credit portfolio over regulatory total capital of the banking sector.

Credit risk stress-scenarios³⁶

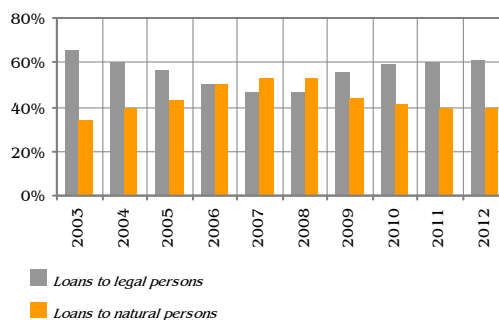
31.12.2012 Դ.	Stress scenarios		
	25 percent of loans in watching, substandard and doubtful categories classified into loss loans	75 percent of loans in doubtful category classified into loss loans	30 percent of loans in standard category classified into watching loans
Loss of the banking system	AMD 10.9 billion or 3.0 percent of regulatory capital of the banking system	AMD 4.1 billion or 1.1 percent of regulatory capital of the banking system	AMD 48.1 billion or 13.0 percent of regulatory capital of the banking system
Total capital adequacy of the banking system in case of stress scenario	16.3%	16.6%	14.9%

In a stress scenario on 30 percent of standard loans classified as "watched", there is violation of the capital adequacy ratio reported with some banks. However,

³⁵ Stress-scenarios are built on an assumption of unchanged bank loan volumes and ignoring of property pledges, whereby loans categorized as 'loss' will not lead to the possibility to sell off the real property pledged.

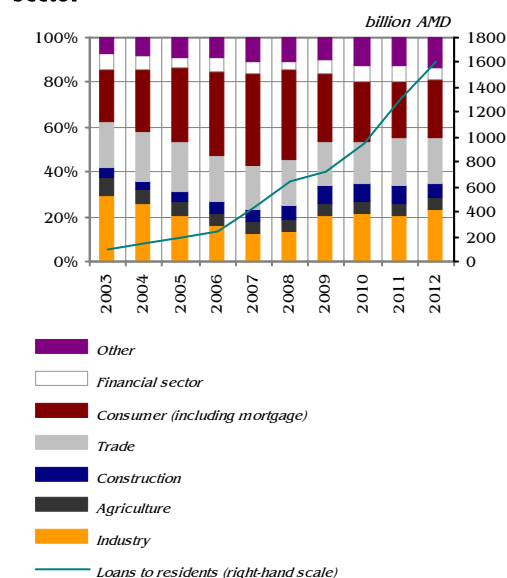
³⁶ This stress-scenario and the other ones following are not prepared to forecast emergence of any risks, but rather aim to reveal the weaknesses of the financial system, as well as assess its ability to absorb such risks.

Share of loans to natural persons and legal persons in total loan portfolio



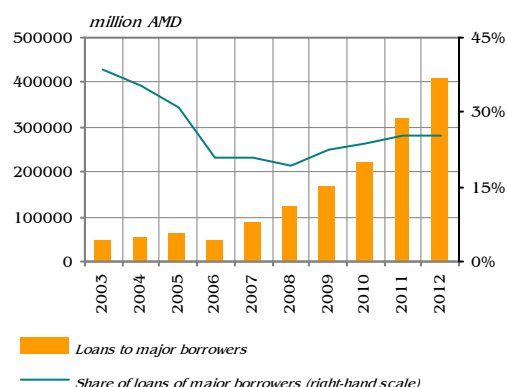
Source: Central Bank of Armenia.

Balance of bank loans to residents, by sector



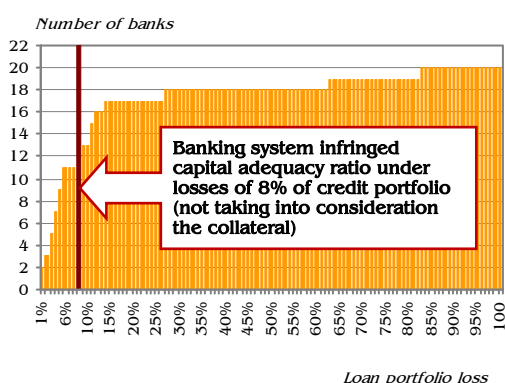
Source: Central Bank of Armenia.

Loans to major borrowers to total loans



Source: Central Bank of Armenia.

Change in the number of banks infringed capital adequacy ratio under dynamic growth of loan losses



indicators of capital adequacy of banks significantly exceed the threshold set by the Basel Committee on Banking Supervision (8%). Thus, although the credit risk remains a major risk to financial stability, the likelihood of problems with solvency because of the possible loss to the credit risk is too small.

Stress-scenario of credit risk derived from off-balance sheet contingent liabilities

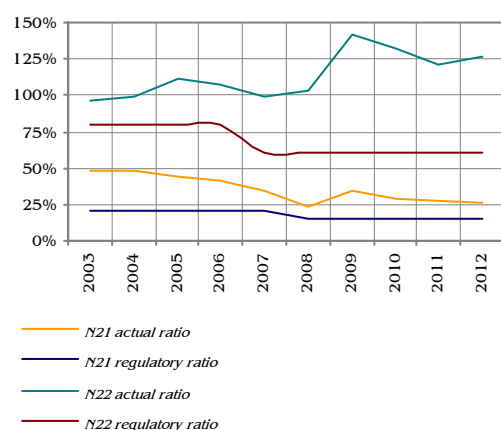
31.12.2012	Stress scenarios
	When 50 percent of off-balance sheet contingent liabilities performed
Banking system total capital adequacy before stress-scenario	16.8%
Banking system total capital adequacy in case of stress scenario	16.5%

As the results of this scenario³⁷ show no bank will be in breach of the capital adequacy requirement, meaning that the credit risk deriving from performance of off balance sheet contingent liabilities is manageable and is estimated to have a negligible impact on financial stability.

4.1.3. Liquidity risk

Liquidity has contracted as banks were active in lending

Actual and regulatory banking system liquidity ratio dynamics



Source: Central Bank of Armenia.

In 2012 the banking system liquidity trended down in spite of fast growing rate of loans provided by the banking sector. During the year, however, the level of liquidity has been almost twice as high the minimum prudential requirement. Relative to the beginning of the year, the prudential ratios of total liquidity and current liquidity have amounted to 25.6 percent and 126.1 percent, with the former reduced by 2.4 pp and the latter grown by 5.3 pp, respectively³⁸.

In terms of duration gaps in assets and liabilities by maturity, there has been a considerable negative gap reported only in regard to the 181-365-day segment, which made up 71.0 percent. However, given the length of the maturity of 181-365 days, one may conclude that this period is sufficient for the banks to ensure that they are able to cover the gap. In other segments (up to 180 days (demand), 1-3-year and 3-year and over) the duration gap amounted to 98.4 percent, 156.7 percent and 172.2 percent, respectively. The ratio of assets and liabilities maturity of 180 days (including demand resources) is very important as it most

³⁷ Post balance sheet contingent liabilities include unused part of lines of credit, credit cards, overdrafts, L/Cs, guaranties and sureties.

³⁸ The prudential standard of total liquidity is calculated as a ratio of high liquid assets to total assets while the prudential standard of current liquidity, as a ratio of high liquid assets to demand liabilities; the minimum prudential requirement of these standards are, respectively, 15 percent and 60 percent.

clearly describes the level of current liquidity management by banks.

The assets and liabilities maturity in up to 180-day (including demand resources) segment has historically been in the region 90-98 percent, which points to the proper liquidity management.

On part of the concentration of credit commitments in the banking system one may see that the risks have reduced: compared with the beginning of the year, the share of large liabilities³⁹ in total liabilities has decreased by 1.1 pp, reaching 26.2 percent at the end of the year.

Foreign borrowings of commercial banks have grown by 46.7 percent. Funds attracted from international financial institutions have increased by 44.3 percent and accounted for 36.8 percent of total foreign borrowings.

The main lender countries to commercial banks included Russia (28.2 percent), Netherlands (6.7 percent), Luxemburg (6.3 percent), Germany (5.8 percent), Kazakhstan (2.9 percent), and U.S.A. (2.6 percent). The share of long-term liabilities is 89.1 percent, which almost rules out the likelihood of emergence of risks associated with the refinancing of these commitments.

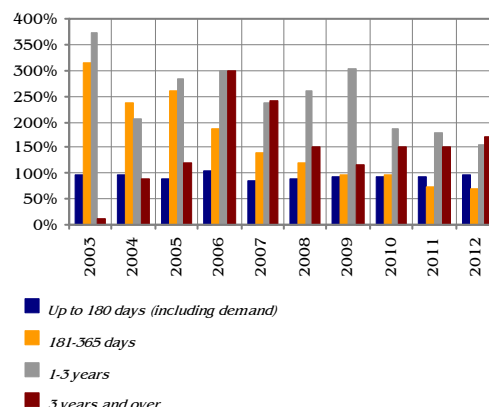
Liquidity risk stress-scenarios

31.12.2012	Stress scenarios		
	Repayment of 25 percent of time deposits of natural persons	Repayment of 25 percent of demand liabilities	Repayment of 25 percent of demand liabilities and repayment of 25 percent of time deposits of natural persons
Ratio of high liquid assets to total assets of the banking system	20.2%	21.6%	15.6%
Ratio of high liquid assets to demand liabilities of the banking system	92.8%	134.5%	90.4%

In case of worst possible stress-scenarios (immediate pay-off of 25 percent of demand deposits and 25 percent of time deposits of individuals) when total and current liquidity ratios of the banking sector make up, respectively, 15.6 percent (versus the required minimum of 15 percent) and 90.4 percent (versus the required minimum of 60 percent), some banks will report infringed total and current liquidity ratios. However, high liquid assets of such banks are well sufficient to cover outflow of liabilities.

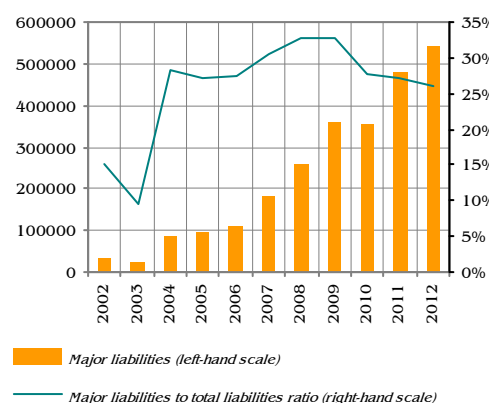
³⁹ This represents the sum of all liabilities, which individually exceed the 5 percent margin of total liabilities of the bank, without taking affiliation into account.

Assets to liabilities ratio by maturity baskets



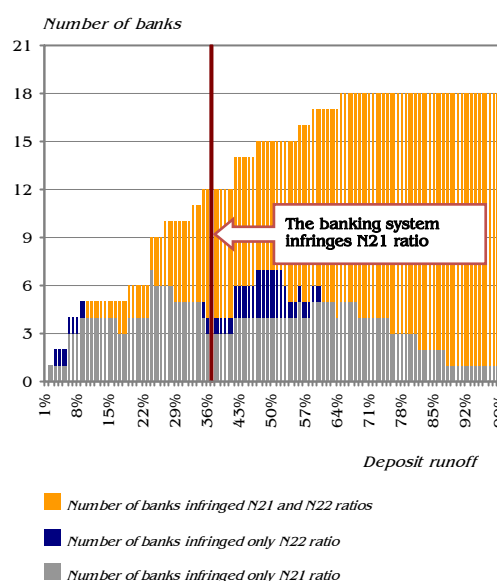
Source: Central Bank of Armenia.

Major liabilities to total liabilities ratio in the banking system



Source: Central Bank of Armenia.

The number of banks in breach of total liquidity requirement in case of household deposit runoff



Source: Central Bank of Armenia.

Stress-scenario of liquidity risk derived from off-balance sheet contingent liabilities

31.12.2012	Stress scenarios
	When 50 percent of off-balance sheet contingent liabilities performed
Banking system high liquid assets to total assets ratio	22.1%
Banking system high liquid assets to total demand liabilities ratio	108.7%

According to the results of stress testing to assess the risk of liquidity derived from performance of off-balance sheet contingent liabilities, some banks will report violation of total and current liquidity ratios. However, the ratios are close to the thresholds. In this context, in terms of financial stability, the likelihood of problems with liquidity remains low.

4.1.4. Market risks

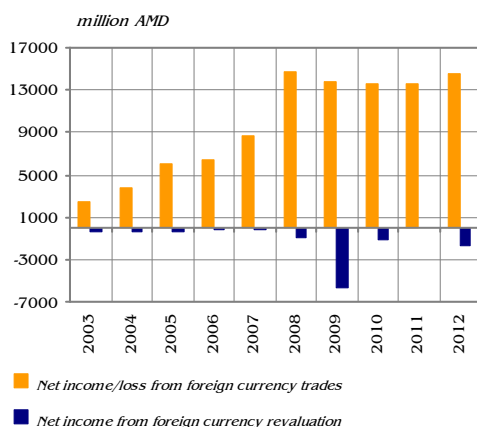
Foreign exchange risk

In 2012 the Dram fluctuations against other currencies led to a situation where the banking system incurred revaluation losses amounting to AMD 1.7 billion. As a result of foreign currency revaluation, 15 banks incurred losses and 7 banks reported profit. The banking system generated net revenue of AMD 14.6 billion from foreign exchange transactions.

Relative to the start of the year, the share of foreign currency loans in total loans and the share of foreign currency deposits in total deposits have grown by 2.9 percent and 1.6 percent to have constituted 65.6 percent and 70.3 percent, respectively, at the end of the year.

At the end of the reporting period commercial banks' net position (inclusive of derivative instruments) of foreign currencies has been a positive value of AMD 3.4 billion or 0.9 percent of regulatory capital (as of 31.12.2011 it has been a negative value of AMD 3.1 billion or 0.9 percent of regulatory capital).

Net income of the banking system from foreign currency trades and revaluation



Source: Central Bank of Armenia.

Foreign exchange risk stress-scenarios

31.12.2012	Stress scenarios		
	AMD/USD appreciation (depreciation) by 1%	AMD/EUR appreciation (depreciation) by 1%	Possible maximum annual loss estimated through VaR Model
Banking system's profit/loss from foreign currency revaluation	AMD 10.6 million or 0.003% of regulatory capital (AMD 10.6 million)	AMD 1.4 million or 0.0004% of regulatory capital (AMD 1.4 million)	AMD 162.3 million or 0.04% of regulatory capital

In case of worst possible stress scenarios reviewed in this stress-test⁴⁰, bank losses incurred as a result of foreign exchange risk are estimated to be insignificant, so the impact of such losses on the financial stability is weak.

Interest rate risk

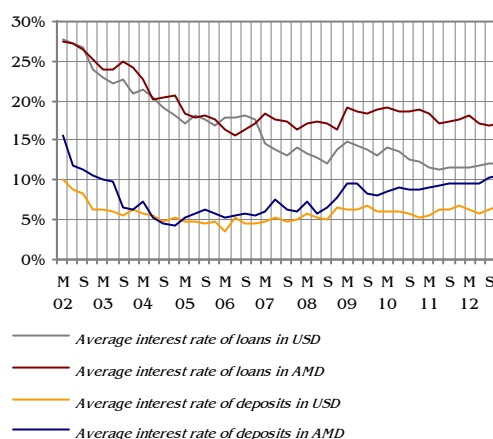
There has been a reported decline in interest rates⁴¹ of both dram and foreign currency loans. Especially pronounced was the drop in interest rates of foreign currency loans. Whereas in the reporting period the average weighted monthly nominal interest rate of dram loans has decreased by 0.2 pp, the average monthly weighted nominal interest rate of foreign currency loans has dropped by 0.4 pp. Such interest rate falls were also fuelled by an increased competition among bigger banks, leading to the narrowing of the interest rate spread.

The gap of average weighted duration of present value of assets and liabilities is nearly filled, reaching merely one month. This means that possible fluctuations in market rates will not entail major losses in the banking system during 2013.

Interest rate risk stress-scenarios

31.12.2012	Impact of 2 pp increase (decrease) of market interest rates on total portfolio, estimated through the "Duration Method"	Where market interest rates decrease (increase) by 2 pp, there will be deviation of net interest income from expected income of the three months ahead, estimated through the "Gap Method" (a method of interest rate-sensitive assets and liabilities gap)
Banking system's profit/loss	AMD 275.2 million or 0.1 percent of banking system capital (AMD -275.2 million or 0.1 percent of banking system capital)	AMD 221.1 million or 0.1 percent of banking system capital (AMD -221.1 million or 0.1 percent of banking system capital)

Average interest rates of bank deposits and loans



Source: Central Bank of Armenia.

The duration gap of the present value of the banking system's assets and liabilities is almost sheltered as it is in the range of six months. This means in 2013 market interest rate volatility will not cause major damage to the banking sector.

In case of worst possible stress scenarios, possible losses of banks from interest rate fluctuation are in the region of 2.5 percent of capital. So, commercial banks' losses as a result of interest rate fluctuation will neither be significant nor leave the system vulnerable to financial stability.

⁴⁰ The calculation of losses estimated through stress-scenarios and the VaR Model (the VaR Model is not considered as a stress-scenario since the calculation of the model takes historical exchange rate series of currencies) is based on FX positions of commercial banks as of 31.12.2012.

⁴¹ Average monthly weighted nominal interest rates on deposits and loans are calculated as the arithmetic mean of the values of the weighted interest rate based on the months of the year.

Price risk

Relative to the beginning of the year, the share of available-for-sale and trading securities in total assets has fallen by 1.3 pp to reach 4.9 percent at the end of the year. Under such conditions, the price risk in the banking sector is estimated rather low.

Risks associated with real estate price volatility remained within a comfortable territory of manageability. Armenian commercial banks further originated mortgages at no more than 60-80 percent of the loan to value ratio while taking quite a strict approach in evaluating borrower credibility. Such restrictions are very instrumental as they hold back potential risks from real estate price volatilities.

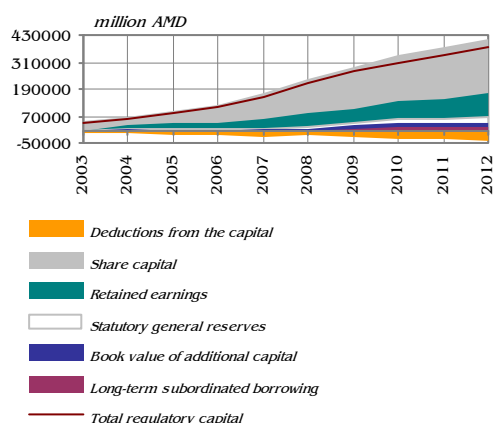
In case possible stress scenarios for a 30 percent devaluation of real estate price emerge, potential maximum commercial bank losses will trend upward, which will be mainly attributable to mortgage lending rate growing faster over that of the regulatory capital. However, real estate price volatility is not high and credit risk and price risk exposures to financial stability non-vulnerable.

Real estate price change stress-scenarios

30 percent depreciation of real estate	31.12.2012
The banking system's loss due to revaluation of own property (price risk)	AMD 10.3 billion (or 2.8 percent of banking system capital)
The banking system's loss due to a 30 percent loss of vulnerable credit portfolio ⁴² (taking into consideration that the collateral involved has been sold at a depreciated cost), if a stress-scenario occurs (credit risk)	AMD 3.8 billion (or 1.0 percent of banking system capital)
The banking system's loss due to a 100 percent loss of vulnerable credit portfolio (taking into consideration that the collateral involved has been sold at a depreciated cost), if a stress-scenario occurs (credit risk)	AMD 12.7 billion (or 3.4 percent of banking system capital)

The capital adequacy of the banking system remains satisfactory

The structure of total regulatory capital



4.1.5. Capital adequacy and profitability

In 2012 the capital adequacy ratio of banks fell by 1.5 pp to 16.8 percent at the end of the year (the required minimum value, 12.0 percent), due mainly to active credit policy of banks.

In recent years, as a result of active credit policy, the regulatory capital adequacy ratio of commercial banks showed a declining trend. The capital adequacy and profitability indicators of the Armenian banking system are well above the minimum requirement, which enables banks to provide a cushion for absorbing risks at their own expense.

⁴² A vulnerable loan portfolio represents the sum of loans outstanding, the residual values of which exceed the 30% devaluated values of the real estate used as collateral.

In 2012 total regulatory capital of the banking sector has grown by 8.8 percent and reached AMD 368.6 billion at the end of the year. Even though the share of regulatory core capital in total regulatory capital has reduced by 0.8 pp, it is still high enough, constituting 90.3 percent. This points to the strong ability of banks to absorb risks associated with the total regulatory capital.

Dynamic credit policy implementation as well as relatively high quality loan portfolio enabled banks to generate sufficient levels of profitability. In 2012 the net profit of the banking system, calculated in accordance with the Central Bank requirements⁴³, amounted to AMD 42.2 billion. During the year, 18 banks operated at a profit and 4 banks at a loss.

Compared with the previous year, return on assets (RoA) and return on equity (RoE) of the banking system have increased by 0.1 pp and 1.4 pp and amounted to 1.9 percent and 11.2 percent, respectively. Profitability of the banking system of Armenia is very close to those of the CIS countries and a number of Eastern European countries.

In 2012, relative 2011, gross revenues of the banking system have grown by 41.0 percent and reached AMD 412.2 billion and gross expenditures have grown by 43.4 percent and amounted to AMD 357.6 billion. In the structure of banks' income, the share of interest and non-interest income has reduced in relation to the previous year by 5.3 pp and 2.9 pp, respectively, while the share of recoveries to assets loss reserves has grown by 8.2 pp.

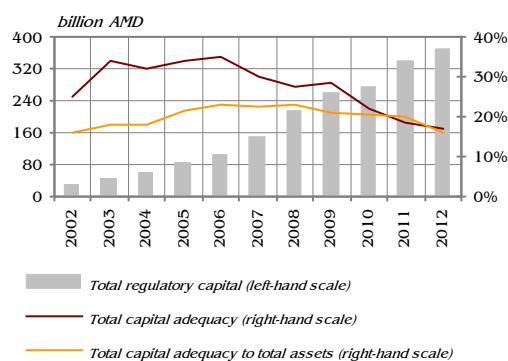
In the structure of expenditures, the share of interest and non-interest expense has reduced by 1.6 pp and 5.6 pp, respectively, and the share of allocations to reserves for losses on assets increased by 7.2 pp. In 2012 the profit of the banking system, calculated in accordance with IFRS, amounted to AMD 42.5 billion, while the return on assets (ROA) was 1.9 percent and return on equity (ROE), 10.8 percent.

4.2. CREDIT ORGANIZATIONS

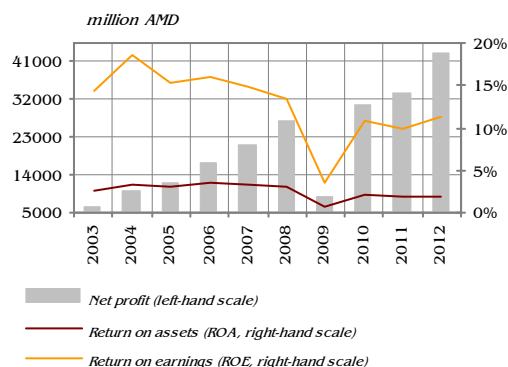
Assets of credit organizations – the second largest sector of Armenia's financial system – constituted about 6.4 percent of the entire financial system assets. In the period under review, credit organizations generated growth of assets, liabilities and capital.

Compared to the commercial banks, capitalization and profitability of credit organizations is stronger, and according

Banking system capital adequacy

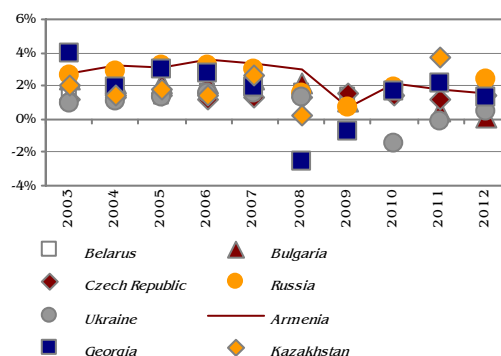


Profitability ratios in the banking system

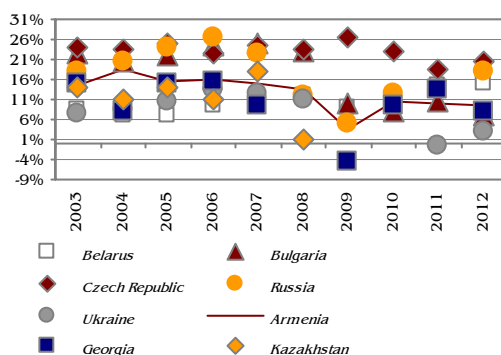


Source: Central Bank of Armenia.

Banking system RoA in selected East European and CIS countries



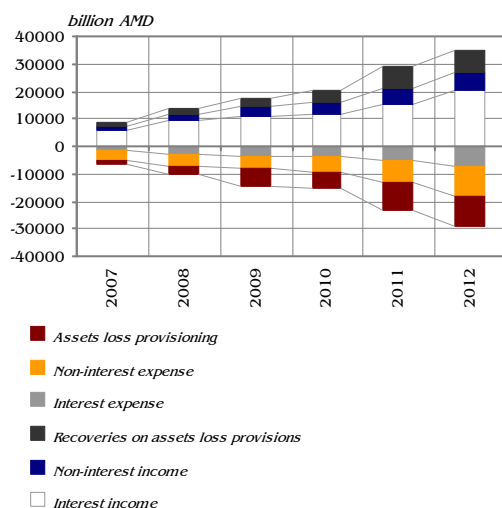
Banking system RoE in selected East European and CIS countries



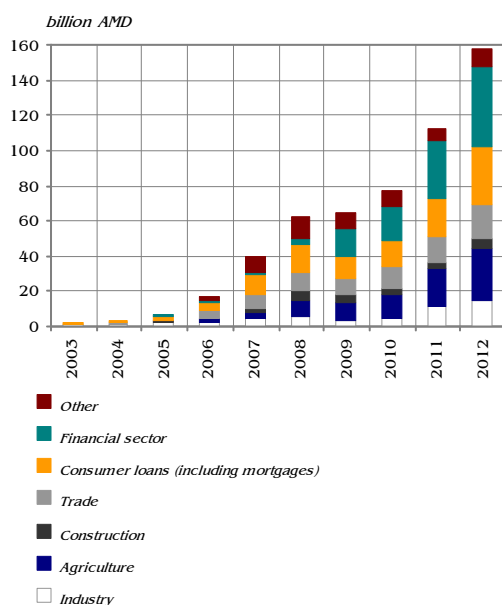
Source: IMF.

⁴³ This differs from IFRS mainly on the part of loan loss provisioning for standard assets.

Income and expense account of credit organizations



Balance of credit organization loans to residents, by sectors



Source: Central Bank of Armenia.

to various stress scenarios, they are fully capable to absorb possible risks. In the period under review the ratio of total capital to total assets (leverage ratio) of credit organizations has fallen by 0.5 pp to 37.0 percent.

Assets, liabilities, capital and profit of credit organizations

(thousand AMD)

Indicator	31.12.2011	31.12.2012	Growth (%)
Assets	123,850,974	168,530,773	36.1
Liabilities	77,006,457	105,653,830	37.2
Capital	46,844,518	62,877,084	34.2
Net profit	4,930,540	4,847,791	-1.7

Based on the 2012 results, 26 credit organizations posted profit and 6 posted loss. Such ratios as return on assets and return on equity of credit organizations calculated according to supervisory requirements of the Central Bank amounted to 3.3 percent and 8.8 percent, respectively (these figures in 2011 were 6.8 percent and 17.5 percent).

In 2012 profit of credit organizations calculated in accordance with IFRS has amounted to AMD 5.8 billion; in this case return on assets was 3.9 percent and return on equity, 10.5 percent.

The share of non-performing loans (classified as “watched”, “substandard”, and “doubtful”) of credit organizations has grown by 1.0 pp and reached 3.7 percent at the end of the reporting period. By sector lending, the share of non-performing loans is the highest in public catering (12.4 percent), transport and communications (8.3 percent), and construction loans (8.1 percent).

The share of non-performing loans (classified as “substandard”, “doubtful” and “loss”) calculated by the IMF methodology has grown by 1.0 pp relative to the start of the year and amounted to 4.9 percent at the end of the year.

Credit risk assessment scenarios⁴⁴

31.12.2012	Stress scenarios		
	25 percent of loans in watched, substandard and doubtful categories classified into loss loans	75 percent of loans in doubtful category classified into loss loans	30 percent of loans in standard category classified into watched loans
Total loss of credit organizations	AMD 1 billion or 1.6% of regulatory capital	AMD 320.4 million or 0.5% of regulatory capital	AMD 4.1 billion or 6.8% of regulatory capital

Source: Central bank of Armenia.

⁴⁴ Stress-scenarios are built on an assumption that the amounts of loans of credit organizations are unchanged and the secured property is ignored (which means that where loans are classified as loss, a possible sale of the collateral is not considered).

In 2012, relative to 2011, the ratio of net provisioning against assets loss to total assets has fallen by 0.6 pp and amounted to 1.4 percent.

In all maturity baskets of assets and liabilities (up to 180-day (including demand resources), from 180 days to one year, more than one year), the volumes of assets outstripped the volumes of liabilities, pointing out, other things being equal, to the low level of liquidity risk with credit organizations.

4.3. SECURITIES MARKET PARTICIPANTS

As of December 31, 2012, there were 22 banks providing investment services, 9 investment companies, and 1 investment fund manager operating in the Armenian securities market.

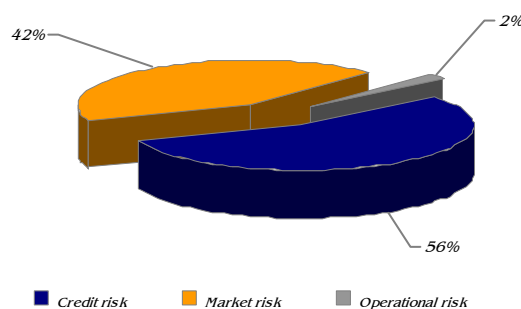
In 2012, relative to 2011, total assets of investment companies have grown by 8.2 percent and amounted to AMD 23.6 billion, and total capital has increased by 17.6 percent to AMD 3.8 billion. As of 31.12.2012, profit of investment companies has totaled AMD 349 million; 6 companies reported profit and 3 reported loss.

As of December 31, 2012, credit risk of investment companies accounted for 55 percent of risk weighted assets; market risk accounted for 42 percent; and operational risk, 2 percent. Remarkably, interest rate risk had the largest share in market risk (67 percent), while foreign exchange and share price risks of investment companies constituted, respectively, 30 percent and 2 percent.

At the end of the year, a total of 17 classes of securities of 14 reporting issuers were admitted to trading in the regulated market. Of these issuers, 4 were financial institutions accounting for 24 percent of equity shares. The total amount of shares admitted to trading in the regulated market was AMD 52.9 billion and the total amount of bonds, AMD 2.9 billion. One issuer is accountable on both shares and bonds.

As of the end of the year, there were 1681 companies running registries of nominal security holders at the Central Depository of Armenia (89 thousand people). Further, in addition to Central Depository of Armenia, two investment service providers in the securities market run registries of 408 companies with a total of 29435 persons involved as owners of registers.

Structure of assets included in capital adequacy ratio of investment companies, as of 31.12.2012

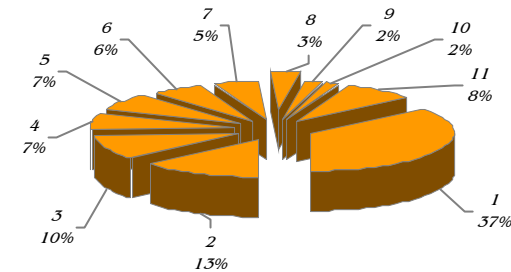


Source: Central Bank of Armenia.

4.4. INSURANCE COMPANIES

This year's growth was mainly determined by the introduction of the health insurance scheme as part of the social package

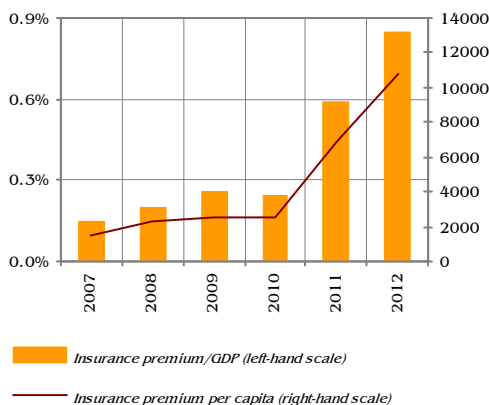
In surance sector assets, as of 31.12.2012



1. Deposits with banks, 2. Sums receivable from policyholders on direct insurance, 3. Government and non-government securities, 4. Fixed assets, 5. Costs for future periods and prepayments on insurance, 6. Securities sold under repo agreements, 7. Reinsurers' share in insurance reserves, 8. Bank accounts, 9. Loans, 10. Claims to reinsurers on compensation, 11. Other assets

Source: Central Bank of Armenia.

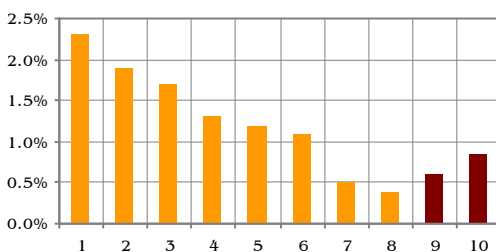
Main ratios of Armenian insurance sector



Source: Central Bank of Armenia.

The capital adequacy of insurance companies is well above the required threshold, so the sector is able to absorb potential risks

Insurance premium/GDP in EEC and CIS (2011)



1. Russia, 2. Ukraine, 3. Iran, 4. Georgia, 5. Rumania, 6. Turkey, 7. Kazakhstan, 8. Azerbaijan, 9. Armenia 2011, 10. Armenia 2012

Source: Central Bank of Armenia, Swiss Re, Sigma No 3/2012.

Over 2012 assets of insurance companies⁴⁵ have increased by 22.0 percent to AMD 38.4 billion at the end of the year; liabilities have grown by 40.9 percent to AMD 24.7 billion, whereas total capital has reduced by 1.7 percent and amounted to AMD 13.7 billion. The share of total assets of insurance companies in the financial sector has grown by 0.1 pp and reached 1.5 percent of the financial sector assets at the end of the year. Accrued premiums have grown by 58.8 percent to AMD 35.3 billion in 2012 (growth of this indicator in the previous year was 171.1 percent). Whereas the growth in the previous year was driven by third party liability motor insurance contracts, the growth this year was due mainly to the introduction of the system of health insurance as part of a social assistance package⁴⁶.

The premiums to GDP ratio⁴⁷, another key indicator for insurance companies, has increased by 0.26 pp relative to the end-year 2011 and amounted to 0.85 percent in December of 2012. The premium per capita ratio was AMD 10.8 thousand⁴⁸ versus AMD 6.8 thousand reported for December of 2011.

In 2012, relative to 2011, the loss ratio of insurance companies has increased by 2.8 pp to 59.2 percent⁴⁹. This has been concurrent with reducing costs ratio⁵⁰ of insurance companies as it had dropped by 3.8 pp and reached 32.3 percent at the end of the year, pointing to an increased operational effectiveness of insurance companies. Net profit, calculated according to supervisory reports, amounted to AMD 411.4 million. Return on assets (RoA) of the insurance system was 1.2 percent and return on equity (RoE), 3.0 percent.

The shares of 1/ risk-weighted assets in capital adequacy and 2/ required solvency of the insurance sector amounted to 36.0 percent and 64.0 percent, respectively. The capital adequacy ratio of the insurance sector was 131.3 percent, as

⁴⁵ Indicators of 7 insurance companies active and reportable have been summarized as of 21.12.2012.

⁴⁶ The system is designed for public servants of Armenia and so financed by the state. Health insurance as part of a package of social assistance allows employees of public institutions to receive a guaranteed free medical care under the program selected in any licensed medical facility in the Republic of Armenia and Nagorno-Karabakh.

⁴⁷ Based on the 2011 results, the premiums to GDP ratio on non-life assurance was 3.57 percent on average in developed countries and 1.30 percent in emerging countries (source: Swiss Re, Sigma No 3/2012, May 2012).

⁴⁸ According to the 2011 results, in the countries with advanced industry insurance premium per capita is on average USD 1,543 (AMD 595,436); in the developing countries it is USD 56 (AMD 27,719) (Source: Swiss Re, Sigma No 3/2012, May 2012).

⁴⁹ The loss ratio was calculated using the following formula: (net accrued indemnity + net provisions to technical reserves (except for unearned insurance premium reserves, UIPR) + other transaction costs on insurance) / (earned insurance premiums - sums refunded on the contracts terminated).

⁵⁰ The costs ratio was calculated using the following formula: non-interest expense / (earned insurance premiums - sums refunded on the contracts terminated).

of 31.12.2012, exceeding the required minimum value by 31.3 pp (marginal value of capital adequacy is 100 percent).

Solvency risk

Where stress-scenarios shown below unfold (10 percent rise in the indemnification rate and 5 percent rise in sums of compensation), level of solvency of insurance companies is estimated to not incur notable changes, so the likelihood of emergence of risks to the financial stability of insurance sector is very low.

Solvency assessment stress-scenarios

31.12.2012	Stress scenarios
	Growth of indemnity rates, 20 %, and price increases, 5 %
Required growth of UIPR of the insurance sector, if the stress-scenario occurs	AMD 0.7 billion or 5.5 % of regulatory capital of the sector
Total capital adequacy ratio of the insurance sector, if the stress-scenario occurs	124.1%

Source: Central Bank of Armenia.

Credit risk

Allocating funds of the insurance sector in low-risk assets allows keeping investment risk at a low level. Assets equivalent to technical reserves are invested primarily in time and demand deposits with commercial banks as well as government and non-government bonds.

The results of credit risk assessment stress-tests show that potential loss of the insurance sector is low.

Credit risk assessment stress-scenarios

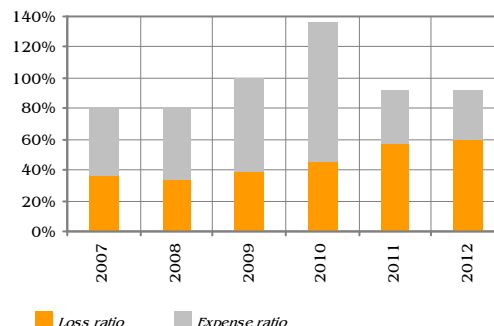
31.12.2012	Stress scenarios		
	Classifying 30 percent of "standard" assets into "watched" category	Classifying 10 percent of "standard" assets into "loss" category	Sharp increase of outstanding claims reserves, 50%
Loss of the insurance sector	AMD 0.7 billion or 5.1% of regulatory capital	AMD 1.3 billion or 9.3% of regulatory capital	AMD 0.7 billion or 4.8% of regulatory capital
The total capital adequacy ratio of the insurance sector, if the stress-scenario occurs	125.6%	120.8%	125.0%

Source: Central Bank of Armenia.

Foreign exchange risk

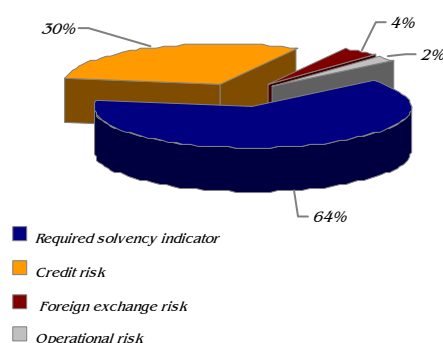
In case of worst stress-scenario, the loss of insurance companies incurred from foreign exchange risk is estimated to be insignificant.

Loss and expense ratios of insurance companies



Source: Central Bank of Armenia.

Risk weighted assets and required solvency in insurance sector capital adequacy ratio, as of 31.12.2012



Source: Central Bank of Armenia.

*Foreign exchange risk assessment stress-scenarios*⁵¹

31.12.2012	Stress scenarios		
	AMD appreciation/depreciation versus USD by 1% for gain/loss	AMD appreciation/depreciation versus USD by 1% for gain/loss	Maximum potential 10-day loss valued through a VaR method
Insurance sector's gain/loss in case of foreign exchange revaluation	AMD 30.5 million or 0.2% of regulatory capital (AMD -30.5 million)	AMD 1.1 million or 0.01% of regulatory capital (AMD -1.1 million)	AMD 41.9 million or 0.3% of regulatory capital

Source: Central Bank of Armenia.

Liquidity risk

The level of liquidity risk in the insurance sector is controllable, and this is supported by the results in the stress-scenario.

Liquidity risk assessment stress-scenario

31.12.2012	Stress-scenarios
	Sharp increase of outstanding claims reserves, 50%
Required growth of outstanding claims reserves when the stress-scenario occurs	AMD 0.7 billion or 4.8% of regulatory capital
Liquidity of insurance companies when the stress-scenario occurs	339.1%

Source: Central Bank of Armenia.

In general, though the mandatory car insurance scheme and health insurance as part of a package of social assistance have boosted up the insurance market in recent years, the total weight of the insurance market in the financial system remains small. In the meantime, however, insurance company risks are controllable and pose no threat to financial stability.

SUMMARY

In 2012 financial institutions of the Republic of Armenia were not bothered with patterns of unstable financial conditions. The banking sector that holds a prevailing part of the financial system has posted 27 percent growth in lending, which had a positive impact on both the profitability and growth of the real economy. It is noteworthy that, in the crisis aftermath, with an average of more than 20 percent annual growth rate of lending, no abrupt change in the quality of the loan portfolio has occurred. In the meantime, the capital adequacy and liquidity ratios remain above the required levels.

In the period under review insurance companies and credit organizations have seen their activities expand while prudential standards were well above the required minimum levels.

⁵¹ The calculation of losses estimated through stress-scenarios and the VaR Model (the VaR Model is not considered as a stress-scenario since the calculation of the model takes historical exchange rate series of currencies) makes an assumption that FX position of insurance companies would not change in a 10-day timespan.

5. FINANCIAL MARKET INFRASTRUCTURES STABILITY

Given the importance and impact of the Armenia's payment and settlement system on its monetary policy and financial stability⁵², the Central Bank further pays due attention to the country's systemically important payment and securities settlement systems and the telecommunication network supporting their activities.

In Armenia, most interbank settlements are made via the Central Bank systems⁵³. The largest value (over 99 percent) of interbank payments is made via the Central Bank systems.

5.1. INTERBANK PAYMENTS VIA ELECTRONIC PAYMENT SYSTEM OF CENTRAL BANK

In 2012 there were about 6 million payments, totaling AMD 7814.5 billion, executed via the Electronic Payment System of the Central Bank of the Republic of Armenia. This represented 8.4 percent and 52.7 percent increase by value and by number, respectively, compared with the previous year.

The EPS monitoring results suggest that the system is safe and reliable

The risks in the system are reviewed separately for each area described below.

Credit risk

Credit risk of the settlement bank (i.e. the Central Bank) in the system lacks since there is no mechanism in place to lend to system participants in case of insufficient funds. Nor is there credit risk to the recipient as it receives the notice of the payment only after the payment is made final and irrevocable⁵⁴.

No credit risk is reported in EPS

⁵² For details, see the "Financial Stability Report", 2007, and the paper "Payments and Securities Clearance and Settlement Systems in the Republic of Armenia", 2010.

⁵³ Payments via the Central Bank systems involve EPS payments, excluding stock exchange trades, ii) payments executed for transactions with indirect monetary instruments of the Central Bank, payments executed within the Central Bank, payments executed for final settlement of ArCa cards system, and payments through the Government Securities Accounting and Settlement Systems. For details, see the paper "Payments and Securities Clearance and Settlement Systems in the Republic of Armenia", 2010.

⁵⁴ For details, see the "Financial Stability Report", 2007, and the paper "Payments and Securities Clearance and Settlement Systems in the Republic of Armenia", 2010.

Liquidity risk

The probability of emergence of liquidity risk and systemic problems in EPS is very small

In 2012, the indicator of own liquidity used for assessment of liquidity risk tended to improve⁵⁵ (2.05 in 2012 and 1.62 in 2011).

During 2012 the system level banks had on average more opening liquidity than they needed for making payments within a day. Moreover, the rate of growth of liquidity at the beginning of the day exceeded the growth rate of average daily payments.

The liquidity indicators are positive by individual banks as well

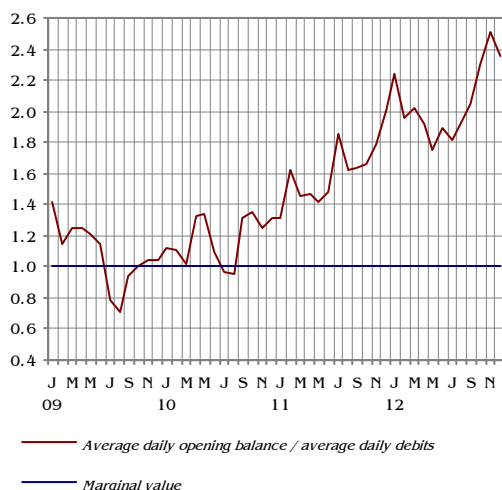
A target analysis conducted in 2012 included was aimed to observe these indicators for each bank individually. The results show that in the period under review banks had, on average, more opening liquidity than they needed to meet their payments within the day.

In assessing liquidity risk in terms of the above indicators one should take into account that the calculation of the indicator does not include reciprocal incoming payments (crediting of the account) and / or funds from other sources to increase liquidity.

Rejections due to insufficient liquidity are negligible

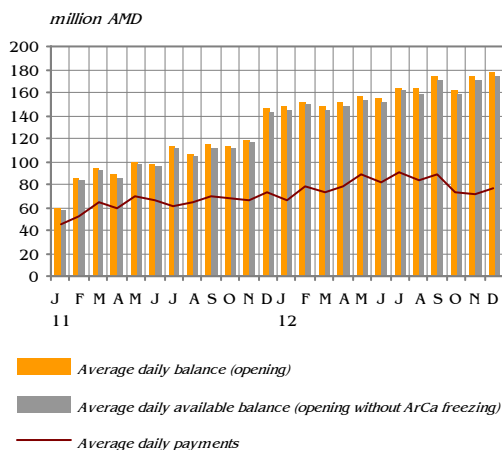
Both the number and value of rejections and their share in total payments made through the system is an important measure for the assessment of the liquidity risk.

Average daily opening balance to average daily payments (debit)



Source: Central Bank of Armenia.

Average daily payments, average daily opening balances, average daily opening available liquidity comparative analyses



Source: Central Bank of Armenia.

⁵⁵ The indicator of own liquidity was calculated on the basis of a ratio of opening liquidity on dram correspondent accounts of commercial banks to debits (payments) through the account. Incoming payments are not included in the indicator so that a stress-scenario can assess the likelihood of bank rejections if additional liquidity is not available within a day, namely to which extent would banks generate their payments using only opening balances of their own funds. The calculation does not include cash enhancements through their own accounts of commercial banks. The indicator is calculated for a system level indicator, so indicators may vary across commercial banks.

Though the value of rejections due to insufficient liquidity in EPS transfers has increased almost thrice compared to the previous year, the small share of such rejections in both the number (0.002 percent in 2012 and 0.005 percent in 2011) and value (0.2 percent in 2012 and 0.4 percent in 2011) of EPS payments suggests that the said increase may be a result of improper management of liquidity (payment flows) by one or more banks within one or several days, which could not have affected the liquidity of the system.

Intraday distribution of payments

Unlike previous years when the closing of the day came as the peak hour for execution of payments, now it spans over 10:00 am - 11:00 am for value (22 percent) and 11:00 am - 12:00 am for number (17 percent). Payments executed after 4:00 pm have reduced sharply. This is a positive trend since, when the system encounters insufficient liquidity or operational failures, the concentrations at the closing of the day may result in rejections or delays in most payments within a day, creating systemic risks.

The results of the analysis⁵⁶ to measure possible adverse impact of concentration of payments at the opening of the day showed that the system has not encountered material problems owing to sufficient capacity of the system and the lack of operational problems. Considering the positive dynamics of the liquidity indicators and availability of the system, a sufficient capacity of the system as well as absence of material incidence and a negligible amount of rejections within a day, an uneven intraday distribution and concentration of payments at certain time intervals of the day did not bring in problems in 2012, while the likelihood of the risk to the system is estimated to be low on the whole.

System capacity

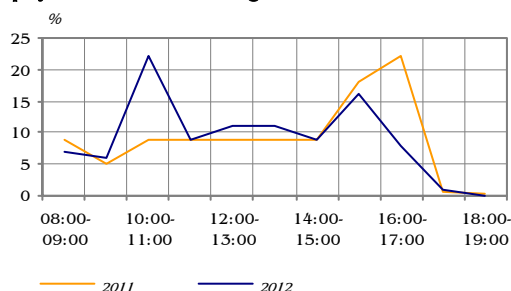
In 2012 the maximum number of payments per hour reached 8181 (5420 payments in 2011).

In the period under review enlargement of payments per hour was observed: there has been considerable rise in payments exceeding the 2500 payments per hour ratio, reaching an average 50 percent of work hours (22 percent in 2011). The share of 3500-4300 payments per hour has grown. The rate of payments in excess of 4300 payments per hour has risen abruptly, reaching an average of about 20 percent of work hours (a mere 1 percent in 2011).

In 2012 the monthly peak-hour payments exceeded the 6000 payments threshold. Peak hours were reported in the time span 11:00 am to 1:00 pm, which is a positive trend as

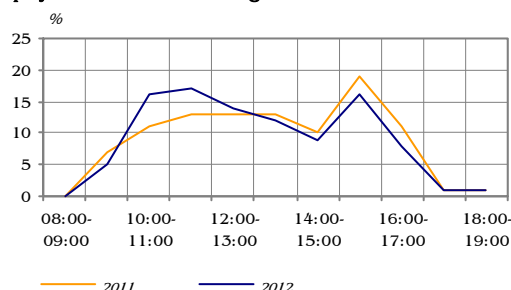
Based on average quarterly data, hourly distribution of payments by number and value has moved to the opening hours of the day

Intraday distribution of the value of payments on an average annual basis



Accumulations at certain time intervals of the operational day did not cause problems

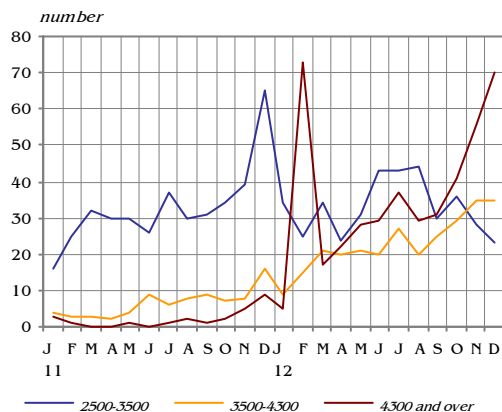
Intraday distribution of the number of payments on an average annual basis



Despite increasing value of the payments, the probability of risks to the system capacity is estimated to be low

⁵⁶ The analysis was performed in order to determine how to what extent these concentrations had affected the time critical payments (in particular, the stock-exchange depositing). The analysis was made using the data of the first 5 months of 2012, and the results showed that only 0.3 percent of the payments was made in delay.

Payments exceeding the threshold of 2500, 3500 and 4300 payments per hour



it prevents concentration of payments at the closing of the day.

The share of peak-hour payments has increased to a certain extent in the number of the same-day payments, whereas the share of peak-hour payments by value has reduced notably.

The above system capacity indicators and the results of special studies⁵⁷ denote that the hourly peaks were driven by increased activity of a few commercial banks in certain days. Because such incidents are still insignificant by share in total payments and no factual incidents have occurred during that period of time, the likelihood of emergence of capacity-related risks is estimated to be low.

Operational availability of the system

During 2012 there were 5 more or less significant incidents (lasted more than 30 minutes) that affected sound operation of EPS. The longest-lasting incident involved a 45-minute failure of the program “Operational Day” of the system server, which caused a half an hour delay of a trade session at NASDAQ OMX Armenia. The incident did not affect other payments adversely, so no need to extend operational hours had arisen thanks to reliable system capacity.

During 2012 a total of 6 incidents were reported in connection with slowing of the “Bank Mail”, an electronic message delivery system, two of which affected the timely execution of orders for pre-depositing of funds for stock exchange transactions. The two incidents led to a 30-minute delay and one-hour delay, respectively, in the trading session, without negative effect on the final settlement of other transactions, however. An appropriate action taken identified and remedied the reason of slowing.

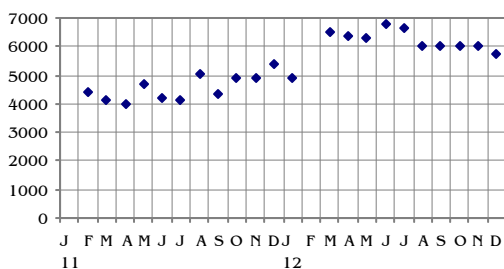
In the period under review the estimated operational availability has been 99.8 percent for EPS and 99.9 percent for Operational Day, which is again a good indicator according to international criteria⁵⁸.

CBANet availability

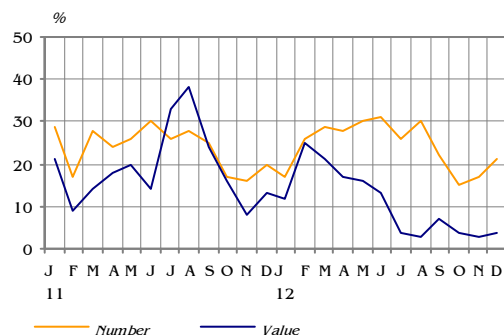
In 2012 disruptions of the CBANet nodes were negligible, so all nodes of the network reported 99.99 percent operational availability and calendar availability. There were only two cases of disruption of the CBANet node in Aragatsotn Region, which lasted 6.5 and 7 operating hours, respectively. Given that payments through EPS in this area

The EPS operational availability reached 99.8%

Maximum number of payments per hour, by month



Share of payments in peak hours in the intraday payments



Source: Central Bank of Armenia.

The hardware and software of the CBANet and backup facilities make it possible for EPS to operate smoothly

⁵⁷ Special studies were made to figure out the nature of utmost payments per hour (on a monthly basis) and identify the behavior of payers.

⁵⁸ The 2008 Financial Stability Report of the National Bank of Denmark states that operational availability for systemically important RTGS system, which is compliant to ESCB system requirements, should be very high, e.g. operational availability of TARGET was 99.65 percent, which is considered a good indicator.

constituted a tiny portion in all EPS payments, one may conclude that the disruption's impact has not been adverse in the financial stability point of view.

Disruptions were not reported in capital Yerevan, either.

In 2012 cases of disruption at head-office subscribers were minor: five subscriber banks reported instable connection in the duration of a few hours 4 of which switched to a backup connection. The bank that lacked a backup connection did not face major problems, either, and had their payments completed up until the closing of the operational day.

5.2. SECURITIES ACCOUNTING SYSTEMS

In Armenia, the settlement of securities is done through two frameworks: the Central Depository of Armenia provides for the settlement of corporate securities while the Central Bank securities are settled through the Government Securities Accounting and Settlement System.

In the period under review secondary market transactions totaling more than AMD 3357318 million were carried out through GSASS, which represented approximately 17 percent increase in relation to the previous year. The transactions executed through GSASS accounted for about 96 percent of secondary market transactions. In the financial stability point of view, GSASS remains a systemically important facility.

The GSASS operational availability is high, and the system is estimated to be reliable and safe

In GSASS, the settlement of OTC transactions is subject to the principle "delivery versus payment" while stock exchange transactions are executed through a procedure of pre-depositing of securities and cash, thereby reducing counterparty risk. The usage of gross settlement and irrevocability principles in the system rules out the emergence of credit risk.

Transfers of securities through the GSASS of the Central Bank pertaining to the transactions with securities in the secondary market⁵⁹

Operations	2010	2011	2012
OTC operations (trades and repo) in nominal value, AMD million	1781748.727	2870957.967	3353038.915
Stock Exchange operations (trades) in nominal value, AMD million	5802.422	5673.775	4279.5
Total	1787551.149	2876631.742	3357318.415

⁵⁹ The statistical information provided includes the GSASS-executed payments and excludes internal transfers made by sub-custodians for their clients.

In 2012 there were 11 reported incidents in GSASS 9 of which caused 15- to 50-minute delays in primary auctions for government securities. Most incidents due to the slowing of the server took place in the first half of the year. The reason of the slowing was identified and remedied. In the second half no such incidents were reported.

Given the small number of incidents as well as the effectiveness of remedy measures, one may conclude that the GSASS operational availability is high, reliable and safe.

Improving infrastructures in the securities market

In 2012 further work was done to improve the securities settlement and clearing mechanisms. NASDAQ OMX Armenia has launched a new platform for credit resources, and a new product – foreign currency bonds – was added to the platform of corporate securities. To this end, the Central Bank, NASDAQ OMX Armenia and the Central Depository of Armenia started appropriate procedures for clearing and final settlement of these securities.

CDA introduced a new software package for a new model that is designed to deliver securities registry services in the Armenian market. The new system supports functions for centralized registry, custody and settlement of securities. The system makes it possible to increase the efficiency and safety of transactions with corporate securities.

In 2012 the Central Bank completed testing and pilot operation of an automated system for repo operations, and starting from 25th February, 2013, the system was functional.

5.3. PAYMENT SYSTEMS OVERSIGHT

EPS self-assessment by the Central Bank

One of the most important objectives and functions of the Central Bank is an oversight of the payment system. The payment system oversight is aimed at providing reliable, stable and efficient operation of systemically important payment and settlement systems by identifying and limiting likely risks and enhancing the efficiency of payment systems.

EPS is a systemically important payment system, as it provides the bulk of the settlements in the territory of Armenia and maintains final settlement of other systems. It is one of the infrastructures that ensure the financial stability of the country⁶⁰.

⁶⁰ Oversight of EPS is carried out according to the Republic of Armenia Law on the Central Bank and the Republic of Armenia Law on Payment and Settlement Systems and Payment and Settlement Organizations, the "Payment System Oversight Conception of the Central Bank" and the "Manual for the Implementation of the Central Bank Payment Systems Oversight". Information on the oversight by the Central Bank is available in official website of the Central Bank (www.cba.am).

In the period 2011-2012 the Central Bank made a thorough assessment of EPS in accordance with core principles for systemically important payment systems developed by the Bank for International Settlements⁶¹. The results of the assessment served a basis for the World Bank in its work under FSAP in 2012.

The summarized results of EPS assessment according to international criteria⁶²

Assessment criteria (rating)	Principles grouped by assessment criteria	
	Number	Principles (S)
Meets	7	S1, S2, S3, S4, S6, S8, S9
Mainly meets	2	S7, S10
Partly meets		
Does not meet		
Does not extend to the system	1	S5

The system performance is estimated to be satisfactory and compliant with the standards. However, recommendations were proposed by the oversight team to deal with deficiencies identified after the assessment, which were later adopted by the Central Bank chairman resolution as an Action Plan. Some of the work has been done during 2012 according to the schedule and the rest of the work is planned to complete by the end of 2013. The system, assessed in accordance with international criteria, was recognized as reliable and stable.

The system is viewed as sustainable and reliable, according to international criteria

5.4. GUARANTY OF DEPOSITS

The deposit guarantee scheme is a facility responsible for the financial stability of the Republic of Armenia. The Deposit Guarantee Fund is an establishment which acts in accordance with the Republic of Armenia Law on Guaranteeing Reimbursement of Bank Deposits of Individuals in order to help strengthen the soundness of the banking system of Armenia, enhance public confidence in the banking system and protect depositor interests in the country.

In 2012 the growth of bank deposits and guaranteed deposits of individuals trended upward. As of the end of reporting period, relative to the end of the previous reporting period, the amount of deposits of individuals has increased by around 14.8 percent and the amount of guaranteed deposits, by 13.9 percent. The number of individuals holding guaranteed deposit has grown by 8.2 percent to 1366512 persons (excluding former ArmSavings Bank depositors who are registered in VTB Armenia Bank CJSC). In the reporting period, the share of depositors who hold only deposits in dram again prevailed, making up 83.49 percent in total. The

⁶¹ Core Principles for Systemically Important Payment Systems", BIS, 2001.

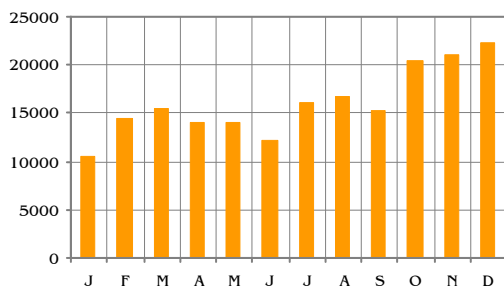
⁶² The principles and assessment methodology are detailed in the Concept and Guideline.

share of depositors only holding foreign currency deposits reached 6.76 percent.

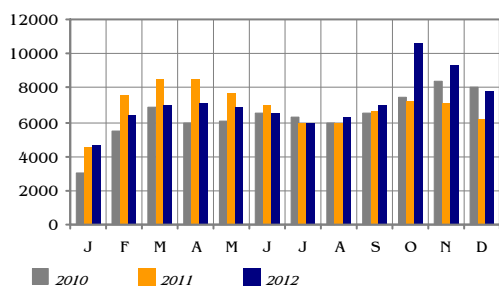
5.5. CREDIT REGISTRY AND ACRA CREDIT BUREAU

The Central Bank Credit Registry

The number of loans in 2012



The number of requests received during 2010-2012



Source: Central Bank of Armenia.

The Credit Registry has been functioning since January 1, 2003. The Credit Registry is designed to collect data on credit history of borrowers, to process such information and provide it to commercial banks, credit organizations, and borrowers. The Credit Registry keeps records of loans in excess of AMD 1.5 million and loans in the amount less than AMD 1.5 million that were overdue and were classified. At the end of 2012 the number of loans recorded in the Credit Registry reached 1346204 from which 1240551 were loans to natural persons and 105653 were loans to legal persons. The total number of loans registered with Credit Registry has increased by 258292 in relation to the previous year.

Based on the end-year 2012 data, the Credit Registry possessed information on 247923 loans outstanding and 1098281 loans repaid.

Relative to the previous year, the number of loans registered has grown 1.2-fold, which points to livelier activity in the credit market. In the period under review the average entry rate of information amounted to 9500 registrations per day; this represents a 10 percent increase compared to the previous year. Work was done to introduce automated data entry software which eliminates interference with the human factor. Increased amounts of data and more effective data entry process have facilitated the use of information to determine creditworthiness of borrowers and identify non-diligent borrowers as well.

Most commercial banks and credit organizations further made their reporting to the Credit Registry on an automated basis, allowing for an increased efficiency of the system. Improved *Credit Registry* software of the Central Bank made it possible to provide banks and credit organizations with information on credit history within one day utmost after receipt of such a request. The share of errors in data presented to the Credit Registry has reduced to a minimum.

As shown in the chart, the number of requests grew especially in the second half of 2012. In 2012, in relation to the previous year, the number of requests has grown by 2597, reflecting the growing number of loans originated. Because credit history can be used to assess borrower credibility and hence reduce credit risks, commercial banks and credit organizations are increasingly receptive in using credit history, especially when it comes to making loans to new clients.

The Credit Registry's activity has pushed business discipline of borrowers upward and scaled down the delays in installments, which reflects the clients' understanding of the importance of their credit history.

The amount of registered information and utilization rate in the Credit Registry would most probably increase during 2013 as well. Work done by commercial banks and credit organizations suggest that provision of information to the Credit Registry will be fully automated at the end of 2013.

More methodological change will come in to reduce weaknesses and raise efficiency of the Credit Registry.

The ACRA Credit Bureau

In 2012 the number of the borrowers registered with the ACRA Credit Bureau has increased by 16 percent relative to the previous year and amounted to 1313485 borrowers. Of this number, 97.6 percent are individuals.

In 2012, relative to 2011, the number of loans available with the database has grown by 27 percent and reached 6873768.

Any natural person or legal person is entitled to receive information from the Bureau concerning his personal credit history. For the legal persons to obtain credit history of its client or counterparty, it should enter into a service contract with the Bureau and receive consent in writing from the borrower.

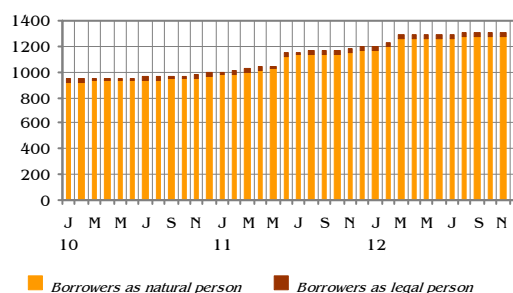
The Bureau started providing credit reports since April of 2007. The number of credit reports provided in 2012 has grown by 75 percent compared to the number of reports provided in 2011.

In 2012 the Credit Bureau began receiving information from "K-Telecom" CJSC, a telecommunications company. The database ACRA compiles information about payments fallen overdue.

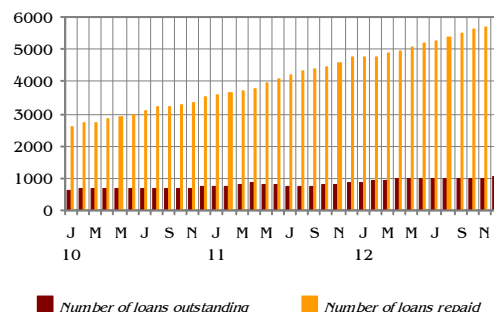
The Credit Bureau receives information from such public databases as the Republic of Armenia Police and the Ministry of Labor and Social Issues. Negotiations between the Credit Bureau and the State Revenue Committee concerning getting information on tax liabilities non-performed in a duly established timeframe are underway.

In 2012 ACRA Score Cards (mortgage score, car score, card score) were introduced by the Credit Bureau. ACRA Score Cards are designed to measure the creditworthiness of the borrower for the near future. These score cards are variants of statistical modeling of credit and operational risk, which imply a delivery of digitized assessment of credit risk of the borrower. Credit scoring is based solely on statistical

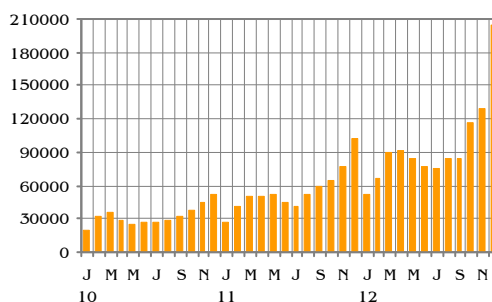
The number of borrowers registered in ACRA database (in thousands)



The number of loans registered in ACRA database (in thousands)



The number of reports provided by ACRA



Source: ACRA.

methods and is set to escape, as much as possible, the use of expert judgment in the processing of digitized assessment of creditworthiness.

As a result of cooperation with “ArmenTel” CJSC, a telecommunications company, ACRA Credit Bureau has introduced an ACRA SMS-report service, which helps obtain in the shortest possible time a summary of credit obligations. In 2012 ACRA Credit Bureau developed and implemented a more versatile data input module.

A multi-level coding system, supported by special firewall hardware, has been developed to protect information owned by the Bureau and to prevent its illegal usage by the third parties whatever. The system traces all actions as well as an ongoing monitoring of the system is in place to prevent suspicious and unauthorized action.

SUMMARY

The results of monitoring denote that credit and liquidity risks to the electronic payment system are minimized, the system capacity is satisfactory, and the intraday payments are made uninterruptedly. No operational risks were identified in the system, so the system’s availability has been at an internationally accepted level. The system’s peak hour moved to the opening of the operational day, which is a positive trend so as to prevent any payment concentration problems at the closing of the day.

The Central Bank has carried out a thorough assessment of the system in accordance with international standards, and the results of the assessment can be used to argue that the system is reliable and contain no such risks that would threaten to the stability of the country’s financial sector.

The GSASS is sound and operational as well, and does not contain risks to financial stability.

In the financial stability point of view, the developments in the payment and settlement system remain manageable while risks leave no room for vulnerability.

**EARLY WARNING SYSTEMS FOR PREDICTING
CURRENCY CRISES IN ARMENIA**

Monetary Policy Department
HAYK AVETISYAN

EXECUTIVE SUMMARY

On the brink of the global financial and economic crisis, developing countries, Armenia among them, were enjoying enormous economic progress, based on huge foreign currency inflows. Against the background of the global crisis, the termination of such flows stirred a wave of currency crises since autumn of 2008, which was also showed up in Armenia. In this study we will attempt to identify leading indicators for predicting currency crises in Armenia (as well as in CIS and CEE countries) and to build applied early warning systems (EWS) by using the conventional Signaling approach and relatively new Classifications tree models. As a result, it was found out that almost all the indicators discussed had good forecasting properties for Armenia's economy, and among them one may especially point out such leading indicators as budget deficit, credit, inflation, foreign debt and bank assets indicators. At the same time 9 out of 24 variables discussed come in to have the best leading properties, signaling at least with 3 quarters' advance. Addressing the issue of the causes of crises it was revealed that most crises observed in developing countries in Europe had been attributable to the problems of budget deficit and excess financing: self-fulfilling crises also hold a significant share. The models (including combined ones) developed in this paper are remarkable for their high forecasting power and good properties while the model, based on a CART methodology, with its main forecasting properties even surpasses all other types of models for EWS available in the literature. In addition, all models best predicted the currency "crisis" in Armenia in March of 2009, so they can be used in forecasting currency and financial crises in Armenia (and other countries in the region as well).

In a crisis you are a hostage of your past...
Guillermo Calvo

INTRODUCTION

Predicting currency crises has a huge importance for both macroeconomic policymakers and financial market participants. However, while participants of the financial market pursue the realization of their own interests, the policymakers need this to respond to the problem in a timely and properly manner. The devastating economic consequences of currency crises call for the need to mobilize efforts in order to prevent them. Therefore, in this context, the need for some mechanism or system that would facilitate in time identification of the problems typical to a country, prediction of the likelihood of emergence of crises and taking appropriate actions becomes inevitable.

* The author's views may not coincide with the official position of the Central Bank of the Republic of Armenia.

Since the 1970s, this issue has been the focal point of economists and researchers. But in the aftermath of the waves of three major crises especially during the 1990s, there has been an increased interest in developing early warning systems (EWS) in order to predict financial and currency crises. To this end, there have been carried out a bunch of analytical work whereby through taking various traditional and modern approaches it was attempted, to pinpoint the causes of crises and the problems associated with building signaling models involving countries, regions and various groups of developing countries.

In the first decade of 2000s, the developing countries, the Republic of Armenia among them, tracked an enormous economic progress, mostly owing to influx of foreign financial resources and huge foreign currency inflows resulting from a favorable environment in world commodity markets. Certainly, in the wake of massive financial inflows, the domestic credit growth, coupled with strengthening real estate market and an unprecedented rise in asset prices, expanded foreign currency liabilities of the private sector and banks. Although it also improved current accounts of balance of payments, and resulted in mounted international reserves, the developing countries were starting to discern symptoms of economy overheating as their currencies began appreciating considerably. Therefore, in the above-mentioned circumstances, an abrupt reduction of the inflow of foreign currency funds proved to be a key concern associated with exchange rate developments. Undoubtedly, the subsequent wave of currency pressures starting in autumn of 2008, which quickly spread over to nearly all the developing countries, points to the statement aforementioned. Although certain macroeconomic weaknesses were attributable to some countries before the crisis, this one however was different from previous ones for the developed world was the epicenter of the crisis, whereas the developing countries faced it as an external shock, unlike previous crises that had started out because of short-sighted economic policies in these countries.

It should be noted that this particular project for crisis prediction for the Armenian economy started back in early 2008. This was based on a number of trends observable in the country in recent years, which were broadly in line with crisis situations previously seen in other developing countries. In the aftermath of sharp currency exchange rate depreciation on March 3, 2009, however, designing early signaling systems became imperative for Armenia in order to detect the origins of this depreciation and prevent such adverse developments in future. The main achievements of the project has been summarized in this paper developed already in 2009.

This work is by nature the first study which addresses the problems of predicting the currency crises (pressures) in Armenia. It has an inclusive account of a bunch of countries in Central and Eastern Europe and some CIS countries which had not been dealt with in other analytical works related to the problems of currency crises. This is, therefore, another interesting aspect of this work. In addition, this analysis is perhaps among the first ones that covered, although partly, the 2008-2009 crises. Finally, the most valuable input here is that it applies one of the most recent approaches in modeling: thus parallel to the traditional signaling approach, the main focus of this paper is on the Classifications and Regressions Tree (CART) method, which is almost non-existent in literature on currency crises prediction and EWS.

The first chapter will give an outline of theoretical models for prediction of currency crises; the second chapter will describe the main steps for building EWS, including the definition of currency crises, the choice of leading indicators and the formulation of applied models and approaches. The third chapter will refer to the developed EWS for prediction of currency crises in Armenia.

CHAPTER 1

Theoretical basis for forecasting currency crises

The theoretical literature on the issues of crisis prediction offers many different models that are designed to explain what causes the currency crises. These models can be conventionally classified into three groups. First generation models (speculative attack models) were created to explain the currency crises in Latin American countries in 1970-1980s (Mexico in 1973-1982, Argentina in 1978-1981). These show that currency crises are the result of speculative attacks, which thus occur due to the implementation of monetary and fiscal policies inconsistent with exchange rate targeting. Second generation models successfully explain the crises in Europe and Mexico in 1990s, and consider self-fulfilling and multiple equilibria as the features inherent to currency crises. Third generation models attribute the phenomenon of banking troubles and contagion effects as causes of currency crises. These

models are designed to explicate the Asian crisis that has occurred in the period 1997-1998. There are also many other models that explain the various phenomena and manifestations of the crisis, yet remain outside the suite of traditional “generation” models.

First generation models

Until the early 1990s, the main theoretical ideas explaining the origination of currency crises were summed up in the first generation models, which considered the crisis as a sudden and sharp decline in the level of international reserves, abandonment of the existing exchange rate regime or simply currency devaluation resulting from speculative attacks. These models were called to explain the reasons of such speculative attacks.

The forefather of first-generation models was Krugman (1979), for whom the model of attacks to manageable gold prices by Salant-Henderson (1978) served as a pre-model. Krugman’s input on behalf of the first-generation models is the explanation of the abandonment of the existing exchange rate regime as a consequence of monetary and fiscal policies inconsistent with the issue of exchange rate targeting and a feeble macroeconomic environment. According to the logic behind the Krugman model, the main cause for the currency crises and speculative attacks lies in the surpassing growth of domestic credit to finance the budget deficit or to support the banking system. Under the implication of the model that the government does not have access to capital markets or cannot endlessly finance its deficit through foreign funds leaves it nothing but to monetize the expenditures. Such an increase in money supply exerts pressures on interest rates, while in the face of interest rate parity condition this will result in a capital outflow, which will then lead to a gradual reduction in international reserves. In addition, the government’s expansionary policy brings about an excess demand in the economy; this leads to deterioration of current account and balance of payments which are financed at the expense of reserves. Finally, the level of international reserves reaches some threshold value, after which the start of speculative attacks causes depletion of the rest of the reserves and collapse of the monetary system.

Now let us draw an outline of the simplest first generation cornerstone model. The model is built for a small open economy which maintains a fixed exchange rate regime.

The condition of domestic money market equilibrium is given in the following form:

$$m - p = -\alpha(i), \quad \alpha > 0 \quad (1)$$

Where: m is monetary base, p is domestic price level, i is domestic currency interest rate (here and now all indicators, except interest rates, are expressed in logarithms).

The domestic money supply is backed by the central bank assets – domestic credit (d) and international reserves (r). This in a simplest linear form can be:

$$m = d + r \quad (2)$$

Domestic interest rates and prices are subject to international arbitrage conditions: that is the conditions of purchasing power parity (PPP) and uncovered interest parity (UIP) are hold:

$$p = p^* + s \quad (3)$$

$$i = i^* + \dot{s} \quad (4)$$

Where: p^* and i^* are respectively prices and interest rates of other countries, s is exchange rate (growth means depreciating local currency), $\dot{s}$ is the difference between the expected and actual levels of the exchange rate (expected change).

In fact, in the fixed exchange rate regime the money market equilibrium is established by adjustment of reserves whilst in the free-floating regime, by adjustment of exchange rate.

Therefore, assuming that the exchange rate is fixed $\dot{s} = 0$ and $i = i^*$, and i^* and p^* are constant, from equations (1)-(4) it follows that:

$$r + d - p^* - \bar{s} = -\alpha(i^*) \quad (5)$$

where: $\bar{s}$ is the fixed exchange rate level.

For a small open economy which carries on a fixed exchange rate policy, assuming that the deficit financing credit expansion is growing at a constant μ rate, international reserves will fall down at the same $\dot{r} = -\mu$ rate. It is obvious that in this case the country's reserves will vanish eventually while the country will found itself in a crisis situation.

The most important feature of this generation models, which is absent from the other models, is the ability to predict the right timing of speculative attacks hence currency crises. To this end, it is necessary to incorporate in the model the so-called "shadow exchange rate", the $\tilde{s}$, which is a floating exchange rate that will occur in the market as a crisis emerges as a result of speculative attacks. Assuming that in the crisis aftermath the country's foreign reserves come close to 0 (it may not necessarily have to be that way, which of course will affect the setting of the shadow exchange rate level, however this is not presented here for simplicity), and $i^* = p^* = 0$, the post-crisis money market equilibrium condition will be expressed through:

$$d - \tilde{s} = -\alpha(\dot{\tilde{s}}) \quad (6)$$

After the onset of the crisis the credit growth at the μ rate, under the condition of equilibrium, will mean depreciation of the exchange rate at the same rate; so the exchange rate will be:

$$\tilde{s} = \alpha\mu + d \quad (7)$$

It turns out that the shadow exchange rate depends on the volume of lending, so there is a level $d = d^A$ in which speculative traders predicting a currency crisis and driven by the lure of getting super profits as a result of eventual exchange rate depreciation rush into speculative attacks. It can be shown that this point complies with the condition $\tilde{s} = \bar{s}$.

Two phenomena observable during the speculative attack keep the money market in equilibrium. These are: 1/ the money supply reduces to the extent of the attack Δr , and 2/ in the crisis aftermath, the μ depreciation of the exchange rate, under interest rate parity, presumes that much increase of interest rates (which reflects future depreciation expectations) at the time of speculative attack, which leads to the reduction of demand for domestic currency. Therefore, the money market equilibrium will be maintained, if $\Delta r = -\alpha\mu$. Since the domestic credit is characterized as $d_t = d_0 + \mu t$, the reserves will be expressed as $r_t = r_0 - \mu t$. At the time of crisis (T) the reserves approach to 0, and the crisis condition is characterized as follows: $-\Delta r = r_0 - \mu T = \alpha\mu$. So, it turns out that:

$$T = \frac{r_0 - \alpha\mu}{\mu} \quad (8)$$

which is to say, the bigger the initial stock of the reserves and the slower the credit expansion, the longer it takes for the fixed exchange rate to last.

The simplest model presented¹, despite a series of simplest assumptions, reflects the logic behind the first-generation models. Many authors after Krugman (Flood and Garber, Connolly and Taylor, Calvo and others) also referred to this, making essential modifications discussing the uncertainty of speculative attacks, the sterilization policy, the credibility of exchange rate regime, the price rigidities, the behaviors of prices of tradable goods, current account and real exchange before the crisis etc.

To summarize, first-generation models made a number of important contributions to the development of theories about currency crises. These include:

- currency crises are predictable,
- macroeconomic indicators and other fundamental factors behave in a typical way before crises; these factors are mainly pertinent to exchange rate and balance of payments models and are amazing indicators from the crisis prediction standpoint,
- crisis may occur at a time when international reserves are not yet fully exhausted,

¹ More details about first-generation models with the main supplements made thereto are available in the paper by Flood, Marion (1997).

- central banks may adopt a fixed exchange rate regime provided they have sufficient foreign exchange reserves,
- central bank reserves need to be able to cover its entire liabilities, especially in economies with a higher dollarization rate²,
- with concern over monetary stability under high mobility of capital flows, the central bank's sterilization policy steered to foreign exchange rate stability is ultimately doomed to failure and the currency crisis is inevitable, if speculative traders predict the authorities' intentions³ (in fact, these structural models touch the phenomenon of the "impossible trinity").

Second generation models

The first generation models failed to explain the European Monetary System's crisis in the period 1992-1993. Before the crisis, the European countries did not have any significant economic difficulties, used to hold sufficient levels of international reserves, nor had the economic policy brought about any considerable challenges. Therefore, the fundamental factors distinguished under crisis theories at hand were not able to explain the crisis. This served a basis for the design of new models, which were conventionally called the second generation models. The founder of first-line models of this generation is Obstfeld (1986, 1995). The main properties inherent in these models include as follows: 1/ the government plays an active role in the economy and seeks to maximize its own objective function, 2/ there comes a phenomenon of circularity, which leads to the multiple equilibria.

These models point to the problem of duality of the government's objective function as to whether to maintain the fixed exchange rate or trade its benefits in for other purposes, such as employment or economic growth. In particular, the fixed exchange rate regime could be abandoned if the government realizes that the economic benefits of sticking to it (monetary stability and credibility) are not outstripping undesired outcome generated in terms of other economic variables (unemployment, troubles in the banking system, a large public debt). Therefore, any policy option contains some alternative, that is, the policy itself grows into an endogenous factor.

Economic agents make their decisions on speculative attacks not on a basis of existing discrepancies between current macroeconomic indicators and current regime but on the expectations of these incompatibilities just after the attack. Such expectations of speculators influence on different macroeconomic indicators and, therefore, on the government's choice of the objective function. This is where the phenomenon of circularity shows up, which, often coupled with non-linearity behavior of the government, results in the condition of multiple equilibria. At one point of the equilibrium, in the face of favorable anticipations, there are neither speculative attacks nor crisis, since at the time of attacks the agents do not win but they do not lose either, while one will see attack and crisis taking place at the other point of the equilibrium. In the latter case, as a result of speculative attack, by virtue of an alternative choice of its objective function, the government eventually abandons the fixed exchange rate regime, which is what justifies the agents' expectations. In fact, multiple equilibria tend to trigger self-fulfilling crises.

As for the problem of multiple equilibria, there is a diversity of well-known authors trying to figure out the factors that determine the existence of it. Transition from one equilibrium state to another occurs when the current speculative market expectations are coordinated and steered to achieve that goal, because otherwise the agents alone (individually) could not lead to any crisis. The multiple equilibria in this case are determined by common knowledge (information) on fundamentals, under which circumstance the simultaneous change in everybody's expectations can provide for the transition from one equilibrium state to another. Turning to the conventional wisdom on economy, Morris and Shin (1995) note that injecting some amount of uncertainty into the information on these fundamentals, will result the equilibrium outcome to be a unique one⁴, since, in uncertainty, every speculative trader will think attacks is the best option in consideration of other agents' possible awareness. Krugman (1996) believed multiple equilibria were existent only if the knowledge of the fundamentals is incorrect or unclear⁵, otherwise the equilibrium would be the one because if it is clear that there is discrepancy

² Eichengreen, Rose, Wyplosz (1996), p. 8.

³ Flood, Marion (1997), p. 11.

⁴ Flood, Marion (1997), p. 21.

⁵ Eichengreen, Rose, Wyplosz (1996), p. 10.

between available fundamentals and the fixed exchange rate regime that would definitely lead to an equilibrium state, namely a speculative attack and crisis.

Next important feature of the second generation models is attributed to the role the fundamentals have in them. Unlike the first generation models, here the causality between the fundamentals (unemployment, the situation in the banking system, government debt, etc.) and crises is dual-sided, which is reflected in demonstration of multiple equilibria and self-fulfilling crises as attributable to the phenomenon of circularity. In general, the second generation models have two diametrically opposite views on fundamentals. Some of them attach great importance to a healthy macroeconomic environment as a way to battle crises, noting that albeit it is not possible to unmistakably reveal the source of the crisis, however, one may be able to determine which countries are most vulnerable to it. According to these models, in the event of various upheavals and changes in the macroeconomic situation the country's authorities would be able to waive their exchange rate policy.

Another suite of the models falling within this generation excludes at all the role of fundamentals in predicting currency crises. They believe that the crisis may arise as a result of a speculative attack, which may be due to two factors: the herd effect and the contagion effect. The latter appears in the second generation models within the mechanism of multiple equilibria, in a form of self-fulfilling crisis arisen as a result of expectations due to crises in other countries. For this reason it is often called a spillover effect, so that it comes distinguishable from the contagion effect⁶. It is worth mentioning that, the contagion effect per se refers to situations of instability observable in one country as a result of the crisis emerged in another country which is due to economic and financial relations that exist between the two countries in question (see details in the section "Third generation models").

Thus, the second generation models mostly withdraw from crisis explanation approaches based on fundamentals and stress the role of expectations at the core of the crises. Furthermore, in the face of immeasurability of the coordination of expectations and the loss of confidence, it is impossible to develop crisis forecasting models based on fundamentals. In such circumstances though, the best way to combat crises not justified by macroeconomic indicators is to increase credibility of central banks, because, if there is a belief that after the crisis the central bank will implement a policy which implies an exchange rate appreciation, it will eliminate the motivation of the agents to achieve a self-fulfilling crisis and own benefits as a result of speculative attacks⁷.

Third generation models

The first and second generation models were mainly focused on the factors explaining the nature of the macroeconomic environment and policy, without regard to such key factors as situation in the financial system and the imperfections of the markets. The latter lay under the Asian currency crises of 1997-1998 and existing theories, therefore, were not able to explain their causes. As a result, new, a third generation models, came in to address the relationship between financial, banking and currency crises as well as the effect of contagion. Distinguishing the authors of the models of this generation is rather difficult but basically they are Chang and Velasco (1998), Kaminsky and Reinhart (1999), and Gerlach and Smets (1994).

In general, these models are divided into three major groups that address, accordingly, three different causes of crises. The first group of theories emphasize on the weaknesses in the banking system (enormous foreign debt, troubles with balance sheet positions, moral hazard provoked by bogus government guarantees, weak supervision, etc.) that lead to banking and currency crises. The link between banking and currency crises is expressed in several ways. Government measures to bail out troubled banks as a lender of last resort may lead to a situation where the level of budget deficit is no longer controllable, which could bring about a currency crisis straightforward (first generation models). The causality between banking and currency crises may also pace the opposite direction: when high foreign currency risk becomes increasingly inherent in the banking system due to huge short-term foreign debt, currency crises may bring in serious difficulties in the banking sector. In fact, although Kaminsky and Reinhart (1999) revealed a dual-sided causality, the banking crises yet used to go before the currency crises⁸.

⁶ Esquivel, Larrain (1998), p. 5.

⁷ Eichengreen, Rose, Wyplosz (1996), p. 11.

⁸ Kaminsky, Reinhart (1999), p. 491.

The second group of this generation models considers the herd effect of banking and financial system agents as the main cause for currency crises. When faced with certain problems, these agents, massively following each other, seek safe haven in foreign currency assets.

The third group of models refers to perhaps the most important contribution of this generation theories, i.e. the effect of contagion. Approaches that explain the contagion effect are different in literature, yet Gerlach and Smets (1994) were the authors who have taken profound systematic theoretical approach to this problem. They view existing trade and financial linkages between countries as the mechanism for transmission of the contagion. Thus, if there has been a depreciation of the real exchange rate due to a crisis in a country, this would imply an improvement of external competitiveness of that country, which would in turn lead to deterioration of the balance of payments and reduction in reserves hence a currency crisis in a partner country. On the other hand, exchange rate depreciation in the countries of the region would have a restrictive impact on particular country's imports and consumer prices and, in an outcome, excess cash funds generated as a result of reduction in demand for money would be channeled to the foreign exchange market.

The financial channel of transmission of contagion is demonstrated through problems lender countries encounter as a result of non-performance of external liabilities of financial intermediaries in borrower countries.

The next channel of transmission of contagion is determined by countries' vulnerabilities to similar external shocks as well as creation and materialization of similar expectations in a country in case a crisis emerges in another country that shares common structural specificities.

The next crisis explanation models are not classified among any generation models: the major one of them views political and structural factors closely linked with macroeconomic variables and expectations as determinants of currency crises.

Summing up the review of theories regarding currency crises, let us note that, as Krugman (2001) said, the future – the fourth generation – models will incorporate a more general framework and will address financial crises, while other financial assets will play the central role in them⁹.

CHAPTER 2

Building early warning systems

An early warning system (EWS) is called to identify and predict currency crises by looking at the developments of variables known from crisis theories. EWS shall be construed to involve a clear definition of the crisis and a practical prediction mechanism in place. Therefore, for currency crises, building EWS will be taking a number of steps, as follows:

- definition and evaluation of currency crisis,
- choice of explanatory or leading variables (indicators),
- choice of the period under review and/or the group of countries,
- choice of the forecast horizon,
- choice of the type and construction of a forecasting model,
- evaluation of the predictive power and properties of the model.

The definition of currency crisis

The currency crisis, which is often referred to as balance of payments crisis, is broadly defined as an episode in which the value of the currency changes abruptly in a short period of time¹⁰, which results in a full or partial loss of exchange or store of value functions. In a narrower sense, the currency crisis is the official devaluation of the currency or a shift to a floating exchange rate regime. This definition, of course, refers to the fixed exchange rate regime. Therefore, the most common definition for currency crisis is the situation when speculative attacks lead to a sharp depreciation of the currency, reduction in international reserves or the two developments altogether. The definition includes both successful and

⁹ Tinakorn (2002), p.5:

¹⁰ Burnside, Eichenbaum, Rebelo (2007), p. 1

unsuccessful attacks, and is applicable to both fixed and floating exchange rate regimes. It should be mentioned that the currency crises are an integral part of financial crises but they can emerge both separately and in concurrence with other crises (banking, debt, etc.).

In practice, there are a lot of approaches for defining currency crises (see Appendix 1). In general, they can be discussed in two major groups: in the first group the crises are related to the segments of upmost pressure based on some *continuous* index, therefore such index also reveals the intensity of the crisis; and in the second group, which is the most common in literature, the crises appear as dual discrete variables, in the form of 0/1 (tranquil period/crisis). The next problem, which deals with distinguishing the crisis episodes in practice, is determined by the choice of factors that provide for the definition of crises – whether to consider the dynamics of the nominal exchange rate (the rate of depreciation) alone or to take other factors into consideration as well. According to one of the above-mentioned definitions of currency crises, pressures in the currency market are discernible through either exchange rate depreciation or reduction in the central bank's foreign exchange reserves. In essence, the change in international reserves are not fully explained by central bank interventions in order to keep the stability of the exchange rate, since the reserves may change for different reasons – as a result of reassessment, interest income, etc. In addition, for the exchange rate regulation, there could be used so called “hidden foreign exchange reserves transactions”¹¹, such as credit lines (Ireland, 1992-1993), derivatives transactions (Thailand, 1997), issuance of foreign currency debt securities (Brazil, 1998-2000) and so on, which are not reflected in the change of reserves. Theoretically, the volatility of reserves should be minor – if not equal 0 – in a floating exchange rate regime. This does not however mean that under this regime the authorities are not capable of safeguarding the exchange rate from speculative attacks. This can be carried through foreign exchange market interventions but, according to the view by Calvo and Reinhart (2000) the interest rate policy as an instrument of smoothing exchange rates is becoming increasingly applicable¹². One example could be a particular case of Mexico where, on the back of the Russian crisis in 1998, the level of interest rates had doubled to 40%¹³. However, the effectiveness of the interest rates calls for an exercise of the functioning of interest rate channel or the interest rate parity¹⁴.

The above discussion makes it clear that taking the dynamics of exchange rate alone as an identifier of a crisis is not enough: the change in reserves and interest rates, or at least one of them needs to be considered along with the exchange rate. It should be noted that interest rates are not often considered in the literature due to the lack of data.

We also among various definitions provided in Appendix 1 selected those ones, which consider reserves and interest rate flows in addition to exchange rate volatilities while trying to identify the crises episodes.

The most common approach in literature is the usage of the exchange market pressure index as an instrument for identifying crisis episodes. The authors of the index are Gorton and Roper (1977) who used it in a completely different context (evaluation of the link between the market pressure and the monetary policy)¹⁵. Subsequently, the index gained popularity in the literature on currency crisis assessment and building of early warning systems. Initially, the index was being constructed by the use of exchange rate and reserves indicators only but later on Eichengreen, Rose, Wyplosz (1996) suggested including the interest rates as well.

The main principle of constructing the exchange market pressure index states that none of the variables have a dominant impact on the value of the index. Therefore, the weights of the components are selected so that their conditional volatilities are equal. The index and its weights are calculated in the following process:

We assign index components, i.e. variables A, B, C¹⁶.

The currency pressure index will be:

$$I = \alpha_1 A + \alpha_2 B + \alpha_3 C$$

¹¹ Calvo, Reinhart (2000), p. 16.

¹² Calvo, Reinhart (2000), p. 28.

¹³ Reinhart, Rogoff (2004), p. 27.

¹⁴ The choice of the nominal interest rate can be founded by an argument that the current exchange rate, under the hypothesis of rational expectations, includes the discounted value of future inflationary expectations, while the current nominal interest rate is also shaped in the light of future inflationary expectations; therefore at the time the exchange rate and interest rate move according to the same principle: the nominal interest rate, inclined towards the future inflation, affects the current level of the exchange rate.

¹⁵ Gorton Lance, Roper Don (1977), p. 541.

¹⁶ Let us not refer to the specific look and signs of the variables but accept the assignments as they are.

According to the principles of index construction, the weights $\alpha_1, \alpha_2, \alpha_3$ are selected so that the volatilities of the weighted values of components are equal while the sum of the weights is 1:

$$\begin{cases} \alpha_1^2 * \text{var}(A) = \alpha_2^2 * \text{var}(B) = \alpha_3^2 * \text{var}(C) \\ \alpha_1 + \alpha_2 + \alpha_3 = 1 \end{cases}$$

where: $\text{var}()$ is the variance of the variable.

By taking square root from the first equation and solving the system with respect to $\alpha_1, \alpha_2, \alpha_3$ we will get:

$$\begin{cases} \alpha_1 = \frac{\sigma_B \sigma_C}{\sigma_A \sigma_B + \sigma_B \sigma_C + \sigma_A \sigma_C} \\ \alpha_2 = \frac{\sigma_A \sigma_C}{\sigma_A \sigma_B + \sigma_B \sigma_C + \sigma_A \sigma_C} \\ \alpha_3 = \frac{\sigma_A \sigma_B}{\sigma_A \sigma_B + \sigma_B \sigma_C + \sigma_A \sigma_C} \end{cases}$$

where: σ is the standard deviation of the respective variable.

Since we are primarily interested in the dynamics of the index rather than its value, after some arrangements (multiplying several times by positive numbers) we will get:

$$I = \frac{1}{\sigma_A} A + \frac{1}{\sigma_B} B + \frac{1}{\sigma_C} C$$

Based on this general profile of the foreign exchange market pressure index, we built a number of sub-type indices where monthly change in nominal effective exchange rate, the U.S. dollar / Armenian dram exchange rate, monthly change in the Central Bank's net foreign assets (excluding the privatization account and corresponding accounts of banks in foreign currency) and the difference between domestic and external interest rates were viewed as elements¹⁷. In the outcome, indices we constructed and discussed are as follows:

Version 1: based on the U.S. dollar / Armenian dram exchange rate:

$$EMP = \frac{1}{\sigma_e} \% \Delta e + \frac{1}{\sigma_i} (i - i^*) - \frac{1}{\sigma_r} \% \Delta r$$

Version 2: similar to version 1, by the use of the nominal effective exchange rate.

Version 3: the first version, excluding interest rates:

$$EMP = \frac{1}{\sigma_e} \% \Delta e - \frac{1}{\sigma_r} \% \Delta r$$

Including the above-mentioned variables based on the table provided in the paper by Hawkins and Klau (2000)¹⁸ (see Appendix 1) an option of the currency market pressure index was constructed, similar to the one discussed in the above-mentioned paper, as well as a version of it with normalized variables¹⁹. This version of the index has undergone some modifications as well: at first the threshold values of indicators as provided in the table were revised based on the study of distribution of relevant series in Armenia and the index was built. Then, in another version, assuming equal distribution of series in the groups, an index was built in consideration of percentiles as marginal (threshold) values. In the outcome, we had the following versions:

¹⁷ Armenia's money market interest rates were taken as domestic interest rates and the U.S. Federal Funds rate as external interest rates. We have built indices too, using the difference of real interest rates. However, after having considered a couple of variants of calculation of real interest rates, the results proved non-satisfactory, so they are not presented here.

¹⁸ Hawkins, Klau (2000), p. 26.

¹⁹ The normalization was performed by calculating the deviation of series from their means relative to the standard deviation of the indicator.

Version 4: according to the table provided in the paper by Hawkins and Klau (2000) (see Appendix 1).

$$EMP = W_1 \cdot xrm + W_2 \cdot xra + W_3 \cdot r + W_4 \cdot res$$

Version 5: similarly, with appropriate normalization, by taking as thresholds {-1.5, -0.5, 0.5, 1.5} values for all variables.

Version 6: after histogram study of the distribution of Armenian series, we had the 4 modified conditional thresholds in the table²⁰.

Version 7: using a version of the table with modifications based on equal percentiles {20, 40, 60, 80}²⁰.

The indices built according to the versions shown above are continuous series by nature (this is especially true for the first three variants) and point to the exchange rate depreciation pressures observed in the currency market in case of higher values, whereas in case of lower or negative values, they denote appreciation pressures in the currency market. In pursuit of building early warning systems one needs to clearly distinguish the crisis and tranquil periods. To tackle this task, one needs to set such thresholds for indices so that the time periods corresponding to the index values above these thresholds are considered as crisis episodes. For the second group of indices (Versions 4, 5, 6, 7), the index value of 5 was chosen to be a threshold²¹. It should be noted that no single approach is available in the literature on the first group of indices, so the thresholds are usually chosen in such a way so that they best fit the objectives of any particular analysis²², or that 5% of observations are crisis episodes²³. A widespread approach is the usage of so-called "standard deviation" rules, which means that crisis episodes are the periods within which the index outstrips its average by some standard deviation. *Appendix 1* and *Appendix 2* show that the options 1.5, 2.0, 2.5 of standard deviation rules are the most common ones but the interval is quite broad and includes a great diversity of values from the range of (1.1, 3.0).

Assuming that the distribution of EMP index calculated for Armenia is close to the normal distribution and under the probabilistic assumption of 5% probability of currency crises, the threshold value has been calculated using the 1.645 standard deviation rule for all three versions, as follows:

A crisis, if:

$$EMP > \mu + 1.645 \cdot \sigma_{EMP}$$

where: μ is average and σ_{EMP} is standard deviation of the index.

Appendix 3 sums up the results of the above-referred 7 versions of EMP indices. Under almost all versions, currency crises²⁴ contemplated for Armenia are mainly distributed in the time interval 1997-2000, with an exception of a few values. Moreover, all versions of the index reported similar results, therefore, for the sake of simplicity, comprehensiveness, coherence and commonality in literature, we decided on *Version 1* as a Crisis Index chosen for further analysis.

Since the main results of the works for building early warning systems will depend on the choice and use of the index designed to distinguish crisis episodes, let us look at the main deficiencies our EMP index has:

- The weights of elements in the index depend on the movement of variables; this means that given abrupt volatilities in the series (potentially crisis-prone dynamics and, especially, dynamics in the opposite direction), the weights calculated based on standard deviation get smaller, so lots of potential crisis points could be missed, as a result. Some authors, disapproving such an approach to the weights of elements in the index, make a point that theoretically correct weights must be the estimated elasticity of reserves and interest rates to the change of exchange rate²⁵.

²⁰ The absolute thresholds applied could be provided.

²¹ Exploring the analysis regarding the Asian currency crisis, provided in the paper by Hawkins and Klau (2000), one may notice that the index has been mainly above 5 in crisis-hit countries, that is why that particular threshold was chosen.

²² Abiad (2003), p. 3.

²³ Kneclik, Scheufele (2007), p. 13.

²⁴ Since actual currency crises (in accordance with the above definitions) have not been registered in the Republic of Armenia in the period under review, these values therefore should be considered as periods of possible crisis or profound depreciation pressures on the exchange rate.

²⁵ Li, Rajan, Willet (2006), p. 9.

- Determination of crisis thresholds also depends on the parameters of index dynamics (mean and standard deviation), so many potential crisis episodes often observable in the beginning of the series may pass unnoticeable due to crisis occurred in future, that is future developments have an impact on the results of past events.
- Many authors argue that some valuable information contained in the relevant index is lost when converting the continuous EMP index to a series with dual (0/1) variables²⁶. That information may specifically relate to the intensity of the crisis or pressures.
- The most important is the rule of choice of the threshold level of the index, which is made at the discretion of the author and does not have a clear rationale.

Currency crises determinants

The stability of foreign exchange rate is usually of greater importance to developing rather than developed countries, since the latter have broader possibilities to affect their terms of trade, whereas the developing countries are largely reliant on the developments in the global market, being involved primarily in the exporting of raw material. Therefore, they increasingly attach greater importance to maintaining exchange rate stability as a tool for anchoring domestic inflationary expectations. Perhaps this is why a fixed exchange rate is an acceptable monetary regime for developing countries, which is possible to combine with only one of the objectives of domestic monetary independence or liberalization of capital flows, according to the rule of the "impossible trinity". However, very often in these countries, policy authorities attempt to accomplish the three objectives altogether, for the realization of some ambitious programs or because of existing financial problems. This may bring about currency crises, as a result. Although some of the above mentioned theories on crises only attribute a limited role to the main macroeconomic variables, it is however evident that the pre-crisis economic developments in developing countries are the main reason for the emergence of currency crises. Therefore, the relative popularity of the fixed exchange rate regime as well as inadequate economic developments provides room for an argument that currency crises are primarily inherent to developing countries. So, in order for crisis variables to be chosen, one must consider the causes for the currency collapses in these countries along with the discussion of the respective theories.

August of 1982 is considered the beginning of the 1980s crisis in Latin America, when Mexico declared about its depleted international reserves and incapacity to meet its own debt obligations. This is why that crisis was called a "debt crisis". A number of countries in Latin America came next to Mexico, crisis events began to be noticeable in the socialist countries of Eastern Europe (Poland) and in Africa as well, thus having involved a total of more than 40 countries²⁷. On the brink of the crisis, the countries in Latin America were suffering budget imbalances, which were mainly financed by exceptionally expansionary monetary policies. However, this was not the only characteristic: external shocks also had a significant role. Specifically, the crisis was mainly determined by tight monetary policies implemented in advanced countries in response to the inflationary pressures observable in early 1980s, which came after an unprecedented buoyance of international credit made to the developing world with low interest rates. Foreign currency inflows to developing countries considerably declined, driven by economic deterioration in developed countries, a sharp drop in prices in international commodity markets and further reduction in the volume of foreign lending. This went in parallel with the deteriorating terms of trade and reduced export proceeds. Under financial liberalization and poor banking supervision Latin American countries were getting increasingly prone to the crisis. The tremendous capital inflows in 1970s were coupled with unprecedented volumes of credit expansion, thriving assets and real estate markets and increasingly stronger consumption. The rise in interest rates globally triggered a phase of capital outflows whilst contributing to an increased volume of non-performing loans, asset and real estate prices falls, and banking system instability problems. With mostly dollar-denominated bank deposits, a persisting dollarization contributed greatly to the economic downturn, as well. Moreover, the dollar credit disbursed from abroad was mainly used to on-lend in local currencies in domestic real estate markets. As a result of this, currency depreciation (devaluation) led to balance sheet problems in the banking sector, bank insolvency, sharp asset price falls, and another round of the vicious circle of depreciations.

²⁶ Abiad (2003), p. 4.

²⁷ Krugman, Obstfeld (2000), p. 697.

Though some theories undermine the role fundamentals played in the Mexican currency crisis in 1994 this was also attributable to some economic imbalances. Back in early 1990s, stepping modestly into the path to exchange rate liberalization, Mexican authorities have nevertheless kept the exchange rate near the ceiling of appreciation which led to real appreciation and creation of a large current account deficit. International reserves fell sharply: the liberalization of the capital account, which was done without adequate tools for regulation of the banking system contributed to this. Authorities' decision to allow a 15% devaluation of the exchange rate triggered a wave of speculative attacks, which led to the outbreak of the currency crisis.

Economic instability on the verge of financial crisis was typical not only to the Latin American crisis of the 1980s. The Asian crisis of the 1997-1998 unfolded through almost the same scenario although some analytics were considering it unique by its nature, attributing the origination of this crisis to sudden change in expectations and confidence and the spread of it to the effect of contagion. However, without detriment to any opinion, it should be noted that although economic, political and structural problems were underlying this crisis, peoples' expectations, the herd behavior and the contagion played a large part in its spreading and intensity. Unlike the Latin American crisis, the Asian crisis did not come after budget imbalances or worldwide rise in interest rates. Nevertheless, external shocks, namely adverse developments with the exchange rates of the main currencies, contributed to the emergence of the crisis. Back in the mid-1990s, the sharp appreciation of the U.S. dollar against the Japanese yen in the Asian countries whose currencies were pegged to the U.S. dollar (in the meantime Japan was their main trading partner), led to a loss of competitiveness. With tight monetary policy implementation in Japan in 1997, there was a threat of funds outflow initiated by the banks of the main lender in the region, virtually re-playing the crisis scenario of the 1980s. With all this, however, instability in the financial system, which came just after the expansion of domestic credit and soaring of assets and real estate prices owing to influx of international loan capital, was the main similarity between the two crises. The Asian countries' financial systems were more advanced, however: the economy monetization ratio was very strong, and the firms' debt was 2-3 times²⁸ the size of their assets. It was obvious that the economy mainly built on short-term foreign liabilities would have to be sensitive enough to any even negligible external shocks. In the context of the Asian crisis, such factors as political situation, legal framework, banking supervision and regulation and other structural variables turned out to be important as well.

Without reference to a number of other crises which came in emerging countries afterwards (Russia in 1998, Brazil in 1999, Argentina in 2001, Turkey in 2001), one may draw some major conclusions based on the developments reported with regard to the main currency crises. The choice of the right exchange rate regime, the monetary policy strategy, the raising of credibility of the central bank, the banking system supervision, the correct sequence of economic reforms, and the ability to understand the effects of contagion are very important considerations.

In the context of building EWS, for the purpose of the choice of leading indicators that signal currency crises, one would need, apart from learning the above theories and countries' experience, to observe the role of any particular variable in crisis prediction in different analytical papers. This problem was first systemically addressed in the paper by Kaminsky, Lizondo and Reinhart (1998)²⁹. The authors have reviewed 105 leading indicators in 28 research papers regarding different aspects of currency crises and opted out a few of them which were of greater importance in most of the papers (see Appendix 4). Hawkins and Klau (2000)³⁰ and Abiad (2003)³¹ have also reviewed the results of many research papers published in later periods, in 1998-2000 and 1999-2003, respectively, which is summed up in Appendix 4, too. We have also examined numerous research papers published in the period 1995-2008 in which predictive properties of variables were evaluated and which were not provided in the above-said three papers. The findings of these papers are also provided in Appendix 2 and Appendix 4. Summing up the findings in a total of 86 works we have chosen leading indicators signaling currency crises, which were relevant in at least 5 research papers (see Appendix 4), as follows:

- ✓ **Overvaluation of real exchange rate:** the real exchange rate is the most popular and practical variable; it is viewed in more than 65% of the works. An overvalued exchange rate has an opposite impact on exports, economic growth and external competitiveness of the economy. Leading to external instability and the loss of competitiveness, it can be viewed as the least level of potential depreciation.

²⁸ Corsetti, Pesenti, Roubini (1998), p. 34.

²⁹ Kaminsky, Lizondo, Reinhart (1998), pp. 25-35.

³⁰ Hawkins, Klau (2000), pp. 3-5.

³¹ Abiad (2003), pp. 46-53.

- ✓ **International reserves:** the decline in the level of reserves points to the existence of problems the country has in external sector as well as to possible depreciation pressures on the exchange rate. In the meantime, a low level of reserves diminishes the central bank's ability to safeguard the local currency from speculative attacks.
- ✓ **M2/International reserves:** this variable is viewed as another indicator of a country's international reserves availability. M2 is considered the most probable broad money that can convert into a more stable currency. Therefore, this indicator denotes the central bank's ability to withstand exchange rate pressures determined by successive currency conversions.
- ✓ **Domestic credit growth:** credit growth is normally observed before the currency crises. This is true in consideration of the countries' experience as well as first-generation theories. The domestic credit growth usually follows the liberalization of the financial system and capital flows, which may result in problems associated with repayment of bank loans and mismatches in foreign exchange positions.
- ✓ **Current account:** the increase of the deficit of current account in GDP gives rise to serious concern in terms of foreign exchange receipts, heightening the likelihood of crisis. For Armenia, observing the current account is of greater importance as it is related to the issue of remittances (although the latter is treated as a separate variable), which provides the bulk of the country's foreign exchange receipts.
- ✓ **Export growth rate:** reduced exports will limit the country's capacity to obtain foreign currency, which may increase the likelihood of crisis. This indicator is another important factor that measures the loss of competitiveness as well as the problems existing with domestic firms. Besides, the low or negative export growth rate may serve basis to presume that the central bank would resort to the exchange rate depreciation in order to shore up exports and tackle current account-related problems.
- ✓ **Real GDP growth rate:** an economic decline is normally observable before the currency crises. In general, the country is more prone to crises when an adequate economic growth is not followed. This factor, however, is more important in the context of the country's dual objective function in the second-generation theories.
- ✓ **Budget deficit:** this is a classical indicator that describes currency crises as offered by Krugman. Persisting increment in the budget deficit points to an unsustainable government policy. It is usually financed owing to two principal sources: monetization of domestic debt and reduction in international reserves, each of which contains the main seeds of currency crises.
- ✓ **Inflation:** Though this indicator is rarely observed in the main theories, its role is important in assessing the country's overall macroeconomic environment. Moreover, it goes hand in hand with the high level of interest rates, which may create problems in the banking sector. It comes as no surprise that the importance of the indicator is underscored in about 20% of works on EWS studied.
- ✓ **Short-term foreign debt:** a massive influx of foreign capital follows the financial liberalization; this can be a cause of macroeconomic instability if we are talking exclusively about short-term debt-creating flows. The ratio of foreign debt to international reserves is another indicator that measures how much the country is secured with reserves. There is the Greenspan-Guidotti rule in economics stating that a country's reserves should at least equal the short-term foreign debt.
- ✓ **Change in asset prices:** bubbles in securities markets or such other asset markets often burst prior to currency crises. In addition, the falling of asset prices may witness the jeopardy of economic slowdown and loss of confidence. The indicator of securities price is usually discussed in various research papers but the real estate prices instead are also possible to consider.

Albeit the most commonly used variables (in 15% and more papers) were presented above, the choice is not limited to that, so nearly 24 leading indicators were chosen to lay under the further study in the paper (see Data Appendix, Table DA -3). Considering the argument of some authors that the structural and institutional variables play an important role in explaining the currency crises³², and that CART methodology applied in our analysis allows evaluating their significance, we have included 3 structural variables – democracy of the political system, the election results and the selected foreign exchange rate regime, although the latter can be considered as classical indicators of currency crises (Fischer's two-polar approach³³). The selected variables were used in different forms (absolute, relative, growth), which we will refer to in the next part of the study.

³² Ghosh, Ghosh (2002), p. 5, 23.

³³ Fischer (2001).

Practical models for building early warning systems

By mid 1990s of the previous century, there has been plenty of theoretical and practical research to explain the various crises observed historically or to check the validity of the theory in question. Only after the so-called “tequila” crisis in Mexico in 1994-1995 researchers began focusing on the development of functional methods for prediction of currency crises. The Asian crisis in 1997-1998 paved a way for heightened motivation to launch work in this direction. The crisis urged many governments and private sector firms to build mechanisms that would be designed to monitor on an ongoing basis the countries’ vulnerability to crises. Currently, in addition to the mechanisms applied by the international Monetary Fund (KLR, DCSD, PDR), similar models were designed and used by private firms, such as GS-Watch by Goldman Sachs, CSFB by Credit Suisse, Alarm Clock by Deutsche Bank, and etc. It is noteworthy that almost all of these mechanisms are used for prediction of crises in developing countries.

Various models are used to predict currency crises, and the most common of them (see Appendix 2) are probit/logit econometric models and Signals Approach modeling technique (this is often called Indicator Approach). The first works regarding the prediction of crises were authored by Eichengreen, Rose and Wyplosz (1995, 1996). These works contain graphically illustrated qualitative comparison of the movement of explanatory indicators in pre-crisis and post-crisis periods (often in crisis-prone and peaceful countries). Although this approach was the first of its kind and later was used by a number of other authors³⁴, it did not however gain much popularity. The two of the approaches introduced later – the probit/logit models and the Signals approach – grew into traditional models and started to be used almost in all early warning systems.

The most practical among them are the **probit/logit models** with dual choice. The first applications of the models are also associated with Eichengreen, Rose Wyplosz (1995, 1996). These models use the classical econometrical assessment techniques, by linking the probability of the crisis to the vector of explanatory variables. It gauges the extent of marginal contribution of each variable in explaining and predicting the crises. The main advantage is that they use a continuous series of explanatory variables, consider their possible multicollinearity and the ability to assess the statistical significance of each variable. The disadvantages are the possibility of using only a limited number of explanatory variables, necessity of certain statistical properties of the variables, the impossibility of addressing the issue of intersection between factors, and etc.

The Signaling approach is one of the non-parametric analytical methods developed by Kaminsky, Lizondo and Reinhart (1998). This is a simplest method based on the data on explanatory variables, which ignores the theoretical explanation underlying one or another variable or the existence of a structural model. Because more information on the Signaling approach will come later in this paper, let us just say that the main feature of this approach is that as opposed to probit/logit models it has a capacity to evaluate the possibility of false signals from different indicators and to measure their predicting power.

In addition to traditional methods, there are more than a dozen other models for building EWS, to the most prominent of which we will refer below³⁵:

The Markov-Switching Models began to be used for explanation of the crises starting from 1998-1999. Because the crises are often determined through the use of multiple equilibria models the Markov’s switching models have come to explain and predict economic switches between these points of equilibria. Whereas constant switching probability variants of the models were used initially like Jeanne, Masson (1998), Fratzscher (1999)³⁶, however at a later point the switching probabilities began to be observed as a function of various explanatory variables. The main advantage of using Markov switching models is that they are free of the need for initial definition and separation of currency crisis episodes (based on EMP index or otherwise), and crisis situations are identified and characterized endogenously as an output variable generated from model predictions. The main disadvantages of the model include the application complexity associated with their lack of standard econometrical software packages and the lack of various tests on statistical properties. However, in some cases, these models provide very good results compared with traditional approaches³⁷.

³⁴ For example, Milesi-Ferretti, Razin (2000). A similar approach will also be used in the next section of this paper.

³⁵ For the review of almost all the main models known in the literature of EWS see Abiad (2003).

³⁶ Abiad (2003), p. 5.

³⁷ Knedlik, Scheufele (2007), p. 25; Abiad (2003), p. 44.

Artificial Neural Networks is a multi-dimensional, non-linear, non-parametric statistical method built on the analogy of human perception and neural system. Likewise, it contains sets of elements which are independent of each other but interact simultaneously; it represents a network that is equipped with properties intrinsic to human cognition, i.e. parallelism, connectionism, adaptability, self-organization. Artificial neural networks began applicable in the late 1980s as a solution to the problem of prognosis in various fields of economics (exchange rates, inflation, GDP, etc.). Currency crises by this approach were first addressed in the paper by Nag and Mitra (1999) in which their forecasting properties have outstripped the Signaling approach³⁸. Multilayer neural networks also benefit when they are compared with another traditional approach, i.e. the probit / logit models³⁹. In general, neural networks are characterized by a number of properties that make them valuable in solving such problems as approximation, cognition, classifications and forecasting. First, the results of these models are independent of the nature of the distribution of the variables. Second, neural networks are applied to the problems of economics, in which the linkage between variables has not been identified theoretically or is impossible to figure out how and when such interrelationships are non-linear. Third, this model is flexible, which allows for excellent results in terms of explanation (overfit), but which is a big disadvantage in terms of forecasting, however. The main disadvantage of neural networks is in their so-called “black box” nature: because there are no clearly estimated coefficients, it is impossible to identify the role and significance of individual variables in the projection. Finally, in view of prediction of currency crises and construction of EWS, artificial neural networks are implied to be complimented other models (mostly traditional ones) as they are not able to identify the key variables that determine the occurrence of crises, but only can provide for excellent forecast by the use of given indicators.

Classification Trees or **Recursive Trees** are a methodology which had been of a very little use in the EWS-related literature in spite of a bunch of most important advantages that are particularly related to the joint effects or intersection of variables and the possibility to study the role of various qualitative factors (details of this method are provided in the respective section of this paper). The reason of nonpopularity, perhaps, lies in the computational complexity of the method and a lack of relevant software provision, as well as the need for a large database.

We know a total of 3 studies that explore the currency and capital account crises by the use of this method. The first is the paper by Gosh and Gosh (2002)⁴⁰, which addresses the role of qualitative (categorical) variables that explain currency crises (features of the political system), considering their possible interactions. This study is the only one that covers EWS, as the paper by Kaminsky (2003)⁴¹ attempts to figure out the nature of currency crises by the use of regression trees, while the other work by Chamon, Manasse, Prati (2007)⁴² relates to the capital account crises, although this paper is more steered to the problem of forecasting.

Obviously, none of the models above-mentioned as well as the ones not considered here can provide excellent qualitative properties as they have a number of drawbacks even though each of them is designed to deal with selected problems. This is why at least two models are often used in the literature on EWS. Our paper will also deal with two models, i.e. the Signaling Approach and the Classification Trees⁴³.

CHAPTER 3

Early Warning Systems in Armenia

Early warning systems are designed to solve problems related to predicting crises in the monetary and banking systems or financial crises on the whole. These are efficient models which, once estimated on a basis of the situations already explored, can provide a disclosure of the set of leading indicators and their signaling mechanism. This paper is done in pursuit of building vibrant mechanisms for Armenia for its ability to predict currency crises. In this paper we attempted to explore two main approaches – the

³⁸ Nag, Mitra (1999), p. 25.

³⁹ Peltonen (2006), p. 5.

⁴⁰ Ghosh and Ghosh (2002).

⁴¹ Kaminsky (2003).

⁴² Chamon, Manasse, Prati (2007).

⁴³ In future, we intend to also refer to probit/logit models, Markov Switching Model as well as Artificial Neural Networks

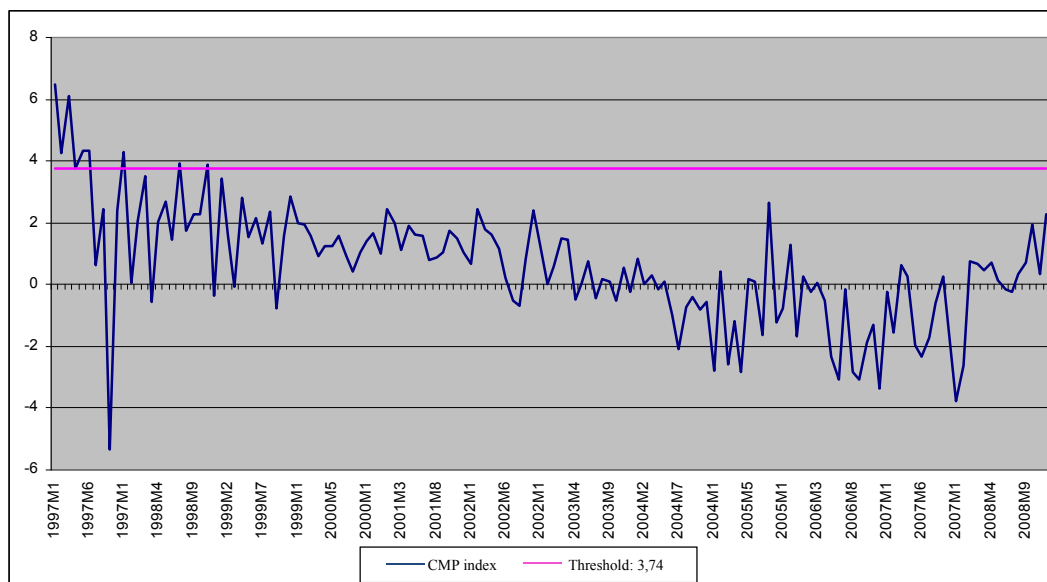
conventional Signaling Approach and the Classification and Regression Trees (CART) Method as a relatively new method which through its own specific algorithm best solves many problems associated with EWS (see the relevant section of the paper). We have also observed a number of EWS options and carried out various analytics (see Appendix 5 for general EWS structure developed for Armenia).

Distinguishing currency crisis episodes is key to understanding how EWS are to be established. In the context of the preliminary analysis of Armenia Exchange Market Pressures Index, the first version of EMP Index was accepted as the main crisis definition tool. Reviewing the results of many studies as well as additional analysis on Armenia, the threshold value for crisis index has been chosen using the 1.645 Standard Deviation Rule. It should be noted that in the construction of the models according to the CART methodology there were also used alternative options to EMP indices construction and crisis threshold calculations that is proposed below, which are called to resolve problems typical to crisis indices.

While discussing the approaches to currency crisis definition, it was noted that one of the main weaknesses of the proposed EMP index was the application of the entire series in building the components of the index and defining crisis threshold values, which could lead to some problems. We think crisis situations or currency pressures are more severe in relatively unstable periods of time but mitigate in periods of sustainable development. Therefore, the pressure of some intensity observable in relatively a stable period of time could bring in considerable crisis developments in that specific period whereas currency pressures with the same intensity might be interpreted as another innocent situation and failed to be characterized as crisis-relevant in an more unstable phase of economic development. Based on the aforementioned, we propose to apply two alternative options for definition of the crisis, on the basis of EMP index: according to the first approach the standard deviations and averages for both the index components (exchange rate, reserves, interest rates) in the phase of building a EMP index and the ultimate index in the phase of determining the crisis threshold⁴⁴ were constructed by the principle of moving window, with its length to have been defined 2 years⁴⁵ (the index and threshold level built for Armenia according to this option is presented in Figure 3-2). In the second option, the 2-year moving window was only applied for determination the crisis threshold only, meaning that though the index is built through the classic version, the crisis threshold is determined by the above-described principle of moving window, by adhering to the 1.645 Standard Deviation Rule (see Figure 3-3 for Armenia).

The comparison of traditional definition of currency crises (Figure 3-1) and two alternative indices for Armenia makes it obvious the problems we might encounter still in the initial phase of construction of EWS.

Figure 3-1: Traditional EMP index version (case of Armenia)



⁴⁴ This is to assume that although the 1.645 SD Rule maintained the crisis threshold is subject to the principle of moving window and can vary at different time intervals.

⁴⁵ This approach is partially close to the proposal by Zhang (2001) (source: Abiad (2003) (see Appendix 1).

Figure 3-2: First alternative approach to EMP index (case of Armenia)

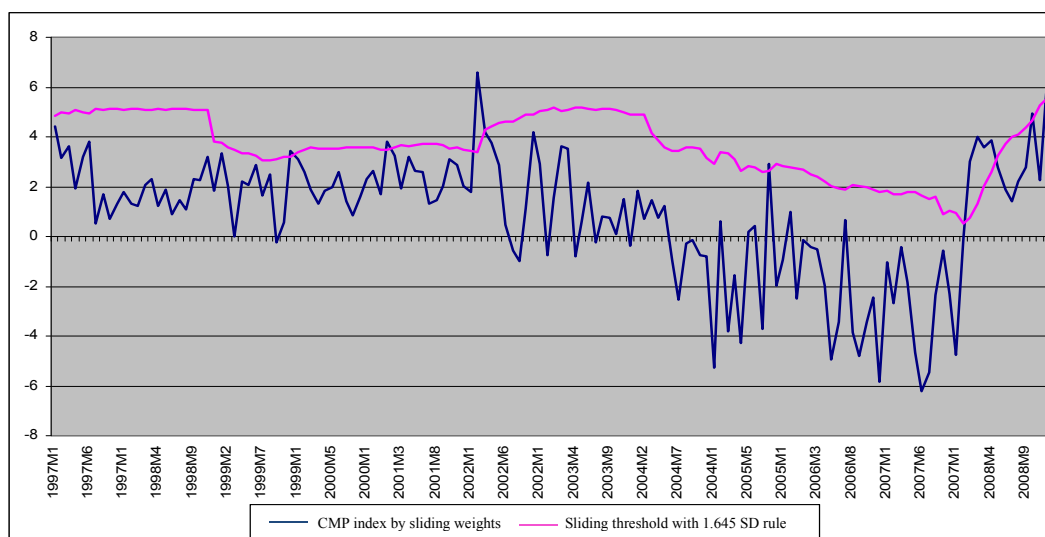
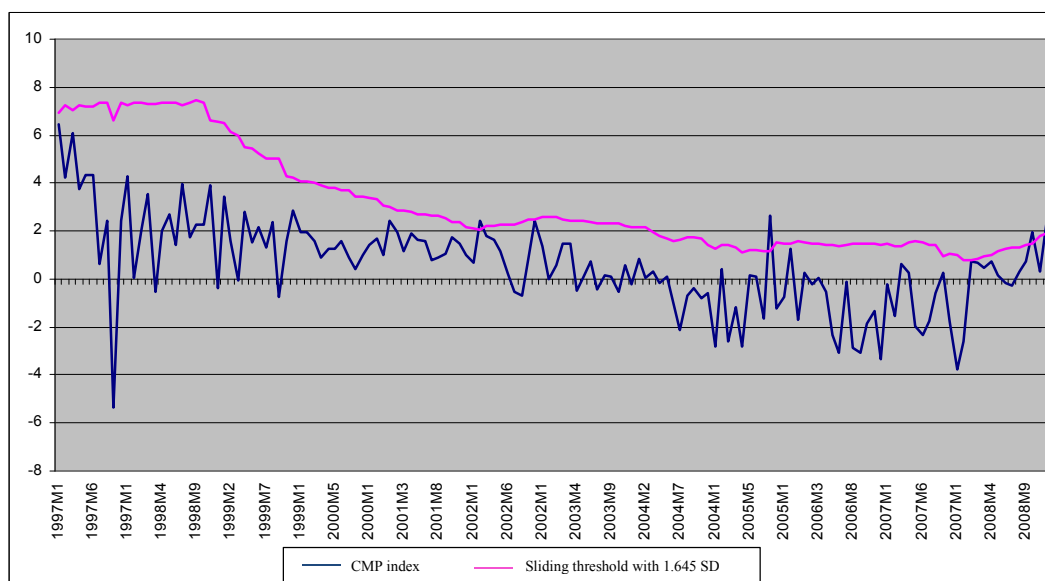


Figure 3-3: Second alternative approach to EMP index (Case of Armenia)



EWS predictive properties are largely determined by the **choice of signaling horizon**. The signaling horizon is the time interval within which different leading indicators are believed to issue different signals about an upcoming crisis. After the review of numerous research papers and the studies of country experience (National Bank of Poland) as well as in consideration of the short-termness of time series, we have decided on a signaling horizon to be a 12-month window (or 4 quarters, in quarterly models).

Data compilation and preparation

The process of currency crisis analysis and construction of early warning systems in this paper was done by basing upon two groups of databases – the panel data and Armenia-relevant data. The panel option incorporates countries of Central and Eastern Europe and CIS, with a total of 21 countries, including the Republic of Armenia. The use of the panel option was suitable in a sense that the short-termness of statistical series pertaining to Armenia as well as the scarcity of crises taken place in the period under discussion did not give us an opportunity to build stable and convincing models. The

choice of the panel is determined by the need to explore the specificities of the region in the first place and the consideration of making useful conclusions about Armenia. However, since most data on the countries observed was not possible to obtain on a monthly basis, which is vital in terms of building an efficient EWS, the models were also built by only using monthly data on Armenia. It should be noted that the Signaling Approach below has considered the monthly data on Armenia only.

The database covers the monthly and quarterly series for the countries under discussion for the period 1990-2009. The length of time series for individual countries was determined as per availability of data (see Data Appendix, Tables DA-4, DA-5).

Most data rely on such main sources as the IMF International Financial Statistics database and the data provided from central banks and statistics services of the respective countries, and publications of various international organizations (see details in Data Appendix, Table DA-1).

The data undergo some preprocessing (individual sets of annual and quarterly data converted into quarterly and monthly data, respectively, seasonal adjustments if needed, etc.), to get the set of leading indicators which were then used in the subsequent analysis (description of data and specifics of respective adjustments is detailed in Data Appendix, Table DA-2).

Preliminary analysis of leading indicators

After we have defined the main EWS parameters, and before going to the construction of prediction models, let us first analyze the movement of the variables in the pre-crisis and post-crisis periods, based on both the panel and Armenia-relevant data. The graphical analysis in Appendix 6, which depicts the performance of individual variables within the signaling horizon and in aftermath the crisis in developing countries and Armenia, makes it clear that there are a number of interesting features to be discussed. One of the most important observations is that the deposits dollarization indicator for both panel and Armenia-relevant data trends up on the very eve of the crisis and afterwards. This is because of the “original sin” problem and the lack of confidence in the local currency in developing countries. Next important conclusion is about the behavior of real exchange rate as it goes abruptly an overvaluation path at least one quarter prior to the crisis and traces undervaluation immediately thereafter. The latter is a consequence of so-called overshooting. The difference of performance of indicators for the set of developing countries and Armenia is pronounced for *terms of trade* indicator: whereas the indicator reports a theoretically reasonable decline in Armenia prior to currency crisis, the panel data show high growth rates instead, which points to the weakness of this variable as a leading indicator (as we’ll see later, almost all panel models support this fact). Going short of analysis of other variables, let us just add that the charts illustrate theoretically explained dynamics of the selected leading variables, so they can be included in the further works of construction of EWS models.

Signaling Approach as a tool for Predicting Currency Crises in Armenia

The Signaling approach is a non-parametric analysis method developed by Kaminsky, Lizondo and Reinhart (1998)⁴⁶. It gained popularity in the literature in studying the problems of building of early warning systems for prediction of currency and financial crises. This method boasts a great scope of applicability in predicting turning points in business cycles based on macroeconomic and financial indicators. The characteristic feature of the latter is that, unlike the methods of parametric analytics (logit, probit), it is able to assess the ability of various factors to issue wrong signals and the capacity to predict crises. In general, the basic principle of Signaling Approach is as follows: when an indicator exceeds a certain threshold value it has been ascribed to, it is a warning signal that there is probability or threat of crisis in the upcoming signaling horizon.

The Signaling Approach involves a series of sequential steps the initial phases of which are common in almost all practical models for building EWS. Accordingly, building a model by the Signaling Approach will involve as follows:

1. definition and evaluation of currency crisis,
2. determination of the set of probable explanatory or leading indicators,
3. compilation of appropriate time series and determination of the length of the series and data frequency,

⁴⁶ Kaminsky, Lizondo, Reinhart (1998).

4. decision on the crisis window or the signaling horizon; this is the period prior to the crisis when variables are expected to issue a warning signal,
5. calculation of individual threshold values for each variable, which would enable to separate the tranquil period from the crisis period,
6. evaluation of predictive properties of various indicators,
7. construction of a Composite Index and evaluation of conditional probabilities of emergence of crises⁴⁷.

Since the first 4 steps are general to all the EWS models and the ones we build as well, these were addressed in detail in the previous sections of this paper. Note only that the model by the Signaling Approach is being built based on *Armenian* monthly data only, which cover a period from January 1996 through March 2009. For leading indicators, a total of 20 indicators were chosen out of the above list (see *Data Appendix*), which are non-institutional (non-categorical) in their nature. All other parameters are analogous to the above general principles, with the crisis rule of 1.645 standard deviation and the signaling window of 12 months.

Signals and thresholds: within a signaling horizon, if the value of an indicator goes beyond a certain level, it means it has signaled about the probability of emergence of a crisis in the course of upcoming 12-months, and that marginal level is the *signaling threshold* of that indicator. The signal is good if the crisis occurs within the crisis window after the signal has been issued, and if otherwise, the signal is considered to be false or a noise. The threshold level of each indicator is chosen so that there is a balance between the risk of false signals and the risk of missing the crises (first and second type errors). This is achieved as the noise-to-signal ratio (false signals to good signals) seeks to the minimum (we'll refer to this problem later).

The selection of indicator thresholds is done in two stages:

- the thresholds are defined in relation to percentiles of the distribution of observations of the respective indicator, and
- a grid of reference percentiles is constructed and the threshold that minimizes the noise-to-signal ratio is chosen to be the best threshold. Depending on which direction the indicators are expected to give a signal (above the threshold values or the values below them is a concern), two edges of the grid of reference percentiles are considered (5%-45% or 55%-95% of distributions)⁴⁸.

In the models under Signaling Approach, where panel data are applied in the main, the choice of the indicator thresholds is as follows: observations of all countries with regard to any particular indicator are brought together (provided the task is not to explore the crises in one country, as is the case with us), then the noise-to-signal ratio is built for each value of the reference percentiles of distribution of the indicator. Finally, the best threshold is the one for which the noise-to-signal ratio is the minimum. Once the best indicator thresholds are chosen, the threshold in question shall apply to the series of distribution of an appropriate indicator for the particular country. This means whereas the relative threshold of an indicator is the same for all countries, the absolute threshold varies across countries. For instance, if the noise-to-signal ratio for the indicator of "export growth" takes its minimum at the 15% percentile of the distribution of the series, the absolute threshold for the same percentile level for Armenia may be -2%, and, for example, for Romania, -0.7%. Our model only includes data pertaining to Armenia, so the chosen relative threshold and absolute value pertinent thereto are unique in the entire model.

The forecasting properties of variables under the Signaling Approach are estimated by dint of a bunch of indicators, the most important of which is the noise-to-signal ratio. For calculation of the latter, Kaminsky and others (1998) suggest using the following matrix:

	Crisis	No Crisis or Tranquility
Signal was issued	A	B
No signal was issued	C	D

In the matrix, A is the number of months for which the indicator has issued good signals, B is the number of months for which the indicator has issued false signals, C is the number of months for which the indicator has issued no such signals that would have been treated as good, D is the number of months for which the indicator has issued no such signals that would have been treated as false. Obviously, the indicator's predictive power would be perfect, if B = 0 and C = 0.

⁴⁷ This stage is absent in the paper by Kaminsky, Lizondo and Reinhart (1998) and is an important addition provided by certain authors to the above 6 classical phases.

⁴⁸ In an alternative version of our models built by the use of Signaling Approach, which is presented in Appendix 7, the grid of percentiles in the range 10%-35% and 65%-90% is applied.

So, the noise-to-signal ratio is calculated as a ratio of actually reported false signals as a share of potentially false signals to actually reported good signals as a share of potentially good signals, or based on the matrix above:

$$NSR = \frac{B / (B + D)}{A / (A + C)}$$

This ratio allows not only figuring out the threshold values of indicators but also assessing ***predictive properties (performance)*** of each factor⁴⁹. The indicator is considered to have predictive properties if its noise-to-signal ratio is considerably below 1. Usually, the variables with values above 1 of the noise-to-signal ratio are not considered in the prediction models.

For calculation of threshold values and the respective noise-to-signal ratios, one would need to analyze the leading indicators with respect to the EMP index movements (this is applied to reveal the crisis episodes), in order to disclose marginal thresholds that provide the minimum level of the noise-to-signal ratio. Therefore, in the context of crisis episodes revealed by the use of the chosen EMP index and a respective rule, we have evaluated predicting properties of the factors and the relevant thresholds, which is presented in Table 3-1. Note that the option of 5%-45% and 55%-95% grid of reference percentiles was used in the example provided⁵⁰.

As is shown in the table, such factors as inflation, credit/deposit ratio, foreign debt, money supply, and other indicators came in with the best performance. It is noteworthy that the best results in terms of both conditional probability and response to the crises were also attributable to the inflation indicator. Thus, if the y-o-y inflation exceeds the threshold value of 9.6%, all else being equal, currency pressures may become possible in the upcoming 12-month horizon with about 97% of probability. It should be noted that only such indicators as inflation and the banking system's assets-to-liabilities ratio have responded to all 10 crises observed in the reference period.

In general, almost all the variables addressed have shown strong predictive power: by 17 factors out of 20, the noise-to-signal ratio is below the value 0.5. Only short-term foreign debt and dollarization indicators posted a complete powerlessness (the noise-to-signal ratio is above 1). This provides good support to the best capabilities of selected variables. These indicators have provided the best results in many studies reviewed. Thus, all the variables (perhaps with the exception of short-term foreign debt/international reserves, dollarization, and, with some reservation, the budget deficit) can be considered as leading indicators for predicting currency crises in Armenia.

Table 3-1: Performance of leading indicators for predicting currency crises (Option 1)⁵¹

	Absolute threshold	Relative threshold (percentile)	Noise-to-signal ratio	Conditional probability* (%)	Crisis signaled** (%)	Significance
	1	2	3	4	5	6
Export growth rate	-26.856	0.08	0.055	85.714	70	6
Real exchange rate overvaluation	4.772	0.94	0.253	54.545	90	14
M2/International reserves	110.663	0.94	0.041	90.909	10	4
Real estate price growth rate	-0.058	0.12	0.082	66.667	10	7
Current account/GDP	-19.940	0.13	0.108	73.684	90	9
Budget deficit/GDP	-2.986	0.07	0.810	27.273	30	18

⁴⁹ The choice of best thresholds of factors, which implies minimization of the noise-to-signal ratio, can also be interpreted in the context of statistical testing by introducing the idea of Type I and Type II errors. Let the emergence of a crisis be the zero hypothesis (H_0) and the lack of a crisis be an alternative hypothesis (H_1). According to the above matrix, we can see that $H_0 = A + C$ and $H_1 = B + D$. The size of Type I error equals the probability of rejection of hypothesis H_0 , while it is true: so, $\Pr(\text{rejection of } H_0 / H_0 \text{ is true})$, that is to say, Type I error is defined as $C / (C + A)$. Type II error is accepting hypothesis H_0 , when it is not true: so, $\Pr(\text{accept } H_0 / H_0 \text{ is wrong})$, that is, it can be defined as $B / (B + D)$. Therefore, the best thresholds are chosen by striking a balance between Type I and Type II errors, which is carried out through the noise-to-signal ratio. So, the latter would be defined as a ratio of Type I error over 1 minus Type II error, that is $[B / (B + D)] / [1 - C / (A + C)]$.

⁵⁰ The results of the alternative version, which uses the grid of percentiles in the range 10%-35% and 65%-90%, are presented in Appendix 7.

⁵¹ Kaminsky, Lizondo, Reinhart (1998) use a lot of other statistics in their paper, which we did not include in this table but they could be provided, if needed.

	1	2	3	4	5	6
Short-term foreign debt/International reserves	28.641	0.56	6.384	5.797	10	19
Domestic credit growth rate	79.388	0.93	0.235	63.636	20	13
External debt/GDP	64.162	0.94	0.036	88.889	70	3
Inflation	9.566	0.8	0.013	96.774	100	1
Economic growth	4.056	0.15	0.301	57.692	90	15
Remittance growth rate	-27.667	0.05	0.118	62.500	20	10
Banks' foreign assets/foreign liabilities	46.285	0.22	0.096	81.081	100	8
Terms of trade	-2.027	0.13	0.442	40	40	17
Credit/Deposits	193.612	0.86	0.020	95.455	90	2
International oil prices	20.140	0.25	0.183	69.231	90	12
Difference of long-term and short-term interest rates	26.612	0.94	0.046	90	90	5
World economic growth	-4.707	0.05	0.411	50	10	16
Dollarization	70.054	0.55	13.964	2.857	20	20
International reserves/GDP	13.219	0.08	0.169	64.286	10	11
* Probability that a crisis may emerge, provided that the indicator has issued a signal A/(A+B).						
** Denotes that part of the crises that a particular indicator has called.						

At any given time interval, the more the indicators issue signals about a potential crisis, the higher the probability that it would happen. So, in order to assess a country's vulnerability to crises, we need to have all the signals in combination. To deal with the problem, Kaminsky (1998) has explored 4 versions of building a Composite Index in them the versions with simple sums of signals and taking into account the intensity of the signals and predictive properties of respective indicators, and arrived at a conclusion that the best results in terms of forecasting power for both banking and currency crises are attributable to that option of Composite Index which accounts for forecasting accuracy of individual indicators⁵².

So, in our paper, we too will use the option of the Composite Index that combines all signaling indicators into a single ratio by taking account the prognostic qualities of indicators (the noise-to-signal ratio).

However, before ever attempting to build a Composite Index, Bruggemann and Linne (2002) are proposing to get the intensity of each indicator within the signaling window⁵³. Furthermore, instead of simply computing the number of signals of the indicator, as is known in conventional wisdom, what they propose though is to weigh each of these signals by their relative position inside the window. That is, realizing that earlier signals are of less importance than the recent ones, the principle of moving average will be used here to build the indicators, as follows:

$$Z_t^j = \sum_{i=1}^{12} \frac{I_{t+1-i}^j}{i} \quad t \geq 12$$

where: j – is the respective number of an indicator, I – is the value of an indicator (0,1): 1, if the indicator has issued a signal about the potential crisis, 0, otherwise, i – is the position of the indicator in the 12-month window.

Once the calculation of these interim indicators is complete, the Composite Index will be built by weighing the specified values by noise-to-signal ratios of respective indicators:

$$CI_t = \sum_{j=1}^k \frac{Z_t^j}{NSR^j}$$

where: j – is the respective number of an indicator, k – is the number of indicators in review, NSR – is the noise-to-signal ratio.

Certainly, this type of Composite Index is important in consideration that the indicators equipped with best predictive qualities (indicators with the least noise-to-signal ratios) get the biggest weights.

Though the Composite Index can give an idea of the change in intensity of crisis-related signals delivered from the variables, its values cannot be interpreted nevertheless: perhaps the growth of the index may denote an relatively heightened likelihood of crisis and, vice versa, the lower values of the index would hint weakened pressures in the macroeconomic environment.

⁵² Kaminsky (1998), p. 16-18, 20.

⁵³ Bruggemann, Linne (2002), p.12.

However, the values of Composite Index allow us determining the conditional probability of emergence of crises, depending on which interval the index has taken a value from. A probability like this is estimated as follows:

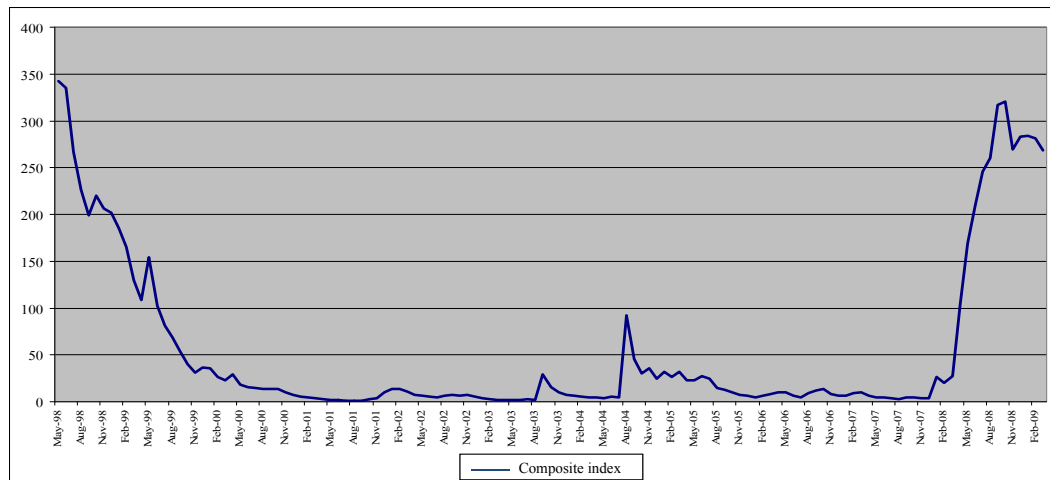
$$P(C_{t,t+24}|CI_u \leq CI_t \leq CI_v) = \frac{\sum \text{month } CI_u \leq CI_t \leq CI_v \longrightarrow \text{crisis}}{\sum \text{month } CI_u \leq CI_t \leq CI_v}$$

where: $C_{t,t+12}$ - is probability of a crisis in the course of the 12 months following t , CI_u and CI_v - are conditional lower and upper bounds of the values of Composite Index. The numerator of the formula has the number of months for which the index has been within the selected range, and the crisis has occurred in the course of 12 months followed, and the denominator has the total number of months for which the index has been within the range.

According to above methodology a Composite Index is built for the Armenian economy. The index comprises all 20 variables despite the fact that two of them – the short-term foreign debt and the dollarization – have a noise-to-signal ratio above 1. Normally, indicators with coefficients above 1 are not included in the models. However, because all the other variables have demonstrated a maximum noise-to-signal ratio of 0.5 (except the budget deficit of 0.81), while that ratio of the two noisy variables is way above 1, we may state the latter would not have a significant impact on the value of the index but could bring the effects of selected events into the model instead⁵⁴.

The dynamics of Composite Index (see Figure 3-4) shows that it has issued most of the signals by the year 2000 but performed fairly steadily in the period 2000-2007.

Figure 3-4: Composite Index dynamics



The Figure demonstrates several steep jumps of the index, which implies that the likelihood of a crisis in the upcoming 12 months was increasing. In particular, starting April 2008, the Composite Index has trended abruptly upward, which meant intensification of currency pressures by end-2008 and the beginning of 2009.

In order to produce a probabilistic summary estimation of the country's vulnerability to crises, we matched the dynamics of Composite Index with the EMP index movement and calculated the conditional probability of currency crises in the event the Composite Index takes values from different ranges. Since in total 10 episodes (including March of 2009) out of 147 possible were chosen out by the use of the EMP index to be crisis-hit, the unconditional probability of currency crises is 6.8%. Usually in literature, the index intervals for calculating the conditional probabilities are chosen arbitrarily. However, for the sake of more reasonable choice, we use CART methodology (see details in the next section) which has distinguished the appropriate ranges (see Table 3-2).

⁵⁴ In Appendix 7, where an alternative network of percentiles was used in building Composite Indices, the factors with noise-to-signal ratios above 1 were excluded.

Table 3-2: Conditional probabilities of the crisis by Composite Index value

Composite index	Conditional probability (%)
0-27.08	0
27.08-102.76	5.55
102.76-167.11	20
167.11 and over	91.43
Non-conditional probability	6.8

As shown in Table 3-2, higher values of the index are associated with higher probability of crisis. Moreover, 32 values out of 35 values above 167.11 of Composite Index have predicted crises. The value 167.11 can be considered the threshold level of the index as, once above that level, the probability of emergence of the crisis exceeds 50%. Sure, the closing interval is anyhow possible to divide into sub-intervals so as to produce a more gradual hierarchy of probabilities but because a mechanism of cross-validations in CART enables to consider the model's general predictive properties in determining the thresholds, we find it reasonable to rely upon the CART results solely.

While the probabilities presented are quite promising, in the context of this methodology it is possible to forecast the probability of a crisis for the upcoming 12 months, i.e. the probability of emergence of the crisis any time in the 12-month window. Therefore, for building a Composite Index, we are proposing to use another indicator that would allow predicting the probability of the crisis as of any particular month. The coefficient is calculated, as follows:

$$Z_t^j = \sum_{i=1}^{12} \frac{I_{t+1-i}^j}{(13-i)}$$

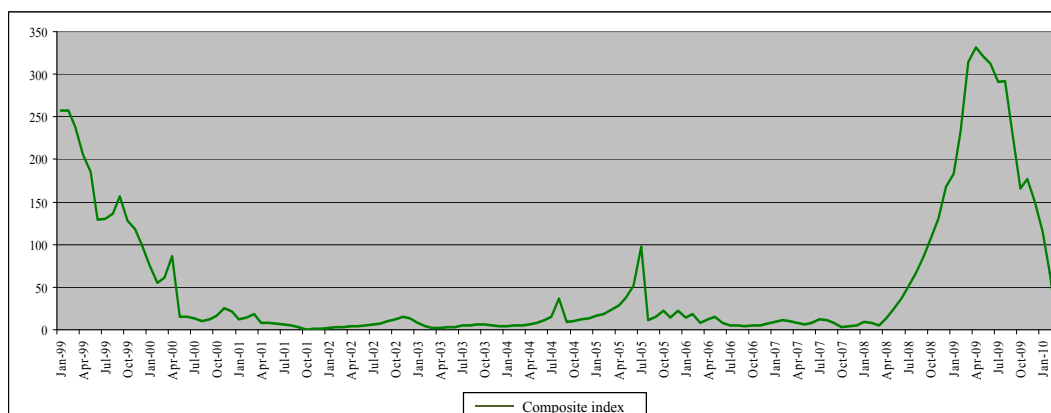
The implication of this coefficient is that the probability of emergence of the crisis at any given time depends on the signals various indicators had issued in the course of 12 months prior to that time. However, since any signal of the indicator is pertinent to the 12 months coming next, the highest weight will therefore be prescribed to the most distant signal and the lowest weight to the nearest signal, for any given time.

The next steps of calculating the Composite Index comply with the above description, with the only difference that the probability of the crisis is estimated as of any particular month:

$$P(C_t | CI_u \leq CI_t \leq CI_v) = \frac{\sum_{month} CI_u \leq CI_t \leq CI_v \longrightarrow crisis}{\sum_{month} CI_u \leq CI_t \leq CI_v}$$

The dynamics of the Composite Index calculated through this approach is presented in Figure 3-5, which exhibits roughly the same trend patterns while predicts relative tranquility for the period 2001-2008.

Figure 3-5: Composite Index dynamics (instant approach)



The index also shows that starting from October of 2008 the value of the index has grown sharply and hit its ceiling in March-May of 2009. These developments demonstrate that the probability of emergence of the crisis reached the peak during those months, which materialized in March of 2009 in the form of sharp depreciation of the exchange rate. Interestingly, the index makes some amount of forecast for the upcoming months by basing upon data prior to March of 2009. Although these forecasts are subject to adjustment, they can confirm to the gradual weakening of overall macroeconomic tensions in the economy in the period up to the first half of 2010.

For this method, the probabilities were also assessed using the CART methodology, and are presented in Table 3-3.

Table 3-3: Conditional probabilities of the crisis by Composite Index value (instant approach)

Composite index	Conditional probability (%)
0 – 314.68	0
314.68-413.9	25
413.9 and over	75
Non-conditional probability	6.8

The distribution of probabilities in the table also pinpoints that high index values determine greater crisis likelihood: no value almost up to 315 of the index has been registered in any crisis observed. If the index value exceeds 413.9, the probability of the crisis reaches 75% (6 crises out of 9 observed have occurred in the incidence of these values). In the most recent March of 2009 depreciation of the exchange rate the index reported a value level of 315, which meant a 25% probabilistic situation.

Classification and Regression Trees in EWS

The Classification and Regression Trees (CART) approach is a binary statistical data classification algorithm which was developed in the mid-1980s by American Scientists⁵⁵. It has applications in many areas: the first applications pertain to shipbuilding, predicting heart seizures; in finance and economics, it has been applicable back in 1985 for the classification of distressed firms by Friedman, Altman, and Kao and classification of commercial loans by Marais, Patel, and Wolfson. Recent applications include the disclosure of the nature of currency crises by Kaminsky (2003), the aspects of prediction and clarification of capital account crisis by Chamon, Manasse, Prati (2007). The only study we know more or less relating to the problems of EWS that uses this methodology is Gosh and Gosh's (2002) research.

CART is a statistical tool or technique for non-parametric analysis, which solves, in a broader sense, the problem of systematic representation of decision rules in the form of binary trees; in a narrower sense, it identifies the list and importance of the input variables that best describe and predict a specific outcome of a certain dependent variable. Moreover, the dependent variable can be either of discrete type (categorical), in which case the Classification tree is used, or continuous, in which case the Regression tree is used (the main principles of construction of Regression trees are presented in Appendix 9).

The main task of CART is to identify classifiers or respective prediction structures, which makes it possible to classify future observations into appropriate groups (for example, crisis or non-crisis, an average exchange rate appreciation of 5% or 2%, or depreciation of 4%, etc.).

CART classification mechanism bases on three main elements:

- the sample-splitting rule,
- the goodness-of-split criteria,
- the criteria for choosing an optimal or final tree.

In general, the construction of the tree through CART is carried in following steps:

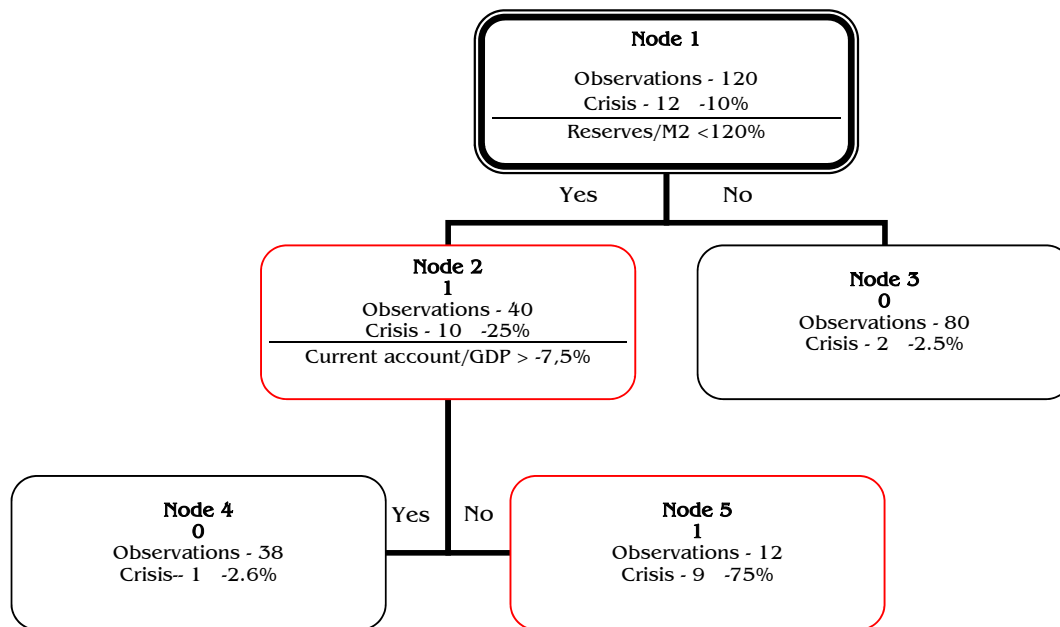
- initial split of observations into two sub-groups, right and left sub-groups, based on some simple question about an explanatory variable requiring 'Yes' or 'No' answers,
- the sub-groups, which are called nodes, are also divided in the manner above described. In these subsequent steps the biggest possible tree is built, and each *terminal node* (which no longer can be split) of the tree is characterized by absolute homogeneity of the observations included,

⁵⁵ The theoretical and empirical aspects of this approach are provided in the book Bremen Leo, Friedman H. Jerome, et. al. "Classification and Regression Trees", The Wadsworth Statistics/Probability Series, 1984.

- from the biggest possible tree, which best interprets the present observations yet falls short of the correct classification of new observations, the optimal or effective tree is pruned, which is the one that meets the chosen criterion (exemplary illustration in Figure 3-6).

In the process of construction of Classification Tree, assigning classes to the appropriate nodes (whether terminal or intermediate) is very important⁵⁶. Although each tree node is described by the number of observations related to each value (class) of the discrete dependent variable, only one adequate class (usually with a bigger share) is assigned to the node. Assigning classes to the nodes is also important in terms of evaluation of predictive properties of the trees and the choice of the optimal trees.

Figure 3-6: An Example of a Classifications Tree for currency crisis



In the figure, Nodes 3, 4 and 5 are terminal nodes, while Node 2 is non-terminal. As such, each node has been assigned a respective class: 0 for non-crisis and 1 for crisis situations.

Classifications Tree Construction Methodology

Constructing a Classifications tree requires three basic elements. These are:

- a set of questions that underlie the split,
- splitting rules and goodness-of-split criteria,
- rules for assigning a class to each terminal node.

There are two formats of *splitting questions* applied in CART:

- Is $X \leq d$, where X is a continuous variable, and d is any constant value out of the X series, e.g. whether *income* $\leq$ \$2000,
- Is $Z=b$, where Z is a categorical variable, and b is any discrete integer value taken by Z , e.g. whether *gender*=1.

Before *splitting rules* and *goodness-of-split criteria* are discussed, let us refer to the *impurity function* and *impurity measure*, which are vital in determining the splitting rules and goodness-of-split criteria.

Let $j=1, 2, \dots, k$ are the numbers of possible classes assigned to the categorical dependent variable; in this case $P(j | t)$ will represent the class probability distribution of the dependent variable in node t , such that:

⁵⁶ In regression trees, the class-assignment is not required, and statistical descriptors of nodes come to substitute them.

$$P(1 | t) + P(2 | t) + \dots + P(k | t) = 1$$

Thus, the impurity function⁵⁷ is defined as a function of the above-said class probabilities:

$$i(t) = \Phi(P(1 | t), P(2 | t), \dots, P(j | t))$$

Moreover, the definition of impurity measure allows for flexibility of functional forms.

Splitting rules: there are many splitting rules applied in CART, and the most common of them are three – the Gini criterion, the twoing rule, and the linear combination splits. In addition to these main splitting rules, CART users can define a number of other rules for their own analytical needs.

The Gini criterion is the most common, so let us examine that in detail. The Gini impurity measure is defined as follows: $i(t) = 1 - S$, where: $S = \sum_{j=1}^k P^2(j | t)$. This impurity function takes its maximum value when the probabilities of all classes are equal in the node: $P(1 | t) = P(2 | t) = \dots = P(k | t)$, and attains its minimum (=0) when all observations of the node belong to only one class.

Goodness-of-split criteria: let s be a split of t node into two sub-nodes. In this case, the goodness-of-split of the “ s ” is defined as reduction of the impurity measure:

$$\Delta i(s, t) = i(t) - P_L[i(t_L)] - P_R[i(t_R)]$$

where: s is a particular split, P_L and P_R are those proportions of cases at node t that go to the left and right child nodes respectively, $i(t_L)$ and $i(t_R)$ are the impurities of the left and right nodes, respectively.

Class assignment rule: before discussing the basics for rules, let us turn to the idea of prior probabilities at first. There are three types of priors in CART – data priors, equal priors and mixed priors. These are to be estimated from the data or have to be inputted by the researcher (user).

Now, assume N is the number of observations in the sample, N_j is the number of cases belonging to the class j in the observations, π_j is the prior of the cases belonging to the class j .

- **Data prior** assumes that the class distribution of the dependent variable in the population is the same as in the sample $\pi_j = N_j / N$.
- **Equal prior** implies that the probabilities that all classes of the dependent variable would appear in the population are equal. For example, if the dependent variable in the sample is a categorical with two classes, then the probability of occurrence of each of them equals.
- **Mixed prior** is the average of the above two priors for each class.

Now, let us refer to the class assignment rules. Classes are assigned to all the nodes, including terminal, intermediate and even root nodes. There are two assignment rules, each of which is based on one type of the misclassification costs.

- **The Plurality rule:** assign terminal node t to a class for which the $P(j | t)$ is the biggest, that is, if majority of cases in the terminal node belong to a class, then the node is assigned to that class. In fact, this rule assumes equal misclassification costs for each class.
- Assign terminal node t to a class for which the expected *misclassification cost* is at a *minimum*. This rule takes into account the severity of wrong classification, so it inputs the variable cost into the Gini criterion.

For example, when discussing aspects of currency crises, wrong assignment of classes to the node is relatively a serious concern; in this context, wrong classification will mean, for example, assigning a period of tranquility to the crisis situation and vice versa. Therefore, this problem is tackled by building a misclassification costs matrix with elements as $c(i | j)$: this is the cost of classifying class j case as class i case:

$$c(i | j) \geq 1, \text{ »}\Gamma\text{» } \#j \in \text{ »}\Gamma\text{» } c(i | j) = 0, \text{ »}\Gamma\text{» } i = j$$

Taking into account the priors and misclassification costs, we will get the cost of assigning a class to the terminal node:

$$r_j(t) = \pi(j) \cdot \prod_{i=1}^k c(i | j), \#j$$

⁵⁷ The impurity function is designed to measure the extent of homogeneity. In this context it can be considered as a variance or dispersion of observations in the node.

Accordingly, if we assume that $r_1(t) < \max(r_j(t), j=2, 3, \dots, k)$, then Class 1 will be assigned to that particular terminal node, according to the Rule 2. If all $c(i | j)$ are equal, then Rule 1 (the Plurality rule) applies, and the node is assigned to a class for which prior probability is the highest. So, the class assignment will be as follows:

node t is assigned to class i , if:

$$\frac{C(j|i)\pi(i)N_i(t)}{C(i|j)\pi(j)N_j(t)} > \frac{N_i}{N_j} \text{ for all } j,$$

where: $N_i(t)$ is the number of observations of class i in node t , N_i is the number of observations of class i in the dataset.

In fact, this definition takes into account the costs associated with the decision on classification of future observations by basing upon the classification tree as well as prior probabilities of different classes.

Based on the main elements above, classification the construction of the tree will involve several stages, aiming to get more homogeneous nodes out of the root node that is strongly heterogeneous. Starting from the root node, the tree construction process includes:

1. The data set based on all possible values (data points) of all the variables is split into two binary sub-groups. Cases with a “yes” response to the question posed are sent to the left node and those with “no” responses are sent to the right node.
2. CART then applies its goodness-of-split criteria to each split point of each of the variables and evaluates the reduction in impurity. CART selects the best split of the best variable as that split for which the reduction in impurity is the highest.
3. CART then assigns classes to these nodes according to the rule that minimizes misclassification costs.
4. Because the CART procedure is recursive, steps 1–3 are repeatedly applied to each non terminal child node at each successive stage.
5. CART continues the splitting process until the largest possible tree is built. The terminal nodes of this largest tree are not susceptible to further split as they are either pure (absolutely homogeneous) or have very few (often one) cases.

Large trees which are called complex trees (the complexity of a tree is measured by the number of its terminal nodes), can have two types of problems: 1/ understanding and interpreting trees with a large number of terminal nodes is a complicated process, and 2/ although they are highly accurate, with low or zero misclassification rates, large trees provide poor results when applied to new data sets and new classification of observations. This is because the tree is fully aligned with the data observed, and is set to explain the impact of both the fundamentals and different noises. Because the noises are different by nature, the branches of the tree that explain such noises shall be separated or eliminated (pruned) so that the tree is able to make accurate forecasts. CART offers a solution to this problem by means of the Tree Pruning Algorithm. The pruning of the tree starts from the lowest branches and gradually prunes terminal nodes, provided that the new misclassification cost is smaller than the change of complexity of the tree. So, there appears a trade-off between complexity of the tree and its accuracy. The relationship between tree complexity and accuracy can be understood with the cost complexity measure, which is defined as follows:

$$\text{Cost Complexity} = \text{Resubstitution Misclassification Cost} + \beta * \text{Number of terminal nodes},$$

The resubstitution misclassification cost is estimated only on the basis of observed data set that is why it is often called internal misclassification cost: the value of the latter declines gradually with the increase in the complexity of the tree, since larger trees better fit the data. Therefore, the misclassification cost of the largest possible tree attains zero. In fact, the latter is similar to R^2 measure of regression, which can be increased with the inclusion of more explanatory variables. However, as it was noted earlier, the increase in size of the tree leads to higher complexity costs in the form of increase in the number of terminal nodes.

CART has a built-in algorithm that estimates β parameter of complexity; the main sense is to achieve a balance between the cost-complexity coefficients of the two neighboring trees pruned, producing the marginal value of β . Refraining from presenting the complicated algorithm of complexity parameter calculation, let us only note that its value increases gradually with the reducing of complexity of the tree.

The pruning of the largest tree results in a series of sequentially nested subtrees from which an optimal tree with the best predictive properties is chosen.

A question may arise as to how the *predictive properties of the trees* are measured. Let us refer to a CART built-in method called K-fold cross-validation. The method implies that the observations for cross-validation and predictive accuracy assessment problems are chosen out of the existing datasets rather than from values expected. Thus, if we define:

- $C(X)$ as a tree-structure classifier of X vector of the characteristics variables that describe observations,
- $R(C(X))$ as the classifier's misclassification rate,
- L as the learning sample (the sample data from which to construct a classification tree),

then the process of K-fold cross-validation can be presented as sequence of the following steps:

1. L sample is split into K sub-samples with equal number of observations $L_1, L_2, \dots, L_K$.
2. A classifier $C(X)$ is constructed from $(K-1)$ subsamples by leaving out, say, the K subsample – L_K .
3. The resulting $C(X)$ classifier is saved.
4. The saved classifier $C(X)$ is applied to the excluded cross-validation sub-sample L_K and the misclassification rate $R(C^K(X))$ is estimated as a proportion of misclassified observations.
5. Steps 2-4 are repeated, using all subsamples except the subsample of L_{K-1} which now becomes a cross-validation test sample. The process above is repeated until every subsample is used at least once as a construction sample and once as a cross-validating test sample.
6. In the outcome, the real estimate of $R(C(X))$ is calculated as a simple mean of misclassification coefficients $R(C^K(X)) R(C^{K-1}(X)) R(C^{K-2}(X)), \dots, R(C^1(X))$, as follows:

$$R^{ck}(C(X)) = 1/K \sum_{k=1} R(C^K(X))$$

It shall be noted that the choice of K is arbitrarily made by the researcher, however a widely accepted and spread value is $K=10$, that is 10-fold cross-validation.

Thus, the K-fold cross-validation method is applied to evaluate qualitative properties of and compare them between different trees of different size. In the closing stage of pruning, the best chosen tree is the one the cross-validation misclassification value of which is one standard deviation away from the minimum value of misclassification, and which has the minimum terminal nodes among the whole subsets of trees. The one standard deviation rule is controversial and can be changed by the researcher, but is a quite widespread rule.

The K-fold cross-validation method also allows determining out-of-sample predictive properties of the tree pruned.

Because applying CART methodology is not widespread in building EWS and this work is among the pioneers, we therefore find it reasonable to talk about strengths and weaknesses of the methodology while considering its use in EWS construction.

Strengths

1. CART makes no distributional assumptions of any kind for dependent and independent variables.
2. CART is a non-parametric method and does not assume specification of functional forms.
3. The explanatory variables in CART can be a mixture of quantitative (continuous) and qualitative (categorical) variables.
4. Linear combination of explanatory variables can be used as a split.
5. The same variable can be used several times in different parts of the tree and with different threshold values.
6. CART has a built-in algorithm to deal with the missing values of a variable. The positions of missing points of a variable can be replaced by the points of so-called surrogate variables, so as to make split similar to the supposed split results so if the real variable has been used.
7. CART is not at all affected by the outliers, collinearities, heteroskedasticity, or distributional error structures that affect parametric procedures. Outliers are isolated into a node and thus have no effect on splitting. Contrary to situations in parametric modeling, CART makes use of collinear variables in "surrogate" splits.
8. CART has the ability to detect and reveal variable interactions in the data set.
9. CART can identify and explain the non-linear and complex relationships between the variables.
10. CART is not affected by modifications in variables, for example change into logarithmic or other forms, etc.

11. In the absence of a reliable theory that could guide a researcher, CART can be viewed as an exploratory, analytical tool to find out the factors and to reveal their effects. In this sense, it may be useful in constructing models under classical parametric analysis.
12. CART effectively deals with large datasets and the issues of higher dimensionality.
13. The tree-like structures produced are fairly easy to explain and understand.

Weaknesses

1. CART is a blunt instrument compared to many other statistical and analytical techniques. At each stage, the subdivision of data into two groups is based on only one value of only one of the potential explanatory variables. If an econometric model that appears to fit the data exists, and if its basic assumptions appear to be satisfied, that model would be preferable.
2. CART is not based on probabilistic assumptions. There is no probability level or confidence interval associated with predictions, as well as there is no way to gauge about significance of variables.
3. When linear relationships are described, CART is unfeasible to be used since it will make successive splits at different points of the same variable.
4. Target cases (for ex. crisis points) in terminal nodes of the tree may be in lesser quantities and often lead to incorrect conclusions⁵⁸.

Classification and Regression Trees for Predicting Currency Crises

Prediction of currency crises involves a process of explaining a dependent variable with the binary outcome by means of various explanatory factors, which can be both macroeconomic fundamentals and institutional indices. In addition, existing threshold effects and non-linear relationships of variables are intrinsic to the building of EWS. In other applied systems, the probability of the crisis is estimated using the “all else being equal” principle. However, the experience of currency crises (particularly the Asian crisis) suggests that they may arise even if the key macroeconomic fundamentals are at acceptable levels, which, when combined with other factors (structural-institutional, in particular) may lead to an undesirable outcome. Currency crises are events of purely a discrete nature hence their explanation through continuous econometrical relationships can lead to incorrect results.

CART models can be a systematic and nice solution to building EWS for currency crises that are characterized by above properties. Thus in the context of prediction of currency crises the CART methodology enables to:

- predict the probability of crises based on diverse sets and sometimes theoretically unjustified combinations of leading variables;
- determine the nature of the crisis and the inherent causes of it⁵⁹;
- determine an estimated model’s out-of-sample predictive power and use the results right in the process of building of the relevant model;
- identify the importance of the explanatory variables and their relative contributions in the model, as well as nature of their intersections;
- estimate the lead-time of factors (how leading are the leading indicators);
- address the arbitrariness of the directions of effects of variables (for example, if an increase or decrease of oil prices away from certain threshold level is a concern);
- simplify the decision-making process related to crises since a few most important variables out of many studied will be included in the final model;
- get the turning points required for converting continuous variables into discrete ones (this was used in assessing conditional probabilities of the crises based on the Composite Index in the Signaling Approach).

In pursuit of building EWS for Armenia, several options have been under consideration, which can be divided into two major areas, panel models and Armenia-relevant-data-based models.

⁵⁸ With the use of the software package like CART 6.0 ProEx it is possible to resolve this problem by figuring out which is the best option for the minimum size of a parent node to be split or the minimum number of cases in terminal nodes.

⁵⁹ Kaminsky (2003).

It should be noted that all CART modeling work was carried out using CART 6.0 ProEX software package developed by Selford Systems. As the only system in the world developed on a basis of the initial CART code created by the authors of this methodology, i.e. Breiman, Friedman, Olshen and Stone, it allows to address the problems related to the method at the core and a lot of supplementary and fundamental aspects developed by the firm with tight cooperation with the authors.

Panel Study: The panel of observation includes 21 countries of Eastern and Central Europe and the CIS region. In the Panel model, the indicator frequency is on a quarterly basis, due to the scarcity of their monthly data. As in the case with Signaling Approach, the crisis horizon is set to be 12 months, or 4 quarters. The building process of the *main model* through CART methodology has been conducted in two phases: at first the initial variant of the tree was constructed, then, after having carried out a few sensitivity and sustainability tests, the final tree was built which represents the basic signaling system for predicting currency crises in emerging countries in Europe as well as Armenia⁶⁰.

The initial tree constructed⁶¹ which under the one standard deviation rule has 8 terminal nodes and good predictive properties, has been tested for sensitivity and sustainability. The results of the tests were used to build the ultimate model.

The final model tree is characterized by 37 terminal nodes as well as strong predictive properties: it predicts out-of-sample nearly 83 percent of currency crises (see the detailed discussion of the analytical study results in Appendix 8-A). As regards the best variables, it should be mentioned that the indicator *international oil price*⁶² is unquestionably a leader. It is the main factor in splitting the root node of the tree. The *inflation* indicator, which was the leader in the Signaling Approach model is just the 4th here, letting behind such variables as budget deficit and asset prices⁶³. There are not any absolute failures in this version of CART models in spite of the fact that variables such as elections, terms of trade and remittances posted to have shown lower predictive qualities⁶⁴ (the 'variable removal' LOVO sensitivity test results also support this statement, see Table A8-T-8).

In the main tree, terminal nodes 36 and 37 are very interesting: an extra analysis reveals that they contain cases related to the most recent currency crises of 2008-2009. Substantially different in nature from other crises, these deserve special treatment in a separate analysis. To this end, a total of 63 observations (in nodes 36 and 37) were separated and modeled individually (see results in Appendix 8-A *).

Albeit that model has predictive properties (merely 71% predictive accuracy out-of-sample) lower than the main model, it however tries to explain the main causes for the recent crises, which really boils down to financial and monetary variables, faster growth rates of broad money and domestic credit, in particular. Interestingly, the paper by Avetisyan (2010) reveals that the stability of the banking system and effective financial intermediation (bank concentration) are among key factors that determine the relative intensity of exchange rate depreciation pressures that countries experienced in the period 2008-2009⁶⁵.

Besides the main model presented, we have built a number of alternative models in pursuit of proposing different solutions to the problem of EWS.

Alternative 1: This model uses the EMP index version whereby standard deviations and means in respect of both index members and final index were built according to the principle of moving window, with its length of 2 years (see Figure 3-2). The generalized results of CART model constructed on a basis of this version of EMP index are provided in Appendix 8-B. This has 60 terminal nodes with predictive properties at a very low level – it predicts out-of-sample merely 65% of the crises. The leading variables here are dominated by such variables as oil price and asset price.

Alternative 2: This variant uses the 2-year moving window crisis threshold rule (see Figure 3-3). The model constructed through this method has 80 terminal nodes but, as was the case with the previous model, still provides weak predictive properties, an average 70% out-of-sample crisis prediction rate.

⁶⁰ In addition to this model, we developed a number of other variants which we will refer to later on (see also Appendix 8-B, 8-C, 8-D, 8-E, 8-G).

⁶¹ The results are not presented here but can be obtained from the author.

⁶² Because the model considers currency crises of different generations and has a special focus on the recent events which are perhaps new generation crises, the indicator of international oil price is the factor that separates the previous and recent crises having occurred after 2000.

⁶³ This may be explained by the differences of datasets applied in the models (panel vs Armenia-relevant data).

⁶⁴ The variables such as short-term foreign debt and dollarization rank 8th and 9th, respectively.

⁶⁵ Avetisyan H. (2010), page 104.

Here, the best properties are attributable to the variable of *asset prices* whereas oil price ranks the third, staying behind the indicator of budget deficit (see Appendix 8-C).

Alternative 3: The above models, including the main one, are designed to predict currency crises within the signaling window, i.e. in the course of the upcoming 4 quarters. This alternative model proposes to use an instant approach and make forecasts as of any particular quarter. However, before the model would have been built, we had to determine the lags of variables. To this end, trees were constructed in consideration of various lags (up to 4 quarters) for each variable, by only including lags of any particular indicator as explanatory variables. Then, in view of the results of LOVO test (significance and sensitivity of CART variables), we selected the best lags for all variables⁶⁶. These are provided in Table 3-4, showing that 9 out of the 24 indicators issue signals at least 3 quarters in advance.

Table 3-4: Best leading indicator lags

	Variable	Best lag
1	International reserves / GDP	4
2	Short-term foreign debt / International reserves	3
3	Foreign debt / GDP	1
4	Real exchange rate overvaluation	1
5	Current account / GDP	4
6	Exports	3
7	Domestic credit	3
8	M2 / International reserves	2
9	Inflation	1
10	Economic growth	1
11	Asset prices	2
12	Budget deficit / GDP	1
13	Remittances	4
14	Banks' foreign assets / foreign liabilities	4
15	Terms of trade	1
16	Democracy of political system	-
17	Elections	4
18	Credit / Deposits	1
19	World oil price	1
20	Difference in short-term and long-term interest rates	1
21	OECD country economic growth	4
22	Dollarization	2
23	Currency regime	-
24	Contagion effect	-

A model built by the use of variables with appropriate lags allows determining the probability of emergence of the crisis as of any particular quarter. In fact, this can be considered a dynamic model as it is also able to show the pattern with which that probability may change from quarter to quarter.

The results summed up in Appendix 8-D suggest that this model is prominent with its pretty good predictive properties, an average rate of 74% out-of-sample. The significance of variables is nearly similar to that of other models. A sudden improvement in the indicator of *dollarization* as well as clear advantage of the indicator of *asset prices* over other factors is noteworthy.

Alternative 4: As was noted earlier, using binary dependent variables may result in the loss of valuable information that continuous EMP index series contain. In this phase of modeling we try to solve this problem by using CART regression tree method (see Appendix 9). Also, this alternative approach would enable to determine how significant is the problem and how justified is the selected SD 1.645 rule when the continuous series are converted into the discrete series. Note, that the model was evaluated based on the previous, third, alternative (since that is the only one providing an instant approach, which is vital for continuous series) by substituting the dependent variable with the continuous series of the EMP index. The results summarized in Appendix 8-E, especially those pertinent to significance of variables, almost match with the results of the previous models. The only difference worth mentioning is the indicator *asset prices*: here it has lost its relevance to others. Increased role of the real exchange rate

⁶⁶ The results can be obtained from the author.

overvaluation is another matter of interest, which even in the initial stage of construction of the model (prior to the relevant adjustments based on sensitivity and sustainability tests) took a lead in the rank of leading variables.

However, these two options have significant differences with regard to the threshold levels of particular variables and how they come to appear in different parts of the terminal tree (see Annexes 8-D and 8-E). Moreover, after having the threshold levels of the candidate variables for the split of the root node compared with each other in the two models (*see Appendix 8-F*) it turned out that only 9 variables out of 24 were able to distribute the data at the same or roughly the same threshold level in either case. This provides evidence that there has been a loss of valuable information when the continuous variable was converted into a binary variable. This can be due to the choice of the crisis threshold determination rule (1.645 S.D.) on the one hand, and the lack of volatilities in the series on the other. It should be noted that the discrepancies in the results of the models can be due to the circumstance that absolute thresholds that distinguishes crisis episodes based on the EMP index in case of the same rule (1.645 S.D.) will differ from country to country (for example, points above 3.7 of the EMP index value are meant to be a crisis situations for Armenia but points above 8.2 will be considered crisis-relevant for Bulgaria), whereas the values of the entire panel will be treated equally in case of continuous EMP usage.

Armenia-relevant data models: These models used monthly data which covered a period of 1996-2009. The crisis window is for a 12-month span. Of the models built for Armenia, only the main version of the model based on the generalized structure of the EMP index is presented⁶⁷. The construction of the model has gone in two phases, too, and its initial version⁶⁸ has been tested for sensitivity and sustainability. The test results were used to build the final model.

Built on Armenia data, the final CART model with its predictive properties even outstrips the main panel version, as it provides an average 92.5% explanation rate out-of-sample and 95.2% explanation rate in-sample (see Appendix 8-G). The model has 5 terminal nodes that contain explanatory variables such as credits/deposits, real exchange rate overvaluation, inflation and remittances. By factor importance, the indicators such as credits/deposits and banks' foreign assets/foreign liabilities take the lead. Quite interestingly, unlike the main panel model, from external explanatory factors explaining crises in Armenia, high significance has been attributed to the *contagion effect* rather than such indicators as *world economic growth* and *international oil price*⁶⁹. All in all, countries, and Armenia among them, have to be open to the debate over considering domestic economic development factors as fundamental leading indicators in predicting currency crises.

Building combinations of models is among recent developments in the CART methodology. Researchers began looking at the advantage of constructing multiple trees back in early 1990s. The main point was that if one tree can have good forecasting features, then a few trees can provide better results. Leo Breiman was one of the authors of the CART methodology who addressed these issues. Very recently, he has introduced the theory of Random Forests that builds an effective predicting model as a result of combination of the best characteristics of individual trees. In practice, this idea has been realized in the framework of another software package which was again developed by Salford Systems. However, the decision-making mechanism based on multiple trees is embedded in its simplest version with the CART methodology in the form of combination of trees. Obviously, in the prediction process, different models can produce quite different results. The final decision comes in favor of taking the results as median. This principle is based on the usage of the CART Combine tool. There are two ways in CART to sum up the results: first to take them as median and second to improve each coming tree by using the unidentified part of the previous tree. Ignoring the main characteristics of each of them, let us note that we have carried out the modeling of combination of the trees based on the main tree by constructing a total of 100 candidate models. In future, this Combination Model will be used for making predictions. Just add that this combination of the models makes it possible to accurately predict more than 96% of the crises in-sample, whereas it was only 83% in the main model.

Types of currency crises: Next problem which allows solving the CART methodology is identification of the types of crises or the main sources of their emergence. We have used the classification of the types

⁶⁷ The results of the others can be obtained from the author.

⁶⁸ The results can be obtained from the author.

⁶⁹ This indicator is among the key ones in almost all panel models.

of currency crises provided in Kaminsky (2003)⁷⁰ and explored the specifics of all terminal nodes (which contain crisis observations) of the main model, having this in mind we also characterize the quarters prior to the crisis with a problem pertinent thereto (see Appendix 10). Then we identified the causes and the type of a particular crisis based on the features inherent to the period prior to each crisis occurred, as a simple attribution to the main cause that had been upmost shown up in the previous quarters. The results of the analysis suggest that around 30% of the currency crises observed in the emerging CEE and CIS countries in the 1990s and 2000s was due to the problems with budget deficit (classic, first generation models), and about 25% due to expansionary monetary policy and excess finance problems. It should be mentioned that self-fulfilling crises hold quite a large share in total, with 20% of them arisen due to an adverse environment and 13% due to unexplainable circumstances (excluding the recent crises). The currency crises (pressures) observed in Armenia in the period 1997-1998 have occurred exclusively due to an unfavorable environment although the crises in early 1997 and late 1998 can also be attributable to the budget deficit and monetary policy expansion issues, respectively⁷¹.

Assessment of predictive properties of the models

Although the above discussions over predictive qualities of models are very promising, we find it necessary to refer to a number of classical standard statistics in order to evaluate the properties of the models with the binary variable. Moreover, these estimations can be used not only for the sake of comparison⁷² with the results of other models common in the literature but also for producing combined model forecasts under the EWS in future⁷³.

In practice, the model results are evaluated by two groups of coefficients. The first is constructed based on the *confusion matrix* known from the Signaling Approach.

Confusion matrix

	Crisis period	Tranquil period
Prediction of crisis	A	B
Prediction of tranquil period	C	D

This matrix can be used to calculate various ratios to assess the “strength” of a signaling system. We will address some of them⁷⁴.

The *sensitivity* or *crisis coverage* ratio is designed to display the called portion of the crises. This, in essence, describes the probability that the signal would be pertinent to the crisis. It is calculated by the use of the matrix above:

$$P_1 = \frac{A}{A + C} \cdot 100\%$$

The *Specificity* ratio displays the share of accurately called tranquil periods. It is calculated as follows:

$$P_2 = \frac{D}{D + B} \cdot 100\%$$

Some authors are proposing to calculate the conditional probability of the crisis subject to the model forecast⁷⁵

$$P_3 = \frac{A}{A + B} \cdot 100\%$$

⁷⁰ Kaminsky (2003), p. 11, 25.

⁷¹ The detailed results about individual countries can be obtained from the author.

⁷² This paper is for our best knowledge the first research in the field of building EWS through CART methodology, so we find it appropriate to address the main features of that methodology.

⁷³ If we weigh each model forecast by its predictive accuracy measure and get average weighted forecasts, we can have an idea of what kind of results to expect (for now, this is not possible to carry out for Armenia as there has been a total of two models evaluated so far; one may note that building CART combination models is somewhat a similar approach to this).

⁷⁴ Most of these ratios are provided in the paper by Apoteker, Barthelemy (2003) p. 6.

⁷⁵ Kiznar (2004), p. 22.

The latter, in essence, describes the probability that the crisis predicted would emerge.

The other ratios deal with misclassifications and correct classifications of all observations:

The model accuracy:

$$P_4 = \frac{A+D}{A+B+C+D} \cdot 100\%$$

Misclassification error:

$$P_5 = \frac{B+C}{A+B+C+D} \cdot 100\% = 1 - P_4$$

The second group of parameters to assess forecasting properties of the models are based on the predicted probability and statistical representation of its distribution. These have been proposed by Diebold and Rudebusch (1989) as signaling model accuracy assessment tools. There are a number of indicators used within this framework, and ratios such as Quadratic Probability Score and Logarithmic Probability Score are common.

The Quadratic Probability Score (QPS) is designed to assess existing divergence between the occurrence of the crisis and the prediction:

$$QPS = \frac{1}{N} \sum_{t=1}^N 2(P_t - R_t)^2$$

where: N is the number of observations or predictions, P is the probability of the model-estimated crisis in the signaling horizon (in the upcoming 12 months), R is the actually occurred crisis in the 12-month window, which make up 1 if the crisis has occurred and 0 if the crisis has not occurred.

The QPS test statistic takes values in the range (0, 2), where the value 0 points to the fact that the model has ideal properties.

The Logarithmic Probability Score (LPS) depends exclusively on the probability forecasted. It is a more generalized rule of assessment where bigger errors of prediction, while compared with the QPS score, are treated more severely. It is calculated as follows:

$$LPS = \frac{1}{N} \sum_{t=1}^N [(1 - R_t) \ln(1 - P_t) + R_t \ln(P_t)]$$

This statistic takes values in the range (0, ∞): the lower they are the higher the predicting properties of the model are.

Apart from these main scores, there is a great diversity of coefficients⁷⁶ known in the literature. Among most prominent of them is the Pesaran-Timmermann Test which allows determining the statistical significance of deviations from the predictions made. It is designed to explore statistical distribution of comparison of predictions with a random selection (random walk) model.

Let us refer to the properties of the models we built, using the above scores. It should be noted that most indicators under the CART methodology were calculated when the model was still under construction process, by the use of CART built-in algorithms, therefore, they will be provided here. Some basic models – CART main panel model, CART Armenia model and Signaling Approach Model with its two composite index versions – were chosen for assessing the predictive properties. Table 3-5 shows that both CART and Signaling Approach models have excellent predicting qualities; particularly, in all variants the QPS does not exceed the value 0.2 and is almost close to 0 in Armenia-relevant data models (CART Armenia, Signaling Approach Models).

⁷⁶ Part of them is provided in Budsayaplakorn, Dibooglu, Mathur (2006), p. 11-12.

Table 3-5: Model predictive capacities

	CART main panel	CART Armenia	Signal approach: Composite Index 1		Signal approach: Composite Index 2 (instant approach)	
			threshold 20%	threshold 50%	threshold 25%	threshold 50%
Share of crises called	96.36	95.74	97.06	94.12	100.00	60.00
Share of tranquil periods called	79.67	94.64	91.13	95.97	89.19	98.65
Crisis probability conditional on forecast	60.88	88.24	75.00	86.49	38.46	75.00
Total predictive accuracy	83.80	94.97	92.41	95.56	89.87	96.20
Misclassifications	16.20	5.03	7.59	4.43	10.13	3.80
QPS	0.1874	0.0699	0.0791		0.0585	
LPS	0.3231	0.2469	0.3321		0.5412	

What is interesting either is that Table 3-5 can indicate the prevalence of predictive properties of Armenia-relevant data models over the panel models. This may be determined by both the shortness of time series (monthly data for 1996-2009) and the scarcity of crises in the period under review, most part of which is distributed at the opening and closing ends of the series. These results, however, are not in conflict with the conventional wisdom that models built by one-country data can have stronger properties in comparison with the panel models⁷⁷.

Obviously, for comparison of predictive properties of the models, their main parameters (data, length of the prediction horizon, and etc.) should be compatible. Therefore, when results of CART and Signaling Approach models are to be compared, the models with 50% threshold level of Composite Index 1 of the Signaling Approach and CART Armenia should be considered. These are compatible in terms of both time series, which are relevant to monthly Armenia data, and the length of the signaling horizon, which is 12 months in all models, and the threshold level as Prior Equal has been used in CART that implies assigning a crisis class to the nodes with crisis class share above 50%.

The comparison of the two models above-mentioned makes it clear that these almost do not vary from each other: though for the called share of the crises CART version outperforms the Signaling Approach Model, the latter has advantage in terms of the total prediction accuracy and misclassifications. The quadratic and logarithmic probability scores give some advantage to the CART method, nonetheless.

To allow for the comparison of predictive properties of CART model to the other models observed in different research and policy papers Table 3-6 summarizes in-sample and out-of-sample predictive properties of these techniques⁷⁸.

Table 3-6: EWS model property comparison matrix

	CART main panel	Signaling Approach	Probit	Markov Switching Model	Artificial Neural Networks
Author		Kaminsky, Lizondo, Reinhart (1998), Source: Berg, Borensztein, Pattillo (2005)	Berg, Borensztein, Pattillo (2005)	Abiad (2003)	Peltonen (2006)
In-Sample (%)					
Share of crises called	96	60	63	65	46
Share of tranquil periods called	80	72	79	89	99
Probability of crisis, conditional on forecast	61	29	37	73	75
Total predictive accuracy	84	70	76	81	92
Misclassifications	16	30	24	19	9
Out-of-Sample (%)					
Share of crises called	83	58	31		4
Share of tranquil periods called	78	79	80		99
Probability of crisis, conditional on forecast	55	35	22		29
Total predictive accuracy	79	76	72		89
Misclassifications	21	24	28		11

⁷⁷ Abiad (2003), p. 40.

⁷⁸ The observation covered the results of the works that contain panel data, especially where the panel includes CEE countries.

Quadratic Probability Score (QPS)					
Author		<i>Bruggemann, Linne (2002)</i>	<i>Shardax (2003)</i>		<i>Peltonen (2006)</i>
	0.1874	0.3310	0.1295-0.1708		0.0459
ROC criterion (area under ROC curve)					
Author		<i>Peltonen (2006)</i>			<i>Peltonen (2006)</i>
<i>In-Sample</i>	0.9185	0.7841			0.7226
<i>Out-of-Sample</i>	0.8227	0.6335			0.4687

Source:

1. Berg, Borensztein, Pattillo (2005) – reestimates the Kaminsky, Lizondo, Reinhart (1998)'s Signaling Model (monthly data of 20 countries for the period 1970-2001, signaling horizon 24 months) and Berg, Patillo (1999)'s probit models (same parameters as in the Kaminsky, Lizondo, Reinhart (1998) signaling approach).
2. Abiad (2003): monthly data of 5 developing Asian countries for the period 1972-1999, with the signaling horizon of 12 months.
3. Peltonen (2006): monthly data of 24 developing countries for the period 1980-2001, with the signaling horizon of 3 months.
4. Bruggemann, Linne (2002): monthly data of 5 CEE countries for the period 1993-2001, with the signaling horizon of 18 months.
5. Shardax (2003): quarterly data of 12 CEE countries for the period 1992-2002, with the signaling horizon of 24 months.

Though the models observed vary by the key parameters, the length of the signaling horizon in particular, we need to emphasize that CART and Artificial Neural Network models are frontrunners among the methodologies currently in use. It is worth mentioning that CART model outperforms all its rivals for the crisis prediction ability out-of-sample as well as for the ROC criterion both in-sample and out-of-sample. Artificial Neural Networks enjoy a greater predictive accuracy rate when they deal with predicting tranquil periods, whereas they report weaknesses in predicting crisis situations, in comparison with all other model versions.

So, modern models, i.e. classification trees and artificial neural networks, best fit to be used for building state-of-the-art early warning systems as they are designed to identify all streamlined flows of valuable information. However, while neural networks operate at the "black box" principle, the CART models enable to figure out relationships and properties of fundamental variables of the model thus taking a lead in the competition with rivals.

CONCLUSION

There is a consensus among economists that early warning systems, however complex and sophisticated they can be, do not provide for the possibility to predict currency crises in an absolute accuracy. Even those researchers who are involved in building such frameworks, the author of this paper among them, realize that they are just important supplements and auxiliary tools built based on certain modeling principles and cannot substitute detailed economic analysis of countries' vulnerabilities to crises. However, an early warning systems in place can be a cornerstone in the further effort for predicting and assessing currency crises or substantial exchange rate pressures in Armenia.

Concluding remarks of this research are especially important for taking further steps in the analytical work in regard to crises in Armenia:

- Almost all variables chosen are prominent with their best predictive properties for the economy of Armenia; as such, the most significant leading indicators include *budget deficit, credit growth, inflation, foreign debt, and banking liabilities*.
- The two composite indices of the signaling approach can be applicable not only for estimating conditional probability of crises but also for identifying and predicting relatively intense currency pressure cycles.
- The panel models provide evidence that the currency crises of 2008-2009 were different by nature from the ones observed previously in developing countries, and financial and monetary variables had played a decisive role in them.

- The analysis of leading indicators shows that 9 variables out of 24 are able to issue signals about the forthcoming crisis at least 3 quarters in advance.
- Building combined model predictions is vital for policy decision-making.
- Most of the crises observed in developing countries of Europe were attributable to the budget deficit and excess finance problems. Self-fulfilling crises constitute a significant share.
- The models built in this paper have strong predictive properties and can be used in forecasting currency as well as financial crises in Armenia.
- The model, constructed through the CART methodology, with its predictive properties considerably outperforms all other types of models common in the literature.

REFERENCE

1. Avetisyan H., "Prediction of Currency Crises in the Republic of Armenia: the Results from Signaling Approach", Yerevan University Periodical ("Banber"), 2 (128), 2009, pp. 150-158.
2. Avetisyan H., "Global Exchange Rate Movements During The Financial Crisis", Periodical of Armenian State University of Economics ("Banber"), 1(19), 2010, pp. 93-104.
3. Avetisyan H., "The Global Financial Crisis and Depreciation Pressures in Developing Countries", Armenia: Finance and Economy, #6-7 (107-108), May-June 2009, pp. 12-14
4. Avetisyan H., "A New Generation Currency Crisis", The economies of Republic of Armenia and Russian Federation During World Economic Crisis: Problems and Prospects of Developments, International Conference Notes, Yerevan, 2010, pp. 220-229
5. Abiad Abdul, "Early-Warning Systems: A Survey and a Regime-Switching Approach", IMF WP/03/32, February 2003.
6. Aghion Philippe, Bacchetta Philippe, Banerjee Abhijit, "A simple model of monetary policy and currency crisis", European Economic Review, 44 (2000), pp. 728-738.
7. Andriyashin Anton, "Financial Applications of Classification and Regression Trees", A Master Thesis, CASE, Humboldt University, Berlin, March 2005.
8. Apoteker Thierry, Barthelemy Sylvain, "Genetic Algorithms and Financial Crises in Emerging Markets", TAC Financial, June 2001.
9. Apoteker Thierry, Barthelemy Sylvain, "Predicting Financial Crisis in Emerging Markets using a Composite Non-Parametric Data Mining Model", TAC Financial, 2003.
10. Basurto Gabriela, Ghosh Atish, "The Interest Rate-Exchange Rate Nexus in Currency Crisis", IMF Staff Papers, Vol. 47, Special Issue, 2001.
11. Berg Andrew, Borensztein Eduardo, and Pattillo Catherine, "Assessing Early Warning Systems: How Have They Worked in Practice?", IMF Staff Papers, Vol. 52, Number 3, 2005, pp. 462-502.
12. Bruggemann Axel, Linne Thomas, "Are the Central and Eastern European Transition Countries still vulnerable to a Financial Crisis? Results from the Signals Approach", IWH-Discussion Papers No.157., 2002.
13. Bubula Andrea, Otker-Robe Inci, "Are Pegged and Intermediate Exchange Rate Regimes More Crisis Prone?", IMF WP/03/223, November 2003.
14. Bubula Andrea, Otker-Robe Inci, "The Evolution of Exchange Rate Regimes Since 1990: Evidence from De Facto Policies", IMF WP/02/155, September 2002.
15. Budsayaplakorn Saksit, Dibooglu Sel, Mathur Ike, "Can macroeconomic indicators predict a currency crisis? Evidence from selected Southeast Asian countries", Department of Finance Southern Illinois University, 2006.
16. Burnside Craig, Eichenbaum Martin, Rebelo Sergio, "Currency Crisis Models", The New Palgrave: A Dictionary of Economics, 2nd Edition, February 2007.
17. Calvo Guillermo A., Reinhart Carmen M., "Fear of Floating", NBER Working Paper 7993, November 2000.
18. "CART: Tree-Structured Non-Parametric Data Analysis", San-Diego, CA: Salford Systems, 2001.

19. Chamon Marcos, Manasse Paolo, Prati Alessandro, "Can We Predict the Next Capital Account Crisis", *IMF Staff Papers*, Vol. 54, No. 2, 2007, pp. 270-305.
20. Chang Roberto, Velasco Andres, "Financial Crises in Emerging Markets: A Canonical Model", Federal Reserve Bank of Atlanta, Working Paper, 98-10, July 1998.
21. Corsetti Giancarlo, Pesenti Paolo, Roubini Nouriel, "What caused Asian currency and financial crisis?", NBER Working Paper, September, 1998.
22. Diebold Francis X., Rudebusch Glenn D., "Scoring the Leading Indicators", *The Journal of Business*, Vol. 62, Jul. 1989, pp. 369-391
23. Edison Hali J., "Do Indicators of Financial Crisis Work? An Evaluation of an Early Warning System", *International Journal of Finance and Economics*, 8 (2003), pp. 11-53.
24. Eichengreen, Barry, Rose Andrew K, Wyplosz Charles, "Contagious Currency Crisis." NBER Working papers 5681, July 1996.
25. Eliasson Ann-Charlotte, Kreuter J. Christof , "On Crisis Models: An alternative crisis definition", Deutsche Bank, Research Note RN-01-1, May 2001.
26. Esquivel Gerardo, Larrain B Felipe, "Explaining Currency Crisis", HIID, Harvard, June 1998.
27. Fischer Stanley, "Exchange Rate Regimes: Is the Bipolar View Correct?", *Journal of Economic Perspectives*, Vol. 15, No. 2, 2001, pp. 3-24.
28. Flood Robert, Marion Nancy, "Perspectives on the Recent Currency Crisis Literature", *International Journal of Finance and Economics*, Vol. 4, No. 1, January 1999, pp. 1-26.
29. Feridun Mete, "Speculative Attacks under Financial Liberalization", Department of Economics, Loughborough University, Leicestershire, 2006, www.caei.com.ar
30. Gerlach Stefan, Smets Frank, "Contagious Speculative Attacks", BIS Working Paper, No. 22, September 1994.
31. Gorton Lance, Roper Don, "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience", *The American Economic Review*, Vol. 67, No. 4, Sept. 1977, pp. 537-548.
32. Ghosh Swati, Ghosh Atish, "Structural Vulnerabilities and Currency Crises", IMF WP/02/9, January 2002.
33. Goldstein Morris, "Emerging Market Financial Crises: Lessons and Prospects", Speech delivered at the 25th Anniversary Membership Meeting of the Institute of International Finance, Washington, DC October 20, 2007.
34. Hattori Masazumi, "On Determinants of the Depth of Currency Crisis: Fundamentals, Contagion, and Financial Liberalization", Bank of Japan, International Department Working Paper Series 02-E-2, September 2002.
35. Hawkins John, Klau Marc, "Measuring Potential Vulnerabilities in Emerging Market Economies", BIS Working Paper, No. 91, October 2000.
36. Kaminsky Graciela, "Varieties of Currency Crises" , NBER Working Paper 10193, December 2003.
37. Kaminsky Graciela, "Currency and Banking Crisis: The Early Warnings of Distress", Board of Governors of the Federal Reserve System, International Finance Discussion Paper No. 629, October 1998.
38. Kaminsky Graciela L., Reinhart Carmen M., "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems", *The American Economic Review*, Vol.89, No. 3, June 1999.
39. Kaminsky Graciela, Lizondo Saul, and Reinhart Carmen M., "Leading Indicators of Currency Crises", *IMF Staff Papers*, Vol. 45, No. 1 (March), 1998, pp. 1-48.
40. Knedlik Tobias and Scheufele Rolf, Three methods of forecasting currency crises: Which made the run in signaling the South African currency crisis of June 2006?, December 2007, IWH-Discussion Papers, Nr. 17, 2007, pp. 1-28.
41. Krugman Paul R., "A Model of Balance-of-Payments Crises", *Journal of Money, Credit and Banking*, Vol. 11, No. 3, Aug. 1979, pp. 311-325.
42. Krugman Paul R., Obstfeld Maurice, "International Economics: Theory and Policy", 5th Edition, An imprint of Addison Wesley Longman, 2000.
43. Krznar Ivo, "Currency Crisis: Theory and Practice with Application to Croatia", Croatian National Bank, August 2004.
44. Kumar Moham, Moorthy Uma, Perraudin William, "Predicting Emerging Market Currency Crashes", *Journal of Empirical Finance*, 10 (2003), pp. 427-454.

45. Lewis Roger J., "An Introduction to Classification and Regression Tree (CART) Analysis", Harbor-UCLA Medical Center, Department of Emergency Medicine, 2000.
46. Liaw Andy, Wiener Matthew, "Classification and Regression by Random Forest", R-News, Vol. 2/3, December 2002, pp. 18-22.
47. Li Jie, Rajan Ramkishan S., Willet Thomas, "Measuring Currency Crisis using Exchange Market Pressure Indices: The Imprecision of Precision Weights", October 2006.
48. Mecagni Mauro, Atoyán Ruben, Hoffman David, Tzanninis Dimitri, "The Duration of Capital Account Crises-An Empirical Analysis", IMF WP/07/258, November 2007.
49. Milesi-Ferretti Gian Maria, Razin Assaf, "Current Account Reversals and Currency Crises: Empirical regularities", in Krugman P., "Currency Crises", Chicago Press, 2000, pp. 285-325.
50. Nag Ashok K., Mitra Amit, "Neural Networks and Early Warning Indicators of Currency Crisis", Reserve Bank of India, 1999.
51. Obstfeld Maurice, "Rational and Self-Fulfilling Balance-of-Payments Crises", NBER Working Paper, No. 1486, 1986.
52. Obstfeld Maurice, "Models of Currency Crises With Self-Fulfilling Features", NBER Working Paper 5285, October 1995
53. Peltonen Tuomas A., "Are Emerging Market Currency Crisis Predictable", ECB Working Paper Series, No. 571, January 2006.
54. Racaru Irina, Copaciu Mihai, Lapteacru Ion, "Early Warning Systems on Currency Crisis", National Bank of Romania, Occasional Papers N5, June 2006.
55. Reinhart Carmen M., Rogoff Kenneth S., "The Modern History of Exchange Rate Arrangements: A Reinterpretation", The Quarterly Journal of Economics, Vol. CXIX, Issue 1, February 2004, pp. 1-48.
56. Salant Stephen W., Henderson Dale W., "Market Anticipations of Government Policies and the Price of Gold", The Journal of Political Economy, Vol. 86, No. 4, Aug 1978, pp. 627-648.
57. Scherbakov Alexander, "Generalized Approach to Currency Crisis Risk Analysis", A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Economics, National University of "Kiev-Mohyla Academy", 2000.
58. Shardax Franz, "An Early Warning Model for Currency Crises in Central and Eastern Europe", Capital Invest, 2003.
59. Steinberg Dan, Golovnya Mikhail, "CART 6.0 User's Guide", San-Diego, CA: Salford Systems, 2007.
60. Tinakorn Pranee, "Indicators and Analysis of Vulnerability to Currency Crisis: Thailand", Thailand Development Research Institute, September, 2002.
61. Toth Jan, "Vulnerability Index – Guessing the Probability of a Currency Crisis Central European Experience", ING Bank, Slovakia, 2002.
62. Vlaar Peter J G, "Early warning systems for currency crises", Econometric Research and Special Studies Department, Netherlands Bank, 2000.
63. Won-Am Park, Indicators and Analysis of Vulnerability to Economic Crisis: Korea, Hongik University Seoul, EADN, Korea, 2002.
64. Yilmazkuday Hakan, "The Effects of Currency Crisis in Emerging Markets on the Industrial Sector: An Alternative Regime-Shifting Approach", Emerging Markets Finance and Trade, October, 2007.
65. Yohannes Yisehac, Webb Patrick, "Classification and Regression Trees, CART: A User Manual For Identifying Indicators of Vulnerability to Famine and Chronic Food Insecurity", International Food Policy Research Institute, Washington D.C., 1999.

Appendix 1: Existing definitions of currency crises

	Main sources	Definition of the crisis	Data																																										
1.	Kaminsky, Lizondo, Reinhart (1998)	The Exchange market pressure index $I_1 = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r \quad I_2 = \frac{1}{\sigma_e} \% \Delta e - \frac{1}{\sigma_r} \% \Delta r \quad I_3 = \frac{\sigma_r}{\sigma_e + \sigma_r} \% \Delta e - \frac{\sigma_e}{\sigma_e + \sigma_r} \% \Delta r$ $I > \mu + K * \sigma_I$ e - exchange rate, r - international reserves, σ_e - standard deviation of exchange rate, σ_r - standard deviation of reserves, μ - index average, σ_I - standard deviation of index, $K = 1.1, 1.28, 1.5, 1.645, 1.96, 2.0, 2.5, 3.0$	Monthly data of 20 countries, for the period 1970-1995																																										
2.	Kumar, Moorthy, Perraudin (2003)	1. <i>Unexpected depreciation</i> $100 \left[\frac{e_{t+\Delta} - e_t}{e_t} \right] \left[\frac{1 + r_t^*}{1 + r_t} \right] > \gamma_1$ r_t^* - external interest rate, r_t - domestic interest rate, e_t - exchange rate, γ_1 - marginal value which is set to be either 5% or 10% 2. <i>General devaluation crisis</i> $100 \left[\frac{e_{t+\Delta} - e_t}{e_t} \right] > \gamma_2 \text{ and } \left[\frac{e_{t+\Delta} - e_t}{e_t} \right] > (1 + \gamma_3) \left[\frac{e_t - e_{t-\Delta}}{e_{t-\Delta}} \right]$ γ_3 - accepted to be 100%, i.e. doubling of the rate of devaluation, γ_2 - 5% or 10%	Monthly and yearly data of 32 developing countries, for the period 1985-1999																																										
3.	Hawkins, Klau (2000)	1. <i>The Exchange market pressure index</i> $I_1 = W_1 \cdot xrm + W_2 \cdot xra + W_3 \cdot r + W_4 \cdot res$ xrm - 3-month depreciation of the exchange rate (in percent), xra - yearly depreciation of the exchange rate (in percent), r - 3-month interest rate less annualized inflation previous 6 months, res - 3-month change of the 12-month moving average of reserves to imports ratio Indicator values are chosen according to the following table: <table><tr><th colspan="2">Indicator</th><th>-2</th><th>-1</th><th>0</th><th>1</th><th>2</th></tr><tr><th>Code</th><th>Weight</th><th></th><th></th><th></th><th></th><th></th></tr><tr><td>xrm</td><td>W_1</td><td>$10 < x$</td><td>$2 < x \leq 10$</td><td>$2 \geq x > -3$</td><td>$-3 \geq x > -8$</td><td>$x \leq -8$</td></tr><tr><td>xra</td><td>W_2</td><td>$20 < x$</td><td>$5 < x \leq 20$</td><td>$5 \geq x > -5$</td><td>$-5 \geq x > -20$</td><td>$x \leq -20$</td></tr><tr><td>r</td><td>W_3</td><td></td><td></td><td>$x \leq 2$</td><td>$2 < x \leq 4$</td><td>$x > 4$</td></tr><tr><td>res</td><td>W_4</td><td>$8 < x$</td><td>$4 < x \leq 8$</td><td>$4 \geq x > -4$</td><td>$-4 \geq x \geq -8$</td><td>$x < -8$</td></tr></table> so that the maximum value of the index equals 10, that is $W_1=W_2=W_3=W_4=1.25$	Indicator		-2	-1	0	1	2	Code	Weight						xrm	W_1	$10 < x$	$2 < x \leq 10$	$2 \geq x > -3$	$-3 \geq x > -8$	$x \leq -8$	xra	W_2	$20 < x$	$5 < x \leq 20$	$5 \geq x > -5$	$-5 \geq x > -20$	$x \leq -20$	r	W_3			$x \leq 2$	$2 < x \leq 4$	$x > 4$	res	W_4	$8 < x$	$4 < x \leq 8$	$4 \geq x > -4$	$-4 \geq x \geq -8$	$x < -8$	Quarterly data of 24 developing countries, for the period 1993-1998
Indicator		-2	-1	0	1	2																																							
Code	Weight																																												
xrm	W_1	$10 < x$	$2 < x \leq 10$	$2 \geq x > -3$	$-3 \geq x > -8$	$x \leq -8$																																							
xra	W_2	$20 < x$	$5 < x \leq 20$	$5 \geq x > -5$	$-5 \geq x > -20$	$x \leq -20$																																							
r	W_3			$x \leq 2$	$2 < x \leq 4$	$x > 4$																																							
res	W_4	$8 < x$	$4 < x \leq 8$	$4 \geq x > -4$	$-4 \geq x \geq -8$	$x < -8$																																							

		2. <i>External vulnerability index</i> $I_2 = W_1 \cdot reer + W_2 \cdot cgd p + W_3 \cdot gx + W_4 \cdot debt + W_5 \cdot gdebt + W_6 \cdot stdebt$ <i>reer</i> - real effective exchange deviation from the average (in percent), <i>cgdp</i> - current account/GDP, <i>gx</i> - annual export growth deviation from the average annual growth, <i>debt</i> - foreign debt/GDP, <i>gdebt</i> - 8 quarters' growth of the above indicator, <i>stdebt</i> - short-term foreign debt/reserves Indicator values are chosen according to the following table: <table><tr><th colspan="2">Indicator</th><th>-2</th><th>-1</th><th>0</th><th>1</th><th>2</th></tr><tr><th>Code</th><th>Weight</th><th></th><th></th><th></th><th></th><th></th></tr><tr><td><i>reer</i></td><td>W_1</td><td>$-20 \geq x$</td><td>$-20 < x \leq -10$</td><td>$-10 < x \leq 10$</td><td>$10 < x \leq 20$</td><td>$x > 20$</td></tr><tr><td><i>cgdp</i></td><td>W_2</td><td>$x > 4$</td><td>$2 < x \leq 4$</td><td>$-2 < x \leq 2$</td><td>$-4 < x \leq -2$</td><td>$-4 \geq x$</td></tr><tr><td><i>gx</i></td><td>W_3</td><td>$x > 10$</td><td>$10 \leq x < 5$</td><td>$0 < x \leq 5$</td><td>$-5 < x \leq 0$</td><td>$-5 \geq x$</td></tr><tr><td><i>debt</i></td><td>W_4</td><td></td><td>$x \leq 20$</td><td>$20 < x \leq 30$</td><td>$30 < x \leq 40$</td><td>$x > 40$</td></tr><tr><td><i>gdebt</i></td><td>W_5</td><td>$-10 \geq x$</td><td>$-10 < x \leq 0$</td><td>$0 < x \leq 10$</td><td>$10 < x \leq 15$</td><td>$x > 15$</td></tr><tr><td><i>stdebt</i></td><td>W_6</td><td></td><td>$x \leq 50$</td><td>$50 < x \leq 100$</td><td>$100 < x \leq 150$</td><td>$x > 150$</td></tr></table> so that the maximum value of the index equals 10, that is $W_1=W_2=W_3=W_4=W_5=W_6=5/6$	Indicator		-2	-1	0	1	2	Code	Weight						<i>reer</i>	W_1	$-20 \geq x$	$-20 < x \leq -10$	$-10 < x \leq 10$	$10 < x \leq 20$	$x > 20$	<i>cgdp</i>	W_2	$x > 4$	$2 < x \leq 4$	$-2 < x \leq 2$	$-4 < x \leq -2$	$-4 \geq x$	<i>gx</i>	W_3	$x > 10$	$10 \leq x < 5$	$0 < x \leq 5$	$-5 < x \leq 0$	$-5 \geq x$	<i>debt</i>	W_4		$x \leq 20$	$20 < x \leq 30$	$30 < x \leq 40$	$x > 40$	<i>gdebt</i>	W_5	$-10 \geq x$	$-10 < x \leq 0$	$0 < x \leq 10$	$10 < x \leq 15$	$x > 15$	<i>stdebt</i>	W_6		$x \leq 50$	$50 < x \leq 100$	$100 < x \leq 150$	$x > 150$	
Indicator		-2	-1	0	1	2																																																					
Code	Weight																																																										
<i>reer</i>	W_1	$-20 \geq x$	$-20 < x \leq -10$	$-10 < x \leq 10$	$10 < x \leq 20$	$x > 20$																																																					
<i>cgdp</i>	W_2	$x > 4$	$2 < x \leq 4$	$-2 < x \leq 2$	$-4 < x \leq -2$	$-4 \geq x$																																																					
<i>gx</i>	W_3	$x > 10$	$10 \leq x < 5$	$0 < x \leq 5$	$-5 < x \leq 0$	$-5 \geq x$																																																					
<i>debt</i>	W_4		$x \leq 20$	$20 < x \leq 30$	$30 < x \leq 40$	$x > 40$																																																					
<i>gdebt</i>	W_5	$-10 \geq x$	$-10 < x \leq 0$	$0 < x \leq 10$	$10 < x \leq 15$	$x > 15$																																																					
<i>stdebt</i>	W_6		$x \leq 50$	$50 < x \leq 100$	$100 < x \leq 150$	$x > 150$																																																					
4.	Won-Am Park (2002)	<i>The Exchange market pressure index</i> $I = \frac{1}{\sigma_e} \Delta e + \frac{1}{\sigma_i} \Delta i - \frac{1}{\sigma_r} \Delta r$ $I > \mu + 1.1 * \sigma_I$ Δi - interest rate change	Monthly data of South Korea, for the period 1990-1997																																																								
5.	Eichengreen, Rose, Wyplosz (1996)	$I = \frac{1}{\sigma_e} \% \Delta e + \frac{1}{\sigma_i} \Delta(i - i^*) - \frac{1}{\sigma_r} (\% \Delta r - \% \Delta r^*)$ Non-weighted version is discussed, as well. i^* - $\% \Delta r^*$ - respectively, change in interest rate and reserves of foreign country (Germany). $I > \mu + 1.5 * \sigma_I$	Quarterly data of 20 developed countries, for the period 1959-1993																																																								
6.	Eliasson, Kreuter (2001)	<i>Continuous Definition of crisis</i> Consists of the simple sum of deviations from long-term averages of the <i>change in exchange rate, changes in the real interest rate and the level of real interest rate</i>, The index is built as a result of the 5-step process: Step 1: Construct the histogram of each indicator. Step 2: Compare the observed distribution with the Gaussian Distribution and get the differences (deviations). Step 3: Compare the distribution of deviations of crisis points (right segment of distribution) with a certain functional form that best describes it. As a result, you will get a distribution function that describes the crises, which is in the (0,1) interval. Step 4: Get functions of 3 variables together. Step 5: The series produced will need to be smoothed out with exponential weighting moving average technique, which smoothens the most remote areas (outlayers) of the series and suggests a gradual transition of the crisis into a peaceful period..	Quarterly data of 10 developing countries, for the period 1990-2000																																																								
7.	Esquivel, Larrain (1998)	1. $\Delta^3 \varepsilon > 15\%$ or 2. $\Delta^1 \varepsilon > 2.54 \sigma_{\Delta \varepsilon}$ & $\Delta^1 \varepsilon > 4\%$ $\Delta^3 \varepsilon$ - 3-month cumulative change of the real exchange rate $\Delta^1 \varepsilon$ - monthly change of the real exchange rate $\sigma_{\Delta \varepsilon}$ - $\Delta^1 \varepsilon$ standard deviation	Annual data of 30 developed and developing countries, for the period 1975-1996																																																								
8.	Shardax (2003)	At least 20% depreciation of the nominal exchange rate during 10 trading days.	Quarterly data of 12 Eastern and Central European countries, for the period 1992-2002																																																								
9.	Tinakorn (2002)	3-month cumulative depreciation of the nominal exchange rate > 15% or 3-month cumulative reduction in net international reserves > 15%	Monthly data of Thailand, for the period 1992-2000																																																								
10.	Goldfaja, Valdes (1997) Source: Tinakorn (2002)	1. Nominal exchange rate depreciation > 1.96* exchange rate standard deviation or 2. Exchange rate depreciation > 2%+1.5* previous month's depreciation	Monthly data of 26 countries, for the period 1984-1997																																																								

11.	Engwatana (1999) Source: Tinakorn (2002)	1. One-month cumulative growth of the nominal exchange rate >10% 2. Monthly deviation of the Forward Premium from its 3-month moving average >10%	Monthly and quarterly data of Thailand, for the period 1990-1998
12.	Poonpatpibul, Ittisupomrat (2001) Source: Tinakorn (2002)	3-month cumulative growth of the nominal exchange rate >15%	Monthly data of Thailand, for the period 1990-2000
13.	Milesi-Ferretti, Razin (2000)	1. Annual depreciation of the nominal exchange rate $\geq 25\%$, which is more than 10pp higher from the previous year's depreciation: $I_t \geq 25\%$ and $I_t - I_{t-1} \geq 10\%$, where: $I_t = \ln(e_t - e_{t-1})$ e_t - nominal exchange rate 2. $I_t \geq 25\%$ and $I_t - I_{t-1} \geq 100\%$ and $I_{t-1} \leq 40\%$ 3. $I_t \geq 15\%$ and $I_t - I_{t-1} \geq 10\%$ and $I_{t-1} \leq 10\%$ 4. $I_t \geq 15\%$ and $I_t - I_{t-1} \geq 10\%$ and $I_{t-1} \leq 10\%$ and if the exchange rate was fixed a year before the crisis.	Annual data of 105 developing countries, for the period 1975-1996
14.	Mecagni, Atoyan, Hoffman, Tzanninis (2007)	<i>The capital account crisis index:</i> $IKAC_t = -(FX_t - FX_t^{trend}) - \ln(NEER_t / NEER_{t+1}) + S_t - K_t$ FX - international reserves $NEER$ - nominal effective exchange rate S - spread of government bonds K - net capital inflow/GDP	
15.	Moreno (2000) Source: Bubula, Otker-Robe (2003)	Annualized depreciation of the nominal exchange rate $\geq 25\%$ $I_t \geq 25\%$, where: $I_t = \ln(e_t - e_{t-1}) * 100\%$ and $I_t > \bar{I}_{12m} + 3.0 * \sigma_{I,12m}$, where: $\bar{I}_{12m}$ - average of changes in the previous 12-month period $\sigma_{I,12m}$ - standard deviation of ratios calculated for the same 12-month period	Monthly data of 7 Eastern Asia countries, for the period 1974-1999
16.	Glick, Hutchinson (1999) Source: Bubula, Otker-Robe (2003)	$I = \% \Delta \mathcal{E} - \frac{\sigma_{\mathcal{E}}}{\sigma_r} \% \Delta r$, where: $\mathcal{E}$ - real exchange rate $I > \mu + 2.0 * \sigma_I$ or $\% \Delta \mathcal{E} > 15\%$, provided that it is well above the same indicator of the previous month and $\% \Delta \mathcal{E} > \text{country-specific average} + 2.0 * \sigma_{\% \Delta \mathcal{E}}$, provided that it is also $\geq 5\%$	Month data of 21 developed and 69 developing countries, for the period 1975-1997
17.	Zhang (2001) Source: Abiad (2003)	Separate threshold levels for exchange rate and reserves: threshold is 3 standard deviations away from the average, where standard deviation is calculated by the 3-year moving window.	Monthly data of 4 Eastern Asia countries, for the period 1993-1997

Appendix 2: Basic characteristics and results of several studies about currency crises

Author	Definition of the crisis	Data	Method	Indicators (significant)																																																																																																		
1. Kaminsky, Lizondo, Reinhart (1998)	<i>The Exchange market pressure index</i> $I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 3.0 * \sigma_I$ e - exchange rate, r - international reserves, σ_e - standard deviation of the exchange rate, σ_r - standard deviation of the interest rate, μ - index average σ_I - standard deviation of the index	Monthly data of 20 countries, for the period 1970-1995	Signaling approach	1. Real exchange rate deviation from equilibrium, 2. Bank crises 3. Exports 4. Asset prices 5. M2/reserves 6. Economic growth 7. M1 surplus 8. International reserves 9. M2 multiplier 10. Domestic credit/GDP 11. Real interest rate 12. Terms of trade																																																																																																		
2. Kumar, Moorthy, Ferraudin (2003)	1. <i>Unexpected depreciation</i> $100 \left[\frac{e_{t+\Delta} - e_t}{e_t} \right] \left[\frac{1+r_t^*}{1+r_t} \right] > \gamma_1$ r_t^* - external interest rate, r_t - domestic interest rate, e_t - exchange rate, γ_1 - marginal value which is set to be either 5% or 10% 2. <i>General devaluation crisis</i> $100 \left[\frac{e_{t+\Delta} - e_t}{e_t} \right] > \gamma_2 \text{ and } \left[\frac{e_{t+\Delta} - e_t}{e_t} \right] > (1 + \gamma_3) \left[\frac{e_t - e_{t-\Delta}}{e_{t-\Delta}} \right]$ γ_3 - accepted to be 100%, i.e. doubling the rate of devaluation, γ_2 - 5% or 10%	Monthly and annual data of 32 developing countries, for the period 1985-1999	Logit model	1. 12-month change in international reserves 2. Deviation of real GDP from the trend 3. Import coverage 4. Public debt/Total debt 5. Dummy variable of regional contagion																																																																																																		
3. Hawkins, Klau (2000)	1. <i>The Exchange market pressure index</i> $I_1 = W_1 \cdot xrm + W_2 \cdot xra + W_3 \cdot r + W_4 \cdot res$ xrm - 3-month depreciation of the exchange rate (in percent), xra - yearly depreciation of the exchange rate (in percent), r - 3-month interest rate less annualized inflation previous 6 months, res - 3-month change of the 12-month moving average of reserves to imports ratio Indicator values are chosen according to the following table: <table><tr><th colspan="2">Indicator</th><th>-2</th><th>-1</th><th>0</th><th>1</th><th>2</th></tr><tr><th>Code</th><th>Weight</th><th></th><th></th><th></th><th></th><th></th></tr><tr><td>xrm</td><td>W_1</td><td>$10 < x$</td><td>$2 < x \leq 10$</td><td>$2 \geq x > -3$</td><td>$-3 \geq x > -8$</td><td>$x \leq -8$</td></tr><tr><td>xra</td><td>W_2</td><td>$20 < x$</td><td>$5 < x \leq 20$</td><td>$5 \geq x > -5$</td><td>$-5 \geq x > -20$</td><td>$x \leq -20$</td></tr><tr><td>r</td><td>W_3</td><td></td><td></td><td>$x \leq 2$</td><td>$2 < x \leq 4$</td><td>$x > 4$</td></tr><tr><td>res</td><td>W_4</td><td>$8 < x$</td><td>$4 < x \leq 8$</td><td>$4 \geq x > -4$</td><td>$-4 \geq x > -8$</td><td>$x < -8$</td></tr></table> so that the maximum value of the index equals 10, that is $W_1=W_2=W_3=W_4=1.25$ 2. <i>External vulnerability index</i> $I_2 = W_1 \cdot reer + W_2 \cdot cgdp + W_3 \cdot gx + W_4 \cdot debt + W_5 \cdot gdebt + W_6 \cdot stdebt$ $reer$ - real effective exchange deviation from the average (in percent), $cgdp$ - current account/GDP, gx - annual export growth deviation from the average annual growth, $debt$ - foreign debt/GDP, $gdebt$ - 8 quarters' growth of the above indicator, $stdebt$ - short-term foreign debt/reserves Indicator values are chosen according to the following table: <table><tr><th colspan="2">Indicator</th><th>-2</th><th>-1</th><th>0</th><th>1</th><th>2</th></tr><tr><th>Code</th><th>Weight</th><th></th><th></th><th></th><th></th><th></th></tr><tr><td>$reer$</td><td>W_1</td><td>$-20 \geq x$</td><td>$-20 < x \leq -10$</td><td>$-10 < x \leq 10$</td><td>$10 < x \leq 20$</td><td>$x > 20$</td></tr><tr><td>$cgdp$</td><td>W_2</td><td>$x > 4$</td><td>$2 < x \leq 4$</td><td>$-2 < x \leq 2$</td><td>$-4 < x \leq -2$</td><td>$-4 \geq x$</td></tr><tr><td>gx</td><td>W_3</td><td>$x > 10$</td><td>$10 \leq x < 5$</td><td>$0 < x \leq 5$</td><td>$-5 < x \leq 0$</td><td>$-5 \geq x$</td></tr><tr><td>$debt$</td><td>W_4</td><td></td><td>$x \leq 20$</td><td>$20 < x \leq 30$</td><td>$30 < x \leq 40$</td><td>$x > 40$</td></tr><tr><td>$gdebt$</td><td>W_5</td><td>$-10 \geq x$</td><td>$-10 < x \leq 0$</td><td>$0 < x \leq 10$</td><td>$10 < x \leq 15$</td><td>$x > 15$</td></tr><tr><td>$stdebt$</td><td>W_6</td><td></td><td>$x \leq 50$</td><td>$50 < x \leq 100$</td><td>$100 < x \leq 150$</td><td>$x > 150$</td></tr></table> so that the maximum value of the index equals 10, that is $W_1=W_2=W_3=W_4=W_5=W_6=5/6$	Indicator		-2	-1	0	1	2	Code	Weight						xrm	W_1	$10 < x$	$2 < x \leq 10$	$2 \geq x > -3$	$-3 \geq x > -8$	$x \leq -8$	xra	W_2	$20 < x$	$5 < x \leq 20$	$5 \geq x > -5$	$-5 \geq x > -20$	$x \leq -20$	r	W_3			$x \leq 2$	$2 < x \leq 4$	$x > 4$	res	W_4	$8 < x$	$4 < x \leq 8$	$4 \geq x > -4$	$-4 \geq x > -8$	$x < -8$	Indicator		-2	-1	0	1	2	Code	Weight						$reer$	W_1	$-20 \geq x$	$-20 < x \leq -10$	$-10 < x \leq 10$	$10 < x \leq 20$	$x > 20$	$cgdp$	W_2	$x > 4$	$2 < x \leq 4$	$-2 < x \leq 2$	$-4 < x \leq -2$	$-4 \geq x$	gx	W_3	$x > 10$	$10 \leq x < 5$	$0 < x \leq 5$	$-5 < x \leq 0$	$-5 \geq x$	$debt$	W_4		$x \leq 20$	$20 < x \leq 30$	$30 < x \leq 40$	$x > 40$	$gdebt$	W_5	$-10 \geq x$	$-10 < x \leq 0$	$0 < x \leq 10$	$10 < x \leq 15$	$x > 15$	$stdebt$	W_6		$x \leq 50$	$50 < x \leq 100$	$100 < x \leq 150$	$x > 150$	Quarterly data of 24 developing countries, for the period 1993-1998	Panel regression	1. Real exchange rate gap 2. Real interest rates 3. Foreign debt/GDP
Indicator		-2	-1	0	1	2																																																																																																
Code	Weight																																																																																																					
xrm	W_1	$10 < x$	$2 < x \leq 10$	$2 \geq x > -3$	$-3 \geq x > -8$	$x \leq -8$																																																																																																
xra	W_2	$20 < x$	$5 < x \leq 20$	$5 \geq x > -5$	$-5 \geq x > -20$	$x \leq -20$																																																																																																
r	W_3			$x \leq 2$	$2 < x \leq 4$	$x > 4$																																																																																																
res	W_4	$8 < x$	$4 < x \leq 8$	$4 \geq x > -4$	$-4 \geq x > -8$	$x < -8$																																																																																																
Indicator		-2	-1	0	1	2																																																																																																
Code	Weight																																																																																																					
$reer$	W_1	$-20 \geq x$	$-20 < x \leq -10$	$-10 < x \leq 10$	$10 < x \leq 20$	$x > 20$																																																																																																
$cgdp$	W_2	$x > 4$	$2 < x \leq 4$	$-2 < x \leq 2$	$-4 < x \leq -2$	$-4 \geq x$																																																																																																
gx	W_3	$x > 10$	$10 \leq x < 5$	$0 < x \leq 5$	$-5 < x \leq 0$	$-5 \geq x$																																																																																																
$debt$	W_4		$x \leq 20$	$20 < x \leq 30$	$30 < x \leq 40$	$x > 40$																																																																																																
$gdebt$	W_5	$-10 \geq x$	$-10 < x \leq 0$	$0 < x \leq 10$	$10 < x \leq 15$	$x > 15$																																																																																																
$stdebt$	W_6		$x \leq 50$	$50 < x \leq 100$	$100 < x \leq 150$	$x > 150$																																																																																																
4. Hattori (2002)	$I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ as the depth of the crisis	Monthly data of 22 developing countries, for the period 1990-1996	Cross-section regression	1. 4-year change of Domestic private credit/GDP ratio 2. Short-term foreign debt/reserves 3. Contagion effect 4. Financial liberalization																																																																																																		

5.	Won-Am Park (2002)	<i>The Exchange market pressure index</i> $I = \frac{1}{\sigma_e} \Delta e + \frac{1}{\sigma_i} \Delta i - \frac{1}{\sigma_r} \Delta r$ $I > \mu + 1.1 * \sigma_I$ Δi - interest rate change	Monthly data of South Korea, for the period 1990-1997	Signaling approach	1. Terms of trade 2. Asset prices 3. Exports 4. Domestic credit/GDP 5. M2 multiplier
6.	Elhengr, Rose, Wyplosz (1996)	$I = \frac{1}{\sigma_e} \% \Delta e + \frac{1}{\sigma_i} \Delta(i - i^*) - \frac{1}{\sigma_r} (\% \Delta r - \% \Delta r^*)$ Non-weighted version is discussed, as well. i^* & $\% \Delta r^*$, respectively, change in interest rate and reserves of foreign country (Germany). $I > \mu + 1.5 * \sigma_I$	Quarterly data of 20 developed countries, for the period 1959-1993	Probit method	1. Contagion effect 2. Inflation 3. Unemployment
7.	Eliasson, Kreuter (2001)	<i>Continuous Definition of crisis</i> Consists of the simple sum of deviations from long-term averages of the <i>change in exchange rate, changes in the real interest rate and the level of real interest rate</i>. The index is built as a result of the 5-step process: Step 1: Construct the histogram of each indicator. Step 2: Compare the observed distribution with the Gaussian Distribution and get the differences (deviations). Step 3: Compare the distribution of deviations of crisis points (right segment of distribution) with a certain functional form that best describes it. As a result, you will get a distribution function that describes the crises, which is in the [0,1] interval. Step 4: Get functions of 3 variables together. Step 5: The series produced will need to be smoothed out with exponential weighting moving average technique, which smoothes the most remote areas (outlayers) of the series and suggests a gradual transition of the crisis into a peaceful period.	Quarterly data of 10 developing countries, for the period 1990-2000	Multivariate logit model	1. Domestic credit/GDP 2. M2/reserves 3. Short-term debt/Reserves 4. Real interest rate 5. Contagion effect
8.	Krzmar (2004)	$I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 2.0 * \sigma_I$	Monthly data of Croatia, for the period 1996-2003	Signaling approach and a Probit method	1. Budget deficit/GDP 2. Current account/GDP 3. Inflation 4. Foreign debt 5. M2 multiplier 6. Real exchange rate deviation from the trend 7. Share of foreign assets in M4 8. Change in domestic credit
9.	Scherbakov (2000)	Data from the paper by Kaminsky and others (1998).	Annual data of 13 developing countries, for the period 1970-1999	Probit method	1. M2/Reserves 2. Change in M1/ reserves 3. Decline in real GDP 4. Claims on government /deviation of GDP from the average 5. Short-term debt / deviation of GDP from the average 6. Real exchange rate 7. Openness 8. Bank crises
10.	Esquivel, Larrain (1998)	1. $\Delta^3 \varepsilon > 15\%$ or 2. $\Delta^1 \varepsilon > 2.54 \sigma_{\Delta \varepsilon}$ & $\Delta^1 \varepsilon > 4\%$ $\Delta^3 \varepsilon$ - 3-month cumulative change of the real exchange rate $\Delta^1 \varepsilon$ - monthly change of the real exchange rate $\sigma_{\Delta \varepsilon}$ - $\Delta^1 \varepsilon$ standard deviation	Annual data of 30 developed and developing countries, for the period 1975-1996	Probit method	1. Change in Broad money/ GDP (seigniorage) 2. Real exchange rate gap 3. Reserves/M2 4. Terms of trade 5. Per capita income 6. Contagion effect 7. Current account
11.	Kaminsky (2003)	Same way, as Kaminsky and others (1998)	Monthly data of 20 countries, for the period 1970-2001	Regression tree method	1. Real exchange rate overvaluation 2. World interest rates 3. Short-term debt/Reserves 4. Foreign debt/Exports 5. Exports 6. Budget deficit 7. Change in domestic credit/GDP 8. Expansionary monetary policy 9. M2/Reserves
12.	Racaru, Copaciu, Lapteacru (2006)	$I = \frac{1}{\sigma_e} \Delta e + \frac{1}{\sigma_i} \Delta i - \frac{1}{\sigma_r} \Delta r$ $I > \mu + 2.0 * \sigma_I$	Monthly data of 26 developing countries, for the period 1994-2004	Signaling approach and a Multivariate Logit method	1. Real exchange rate overvaluation 2. Domestic private credit/GDP 3. Current account/GDP 4. M2/Reserves 5. Export growth rate

13. Budsayapla-korn, Dibooglu, Mathur (2006)	$I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 2.0 * \sigma_I$	Quarterly data of 5 Asian countries, for the period 1975-1997	Signaling approach and a Multivariate Probit method	1. International reserves 2. Asset prices 3. GDP 4. Domestic credit/GDP 5. Export growth rate
14. Schardax (2003)	At least 20% depreciation of the nominal exchange rate during 10 trading days.	Quarterly data of 12 Eastern and Central European countries, for the period 1992-2002	Signaling approach	1. Change in M2/ gross reserves 2. M2/gross reserves 3. Change in exports 4. Deviation of real exchange rate from the trend 5. Budget deficit/GDP
15. Bruggeman, Linne (2002)	At least 20% depreciation of the nominal exchange rate during 10 trading days.	Monthly data of 5 Eastern and Central European countries, for the period 1993-2001	Signaling approach	1. Export 2. Reserves 3. Credit interest rate /Deposit interest rate 4. Real exchange rate 5. Bank deposits 6. Budget deficit/GDP 7. Industrial production 8. M2 multiplier 9. Domestic credit/GDP 10. Domestic interest rates 11. M2/Reserves 12. Short-term external debt
16. Knedlik, Scheufele (2007)	$I = \frac{1}{\sigma_e} \Delta e + \frac{1}{\sigma_i} \Delta i - \frac{1}{\sigma_r} \Delta r$ $I > \mu + 1.645 * \sigma_I$ 1.645 standard deviation suggests that in case of normal distribution, 5% of the distribution would be crisis-relevant	Monthly data of South Africa countries, for the period 1995-2005	Signaling approach, a Probit method, a Markov-Switching method	1. International liquidity position 2. Change in import of goods 3. Growth rate of Domestic credit/GDP 4. Domestic interest rate 5. Difference between domestic and external interest rates 6. Deposits 7. Growth rate Government's external debt 8. Budget deficit/GDP 9. Growth rate of international gold prices
17. Tinakorn (2002)	3-month cumulative depreciation of the nominal exchange rate > 15% or 3-month cumulative reduction in net international reserves >15%	Monthly data of Thailand, for the period 1992-2000	Signaling approach, a Probit method	1. Change in terms of trade 2. Export growth rate 3. Current account/GDP 4. Real exchange rate gap 5. Short-term debt/Reserves 6. Growth rate of M2/Reserves 7. Growth rate of Domestic credit/GDP 8. Budget deficit/GDP 9. Inflation 10. Real GDP growth rate 11. Change in Asset prices
18. Feridun (2006)	$I = \frac{1}{\sigma_e} \% \Delta e + \frac{1}{\sigma_i} \Delta(i - i^*) - \frac{1}{\sigma_r} (\% \Delta r - \% \Delta r^*)$ $\% \Delta r \hat{=} \% \Delta r^* \text{ - change in the ratio of reserves to M1 of the country and of the foreign country}$ $I > \mu + 1.5 * \sigma_I$	Monthly data of Turkey, for the period 1980-2006	Signaling approach, Paired and Multivariate Probit methods	1. Banking system crises 2. Short-term debt/Reserves 3. GDP of the USA 4. Interest rates of US treasury bills 5. M1
19. Goldfaja, Valdes (1997) Source: Tinakorn (2002)	1. Depreciation of the nominal exchange rate > 1.96* exchange rate standard deviation 2. Depreciation of the exchange rate > 2%+1.5* previous month's depreciation 3. $I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 3.0 * \sigma_I$	Monthly data of 26 countries, for the period 1984-1997	Logit model	1. Overvaluation of the real exchange rate
20. Kruger, Osakwe, Page (1998) Source: Tinakorn (2002)	$I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 1.5 * \sigma_I$	Annual data of 19 countries, for the period 1977-1993	Probit model	1. M2/International reserves 2. Bank claims on private sector/GDP 3. Real exchange rate gap

21. Engwatana (1999) Source: Tinakorn (2002)	1. One-month cumulative growth of the nominal exchange rate >10% 2. Monthly deviation of the Forward Premium from its 3-month moving average >10%	Monthly and quarterly data of Thailand, for the period 1990-1998	Probit model	1. Domestic credit 2. M2/International reserves 3. Import coverage 4. Difference between domestic and external interest rates 5. Deviation of the real exchange rate 6. Short-term debt/Reserves 7. Current account deficit
22. Poonpatpibul Ittisupornrat (2001) Source: Tinakorn (2002)	3-month cumulative growth of the nominal exchange rate >15%	Monthly data of Thailand, for the period 1990-2000	Signaling approach and a Probit method	1. Export growth rate 2. Change in real exchange rate 3. Terms of trade 4. Loan and deposit interest rates spread 5. M2/Reserves 6. Credit growth rate 7. Inflation
23. Milesi-Ferretti, Razin (2000)	1. Annual depreciation of the nominal exchange rate $\geq 25\%$, which is more than 10pp higher from the previous year's depreciation: $I_t \geq 25\%$ and $I_t - I_{t-1} \geq 10\%$, where: $I_t = \ln(e_t - e_{t-1})$ e_t - nominal exchange rate 2. $I_t \geq 25\%$ and $I_t - I_{t-1} \geq 100\%$ and $I_{t-1} \leq 40\%$ 3. $I_t \geq 15\%$ and $I_t - I_{t-1} \geq 10\%$ and $I_{t-1} \leq 10\%$ 4. $I_t \geq 15\%$ and $I_t - I_{t-1} \geq 10\%$ and $I_{t-1} \leq 10\%$ and if the exchange rate was fixed a year before the crisis.	Annual data of 105 developing countries, for the period 1975-1996	Multiple Probit	1. International reserves 2. Deviation of the real exchange rate 3. Real US interest rates 4. Economic growth of developed countries 5. Terms of trade 6. Openness of the economy 7. Deficit of current account
24. Edison (2003)	$I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 2.5 * \sigma_I$ <i>For one country:</i> $I > \mu + 1.5 * \sigma_I$	Monthly data of 28 developed and developing countries, for the period 1970-1999	Signaling approach	1. Real exchange rate gap 2. Short-term debt/Reserves 3. International reserves 4. M2/International reserves 5. Export 6. Assets prices 7. Economic growth 8. Excess in M1 9. Economic growth in G-7 countries 10. Real interest rate 11. Credit/GDP
25. Abiad (2003)	Defined endogenously in a Markov-switching model framework	Monthly data of 5 developing countries, for the period 1972-1999	Markov switching model	1. Overvaluation of the real exchange rate 2. M2/International reserves 3. Real GDP growth 4. LIBOR
26. Nag, Mitra (1999)	$I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 2.0 * \sigma_I$	Monthly data of 3 developing countries, for the period 1980-1999	Signaling approach and Neural networks	1. M2/ International reserves 2. International reserves 3. Difference between foreign assets and liabilities 4. Export 5. Money multiplier
27. Peltonen (2006)	$I = \% \Delta e - \frac{\sigma_e}{\sigma_r} \% \Delta r$ $I > \mu + 2.0 * \sigma_I$	Monthly data of 24 developing countries, for the period 1980-2001	Probit Model and Neural Networks	1. Contagion effect 2. De-facto exchange rate regime 3. Current account deficit 4. Budget deficit 5. Real GDP growth
28. Ghosh and Ghosh (2002)	$I = \% \Delta \mathcal{E} - \frac{\sigma_e}{\sigma_r} \% \Delta r$, where: $\mathcal{E}$ is the real exchange rate $I > \mu + 2.0 * \sigma_I$ and the GDP decline > 3%, 5%	Annual data of 42 developed and developing countries, for the period 1987-1999	Classification tree method and a Probit method	1. Good governance system 2. Current account 3. Real exchange rate 4. Foreign debt/Reserves

Appendix 3. Currency crises (pressures) observed in Armenia, according to various types of exchange market pressure indices

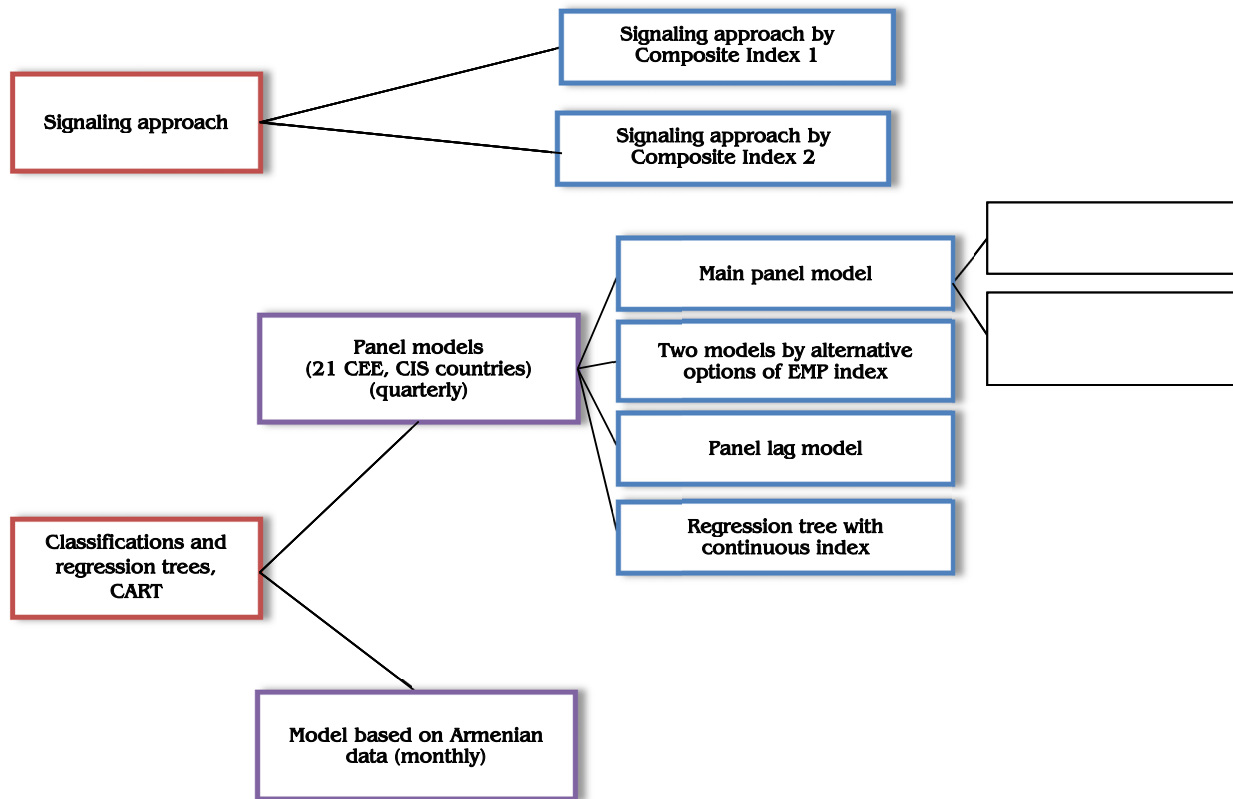
Crises	Version 1 9*	Version 2 8*	Version 3 6*	Version 4 14*	Version 5 11*	Version 6 11*	Version 7 12*
1/31/1997	1	1	1	1	1	1	1
2/28/1997	1	0	1	1	1	1	1
3/31/1997	1	1	1	1	1	1	1
4/30/1997	1	1	0	1	1	1	1
5/31/1997	1	1	0	1	1	1	1
6/30/1997	1	1	1	0	0	1	0
7/31/1997	0	0	0	0	0	0	0
8/31/1997	0	0	0	0	0	0	0
9/30/1997	0	0	0	0	0	0	0
10/31/1997	0	0	0	1	0	0	0
11/30/1997	1	1	0	1	1	1	1
12/31/1997	0	0	0	0	0	0	0
1/31/1998	0	0	0	0	0	0	0
2/28/1998	0	1	0	1	0	0	0
3/31/1998	0	0	0	0	0	0	0
4/30/1998	0	0	0	0	0	0	0
5/31/1998	0	0	0	0	0	0	0
6/30/1998	0	0	0	0	0	0	0
7/31/1998	1	1	0	1	1	1	1
8/31/1998	0	0	0	0	0	0	1
9/30/1998	0	0	0	0	0	0	0
10/31/1998	0	0	0	0	0	0	0
11/30/1998	1	0	0	1	1	1	0
12/31/1998	0	0	0	0	0	0	0
1/31/1999	0	0	1	1	1	1	1
2/28/1999	0	0	0	0	0	0	0
3/31/1999	0	0	0	0	0	0	0
4/30/1999	0	0	0	1	1	1	1
5/31/1999	0	0	0	0	0	0	0
6/30/1999	0	0	0	0	0	0	0
7/31/1999	0	0	0	0	0	0	0
8/31/1999	0	0	0	0	0	0	0
9/30/1999	0	0	0	0	0	0	0
10/31/1999	0	0	0	1	0	0	0
11/30/1999	0	0	0	0	0	0	0
12/31/1999	0	0	0	0	0	0	0
1/31/2000	0	0	0	0	0	0	0
2/29/2000	0	0	0	0	0	0	0
3/31/2000	0	0	0	0	0	0	0
4/30/2000	0	0	0	0	0	0	0
5/31/2000	0	0	0	0	0	0	0
6/30/2000	0	0	0	0	0	0	0
7/31/2000	0	0	0	0	0	0	0
8/31/2000	0	0	0	0	0	0	0
9/30/2000	0	0	0	0	0	0	0
10/31/2000	0	0	0	0	0	0	0
11/30/2000	0	0	0	0	0	0	0
12/31/2000	0	0	0	0	0	0	0
1/31/2001	0	0	0	1	1	0	1
2/28/2001	0	0	0	0	0	0	0
3/31/2001	0	0	0	0	0	0	0
4/30/2001	0	0	0	0	0	0	0
5/31/2001	0	0	0	0	0	0	0
6/30/2001	0	0	0	0	0	0	0
7/31/2001	0	0	0	0	0	0	0
8/31/2001	0	0	0	0	0	0	0
9/30/2001	0	0	0	0	0	0	0
10/31/2001	0	0	0	0	0	0	0
11/30/2001	0	0	0	0	0	0	0
12/31/2001	0	0	0	0	0	0	0
1/31/2002	0	0	0	0	0	0	0
2/28/2002	0	0	0	0	0	0	0
3/31/2002	0	0	0	0	0	0	0
4/30/2002	0	0	0	0	0	0	1
5/31/2002	0	0	0	0	0	0	0
6/30/2002	0	0	0	0	0	0	0
7/31/2002	0	0	0	0	0	0	0
8/31/2002	0	0	0	0	0	0	0
9/30/2002	0	0	0	0	0	0	0
10/31/2002	0	0	0	0	0	0	0
11/30/2002	0	0	0	0	0	0	0
12/31/2002	0	0	0	0	0	0	0
1/31/2003	0	0	0	0	0	0	0
2/28/2003	0	0	0	0	0	0	0
3/31/2003	0	0	0	0	0	0	0

4/30/2003	0	0	0	0	0	0	0	0
5/31/2003	0	0	0	0	0	0	0	0
6/30/2003	0	0	0	0	0	0	0	0
7/31/2003	0	0	0	0	0	0	0	0
8/31/2003	0	0	0	0	0	0	0	0
9/30/2003	0	0	0	0	0	0	0	0
10/31/2003	0	0	0	0	0	0	0	0
11/30/2003	0	0	0	0	0	0	0	0
12/31/2003	0	0	0	0	0	0	0	0
1/31/2004	0	0	0	0	0	0	0	0
2/29/2004	0	0	0	0	0	0	0	0
3/31/2004	0	0	0	0	0	0	0	0
4/30/2004	0	0	0	0	0	0	0	0
5/31/2004	0	0	0	0	0	0	0	0
6/30/2004	0	0	0	0	0	0	0	0
7/31/2004	0	0	0	0	0	0	0	0
8/31/2004	0	0	0	0	0	0	0	0
9/30/2004	0	0	0	0	0	0	0	0
10/31/2004	0	0	0	0	0	0	0	0
11/30/2004	0	0	0	0	0	0	0	0
12/31/2004	0	0	0	0	0	0	0	0
1/31/2005	0	0	0	0	0	0	0	0
2/28/2005	0	0	0	0	0	0	0	0
3/31/2005	0	0	0	0	0	0	0	0
4/30/2005	0	0	0	0	0	0	0	0
5/31/2005	0	0	0	0	0	0	0	0
6/30/2005	0	0	0	0	0	0	0	0
7/31/2005	0	0	0	0	0	0	0	0
8/31/2005	0	0	1	0	0	0	0	0
9/30/2005	0	0	0	0	0	0	0	0
10/31/2005	0	0	0	0	0	0	0	0
11/30/2005	0	0	0	0	0	0	0	0
12/31/2005	0	0	0	0	0	0	0	0
1/31/2006	0	0	0	0	0	0	0	0
2/28/2006	0	0	0	0	0	0	0	0
3/31/2006	0	0	0	0	0	0	0	0
4/30/2006	0	0	0	0	0	0	0	0
5/31/2006	0	0	0	0	0	0	0	0
6/30/2006	0	0	0	0	0	0	0	0
7/31/2006	0	0	0	0	0	0	0	0
8/31/2006	0	0	0	0	0	0	0	0
9/30/2006	0	0	0	0	0	0	0	0
10/31/2006	0	0	0	0	0	0	0	0
11/30/2006	0	0	0	0	0	0	0	0
12/31/2006	0	0	0	0	0	0	0	0
1/31/2007	0	0	0	0	0	0	0	0
2/28/2007	0	0	0	0	0	0	0	0
3/31/2007	0	0	0	0	0	0	0	0
4/30/2007	0	0	0	0	0	0	0	0
5/31/2007	0	0	0	0	0	0	0	0
6/30/2007	0	0	0	0	0	0	0	0
7/31/2007	0	0	0	0	0	0	0	0
8/31/2007	0	0	0	0	0	0	0	0
9/30/2007	0	0	0	0	0	0	0	0
10/31/2007	0	0	0	0	0	0	0	0
11/30/2007	0	0	0	0	0	0	0	0
12/31/2007	0	0	0	0	0	0	0	0
1/31/2008	0	0	0	0	0	0	0	0
2/29/2008	0	0	0	0	0	0	0	0
3/31/2008	0	0	0	0	0	0	0	0
4/30/2008	0	0	0	0	0	0	0	0
5/31/2008	0	0	0	0	0	0	0	0
6/30/2008	0	0	0	0	0	0	0	0
7/31/2008	0	0	0	0	0	0	0	0
8/31/2008	0	0	0	0	0	0	0	0
9/30/2008	0	0	0	0	0	0	0	0
10/31/2008	0	0	0	0	0	0	0	0
11/30/2008	0	0	0	0	0	0	0	0
12/31/2008	0	0	0	0	0	0	0	0
1/31/2009	0	0	0	1	1	0	0	0
2/28/2009	0	0	1	1	1	0	0	0
3/31/2009	1	1	1	1	1	1	1	1
4/30/2009	0	1	1	1	1	1	1	1
5/31/2009	0	0	0	0	0	0	0	0
6/30/2009	0	0	0	0	0	0	0	0
7/31/2009	0	0	0	0	0	0	0	0
8/31/2009	0	0	0	0	0	0	1	0
9/30/2009	0	0	0	0	0	0	0	0

* Number of the crises (pressures) observed up to December of 2008.

Appendix 4: The Main leading indicators discussed in different papers

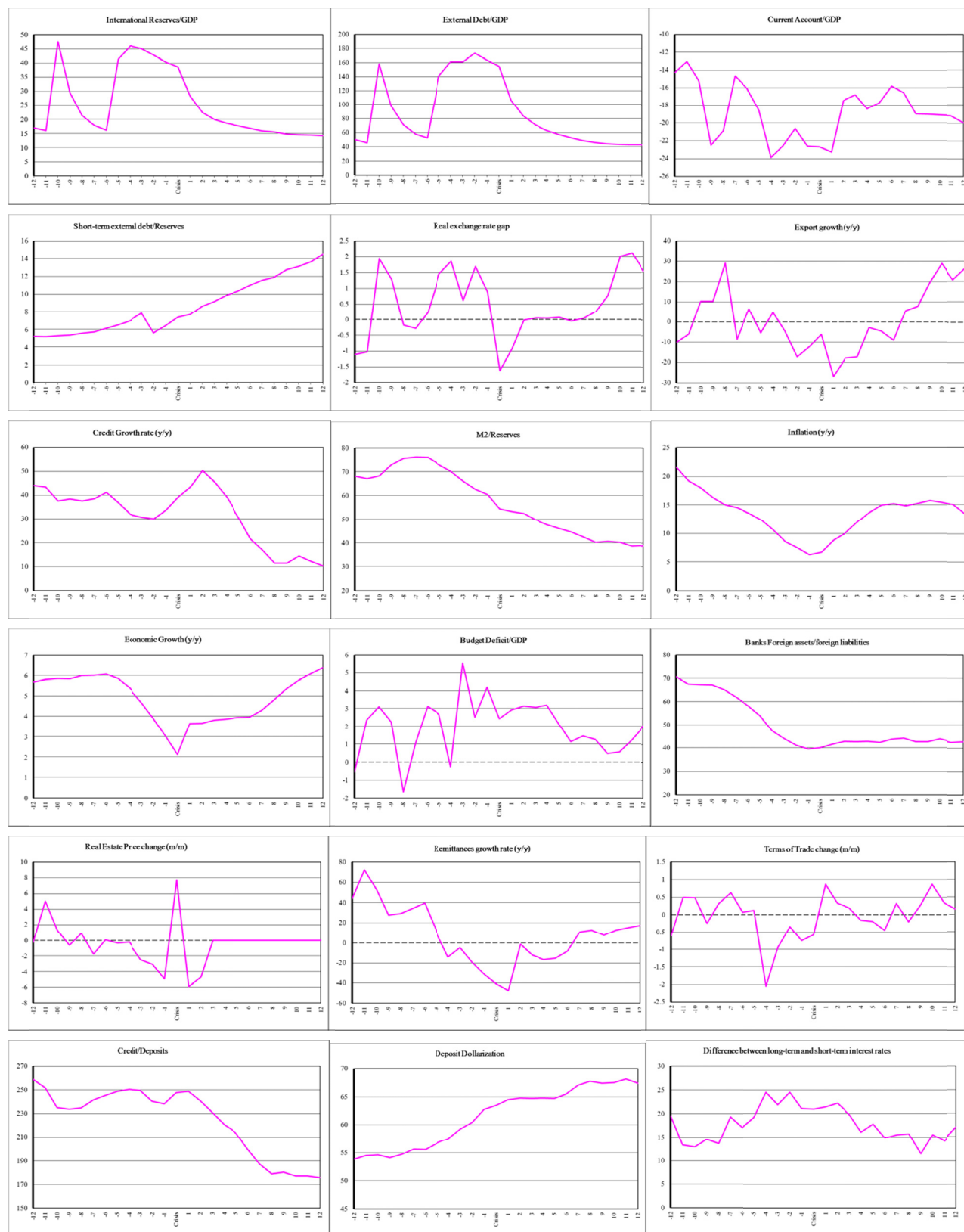
Indicator	Kaminsky, Lizondo, Reinhart (1998) – the results of 28 papers	Hawkins, Klau (2000) – the results of 34 papers of financial crises for 1998-2000, 27 of which related to currency crises	Abiad (2003) – the results of those 6 works out of 34, which were not reviewed in the previous two papers	The results of 25 papers reviewed which were not discussed in the previous ones	A total of 86 papers	Appearance rate, (%)	Rank
Real exchange rate	12	23	5	16	56	65.12	1
International reserves	11	23	1	9	44	51.16	2
M2/International reserves	3	15	3	15	36	41.86	3
Credit growth	5	9	4	15	33	38.37	4
Current account	2	15	5	6	28	32.56	5
Exports	2	9	1	12	24	27.91	6
Real GDP growth rate or level	5	11		8	24	27.91	6
Budget deficit	3	6	2	7	18	20.93	8
Inflation	5	7	1	4	17	19.77	9
Short-term external debt/Reserves			3	11	14	16.28	10
Change in asset prices	1	7		6	14	16.28	10
Terms of trade	2	6		5	13	15.12	12
Real interest rate	1	5		6	12	13.95	13
Crisis in the region, contagion effect	1	7		4	12	13.95	13
Foreign debt	0	5	2	4	11	12.79	15
Foreign interest rate	2		1	4	7	8.14	16
Money multiplier	1			5	6	6.98	17
Trade account	2		1	1	4	4.65	18
Real GDP growth of foreign country	1			3	4	4.65	18
Broad money	2			2	4	4.65	18
Credit to public sector	3			1	4	4.65	18
Banking system crisis	1			3	4	4.65	18
Current government wins or government loses in elections	1	3			4	4.65	18
Money supply/Demand gap	1			2	3	3.49	24
Difference between domestic and foreign interest rates			1	2	3	3.49	24
Employment/unemployment	2		1		3	3.49	24
Openness of the economy	1			2	3	3.49	24
Import coverage				2	2	2.33	28
Foreign direct investment	2				2	2.33	28
Import	1			1	2	2.33	28
Loans and deposits interest rates spread				2	2	2.33	28
Change in bank deposits	0			2	2	2.33	28
Output gap	1			1	2	2.33	28
Exchange rate regime			1	1	2	2.33	28
Financial liberalization	1			1	2	2.33	28
Public debt	0			1	1	1.16	36



Appendix 6-A: Graphical presentation of the pre-crisis and post-crisis movement of leading indicators (Panel version)



**Appendix 6-B: Graphical presentation of the pre-crisis and post-crisis movement of leading indicators
(Case of Armenia)**



Appendix 7: Signaling approach: An alternative model results

This alternative model of signaling approach was built under the following assumption:

- A grid of reference percentiles of 10%-35% and 65%-90%,
- Composite index does not include the variables with noise-to-signal ratios above 1.

In this option the leading indicators have produced more diversified results in terms of distribution of noise-to-signal ratios (see Table A7-1). Most of the indicators, with the exception of those of short-term foreign debt and dollarization, proved to have contained good forecasting characteristics in the primary model as well. It should be noted that some changes have taken place in the comparative advantages of indicators, although here, as in the primary model, the best ones are inflation and lending/deposit indicators. In this model, however, indicators such as real estate prices⁷⁹, the banks' foreign assets/liabilities as well as export and current account variables are gaining importance.

Table A7-1: Leading indicators by relevance (Alternative)

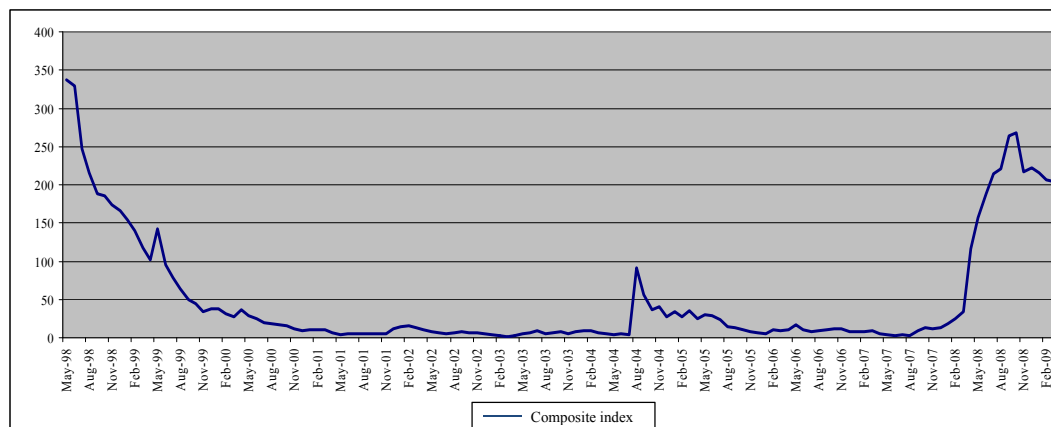
	Absolute thresholds	Relative thresholds (percentile)	Noise to signal ratio	Conditional probability* %	Called crises** %	Rank
Export growth rate	-19.92	0.10	0.10	76.47	100	5
Real exchange rate overvaluation	3.10	0.86	0.47	39.13	90	16
M2/International reserves	99.65	0.89	0.22	65.00	70	9
Real estate price growth rate	-0.06	0.12	0.08	66.67	10	3
Current account/GDP	-19.94	0.13	0.11	73.68	90	6
Budget deficit/GDP	-0.89	0.20	0.95	24.14	30	18
Short-term foreign debt/International reserves	10.89	0.20	2.26	14.52	30	19
Domestic credit growth rate	68.60	0.89	0.26	61.11	30	11
Foreign debt/GDP	63.00	0.89	0.29	50.00	70	12
Inflation	9.57	0.80	0.01	96.77	100	1
Economic growth	4.06	0.15	0.30	57.69	90	13
Remittances growth rate	-7.71	0.12	0.31	38.89	20	14
Banks' foreign assets/foreign liabilities	46.29	0.22	0.10	81.08	100	4
Terms of trade	-2.03	0.13	0.44	40.00	40	15
Credit/Deposits	193.61	0.86	0.02	95.45	90	2
International oil prices	20.14	0.25	0.18	69.23	90	7
Difference between long-term and short-term interest rates	22.70	0.88	0.19	68.42	90	8
Global economic growth	-1.66	0.10	0.65	38.89	10	17
Dollarization	71.98	0.67	20.95	1.92	20	20
International reserves/GDP	13.41	0.11	0.243	55.556	10	10

* Denotes the probability of emergence of the crisis, provided that the indicator has signaled $A/(A+B)$.

** Denotes part of crises that a particular indicator has called.

Despite the differences in the results in terms of relevance of leading indicators and forecasting characteristics, the Composite Indices trended through similar paths and outcome.

Figure A7-1: Composite index dynamics (Alternative)



⁷⁹ Some caution needs to be exercised with respect of the results of real estate price indicator as it has been only able to respond to the March 2009 devaluation due to shortness in time series.

Table A7-2: Conditional probability of the crisis by Composite Index value (Alternative)

Composite Index	Conditional probability (%)
0-33.66	0
33.66-155.80	9.52
155.80 and over	94.3
Unconditional probability	6.8

In this model, the value of 155.8 can be considered the threshold for the Composite Index; values coming above that may mean the probability of the crisis would exceed the 50% level.

Figure A7-2: Composite Index dynamics (Instant approach) (Alternative)

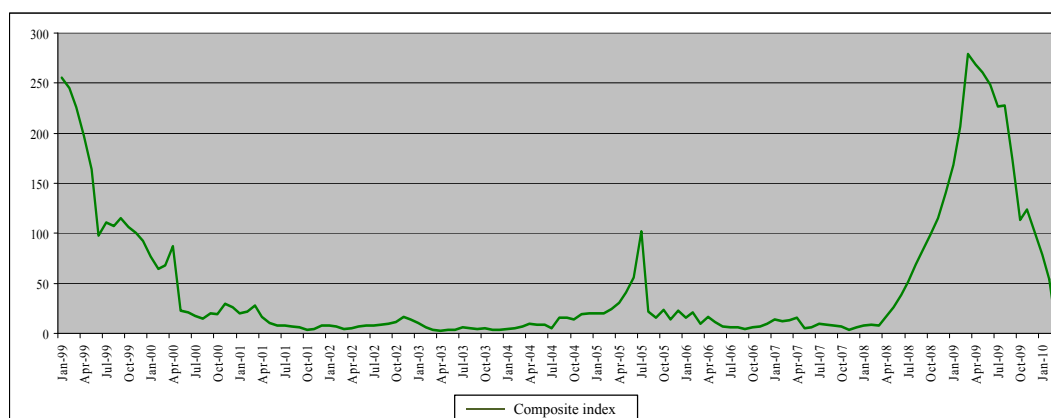


Table A7-3: Conditional probability of crisis by Composite Index value (Instant approach) (Alternative)

Composite Index	Conditional probability (%)
0 – 272.60	0
272.60- 378.22	18.75
378.22 and over	87.5
Unconditional probability	6.8

Three of the crises registered occurred when the index was in the range of 272.6-378.22 range, and the remaining 7, in the range with more than 378.22 of value, and therefore an index value of 378.22 can be regarded as the threshold level. Let's just say that in March of 2009 the combined index value was 279.25, which is only about 20% probability of a crisis.

Appendix 8-A⁸⁰: Results of the main panel CART model

The following basic rules and restrictions were used in building the classifications tree:

1. The Gini criterion was used as a splitting-rule, which provides the smallest relative error compared to the other rules:

Table A8-A-1⁸¹: RULE Battery sensitivity test results

Model Name	1SE Terminal Nodes	Rel. Error	SplittingRule
Tree 1	37	0.3994	Sym Gini
Tree 2	37	0.3994	Gini
Tree 3	21	0.4168	Twoing
Tree 4	15	0.4189	Ord. Twoing
Tree 5	9	0.4390	Entropy
Tree 6	19	0.6707	Cl. Prob

2. Equal priors option was used in the class assignment process (the sensitivity test results are the best).
3. The predictive accuracy of trees was assessed by 5-fold cross-validation method (best by the sensitivity test results: *Table A8-A-2*).

Table A8-A-2: CV Battery sensitivity test results

Model Name	1SE Terminal Nodes	Rel. Error	CV Fold
Tree 1	37	0.3994	5
Tree 2	39	0.4316	10
Tree 3	16	0.4373	20
Tree 4	16	0.4362	50

4. The following restrictions were set: the minimum number of observations in parent nodes, 10, the maximum depth of the model 17, the minimum size of the terminal node, 2 observations (one of the bests by the sensitivity test).
5. Since there are a number of high-level categorical variables (elections, democracy) in the model, a penalty coefficient of 1 (Categorical Penalty for High Level=1) was used to get their diverse influences limited.

The estimated model is characterized by the following results:

1. The data contain 1222 observations, of which 302 (24.71%) are crisis situations:

Class	Learn	%	Total
0	920	75.29	920
1	302	24.71	302
Total:	1222	100.00	1222

2. The classifications tree with the smallest misclassification cost according to the Cost-Complexity equation consists of 58 terminal nodes while the best tree selected through the 1 SD rule consists of 37 terminal nodes (*see Table P8-A-3*), which provides the description of currency crises by the use of 24 variables⁸².

⁸⁰ Apart from diverse estimation result presented, other indicators or statistics are also possible to get, which is a matter of separate analyses.

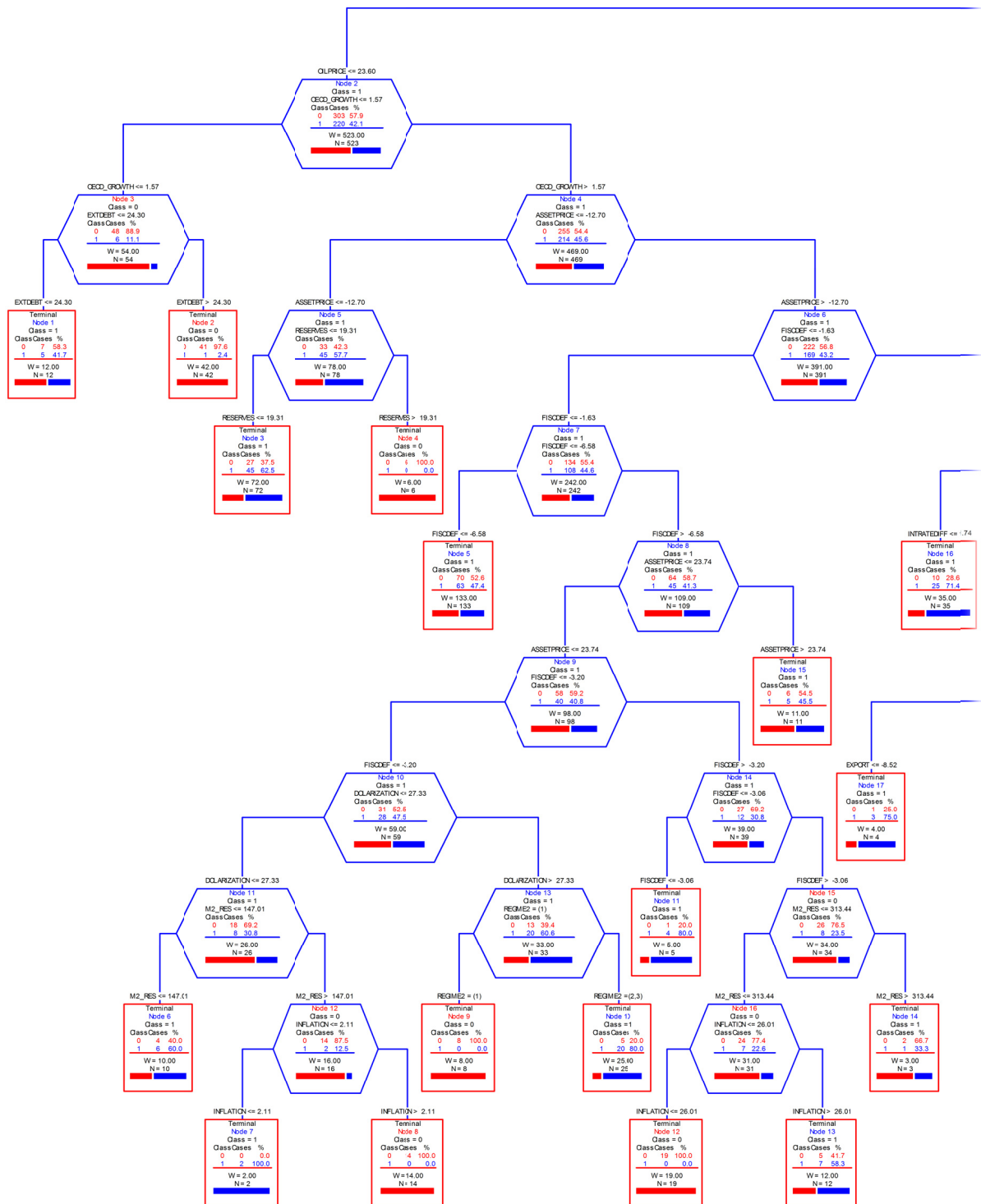
⁸¹ Because, in other appendices of the paper, the results of the models will be presented without comments, all the tables are presented in the form as the software gives.

⁸² From now and on, all the results are pertinent to the best tree selected through the 1 SD rule.

Table A8-A-3. Set of nested and pruned trees

Tree Num.	Terminal Nodes	Cross-Validated Relative Cost	Resubstitution Relative Cost	Complexity
1	95	0.43209 ± 0.02801	0.10263	0.00000
2	92	0.43100 ± 0.02799	0.10263	1.00000E-005
3	91	0.43861 ± 0.02809	0.10361	0.00050
4	83	0.43861 ± 0.02809	0.11231	0.00055
5	81	0.43085 ± 0.02781	0.11453	0.00057
6	80	0.40644 ± 0.02682	0.11666	0.00107
7	75	0.40644 ± 0.02682	0.12753	0.00110
8	70	0.39868 ± 0.02648	0.13865	0.00112
9	60	0.40194 ± 0.02652	0.16468	0.00131
10*	58	0.38523 ± 0.02558	0.17007	0.00136
11	54	0.40075 ± 0.02633	0.18094	0.00137
12	51	0.40075 ± 0.02633	0.18979	0.00148
13	48	0.40075 ± 0.02633	0.19947	0.00162
14	45	0.40075 ± 0.02633	0.20925	0.00164
15	39	0.40292 ± 0.02636	0.23099	0.00182
16**	37	0.39941 ± 0.02585	0.23968	0.00218
17	27	0.41364 ± 0.02620	0.28425	0.00224
18	26	0.42125 ± 0.02629	0.28963	0.00270
19	16	0.41784 ± 0.02595	0.34388	0.00272
20	15	0.41784 ± 0.02595	0.34942	0.00278
21	13	0.42871 ± 0.02606	0.36163	0.00306
22	10	0.42866 ± 0.02596	0.38010	0.00309
23	9	0.43627 ± 0.02603	0.38673	0.00332
24	8	0.42846 ± 0.02551	0.39433	0.00381
25	7	0.46728 ± 0.02509	0.40328	0.00448
26	6	0.47009 ± 0.02378	0.41731	0.00702
27	5	0.47009 ± 0.02378	0.43215	0.00743
28	4	0.47603 ± 0.02528	0.44792	0.00790
29	3	0.48778 ± 0.02480	0.48023	0.01616
30	2	0.60087 ± 0.02992	0.60087	0.06033
31	1	1.00000 ± 0.00009	1.00000	0.19957
* A tree with the smallest costs				
** Optimal tree				

3. General topology of the tree



5. Among key indicators that describe the properties of the model is criterion ROC, which represents the relative proportion of observations classified to be right or wrong as a result of cross-validations. That said, this may also provide an understanding of the sensitivity of the results in response to negligible change in sampling. This can be compared with R^2 coefficient of the regression analysis. The criterion ROC accepts values from the range (0,1) – the bigger, the better. Our model has got excellent results:

ROC Train=0.9185, ROC Test=0.8227:

6. The extent to which each node has a contribution in the tree for evaluation of the crisis episodes (we may have it also obtained for a non-crisis class) is presented through a Gains Chart and Table, as follows:

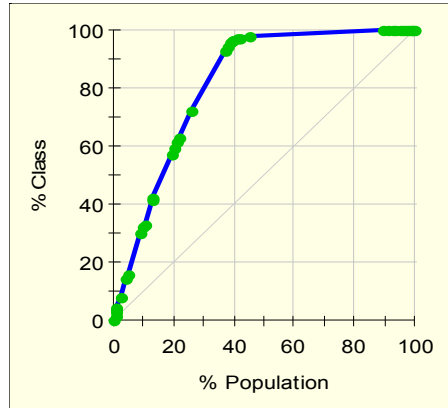


Table A8-A-4: The Gains table for the crisis class

Node	Cases Tgt. Class	% of Node Tgt. Class	% Tgt. Class	Cum % Tgt. Class	Cum % Pop	% Pop	Cases In Node	Cum lift	Lift Pop
27	5	100.00	1.66	1.66	0.41	0.41	5	4.05	4.05
18	4	100.00	1.32	2.98	0.74	0.33	4	4.05	4.05
7	2	100.00	0.66	3.64	0.90	0.16	2	4.05	4.05
33	2	100.00	0.66	4.30	1.06	0.16	2	4.05	4.05
34	11	84.62	3.64	7.95	2.13	1.06	13	3.74	3.42
10	20	80.00	6.62	14.57	4.17	2.05	25	3.49	3.24
11	4	80.00	1.32	15.89	4.58	0.41	5	3.47	3.24
37	43	76.79	14.24	30.13	9.17	4.58	56	3.29	3.11
24	6	75.00	1.99	32.12	9.82	0.65	8	3.27	3.03
17	5	75.00	0.99	33.11	10.15	0.33	4	3.26	3.03
16	25	71.43	8.28	41.39	13.01	2.86	35	3.18	2.89
28	2	66.67	0.66	42.05	13.26	0.25	3	3.17	2.70
3	45	62.50	14.90	56.95	19.15	5.89	72	2.97	2.53
6	6	60.00	1.99	58.94	19.97	0.82	10	2.95	2.43
13	7	58.33	2.32	61.26	20.95	0.98	12	2.92	2.36
31	5	55.56	1.66	62.91	21.69	0.74	9	2.90	2.25
22	27	50.00	8.94	71.85	26.10	4.42	54	2.75	2.02
5	63	47.37	20.86	92.72	36.99	10.88	133	2.51	1.92
15	5	45.45	1.66	94.37	37.89	0.90	11	2.49	1.84
1	5	41.67	1.66	96.03	38.87	0.98	12	2.47	1.69
14	1	33.33	0.33	96.36	39.12	0.25	3	2.46	1.35
35	1	11.11	0.33	96.69	39.85	0.74	9	2.43	0.45
20	1	9.09	0.33	97.02	40.75	0.90	11	2.38	0.37
21	1	8.33	0.33	97.35	41.73	0.98	12	2.33	0.34
2	1	2.38	0.33	97.68	45.17	3.44	42	2.16	0.10
29	7	1.30	2.32	100.00	89.28	44.11	539	1.12	0.05
12	0	0.00	0.00	100.00	90.83	1.55	19	1.10	0.00
32	0	0.00	0.00	100.00	92.39	1.55	19	1.08	0.00
19	0	0.00	0.00	100.00	93.86	1.47	18	1.07	0.00
8	0	0.00	0.00	100.00	95.01	1.15	14	1.05	0.00
50	0	0.00	0.00	100.00	95.99	0.98	12	1.04	0.00
23	0	0.00	0.00	100.00	96.89	0.90	11	1.03	0.00
26	0	0.00	0.00	100.00	97.79	0.90	11	1.02	0.00
9	0	0.00	0.00	100.00	98.45	0.65	8	1.02	0.00
36	0	0.00	0.00	100.00	99.02	0.57	7	1.01	0.00
4	0	0.00	0.00	100.00	99.51	0.49	6	1.00	0.00
25	0	0.00	0.00	100.00	100.00	0.49	6	1.00	0.00

Node – a respective in the tree;

Cases Tgt. Class – the number of observations of target class (crisis) in any particular node;

% of Node Tgt. Class – the share of observations of target class in any particular node;

% Tgt. Class – the share of target observations in any particular node in the entire population of the given class;

Cum % Tgt. Class – the cumulative share of observations of the target class in the observations of the given class;
Cum % Pop – the cumulative share of observations in the entire population;
% Pop – the share of observations in any particular node in the entire population;
Cases in Node – the number of observations in any particular node;
Cum lift – the ratio of cumulative share of the target class to the cumulative share of observations;
Lift Pop – the ratio of the share of observations of the target class in any particular node to the share of total observations in the same node.

The Gains analysis shows which part of observations of the target class has been classified while using a certain segment of the entire dataset. In particular, the table and chart show that more than 30% of the crisis situations have been classified using only 15% observation of the entire dataset. In addition, about 20% of the crisis points have been separated in the 5th node of the tree, with a 47.4% probabilistic distribution.

7. The importance and relevance of leading indicators in the model is estimated by the use of algorithm in the CART which takes into account not only the role of that particular variable played in the final tree but also the fact of appearing as surrogates instead of any other variables with missing observations.

Unlike a regression analysis, the variables can be of high significance (importance), even if they never appear in the model (tree) as explanatory variables. This is due to the effect of the aforementioned “surrogate variables”. The importance of factors in CART is estimated on the basis of the sum of improvement measures of goodness-of-split, in all segments of the tree regardless the variable acted as a main or surrogate splitter. Then a hierarchy of variable importance is constructed with score of 100 given to the variable with the highest sum of improvements, and relatively lower scores to others until it reaches 0.

In our model:

Table A8-A-5: Importance of factors

Variable	Score	
OILPRICE	100.00	
FISCDEF	95.24	
ASSETPRICE	59.58	
INFLATION	53.20	
DOMCREDIT	39.00	
M2_RES	34.32	
OECD_GROWTH	30.55	
SHTDEBT	30.24	
DOLARIZATION	27.06	
INTRATEDIFF	25.84	
EXTDEBT	25.22	
ECONGROWTH	19.18	
CRED_DEPOSIT	18.85	
CURRACC	17.36	
RESERVES	15.61	
EXPORT	15.08	
FORASS_LIAB	14.85	
CONTAGION	13.70	
DEMOCRAT	11.98	
REEROVER	9.55	
REGIME2	9.06	
TRANSFER	5.16	
TOT	3.35	
ELECTION	0.03	

However, the results of importance of the variables are relative, depending on the tree structure, and therefore they should not be interpreted as absolute truth concerning variables. These estimates only point to any particular factor’s ability to imitate the construction of the tree.

8. To have an understanding of the importance of the factors and especially of their threshold values, one should also refer to the role of variables in splitting the root or original node. As we know, the root split variable is the international oil price indicator that contributed to the biggest improvement in impurity measure.

Table A8-A-6: Root node splitters

	Competitor	Split	Improvement	N Left	N Right	N Missing
Main	OILPRICE	23.60500	0.07992	523	699	0
1	ASSETPRICE	-14.78764	0.05377	52	566	604
2	INFLATION	15.44300	0.04653	826	392	4
3	EXPORT	6.04093	0.03780	335	840	47
4	CRED_DEPOSIT	216.47983	0.03422	1049	153	20
5	INTRATEDIFF	1.27195	0.03170	132	906	184
6	ECONGROWTH	0.55213	0.02791	136	932	154
7	REEROVER	10.34594	0.02526	1042	47	133
8	EXTDEBT	32.13385	0.01987	283	755	184
9	OECD_GROWTH	1.75004	0.01980	147	811	264
10	M2_RES	351.88068	0.01917	914	87	221
11	CONTAGION	0	0.01560	425	797	0
12	DOMCREDIT	63.29155	0.01531	974	194	54
13	DOLARIZATION	43.80932	0.01495	586	446	190
14	RESERVES	10.70100	0.01447	316	764	142
15	SHTDEBT	4.06681	0.01162	52	1105	65
16	FORASS_LIAB	1636.12427	0.01143	1195	15	12
17	DEMOCRAT	-6,1,7,9	0.01094	345	821	56
18	TRANSFER	-33.67991	0.01061	272	822	128
19	FISCDEF	-46.26472	0.00773	10	699	513
20	CURRACC	7.65018	0.00659	1008	70	144
21	TOT	6.43895	0.00429	667	55	500
22	REGIME2	1	0.00333	367	855	0
23	ELECTION	0,1,2,1	0.00179	1145	77	0

9. The general predictive properties of the model are estimated both in-sample and out-of-sample. In the main tree, as much as 83,8% of total observations were classified correctly in-sample, 78,8%, out-of-sample; furthermore, of crisis points, as much as 96,4% and 82,5% were classified correctly in-sample and out-of-sample respectively.

Table A8-A-6: The results of in-sample forecast

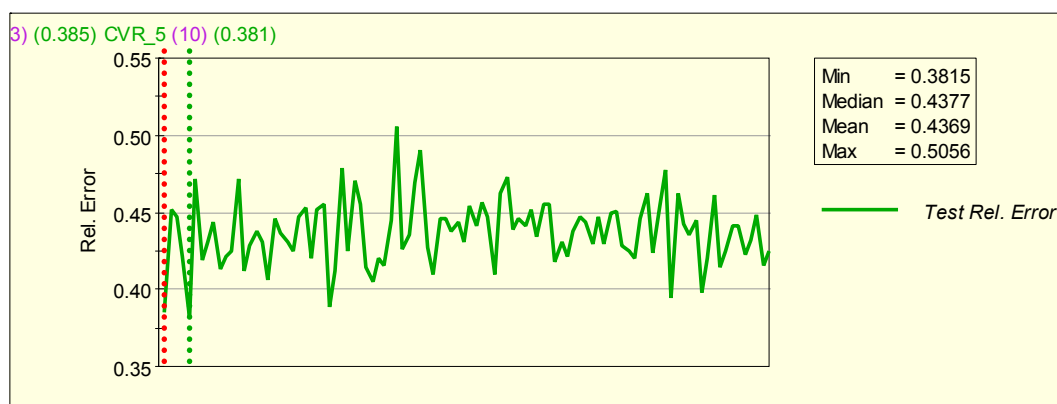
Prediction Success-Learn-Count				
Actual Class	Total Cases	Percent Correct	0 N=744	1 N=478
0	920	79.67	735	187
1	302	96.36	11	291
Total:	1,222.00			
Average:		88.02		
Overall % Correct:		83.80		

Table A8-A-7: The results of out-of-sample forecast

Prediction Success-Test-Count				
Actual Class	Total Cases	Percent Correct	0 N=767	1 N=455
0	920	77.61	714	206
1	302	82.45	53	249
Total:	1,222.00			
Average:		80.03		
Overall % Correct:		78.81		

The CART modeling is characterized by defining a number of preliminary parameters until the very models are built. This means the key issue is to determine these parameters and decide on the best options. There are mechanisms in CART software package, which are designed to measure the model sensitivity to different parameters and decide on the best possible option. The package includes CART Batteries which gets the process automated. The results of some of the parameters concerning the size of nodes, the depth of the model, cross-validation and split rules and so on were addressed when we defined the main model parameters and restriction. Let us now review a couple of sensitivity tests which we consider appropriate from the standpoint of the results of the model.

The CVR test is used to check the sensitivity of cross-validation results produced from different observations. A one hundred time repetition of the test showed that a minimum level of cross-validation errors was 0.3815, the maximum level, 0.5056, and the average level, 0.4369. Because the estimate in our model is 0.399, it is not difficult to see that it is way below the average, so our main model has best properties among the trees of its class.



The LOVO (Leave One Variable Ot) test is designed to build a number of trees, each with exclusion of one of explanatory variables. The goal here is to figure out if there are redundant or troubling factors. The results of *Table A8-A-8* suggest that the model results can improve a bit if variables such as terms of trade, remittances, and etc. are removed. However, because the size of their contribution is not large, exclusion of any such variables from the model does not make sense.

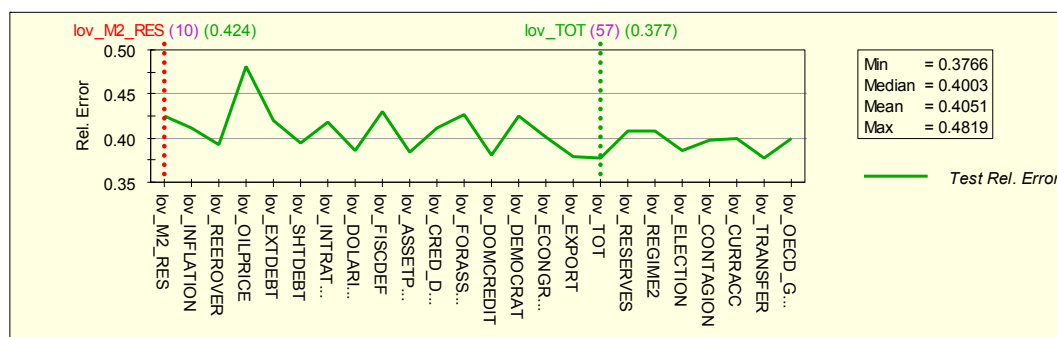


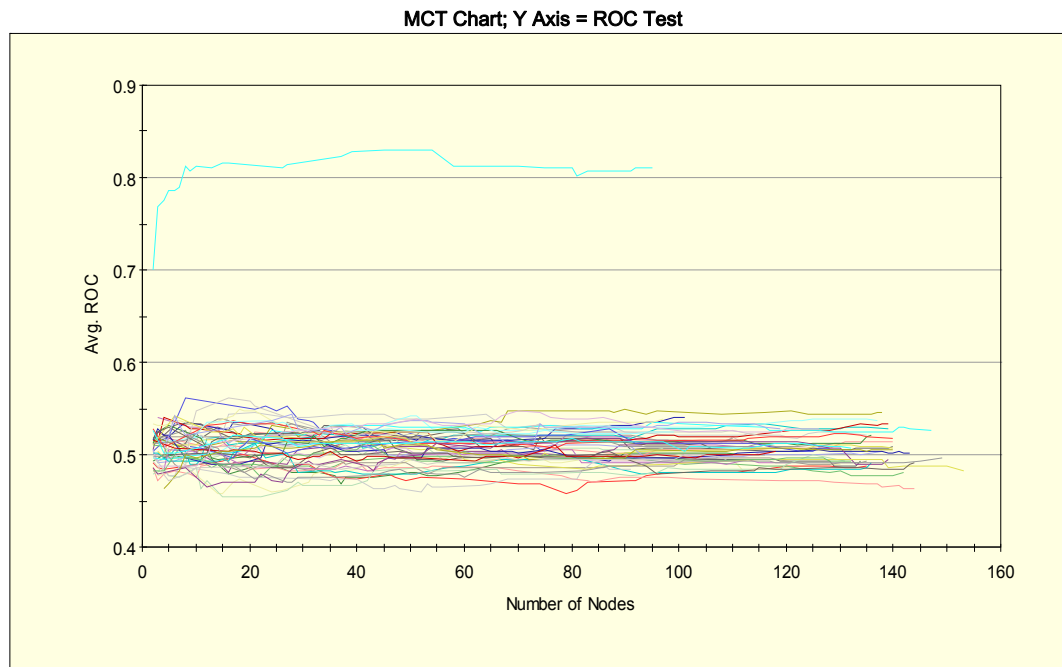
Table A8-A-8: LOVO Battery sensitivity tests results

Model Name	Opt. Terminal Nodes	Rel. Error	LOVO Predictor
Tree 19	57	0.3766	TOT
Tree 17	73	0.3779	TRANSFER
Tree 10	57	0.3789	EXPORT
Tree 11	55	0.3809	DOMCREDIT
Tree 15	47	0.3847	ASSETPRICE
Tree 24	44	0.3863	DOLARIZATION
Tree 2	58	0.3864	ELECTION
Tree 8	17	0.3925	REEROVER
Tree 6	36	0.3950	SHTDEBT
Tree 3	71	0.3976	CONTAGION
Tree 23	74	0.3990	OECD_GROWTH
Tree 9	73	0.4000	CURRACC
Tree 14	56	0.4006	ECONGROWTH
Tree 4	58	0.4084	REGIME2
Tree 5	58	0.4087	RESERVES
Tree 20	50	0.4108	CRED_DEPOSIT
Tree 13	15	0.4111	INFLATION
Tree 22	41	0.4184	INTRATEDIFF
Tree 7	29	0.4191	EXTDEBT
Tree 12	10	0.4245	M2_RES
Tree 1	55	0.4252	DEMOCRAT
Tree 18	54	0.4262	FORASS_LIAB
Tree 16	46	0.4308	FISCDEF
Tree 21	28	0.4819	OILPRICE

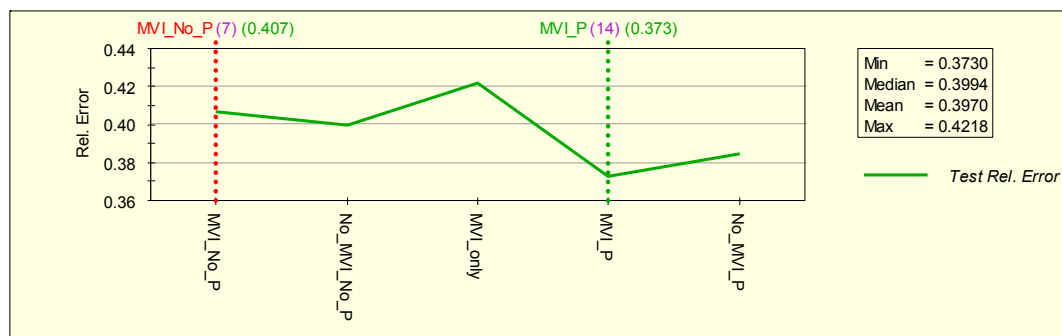
The MCT stands for a Monte Carlo Test designed to assess the significance of model properties. The dependent variable's points in the series get randomly mixed (this implies that all possible relationships between explanatory and dependent variables are demolished), and then a usual model is built. Once this process is repeated many times, the results obtained are to be compared with the main model results. In fact, this sensitivity test allows

determining the importance of correlations available in the model and of the information contained in explanatory variables.

The 20-time repeated tests showed that the 'demolished' models provide the value of 0.5216 of ROC indicator (ROC Test=0.5216), whereas in the main model the ROC Test=0.8227. This presumes that all models which would provide a ROC indicator above the values of 0.48-0.57 could be qualified as eligible. In our model it fairly outstrips its marginal value, so this can witness about the best properties of the model.



The MVI test allows identifying the role the missing points in variables play in the results of the model. The results of the test indicate that the inclusion of dummy variables to substitute missing points and the appropriate penalty scores assigned may reduce the model error up to 0.3730, which is just slightly lower than the 0.3994 value of the main model. Therefore, we can conclude that the problem of the missing values in our model was resolved in a possibly best manner by the use of surrogate variables.



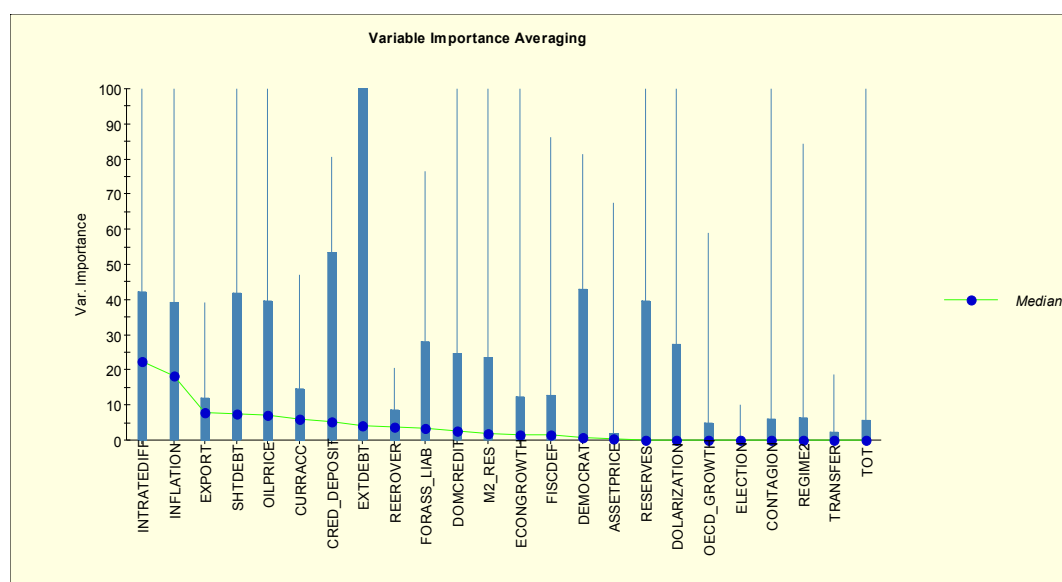
TARGET: The absence of multicollinearity in explanatory variables is an important prerequisite for any analysis. The use of a traditional covariance matrix can help us understand the correlations between individual peers but it cannot report relevant results if there are multiple as well as non-linear links. TARGET Battery makes it possible to resolve this problem. Here is the process: each of the explanatory variables, once chosen to be dependent variable, goes to the modeling process (classification trees are built for categorical and regression trees are built for continuous variables) while the other factors are considered as explanatory factors. The resulting model properties point to the correlations between any given variable and other variables, while the importance of the variables shows which factors appeared in models.

As shown in *Table A8-A-9*, the mostly explained are indicators such as OILPRICE, RESERVES, OECD Growth, CRED_DEPOSIT, EXTDEBT, SHTDEBT. Whereas, indicators such as overvaluation of the exchange rate, export or inflation, were not possible to forecast by any reasonable combination of the factors (Rel.Error>1).

Table A8-A-9: TARGET Battery test results

Model Name	ISE Terminal Nodes	Rel. Error	Target
Tree 21	6	0.2005	OILPRICE
Tree 5	70	0.3017	RESERVES
Tree 23	16	0.3106	OECD_GROWTH
Tree 20	47	0.3419	CRED_DEPOSIT
Tree 7	38	0.3451	EXTDEBT
Tree 6	41	0.3588	SHTDEBT
Tree 18	21	0.3702	FORASS_LIAB
Tree 24	14	0.4973	DOLARIZATION
Tree 12	17	0.5181	M2_RES
Tree 16	2	0.6281	FISCDEF
Tree 11	4	0.6793	DOMCREDIT
Tree 22	2	0.7986	INTRATEDIFF
Tree 9	16	0.8715	CURRACC
Tree 15	2	1.0121	ASSETPRICE
Tree 8	2	1.0333	REEROVER
Tree 17	3	1.0434	TRANSFER
Tree 10	4	1.1329	EXPORT
Tree 13	2	1.1958	INFLATION
Tree 14	3	1.3423	ECONGROWTH
Tree 19	2	1.4254	TOT

It is noteworthy that INTRATEDIFF has the biggest role in the explanation of the rest of variables, and has an average 23% importance rate in all variables.

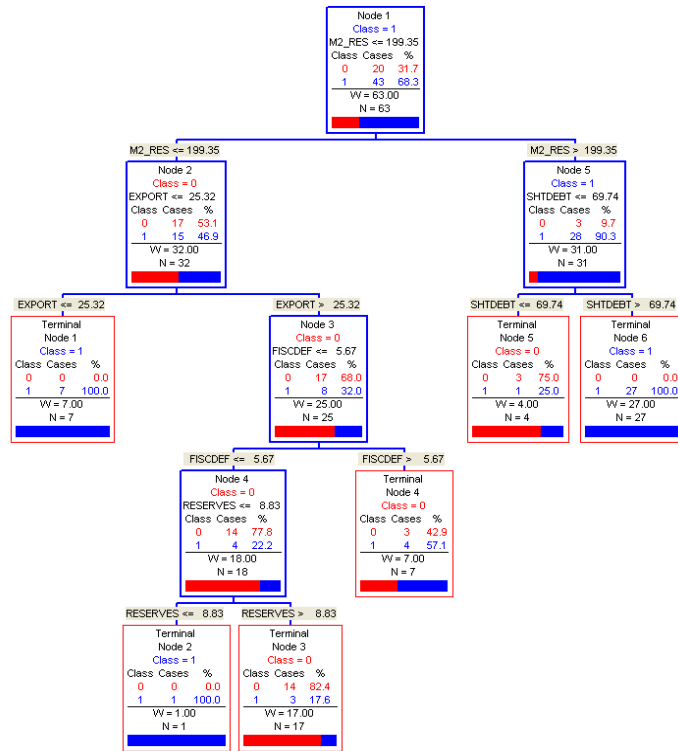


Appendix 8-A*: The results of modeling of an auxiliary segment separated from the main model⁸³

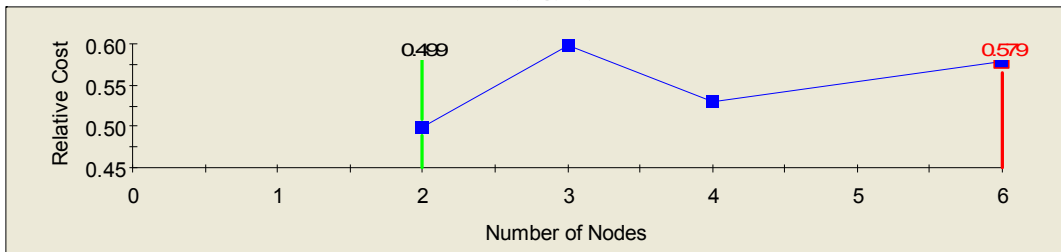
Data Sample 63 Records Total			
Class	Learn	%	Total
0	43	68.25	43
1	20	31.75	20
Total:	63	100.00	63

⁸³ Other characteristics of the model can be obtained from the author.

Classification tree topology for: CRISIS



Error Curve



Variable Importance

Variable	Score	
M2_RES	100.00	
DOMCREDIT	84.98	
RESERVES	60.06	
INTRATEDIFF	50.32	
SHITDEBT	41.16	
EXPORT	35.44	
DOLARIZATION	32.54	
EXTDEBT	29.11	
FISCDEF	28.16	
FORASS_LIAB	20.37	
INFLATION	10.04	
TRANSFER	6.44	
REGIME2	5.10	
REEROVER	2.52	

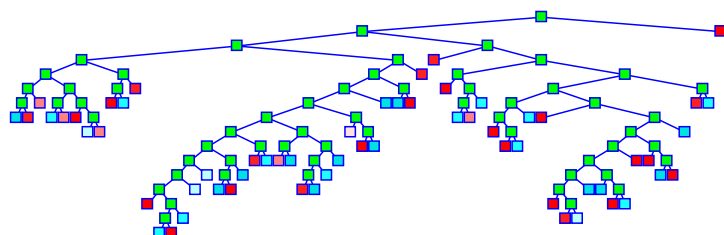
Prediction Success-Learn-Count				
Actual Class	Total Cases	Percent Correct	0 N=28	1 N=35
0	20	100.00	20	0
1	43	81.40	8	35
Total:	63.00			
Average:		90.70		
Overall % Correct:		87.30		

Prediction Success-Test-Count				
Actual Class	Total Cases	Percent Correct	0 N=26	1 N=37
0	20	70.00	14	6
1	43	72.09	12	31
Total:	63.00			
Average:		71.05		
Overall % Correct:		71.43		

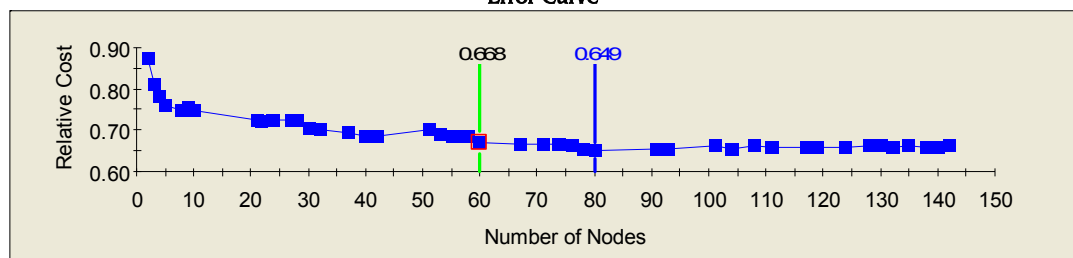
Appendix 8-B: The results of Panel alternative model 1⁸⁴

Data Sample 1218 Records Total			
Class	Learn	%	Total
0	580	47.62	580
1	638	52.38	638
Total:	1218	100.00	1218

Classification tree topology for: CRISIS



Error Curve



Variable Importance

Variable	Score	
OILPRICE	100.00	
ASSETPRICE	87.25	
M2_RES	68.97	
FORASS_LIAB	62.79	
OECD_GROWTH	62.71	
TOT	49.40	
REEROVER	46.63	
FISCDEF	41.39	
EXTDEBT	39.25	
CRED_DEPOSIT	33.88	

⁸⁴ The detailed description of the tree as well as other characteristics of the model can be obtained from the author.

INFLATION	32.78	
RESERVES	30.86	
SHTDEBT	29.57	
DEMOCRAT	25.51	
DOLARIZATION	24.82	
INTRATEDIFF	24.64	
DOMCREDIT	21.38	
ECONGROWTH	21.02	
TRANSFER	17.02	
CURRACC	14.48	
EXPORT	8.54	
CONTAGION	4.47	
REGIME2	3.39	
ELECTION	1.95	

Prediction Success-Learn-Count

Actual Class	Total Cases	Percent Correct	0 N=614	1 N=604
0	580	86.38	501	79
1	638	82.29	113	525
Total:	1,218.00			
Average:		84.33		
Overall % Correct:		84.24		

Prediction Success-Test-Count

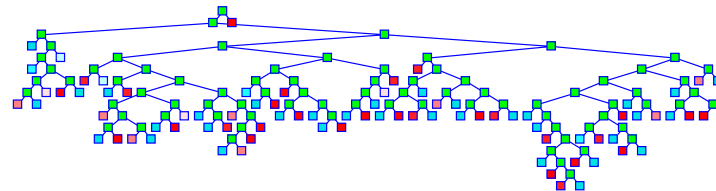
Actual Class	Total Cases	Percent Correct	0 N=622	1 N=596
0	580	68.45	397	183
1	638	64.73	225	413
Total:	1,218.00			
Average:		66.59		
Overall % Correct:		66.50		

Appendix 8-C: The results of Panel alternative model 2⁸⁵

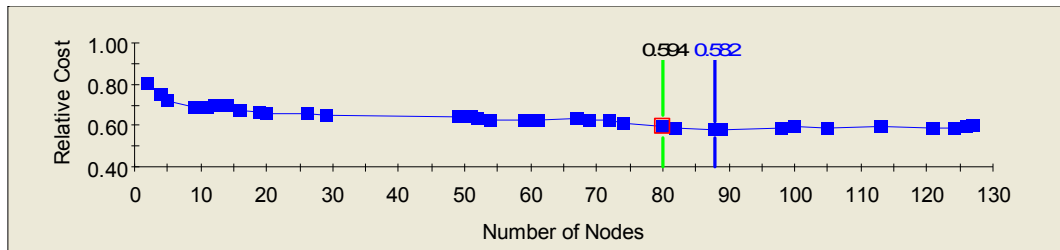
Data Sample
1222 Records Total

Class	Learn	%	Total
0	765	62.60	765
1	457	37.40	457
Total:	1222	100.00	1222

Classification tree topology for: CRISIS



Error Curve



⁸⁵ The detailed description of the tree as well as other characteristics of the model can be obtained from the author.

Variable Importance

Variable	Score	
ASSETPRICE	100.00	
FISCDEF	65.96	
OILPRICE	55.78	
DOLARIZATION	50.51	
M2_RES	41.46	
ECONGROWTH	38.39	
OECD_GROWTH	38.19	
FORASS_LIAB	37.25	
INTRATEDIFF	36.58	
SHTDEBT	35.60	
REEROVER	33.43	
TOT	32.99	
CRED_DEPOSIT	31.73	
EXTDEBT	30.22	
DEMOCRAT	28.33	
TRANSFER	27.22	
DOMCREDIT	25.00	
CURRACC	23.56	
RESERVES	23.49	
INFLATION	22.53	
EXPORT	20.63	
REGIME2	9.06	
CONTAGION	4.31	
ELECTION	3.80	

Prediction Success-Learn-Count

Actual Class	Total Cases	Percent Correct	0 N=694	1 N=528
0	765	86.67	663	102
1	457	93.22	31	426
Total:	1,222.00			
Average:		89.94		
Overall % Correct:		89.12		

Prediction Success-Test-Count

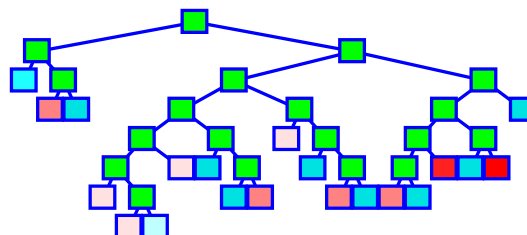
Actual Class	Total Cases	Percent Correct	0 N=698	1 N=524
0	765	72.29	553	212
1	457	68.27	145	312
Total:	1,222.00			
Average:		70.28		
Overall % Correct:		70.79		

Appendix 8-D: The results of Panel alternative model 3⁸⁶

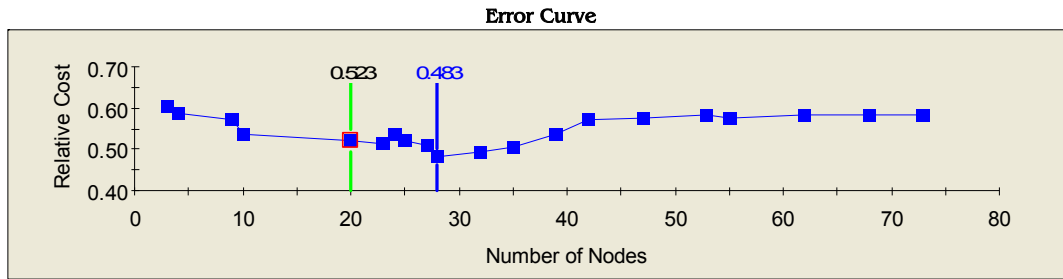
Data Sample 1180 Records Total

Class	Learn	%	Total
0	1056	89.49	1056
1	124	10.51	124
Total:	1180	100.00	1180

Classification tree topology for: CRISIS



⁸⁶ The detailed description of the tree as well as other characteristics of the model can be obtained from the author.



Variable Importance

Variable	Score	
ASSETPRICE2	100.00	
OILPRICE1	32.19	
DOLAR2	24.58	
FISCDEF1	22.59	
INFLATION1	20.44	
CONTAGION	18.02	
ECONGROWTH1	17.82	
CRED_DEPOSIT1	16.81	
EXTDEBT1	13.48	
REROV1	13.30	
DEMOCRAT	10.97	
OECD_GROWTH4	10.10	
M2_RES2	9.49	
SHTDEBT3	9.17	
INTRATEDIFF1	8.86	
DOMCREDIT3	6.11	
EXPORT3	5.64	
FORASS_LIAB4	5.50	
CA4	4.33	
RES4	2.67	
TRANSFER4	2.56	
REGIME3LEV	0.51	

Prediction Success-Learn-Count

Actual Class	Total Cases	Percent Correct	0 N=854	1 N=326
0	1,056	79.73	842	214
1	124	90.32	12	112
Total:	1,180.00			
Average:		85.03		
Overall % Correct:		80.85		

Prediction Success-Test-Count

Actual Class	Total Cases	Percent Correct	0 N=780	1 N=400
0	1,056	71.12	751	305
1	124	76.61	29	95
Total:	1,180.00			
Average:		73.87		
Overall % Correct:		71.69		

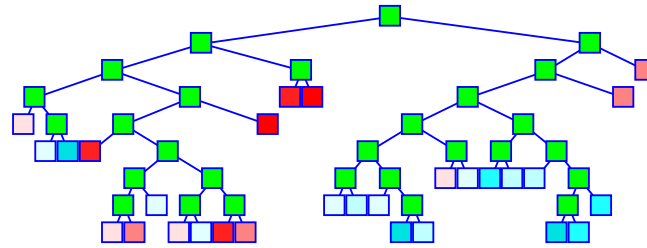
Appendix 8-E: The results of Panel alternative model 4⁸⁷

Data Sample
1180 Records Total

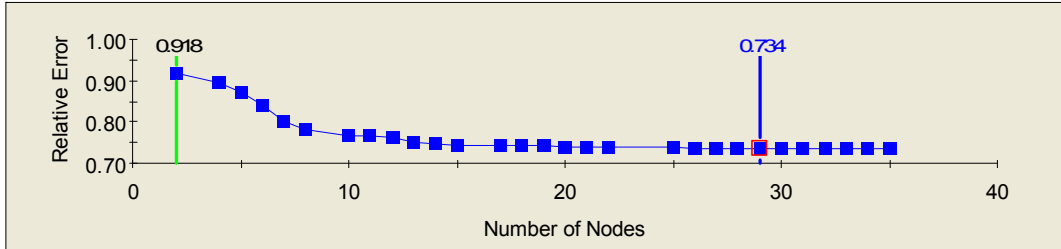
Class	Learn	%	Total
Total:	1180	100.00	1180

⁸⁷ The detailed description of the tree as well as other characteristics of the model can be obtained from the author.

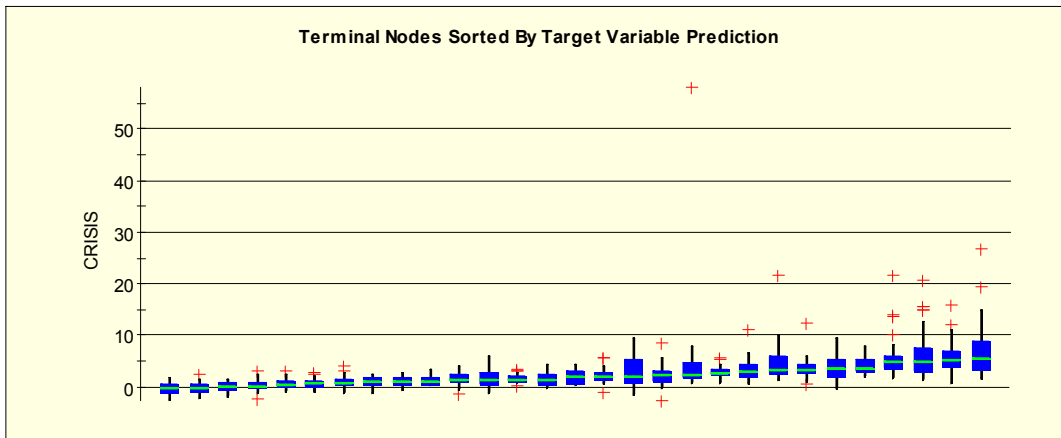
Regression tree topology for: CRISIS



Error Curve



Terminal Nodes



Variable Importance

Variable	Score	
OILPRICE1	100.00	
INFLATION1	98.75	
M2_RES2	85.69	
CONTAGION	67.61	
EXTDEBT1	46.31	
INTRATEDIFF1	40.83	
REROV1	39.90	
DOMCREDIT3	38.25	
RES4	31.49	
REGIME3LEV	24.28	
DEMOCRAT	21.79	
CRED_DEPOSIT1	12.13	
SHTDEBT3	8.47	
DOLAR2	6.28	
CA4	4.63	
OECD_GROWTH4	4.20	
ASSETPRICE2	4.03	
FORASS_LIAB4	3.32	
EXPORT3	2.64	
ECONGROWTH1	2.13	
TRANSFER4	1.62	
FISCDEF1	0.76	
TOT1	0.29	
ELECTION4	0.00	

Appendix 8-F: Comparison of splitters of the root node in the two models

Splitters of the root node in binary index lag model
Main Splitter Improvement = 0.09492

	Competitor	Split	Improvement	N Left	N Right	N Missing
Main	ASSETPRICE2	-4.56167	0.09492	135	481	564
1	CONTAGION	0	0.08461	416	764	0
2	OILPRICE1	23.60500	0.08447	463	717	0
3	ECONGROWTH1	1.41162	0.06404	164	901	115
4	INFLATION1	17.36325	0.05794	865	314	1
5	CRED_DEPOSIT1	223.23669	0.04354	1044	127	9
6	REROV1	4.78957	0.03979	936	137	107
7	INTRATEDIFF1	-0.16335	0.03958	87	939	154
8	OECD_GROWTH4	2.24037	0.03833	210	706	264
9	M2_RES2	364.61993	0.03623	920	64	196
10	EXTDEBT1	31.22720	0.02898	257	770	153
11	EXPORT3	6.03176	0.02886	330	814	36
12	FISCDEF1	-6.60509	0.02136	63	644	473
13	TRANSFER4	-107.65033	0.02034	130	931	119
14	SHTDEBT3	4.06681	0.01922	50	1074	56
15	DEMOCRAT	1.9	0.01820	150	938	92
16	DOLAR2	73.30055	0.01648	920	58	202
17	RES4	10.10812	0.01494	281	765	134
18	DMCREDIT3	51.43970	0.01408	885	252	43
19	FORASS_LIAB4	1001.94928	0.01097	1138	30	12
20	TOT1	-0.34092	0.00676	264	434	482
21	CA4	-13.66245	0.00522	130	916	134
22	REGIME3LEV	1	0.00338	347	791	42
23	ELECTION4	0.1,2	0.00288	1131	49	0
		2.1				

Splitters of the root node in continuous EMP index model
Main Splitter Improvement = 1.30952

	Competitor	Split	Improvement	N Left	N Right	N Missing
Main	OILPRICE1	24.56000	1.30952	484	696	0
1	INFLATION1	24.67720	1.27019	939	240	1
2	REROV1	10.34594	1.26751	1031	42	107
3	CONTAGION	0	1.09567	416	764	0
4	M2_RES2	465.70514	0.93234	959	25	196
5	ASSETPRICE2	-19.58232	0.70093	32	584	564
6	ECONGROWTH1	-0.33521	0.65718	111	954	115
7	INTRATEDIFF1	-1.86500	0.60355	58	968	154
8	DMCREDIT3	61.49816	0.55351	947	190	43
9	CRED_DEPOSIT1	220.34204	0.52208	1039	132	9
10	RES4	10.36186	0.47501	290	756	134
11	FISCDEF1	-6.60509	0.41477	63	644	473
12	EXPORT3	6.03176	0.41336	330	814	36
13	REGIME3LEV	1	0.32417	347	791	42
14	DEMOCRAT	-7,-6,-5	0.29323	1040	48	92
		1,5,6,7				
		8,9,10				
15	OECD_GROWTH4	3.59235	0.22358	772	144	264
16	EXTDEBT1	120.86922	0.18309	1002	25	153
17	SHTDEBT3	4.06681	0.10421	50	1074	56
18	CA4	-3.95147	0.10391	585	461	134
19	DOLAR2	23.13165	0.09316	220	758	202
20	TOT1	-2.94011	0.09051	128	570	482
21	FORASS_LIAB4	415.26443	0.05866	1067	101	12
22	TRANSFER4	-7.76749	0.05700	414	647	119
23	ELECTION4	0.1,2	0.01779	1131	49	0
		2.1				

Appendix 8-G: The results of the model built on Armenian data⁸⁸

Tree Sequence

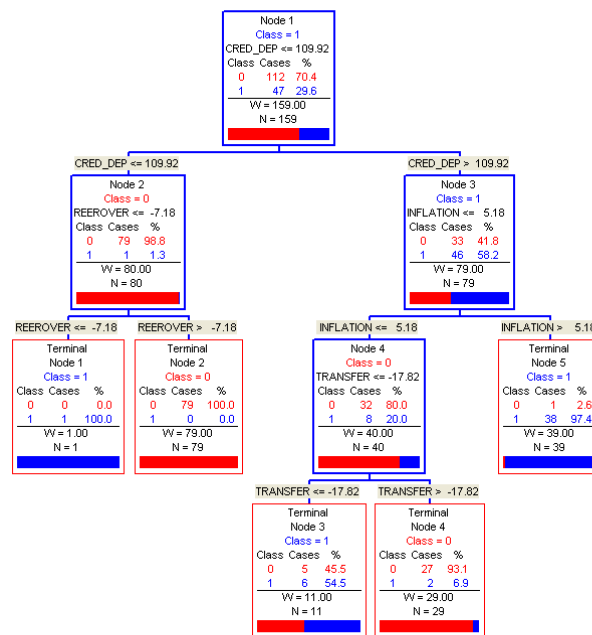
Tree Number	Terminal Nodes	Cross-Validated Relative Cost	Resubstitution Relative Cost	Complexity
1	6	0.17230 ± 0.05244	0.08720	0.00000
2**	5	0.15103 ± 0.04903	0.09612	0.00449
3	4	0.21486 ± 0.05819	0.11740	0.01065
4	3	0.33777 ± 0.06738	0.20042	0.04152
5	2	0.35847 ± 0.05592	0.31592	0.05776
6	1	1.00000 ± 0.00000	1.00000	0.34205

* Minimum Cost
** Optimal

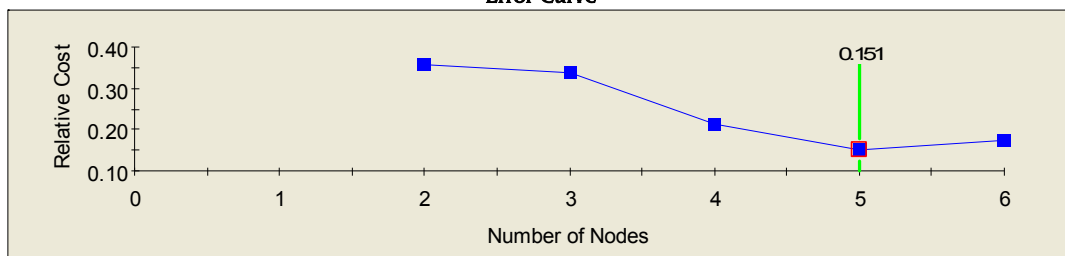
Data Sample
159 Records Total

Class	Learn	%	Total
1	47	29.56	47
0	112	70.44	112
Total:	159	100.00	159

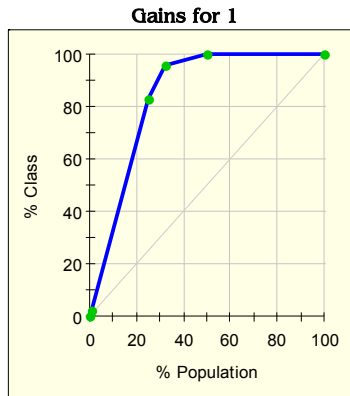
Classification tree topology for: CRISIS



Error Curve



⁸⁸ Other characteristics of the model can be obtained from the author.



Navigator 1 (5): Tree Summary Reports: Gains Data for 1

Node	Cases Tgt. Class	% of Node Tgt. Class	% Tgt. Class	Cum % Tgt. Class	Cum % Pop	% Pop	Cases in Node	Cum lift	Lift Pop
1	1	100.00	2.13	2.13	0.63	0.63	1	3.38	3.38
5	38	97.44	80.85	82.98	25.16	24.53	39	3.30	3.30
3	6	54.55	12.77	95.74	32.08	6.92	11	2.98	1.85
4	2	6.90	4.26	100.00	50.31	18.24	29	1.99	0.23
2	0	0.00	0.00	100.00	100.00	49.69	79	1.00	0.00

Variable Importance

Variable	Score	
CRED_DEP	100.00	
FORASSET_LAIB	99.05	
SHTDEBT	70.67	
REGIME	69.80	
ECOGROWTH	64.36	
CONTAGION	41.50	
INFLATION	40.74	
TRANSFER	35.54	
M2_RES	30.88	
DEMOCRACY	19.22	
EXTDEBT	16.31	
EXPORT	15.32	
RESERVES	12.10	
REEROVER	7.58	
CREDIT	7.58	
GLOBALTECOGROWTH	7.58	
OILPRICE	2.54	
CURRACC	0.00	

Prediction Success-Learn-Count

Actual Class	Total Cases	Percent Correct	0 N=108	1 N=51
0	112	94.64	106	6
1	47	95.74	2	45
Total:	159.00			
Average:		95.19		
Overall % Correct:		94.97		

Prediction Success-Test-Count

Actual Class	Total Cases	Percent Correct	0 N=112	1 N=47
0	112	95.54	107	5
1	47	89.36	5	42
Total:	159.00			
Average:		92.45		
Overall % Correct:		93.71		

Appendix 9: Methodology for building the regression tree

As was mentioned earlier, CART builds regression trees when a dependent or explained variable is continuous. The process of building regression trees is similar to the building of classification trees but priors as well as class assignment rules are not used here. What are used instead are final statistics (characteristics) of terminal nodes; in addition other splitting, goodness-of-split rules and predictive accuracy measures are used.

Building a regression trees is also based on three elements:

- group of questions underlying the split,
- splitting rules and goodness-of-split criteria,
- final statistics of terminal nodes.

The last element is inherent to regression trees, since there are no classes here, so the final nodes will be differentiated by statistical characteristics of dependent variable.

The main purpose of CART regression is to obtain, in the form of a tree, a forecast or prediction rule which aims at two targets: 1/ accurately predict the value of a dependent variable based on explanatory variables, and 2/ explain the links between independent and dependent variables.

The regression forecast in the form of a tree is constructed, gradually identifying and further reducing heterogeneity in the data, which is reflected as variance. In each terminal node the mean of the dependent variable is treated as predicted. If the goal of a regression tree is explanation it will be realized by tracking a path from the upper part of the tree to the appropriate node.

Sample-Splitting rules and goodness-of-split criterion: There are two rules for splitting nodes in the regression trees or two types of impurity functions, such as: 1/ the least square function (LS), and 2/ the least absolute deviation function (LAD). Since the mechanism for the two is the same, let us review the first only.

For LS criterion the impurity measure of a node is described by the sum of squares of intranode cases:

$$SS(t) = \sum_{i=1}^{N_t} (y_{it} - \bar{y}_t)^2$$

where: y_{it} - is the values of dependent variable in the node t , $\bar{y}_t$ - is the mean of the dependent variable in the node t .

For the given impurity function $SS(t)$ and split s , which separates the observations into right (t_r) and left (t_l) sub-samples, the goodness-of-split criterion is calculated as follows:

$$\phi(s, t) = SS(t) - SS(t_r) - SS(t_l)$$

Of the divisions made on a basis of all variables and their respective values, one shall choose the one for which the specified criterion is the maximum.

As an alternative to LS, we may use the method of weighted variance in the right and left nodes where the weights are the share of observations in a particular node in the total observation of parent node : $p(t)=N_t/N$. Let $s^2(t)$ is the variance of a dependent variable in t node:

$$s^2(t) = \frac{1}{N_t} \sum_{i=1}^{N_t} [y_{it} - \bar{y}_t]^2$$

In this case, the goodness-of-split is estimated as follows:

$$\phi(s, t) = s^2(t) - [p_l s^2(t_l) + p_r s^2(t_r)]$$

The best split is the one for which the specified expression is the biggest or for which the sum of weighted variances $[p_l s^2(t_l) + p_r s^2(t_r)]$ is the smallest.

In splitting, because observations of the parent node are distributed into child-nodes, the average of the variable in one of them shall always be smaller than that in the parent node.

The construction of the tree according to the main principles of regression tree building is carried out in the following steps:

1. CART, with the use of its splitting rule and goodness-of-split criterion, divides the combination into two groups and selects the split (a variable and its threshold value) which utmost reduces the impurity measure.
2. Since this method uses a recursive algorithm, the above mentioned steps apply to every non-terminal node, and the biggest possible tree is built.
3. Finally, CART uses its pruning algorithm, gets series of sequentially nested and pruned subtrees and chooses the best tree.

It should be noted that, for cross-validation evaluation of the qualitative properties of the trees, the mean squared error is applied in case of LS and the mean absolute deviation for LAD. . As a result, the best tree is chosen by applying the one standard deviation rule to the indicators specified.

After the best tree is constructed, the descriptors of the variable shall be calculated and presented for terminal nodes: if LS is chosen as a splitting rule, the mean is delivered as the forecast, whereas LAD is chosen, the median is delivered as the forecast.

Appendix 10: Types of currency crises

Nº	Description	Current Account	Monetary Expansion, Excess Finance	Budget Deficit	Debt Crisis	Capital Account Crisis	Self-fulfilling		Crises	
							Adverse environment	Self-fulfilling	Number of crises in the node	Probability
1	OILPRICE <= 23.605 && OECD_GROWTH <= 1.56697 && EXTDEBT <= 24.2974						*		5	41.67
2	OILPRICE <= 23.605 && OECD_GROWTH <= 1.56697 && EXTDEBT > 24.2974				*				1	2.38
3	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE <= -12.7006 && RESERVES <= 19.3121		*						45	62.5
5	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && FISCDEF <= -6.57797			*					63	47.37
6	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && ASSETPRICE <= 23.7437 && FISCDEF > -6.57797 && FISCDEF <= -3.2044 && DOLARIZATION <= 27.3282 && M2_RES <= 147.011			*					6	60
7	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && ASSETPRICE <= 23.7437 && FISCDEF > -6.57797 && FISCDEF <= -3.2044 && DOLARIZATION <= 27.3282 && M2_RES > 147.011 && INFLATION <= 2.1101		*						2	100
10	REGIME2 == 2 REGIME2 == 3 && OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && ASSETPRICE <= 23.7437 && FISCDEF > -6.57797 && FISCDEF <= -3.2044 && DOLARIZATION > 27.3282					*			20	80
11	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && ASSETPRICE <= 23.7437 && FISCDEF > -3.2044 && FISCDEF <= -3.05659						*		4	80
13	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && ASSETPRICE <= 23.7437 && FISCDEF > -3.05659 && FISCDEF <= -1.63419 && M2_RES <= 313.442 && INFLATION > 26.0065		*						7	58.33
14	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && ASSETPRICE <= 23.7437 && FISCDEF > -3.05659 && FISCDEF <= -1.63419 && M2_RES > 313.442		*						1	33.33
15	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && FISCDEF > -6.57797 && FISCDEF <= -1.63419 && ASSETPRICE > 23.7437			*					5	45.46
16	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && ASSETPRICE > -12.7006 && FISCDEF > -1.63419 && INTRATEDIFF <= 1.7415							*	25	71.43
17	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && FISCDEF > -1.63419 && INTRATEDIFF > 1.7415 && ASSETPRICE > -12.7006 && ASSETPRICE <= -1.65255 && EXPORT <= -8.51742	*							3	75

Nº	Description	Current Account	Monetary Expansion, Excess Finance	Budget Deficit	Debt Crisis	Capital Account Crisis	Self-fulfilling		Crises		
							Adverse environment	Self-fulfilling	Number of crises in the node	Probability	
18	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && FISCDEF > -1.63419 && INTRATEDIFF > 1.7415 && ASSETPRICE > -12.7006 && ASSETPRICE <= -1.65255 && EXPORT > -8.51742 && SHTDEBT <= 8.34482		*					4	100		
20	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && FISCDEF > -1.63419 && INTRATEDIFF > 1.7415 && ASSETPRICE > -1.65255 && CURRACC <= -1.60386 && EXTDEBT <= 14.1113	*						1	9.09		
21	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && FISCDEF > -1.63419 && INTRATEDIFF > 1.7415 && ASSETPRICE > -1.65255 && CURRACC <= -1.60386 && EXTDEBT > 14.1113 && DOLARIZATION <= 23.6321				*			1	8.33		
22	OILPRICE <= 23.605 && OECD_GROWTH > 1.56697 && FISCDEF > -1.63419 && INTRATEDIFF > 1.7415 && ASSETPRICE > -1.65255 && CURRACC <= -1.60386 && EXTDEBT > 14.1113 && DOLARIZATION > 23.6321						*		27	50	
24	OILPRICE > 23.605 && OILPRICE <= 82.025 && DOMCREDIT <= -5.65811 && DOLARIZATION <= 42.8958 && M2_RES <= 82.454							*	6	75	
27	OILPRICE > 23.605 && OILPRICE <= 82.025 && DOMCREDIT <= -5.65811 && DOLARIZATION > 42.8958 && RESERVES > 24.0601						*		5	100	
28	DOMCREDIT > -5.65811 && INFLATION <= 29.6307 && OILPRICE > 23.605 && OILPRICE <= 72.565 && ECONGROWTH <= -4.35711						*		2	66.67	
29	DOMCREDIT > -5.65811 && INFLATION <= 29.6307 && OILPRICE > 23.605 && OILPRICE <= 72.565 && ECONGROWTH > -4.35711							*	7	1.3	
31	DOMCREDIT > -5.65811 && INFLATION <= 29.6307 && OILPRICE > 72.565 && OILPRICE <= 82.025 && TRANSFER > 28.5658							*	5	55.56	
33	REGIME2 == 1 && OILPRICE > 23.605 && OILPRICE <= 82.025 && INFLATION > 29.6307 && DOMCREDIT > -5.65811 && DOMCREDIT <= 60.2076		*						2	100	
34	OILPRICE > 23.605 && OILPRICE <= 82.025 && INFLATION > 29.6307 && DOMCREDIT > 60.2076 && DOLARIZATION <= 57.0519		*						11	84.63	
35	OILPRICE > 23.605 && OILPRICE <= 82.025 && INFLATION > 29.6307 && DOMCREDIT > 60.2076 && DOLARIZATION > 57.0519						*		1	11.11	
37*	OILPRICE > 82.025 && CURRACC > -23.6052									43	76.79
* The 37th node is not described as it has been reviewed separately (see Appendix 8-A*)											

* The 37th node is not described as it has been reviewed separately (see Appendix 8-A*)

Data Appendix

Table DA-1: Data source matrix

	Albania	Armenia	Azerbaijan	Belarus	Bulgaria	Croatia	Czech Rep	Estonia	Georgia	Hungary	Kazakhstan	Latvia	Lithuania	Macedonia	Moldova	Poland	Romania	Russia	Slovakia	Turkey	Ukraine
Nominal exchange rate (monthly average)	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Nominal exchange rate (quarterly average)	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Nominal exchange rate (end of period)	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
International reserves	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
CB net foreign assets		UNISIS																			
Banks' corresponding accounts in foreign currency		UNISIS																			
Money market rate	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
US Federal Funds rate	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Lending rate	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Inflation	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Exports	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Broad money, M2	IFS+ Bank of Albania	UNISIS	IFS	IFS	IFS	Croatian National Bank	IFS	IFS	IFS+ National Bank of Georgia	IFS	IFS+ National Bank of Kazakhstan	IFS	IFS+ Bank of Lithuania	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Domestic credit	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Deposits	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Banks' foreign assets	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Banks' foreign liabilities	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Real exchange rate		UNISIS	CB of Azerbaijan National Bank of Belarus		IFS	IFS	IFS	BIS	IFS	IFS	National Bank of Kazakhstan	BIS	BIS	IFS	IFS	IFS	IFS	IFS	IFS	BIS	IFS
Nominal GDP	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS+ Stat. Service of Moldova	IFS+ Eurostat	IFS+ EuroStat	IFS+ Stat. Service of Russia	IFS	IFS	IFS
Current account	IFS+ Bank of Albania	IFS	IFS	IFS+ National Bank of Belarus	IFS	IFS	IFS	IFS	IFS+ National Bank of Georgia	IFS	IFS+ National Bank of Kazakhstan	IFS	IFS+ Bank of Lithuania IFS+ National Bank of Macedonia	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Remittances	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS	IFS
Short-term external debt	WDI	BIS+ WDI	WDI	BIS	Bulgarian National Bank + WDI	BIS+ Croatian National Bank+ WDI	BIS	BIS+ Bank of Estonia	National Bank of Georgia + WDI	BIS+ WDI	BIS+ National Bank of Kazakhstan + WDI	BIS+ Bank of Latvia	BIS+ Bank of Lithuania	National Bank of Macedonia + WDI	BIS+ WDI	BIS+ National Bank of Poland + WDI	National Bank of Romania + WDI	BIS+ WDI	BIS+ National Bank of Slovakia + WDI	BIS+ CB of Turkey	BIS+ WDI

[illegible]

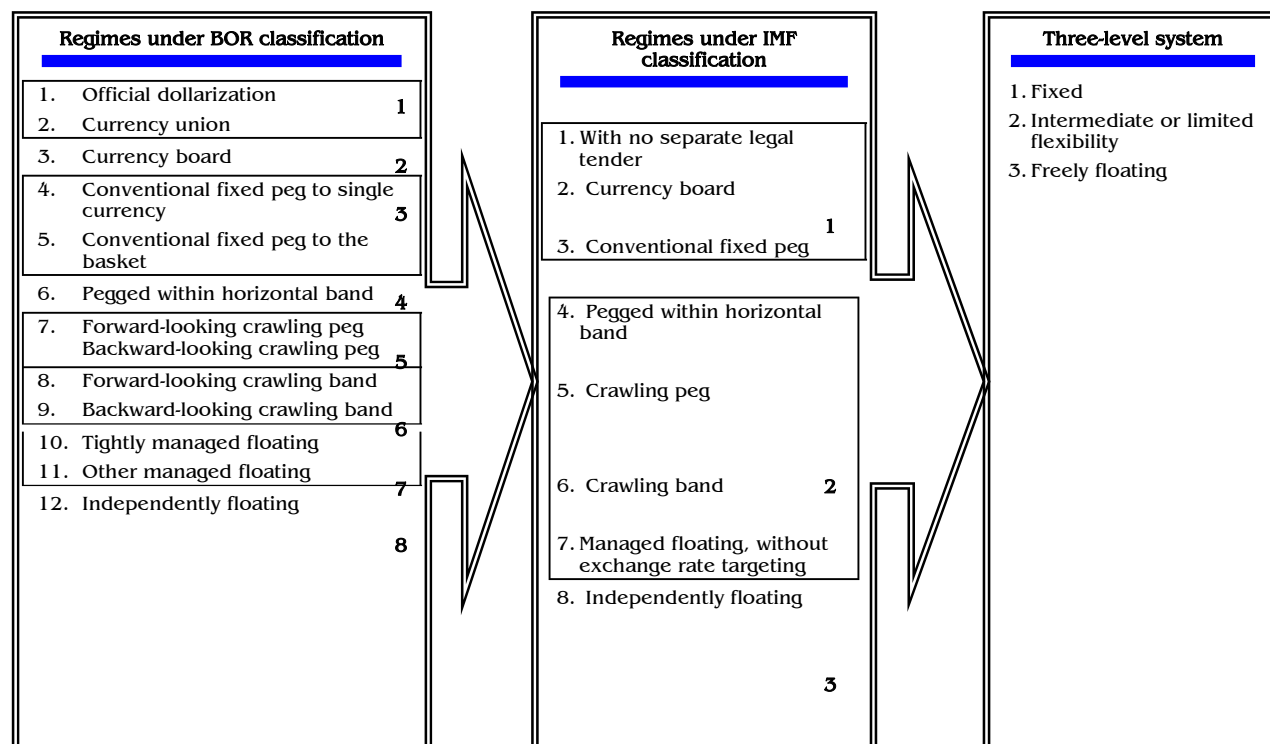
Table DA-2: Data descriptors and respective modifications

	Description	Modification
Nominal exchange rate (average monthly)		-
Nominal exchange rate (average quarterly)		-
Nominal exchange rate (end period)		-
International reserves	Total Reserves minus Gold	-
<i>CBA net foreign assets</i>	<i>CB net foreign assets less Privatization Account</i>	-
<i>Banks' corresponding accounts in foreign currency</i>	<i>Banks' corresponding accounts at CB in foreign currency</i>	Expressed in US dollar, period-end exchange rate
Money Market Rate	Money Market Rate	Albania, Azerbaijan, Hungary, Kazakhstan: treasury bonds interest rates; Belarus, Macedonia: bank refinancing rate
<i>Federal Funds (effective) rate</i>	<i>Federal Funds (effective) rate</i>	-
Lending Rate	Lending Rate	-
Inflation	Annualized (y/y) inflation	-
Export	Export FOB	-
Broad money, M2	Broad money, M2	The beginning of Moldova and Ukraine series is interpolated from the yearly series by the Cubic Line Last Match method
Domestic credit	Domestic Credit	-
Deposits	Demand, Time, Savings, Foreign Currency Deposits	-
Banks' foreign assets	Banks' foreign assets	-
Banks' foreign liabilities	Banks' foreign liabilities	-
Real exchange rate	Real effective exchange rate	The beginning of Azerbaijan series is interpolated from yearly series by the Quadratic Average method
Nominal GDP		Series adjusted seasonally; yearly data for some countries (Albania, Azerbaijan, Macedonia, Moldova) converted into quarterly by the Quadratic Sum method, and were not seasonally adjusted
Current account	Current account	-
Remittances	Remittances through the banking system (monthly). From Balance of Payments: Current transfers + Income (quarterly)	-
Short-term external debt	Short-term external debt of all the sectors of the economy	Yearly parts of series of all countries are interpolated by the Cubic Line method
External debt	External debt of government, banks, private and other sectors	Yearly parts of series of all countries are interpolated by the Cubic Line method
Fiscal deficit	Central Government budget deficit	Seasonally adjusted by the X11 Additive method
Terms of trade	Terms of trade index (1997=100)	-
Asset Price index or real estate prices	Stock indices; For Armenia the average price per sq. m. of real estate in Yerevan is used	-
Foreign currency deposits	Time and demand deposits in foreign currency	The beginning of Azerbaijan series is interpolated from yearly series by the Cubic Line method
Economic growth		Yearly data were not interpolated but were attributed to the 4th quarter; indicators of the other quarters were calculated by the use of interpolated series of nominal GDP and GDP deflators or CPI
World economic growth	OECD economic growth index	-
International oil prices	UK Brent oil price	-
Democracy of the political system	Center of International Development and Conflict Management Polity IV dataset, Polity 2 variable, yearly figures	Yearly indices were attributed to the quarters of the particular year, taking into account the date on which the index has been assigned
Elections	Database of Political Institutions (DPI): legelec and execec series	-
Currency regime	From AREAER report with 3 levels of classification	See <i>Figure DA-1</i>

Exchange rate regimes

Of a great diversity of classifications for currency regimes, BOR and IMF classifications⁸⁹ were chosen, taking into account close correlation between these two as well as the appropriateness of using the IMF classifications for analytical purposes. For the 1990-2001 BOR classification and for 2002-2008 IMF classification. However, because these two systems use different groupings of classification, we had to match them with each other. Thus from BOR classification (13 regimes) we passed to the IMF classification (8 regimes), and then build a three-level classification system (see Figure DA-1).

Figure DA-1: Matching of the two regime classifications



The yearly series built by the help of the above figure were converted into quarterly series, taking into account the date of regime assignment (normally as of April or December).

Table DA-3: Variables chosen

Variable	Descriptor	Variable	Descriptor
International reserves / GDP	percent	Remittance growth rate (y/y)	percent
Short-term External debt / International reserves	percent	Banks' foreign assets / foreign liabilities	percent
External debt / GDP	percent	Change in terms of trade (q/q)	percent
Real exchange rate overvaluation	percent	Political democracy	index
Current account / GDP	percent	Elections	index
Export growth rate (y/y)	percent	Credit/Deposits	percent
Domestic credit growth rate (y/y)	percent	International oil prices (US dollar)	absolute value
M2 / International Reserves	percent	Difference in short-term and long-term interest rates	percent
Inflation (y/y)	percent	World economic growth (OECD growth, y/y)	percent
Economic growth (y/y)	percent	Exchange rate regime (3-level)	ratio
Changes in asset prices (q / q)	percent	Dollarization	percent
Budget deficit / GDP	percent	Contagion effect	index: binary dummy variable

⁸⁹ Source: BOR classification: Bubula, Otker-Robe (2002), pp. 31-35, Appendix I; IMF classification: AREAER 2002, 2003, 2004, 2005, 2006, 2007, 2008.

Table DA-4: Datasets used in the main models, by country

<i>Country</i>	<i>Data</i>	<i>Country</i>	<i>Data</i>
Azerbaijan	Q1, 1996 – Q2, 2008	Hungary	Q1, 1990 – Q2, 2008
Albania	Q1, 1994 – Q2, 2008	Kazakhstan	Q1, 1995 – Q2, 2008
Belarus	Q1, 1995 – Q2, 2008	Macedonia	Q1, 1994 – Q2, 2008
Bulgaria	Q1, 1993 – Q2, 2008	Moldova	Q1, 1996 – Q2, 2008
Estonia	Q1, 1993 – Q2, 2008	Czech Republic	Q1, 1993 – Q2, 2008
Turkey	Q1, 1990 – Q2, 2008	Romania	Q1, 1994 – Q2, 2008
Latvia	Q1, 1990 – Q2, 2008	Russia	Q1, 1995 – Q2, 2008
Poland	Q1, 1990 – Q2, 2008	Slovakia	Q1, 1999 – Q2, 2008
Lithuania	Q1, 1993 – Q2, 2008	Georgia	Q1, 1995 – Q2, 2008
Croatia	Q1, 1993 – Q2, 2008	Ukraine	Q1, 1996 – Q2, 2008
<i>Armenia</i>	<i>Q1, 1996 – Q2, 2008</i>		

Table DA-5: Existing data points on individual leading indicators, by country

	<i>Albania</i>	<i>Armenia</i>	<i>Azerbaijan</i>	<i>Belarus</i>	<i>Bulgaria</i>	<i>Croatia</i>	<i>Czech Rep.</i>	<i>Estonia</i>	<i>Georgia</i>	<i>Greece</i>	<i>Kazakhstan</i>	<i>Latvia</i>	<i>Lithuania</i>	<i>Macedonia</i>	<i>Moldova</i>	<i>Poland</i>	<i>Romania</i>	<i>Russia</i>	<i>Slovakia</i>	<i>Turkey</i>	<i>Ukraine</i>
Currency market pressure index	1994 III- 2008 IV	1997I- 2009I	1997 I-2008 IV	1996 I-2009 I	1994 I-2008 IV	1993 I-2008 IV	1994 I-2008 IV	1994 I-2008 IV	1996 I-2008 III	1990 I-2008 IV	1995 I-2009 I	1994 I-2008 IV	1994 I-2008 IV	1994 I-2008 IV	1997 I-2009 I	1991 I-2008 IV	1995 I-2008 IV	1996 I-2008 IV	2000 I-2008 IV	1990 I-2008 IV	1997 I-2008 IV
International reserves/GDP	1993 III-2007 IV	1994 IV-2008 II	1996 III-2007 IV	1994 IV-2008 II	1994 IV-2008 II	1997 IV-2008 II	1993 I-2008 II	1993 IV-2008 II	1996 IV-2008 II	1995 IV-2008 II	1994 IV-2007 IV	1993 III-2008 II	1993 IV-2008 II	1994 III-2006 IV	1996 III-2008 II	1995 IV-2008 II	1997 IV-2008 II	1994 II-2008 II	1993 IV-2008 II	1990 IV-2008 II	2000 IV-2008 II
Short-term external debt/International reserves	1997 IV-2006 IV	1993 IV-2008 II	1993 IV-2006 IV	1994 IV-2008 II	1991 IV-2008 II	1993 IV-2008 II	1999 IV-2008 II	1996 I-2008 II	1995 IV-2008 II	1990 IV-2008 II	1993 IV-2008 II	1993 III-2008 II	1992 IV-2008 II	1993 IV-2008 II	1993 I-2008 II	1990 IV-2008 II	1990 IV-2008 II	1993 IV-2008 II	1993 IV-2008 II	1990 I-2008 II	1992 IV-2008 II
External debt/GDP	1992 I-2006 IV	1994 IV-2008 II	1996 III-2006 IV	1993 IV-2008 II	1994 IV-2008 II	1997 IV-2008 II	1999 IV-2008 II	1996 I-2008 II	1996 IV-2008 II	1995 IV-2008 II	1994 IV-2007 IV	1992 IV-2008 II	1993 IV-2008 II	1994 III-2006 IV	1996 III-2008 II	1995 IV-2008 II	1997 IV-2008 II	1994 II-2008 II	1993 IV-2008 II	1990 IV-2008 II	2000 IV-2008 II
Real exchange rate overvaluation	-	1997 I-2008 II	2000 IV-2008 II	1996 I-2008 II	1992 I-2008 II	1992 I-2008 II	1990 I-2008 II	1994 I-2008 II	1993 IV-2008 II	1990 I-2008 II	2000 I-2008 II	1994 I-2008 II	1994 I-2008 II	1992 I-2008 II	1994 I-2008 II	1990 I-2008 II	1990 I-2008 II	1994 I-2008 II	1990 I-2008 II	1994 I-2008 II	1992 I-2008 II
Current account/GDP	1993 I-2007 IV	1994 IV-2008 II	1999 I-2007 IV	1996 I-2008 II	1994 I-2008 II	1997 I-2008 II	1993 I-2008 II	1993 I-2008 II	1996 I-2008 II	1995 I-2008 II	1995 I-2007 IV	1993 I-2008 II	1993 I-2008 II	1994 I-2006 IV	1995 IV-2008 II	2000 I-2008 II	1997 I-2008 II	1994 I-2008 II	1993 I-2000 IV, 2001 I-2007 IV	1990 I-2008 II	2000 I-2008 II
Export growth rate (y/y)	1995 I-2008 II	1994 I-2008 II	1991-1995 IV, 1999 I-2008 II	1995 I-2008 II	1992 I-2008 II	1991 I-2008 II	1994 I-2008 II	1993 III-2008 II	1996 I-2008 II	1994 I-2008 II	1994 III-2008 I	1994 I-2008 II	1994 I-2008 II	1994 I-2008 II	1995 I-2008 II	1991 I-2008 II	1991 I-2008 II	1993 I-2008 II	1994 I-2008 II	1991 I-2008 II	1994 I-2008 II

Credit/Deposits	Elections	Political democracy	Change in terms of trade (q/q)	Banks' foreign assets / foreign liabilities	Remittance growth rate (y/y)	Budget deficit/GDP	Change in asset price (q/q)	Economic growth (y/y)	Inflation (y/y)	M2/International reserves	Domestic credit growth rate (y/y)	
1994 IV-2008 II	1990 I-2008 II	1990 I-2007 IV	1990 II-2008 II*	1994 IV-2008 II	1996 I-2007 IV	1998 I-2007 IV	-	199 I IV-2007 IV	1992 I-2008 II	1993 IV-2008 II	1995 IV-2008 II	<i>Albania</i>
1992 IV-2008 II	1990 I-2008 II	1991 III-2007 IV	1997 II-2008 II	1992 IV-2008 II	1994 II-2008 II	1997 I-2008 II	2002 II-2008 II	1996 I-2008 II	1994 I-2008 II	1995 I-2008 II	1993 IV-2008 II	<i>Armenia</i>
1992 IV-2008 II	1990 I-2008 II	1991 IV-2007 IV	-	1992 IV-2008 II	2000 I-2008 II	2001 II-2007 IV	-	1996 IV-2007 IV	1992 I-2008 II	1995 IV-2008 II	1993 IV-2008 II	<i>Azerbaijan</i>
1994 IV-2008 II	1990 I-2008 II	1991 IV-2007 IV	-	1994 IV-2008 II	1997 I-2008 II	1998 I-2002 IV, 2007 I-2007 IV	-	1993 I-2008 II	1993 I-2008 II	1999 IV-2008 II	1995 IV-2008 II	<i>Belarus</i>
1991 IV-2008 II	1990 I-2008 II	1990 I-2007 IV	2001 I-2008 II	1991 IV-2008 II	1992 I-2008 II	1994 I-2008 II	2001 I-2008 II	1995 I-2008 II	1991 I-2008 II	1995 IV-2008 II	1992 IV-2008 II	<i>Bulgaria</i>
1994 II-2008 II	1990 I-2008 II	1991 II-2007 IV	1990 II-2008 II*	1994 II-2008 II	1994 I-2008 II	1997 I-2008 II	1997 IV-2008 II	1994 I-2008 II	1993 I-2008 II	1993 IV-2008 II	1995 II-2008 II	<i>Croatia</i>
1993 I-2008 II	1990 I-2008 II	1990 I-2007 IV	1993 II-2008 II	1993 I-2008 II	1994 I-2008 II	1993 I-2007 II	1998 I-2008 II	1995 I-2008 II	1994 I-2008 II	2002 I-2008 II	1994 I-2008 II	<i>Czech Rep.</i>
1991 IV-2008 II	1990 I-2008 II	1991 IV-2007 IV	-	1991 IV-2008 II	1993 I-2008 II	1999 I-2008 II	1996 IV-2008 II	1994 I-2008 II	1993 I-2008 II	1993 I-2008 II	1992 IV-2008 II	<i>Estonia</i>
1995 IV-2008 II	1990 I-2008 II	1991 IV-2007 IV	-	1995 IV-2008 II	1998 I-2008 I	2006 I-2008 II	-	1997 I-2008 II	1995 I-2008 II	1995 I-2008 II	1996 IV-2008 II	<i>Georgia</i>
1990 I-2008 II	1990 I-2008 II	1990 I-2007 IV	1990 II-2008 II	1990 I-2008 II	1991 I-2008 I	1996 I-2008 II	2000 II-2008 II	1996 I-2008 II	1990 I-2008 II	1990 IV-2008 II	1991 I-2008 II	<i>Greece</i>
1997 I-2008 II	1990 I-2008 II	1991 IV-2007 IV	-	1993 IV-2008 II	1996 I-2008 II	1999 I-2007 IV	2000 IV-2008 II	1995 I-2007 IV	1994 I-2008 II	1993 IV-2008 II	1994 IV-2008 II	<i>Kazakhstan</i>
1993 III-2008 II	1990 I-2008 II	1991 III-2007 IV	1998 II-2008 II	1993 III-2008 II	1994 I-2008 II	1996 I-2008 II	1996 III-2008 II	1991 I-2008 II	1992 I-2008 II	2003 I-2008 II	1994 III-2008 II	<i>Latvia</i>
1993 I-2008 II	1990 I-2008 II	1991 III-2007 IV	2006 II-2008 II	1993 I-2008 II	1994 I-2008 II	1999 I-2008 II	2001 I-2008 II	1994 I-2008 II	1993 I-2008 II	1993 IV-2008 II	1994 I-2008 II	<i>Lithuania</i>
1993 IV-2008 II	1990 I-2008 II	1991 III-2007 IV	1990 II-2008 II*	1993 IV-2008 II	1991 I-2007 IV	-	-	1994 IV-2006 IV	1994 I-2008 II	2003 I-2008 II	1994 IV-2008 II	<i>Macedonia</i>
1991 IV-2008 II	1990 I-2008 II	1991 III-2007 IV	-	1992 I-2008 II	1995 I-2008 II	-	-	1996 IV-2008 II	1995 I-2008 II	1993 IV-2008 II	1992 IV-2008 II	<i>Moldova</i>
1990 I-2008 II	1990 I-2008 II	1990 I-2007 IV	1990 II-2008 II	1990 I-2008 II	1991 I-1995 II, 2001 I-2008 I	1996 I-2008 II	1993 II-2008 II	1996 I-2008 II	1990 I-2008 II	1996 IV-2008 II	1991 I-2008 II	<i>Poland</i>
1990 I-2008 II	1990 I-2008 II	1990 I-2007 IV	1990 II-2008 II*	1990 I-2008 II	1992 I-2008 II	2001 I-2006 IV	2001 I-2008 II	1999 I-2008 II	1991 I-2008 II	2001 IV-2008 II	1991 I-2008 II	<i>Romania</i>
1993 IV-2008 II	1990 I-2008 II	1992 I-2007 IV	1990 II-2005 IV**	1993 IV-2008 II	1995 I-2008 II	1994 II-2008 II	1996 I-2008 II	1996 I-2008 II	1993 I-2008 II	1995 II-2008 II	1994 IV-2008 II	<i>Russia</i>
1993 I-2008 II	1990 I-2008 II	1993 I-2007 IV	1990 II-2008 II*	1993 I-2008 II	1994 I-2000 IV, 2003 I-2007 IV	1993 I-2008 II	2000 II-2008 II	1994 I-2008 II	1994 I-2008 II	2000 IV-2008 II	1994 I-2008 II	<i>Slovakia</i>
1990 I-2008 II	1990 I-2008 II	1990 IV-2007 IV	1990 II-2008 II	1990 I-2008 II	1991 I-2008 II	2006 I-2008 II	1990 I-2008 II	1991 I-2008 II	1990 I-2008 II	1990 I-2008 II	1991 I-2008 II	<i>Turkey</i>
1992 IV-2008 II	1990 I-2008 II	1991 IV-2007 IV	-	1992 IV-2008 II	1995 I-2008 II	2002 I-2007 IV	1998 I-2008 II	2001 I-2008 II	1993 I-2008 II	1992 IV-2008 II	1993 IV-2008 II	<i>Ukraine</i>

Contagion effect	Dollarization	Currency regime (3-level)	World economic growth (OECD country growth y/y)	Difference in short-term and long-term interest rates	International oil price (US dollar)	<i>Albania</i>
1990 II:2008 II	1994 IV:2008 II	1991 I:2008 II	1997 I:2008 II	1994 III:1997 III, 1999 I:2008 II	1994 I:2008 II	
1990 II:2008 II	1995 I:2008 II	1992 I:2008 II	1997 I:2008 II	1995 IV:2008 II	1994 I:2008 II	<i>Armenia</i>
1990 II:2008 II	1995 IV:2000 IV, 2002 IV:2008 II	1992 I:2008 II	1997 I:2008 II	1999 I:2008 II	1994 I:2008 II	<i>Azerbaijan</i>
1990 II:2008 II	2000 I:2008 II	1992 I:2008 II	1997 I:2008 II	1992 IV:2008 II	1994 I:2008 II	<i>Belarus</i>
1990 II:2008 II	1995 IV:2008 II	1990 I:2008 II	1997 I:2008 II	1990 IV:2008 II	1994 I:2008 II	<i>Bulgaria</i>
1990 II:2008 II	1994 II:2008 II	1992 I:2008 II	1997 I:2008 II	1992 I:2008 II	1994 I:2008 II	<i>Croatia</i>
1990 II:2008 II	1993 I:2008 II	1990 I:2008 II	1997 I:2008 II	1993 I:2008 II	1994 I:2008 II	<i>Czech Rep.</i>
1990 II:2008 II	1993 I:2008 II	1992 I:2008 II	1997 I:2008 II	1993 IV:2008 II	1994 I:2008 II	<i>Estonia</i>
1990 II:2008 II	1995 IV:2008 II	1992 I:2008 II	1997 I:2008 II	1995 III:2007 IV	1994 I:2008 II	<i>Georgia</i>
1990 II:2008 II	1997 I:2008 II	1990 I:2008 II	1997 I:2008 II	1990 I:2008 II	1994 I:2008 II	<i>Greece</i>
1990 II:2008 II	1997 IV:2008 II	1992 I:2008 II	1997 I:2008 II	-	1994 I:2008 II	<i>Kazakhstan</i>
1990 II:2008 II	1994 I:2008 II	1992 I:2008 II	1997 I:2008 II	1993 IV:2008 II	1994 I:2008 II	<i>Latvia</i>
1990 II:2008 II	1993 IV:2008 II	1992 I:2008 II	1997 I:2008 II	1994 I:2008 II	1994 I:2008 II	<i>Lithuania</i>
1990 II:2008 II	1997 I:2008 II	1992 I:2008 II	1997 I:2008 II	1994 I:2008 II	1994 I:2008 II	<i>Macedonia</i>
1990 II:2008 II	1999 IV:2008 II	1992 I:2008 II	1997 I:2008 II	1996 II:2008 II	1994 I:2008 II	<i>Moldova</i>
1990 II:2008 II	1996 IV:2008 II	1990 I:2008 II	1997 I:2008 II	1991 I:2006 IV	1994 I:2008 II	<i>Poland</i>
1990 II:2008 II	1994 I:2008 II	1990 I:2008 II	1997 I:2008 II	1995 I:2008 II	1994 I:2008 II	<i>Romania</i>
1990 II:2008 II	1998 I:2008 II	1992 I:2008 II	1997 I:2008 II	1994 III:2008 II	1994 I:2008 II	<i>Russia</i>
1990 II:2008 II	2005 I:2008 II	1993 I:2008 II	1997 I:2008 II	2000 I:2008 II	1994 I:2008 II	<i>Slovakia</i>
1990 II:2008 II	1990 I:2008 II	1990 I:2008 II	1997 I:2008 II	-	1994 I:2008 II	<i>Turkey</i>
1990 II:2008 II	1996 IV:2008 II	1992 I:2008 II	1997 I:2008 II	1996 IV:2008 II	1994 I:2008 II	<i>Ukraine</i>

CHARTS

<i>FSAP comparative evaluation among selected countries</i>	<i>8</i>
<i>Regional growth rates</i>	<i>10</i>
<i>Annual growth rate of world trade</i>	<i>10</i>
<i>Brent oil prices</i>	<i>11</i>
<i>Copper prices</i>	<i>11</i>
<i>Molibdenum prices</i>	<i>11</i>
<i>Wheat prices</i>	<i>11</i>
<i>Gold prices</i>	<i>11</i>
<i>Inflation in selected countries</i>	<i>12</i>
<i>10-year government bond yield</i>	<i>12</i>
<i>Central banks' policy rates</i>	<i>13</i>
<i>USD exchange rate versus EUR and GBP</i>	<i>13</i>
<i>Interbank interest rates</i>	<i>13</i>
<i>Stock exchange indices</i>	<i>14</i>
<i>Economic growth rate, by sector</i>	<i>17</i>
<i>Growth of lending to main sectors of economy</i>	<i>18</i>
<i>GDP expenditure components</i>	<i>18</i>
<i>Armenia's imports by commodity groups</i>	<i>20</i>
<i>Armenia's exports by commodity groups</i>	<i>20</i>
<i>Armenia's foreign trade, by country</i>	<i>20</i>
<i>Net private remittances and compensation of employees</i>	<i>21</i>
<i>Money transfers-to-GDP ratio in different countries in 2011</i>	<i>21</i>
<i>Transfers of natural persons through the banking system</i>	<i>21</i>
<i>Nominal average wage</i>	<i>22</i>
<i>Households' debt burden indicators</i>	<i>22</i>
<i>Households' financial liabilities/GDP</i>	<i>23</i>
<i>Structure of household liabilities</i>	<i>23</i>
<i>Consumer loan portfolio of banks and credit organizations</i>	<i>23</i>
<i>Consumer and mortgage loan portfolio of banks and credit organizations</i>	<i>24</i>
<i>Average weighted interest rate of loans of natural persons</i>	<i>24</i>
<i>Future conditions index and its components</i>	<i>24</i>
<i>Average apartment price index in Yerevan</i>	<i>25</i>
<i>Real estate transactions index</i>	<i>25</i>
<i>Home sales and mortgage loans by region</i>	<i>25</i>
<i>Volume of loans to real estate market</i>	<i>26</i>
<i>Repo agreements and repo interest rates</i>	<i>27</i>
<i>Dram correspondent accounts of commercial banks with Central Bank and dram reserve requirement ratio ...</i>	<i>27</i>

<i>Volume of transactions on credit resource platform and average weighted interest rate</i>	<i>27</i>
<i>Government bond yield curves</i>	<i>28</i>
<i>Treasury bills allocation volumes and average weighted yield</i>	<i>28</i>
<i>Securities trades by investment service providers</i>	<i>28</i>
<i>Volume of transactions with government securities and volume of transactions with government securities / outstanding government securities ratio</i>	<i>29</i>
<i>Repo transactions by investment service providers</i>	<i>29</i>
<i>Securities trades at regulated market of securities</i>	<i>30</i>
<i>Volumes of operations in Armenian foreign exchange market and exchange rates</i>	<i>30</i>
<i>Transactions at exchange market by currencies</i>	<i>31</i>
<i>Exchange rates in exchange market of Armenia</i>	<i>31</i>
<i>Financial system assets, by financial institutions</i>	<i>32</i>
<i>Banking system stability map</i>	<i>32</i>
<i>Financial intermediation</i>	<i>33</i>
<i>Banking Intermediation in 2012</i>	<i>33</i>
<i>Foreign participation in Armenia's banking capital</i>	<i>33</i>
<i>Share of 4 largest bank assets, liabilities and capital in total banking system</i>	<i>33</i>
<i>Annual growth of loan portfolio</i>	<i>34</i>
<i>Volume of loans to the economy</i>	<i>34</i>
<i>Share of non-performing loans in total loan portfolio</i>	<i>34</i>
<i>Share of loans to natural persons and legal persons in total loan portfolio</i>	<i>35</i>
<i>Balance of bank loans to residents, by sector</i>	<i>35</i>
<i>Loans to major borrowers to total loans</i>	<i>35</i>
<i>Change in the number of banks infringed capital adequacy ratio under dynamic growth of loan losses</i>	<i>36</i>
<i>Actual and regulatory banking system liquidity ratio dynamics</i>	<i>36</i>
<i>Assets to liabilities ratio by maturity baskets</i>	<i>37</i>
<i>Major liabilities to total liabilities ratio in the banking system</i>	<i>37</i>
<i>The number of banks in breach of total liquidity requirement in case of household deposit runoff</i>	<i>37</i>
<i>Net income of the banking system from foreign currency trades and revaluation</i>	<i>38</i>
<i>Average interest rates of bank deposits and loans</i>	<i>39</i>
<i>The structure of total regulatory capital</i>	<i>40</i>
<i>Banking system capital adequacy</i>	<i>41</i>
<i>Profitability ratios in the banking system</i>	<i>41</i>
<i>Banking system RoA in selected East European and CIS countries</i>	<i>41</i>
<i>Banking system RoE in selected East European and CIS countries</i>	<i>41</i>
<i>Income and expense account of credit organizations</i>	<i>42</i>
<i>Balance of credit organization loans to residents, by sectors</i>	<i>42</i>
<i>Structure of assets included in capital adequacy ratio of investment companies, as of 31.12.2012</i>	<i>43</i>
<i>In surance sector assets, as of 31.12.2012</i>	<i>44</i>
<i>Main ratios of Armenian insurance sector</i>	<i>44</i>
<i>Insurance premium/GDP in EEC and CIS (2011)</i>	<i>44</i>

<i>Loss and expense ratios of insurance companies</i>	<i>45</i>
<i>Risk weighted assets and required solvency in insurance sector capital adequacy ratio, as of 31.12.2012</i>	<i>45</i>
<i>Average daily opening balance to average daily payments (debit)</i>	<i>48</i>
<i>Average daily payments, average daily opening balances, average daily opening available liquidity comparative analyses</i>	<i>48</i>
<i>Intraday distribution of the value of payments on an average annual basis</i>	<i>49</i>
<i>Intraday distribution of the number of payments on an average annual basis</i>	<i>49</i>
<i>Payments exceeding the threshold of 2500, 3500 and 4300 payments per hour</i>	<i>50</i>
<i>Maximum number of payments per hour, by month</i>	<i>50</i>
<i>Share of payments in peak hours in the intraday payments</i>	<i>50</i>
<i>The number of loans in 2012</i>	<i>54</i>
<i>The number of requests received during 2010-2012</i>	<i>54</i>
<i>The number of borrowers registered in ACRA database</i>	<i>55</i>
<i>The number of loans registered in ACRA database</i>	<i>55</i>
<i>The number of reports provided by ACRA</i>	<i>55</i>

TABLES

<i>IMF revisions of the 2012-2013 estimation of world economic growth outlook</i>	<i>9</i>
<i>Qualitative public debt indicators of the Republic of Armenia</i>	<i>19</i>
<i>Dwelling house operation by sources of financing</i>	<i>26</i>
<i>Modified duration of outstanding government securities as of 31.12.2012 for different maturity groups</i>	<i>28</i>
<i>Modified duration of available-for-sale and trading government securities of commercial banks as of 31.12.2012 and probable profit/loss in case of 1% change in yield for different maturity groups</i>	<i>28</i>
<i>The 3 and 5 largest share issuer concentration by capitalization, 2008 - 2012</i>	<i>30</i>
<i>The Herfindahl-Hirschman Concentration Index</i>	<i>33</i>
<i>Credit risk stress-scenarios</i>	<i>35</i>
<i>Stress-scenario of credit risk derived from off-balance sheet contingent liabilities</i>	<i>36</i>
<i>Liquidity risk stress-scenarios</i>	<i>37</i>
<i>Stress-scenario of liquidity risk derived from off-balance sheet contingent liabilities</i>	<i>38</i>
<i>Foreign exchange risk stress-scenarios</i>	<i>38</i>
<i>Interest rate risk stress-scenarios</i>	<i>39</i>
<i>Real estate price change stress-scenarios</i>	<i>40</i>
<i>Assets, liabilities, capital and profit of credit organizations</i>	<i>42</i>
<i>Credit risk assessment scenarios</i>	<i>42</i>
<i>Solvency assessment stress-scenarios</i>	<i>45</i>
<i>Credit risk assessment stress-scenarios</i>	<i>45</i>
<i>Foreign exchange risk assessment stress-scenarios</i>	<i>46</i>
<i>Liquidity risk assessment stress-scenario</i>	<i>46</i>
<i>Transfers of securities through the GSASS of the Central Bank pertaining to the transactions with securities in the secondary market</i>	<i>51</i>
<i>The summarized results of EPS assessment according to international criteria</i>	<i>53</i>

GLOSSARY OF TERMS

<i>Economic growth</i>	The growth of volume of goods and services produced in the economy during a certain period of time.
<i>Inflation</i>	An increase in the general level of prices of goods and services.
<i>Consumer price index</i>	An index of the variation in prices paid by typical consumers for retail goods and other items. The consumer price index measures the changes in the price of a market basket of consumer goods and services purchased by households.
<i>Balance of payments</i>	A system of recording of all economic transactions of Armenia (residents and non-residents) with the rest of the world over a reporting period (a quarter, a year).
<i>Foreign trade</i>	This involves an exchange of capital, goods, and services across international borders or territories, in the form of exports and imports.
<i>Gross external debt</i>	Gross external debt, at any given time, is the outstanding amount of those actual current, and not contingent, liabilities that require payment(s) of principal and/or interest by the debtor at some point(s) in the future and that are owed to nonresidents by residents of an economy.
<i>Credit risk</i>	Credit risk refers to the risk that a borrower will default on any type of debt by failing to make payments which it is obligated to do. The risk is primarily that of the lender and includes the lost principal and interest, disruption to cash flows and increased collection costs.
<i>Liquidity risk</i>	Liquidity risk is the risk that a given security or asset cannot be traded by the financial institution quickly enough in the market to prevent a loss (or make the required profit).
<i>Foreign currency risk</i>	Foreign currency risk is the risk that a change in exchange rate in the market will adversely affect profits and/or capital of the financial institution.
<i>Interest rate risk</i>	Interest rate risk is the risk that interest rate volatilities in the market will adversely affect profits and/or capital of the financial institution.
<i>Price risk</i>	Price risk is the risk that a change in price of securities in the market or price of similar financial instruments on balance sheets will adversely affect profits and/or capital of the financial institution.
<i>Standard asset</i>	An asset which is serviced under a contract, and is not problematic.
<i>Watched asset</i>	An asset which is serviced under an original contract yet certain circumstances have emerged that may undermine the borrower's ability to serve that asset.
<i>Substandard asset</i>	An asset the contractual obligations towards which are not performed due to the borrower's fragile financial standing or inability to repay the debt.
<i>Doubtful asset</i>	An asset the contractual obligations towards which are not performed; it is more problematic, making its collection at the given time very difficult or impossible.
<i>Bad asset</i>	An asset non-collectable and fully impaired uncollectible, so that its recording on the balance sheet is no longer reasonable.
<i>Nonperforming asset</i>	An asset which has been classified by the bank as watched or substandard or doubtful or bad.
<i>Major borrower</i>	A party the risk on which exceeds 5 percent of total capital of the bank.

<i>Major liability</i>	A liability that amounts to 5 percent and more of total liabilities of the financial institution, without regard to affiliation.
<i>Return on assets (RoA)</i>	A ratio of net annual profit to average annual total assets.
<i>Return on equity (RoE)</i>	A ratio of net annual profit to average annual total capital.
<i>Total liquidity</i>	A ratio of high liquid assets to total assets.
<i>Current liquidity</i>	A ratio of high liquid assets to demand liabilities.
<i>Regulatory total capital</i>	The difference between total capital as shown in statement on financial standing and deductions as specified in Central Bank "Regulation 2 on Banks and Banking".
<i>Capital adequacy</i>	A ratio of regulatory total capital to risk weighted assets.
<i>Leverage</i>	A ratio of total assets to total capital.
<i>Off-balance sheet contingent asset</i>	Off-balance sheet contingent assets include outstanding credit lines, credit cards and overdrafts as well as letters of credit, guarantees and warranties provided.
<i>Net provisioning</i>	The difference between provisions to and recoveries from assets loss reserve fund.
<i>Net foreign currency position</i>	The difference between assets and liabilities in FX assets and local currency assets containing FX risk.
<i>Gross foreign currency position</i>	This position measures the sum of absolute values of positions of various currencies.
<i>The Herfindahl-Hirschman index</i>	This index is defined as the sum of the squares of the market shares. It varies between 0 and 1, characterizing the level of concentration (values near to 0 denote lower concentration).
<i>Economic cost of capital</i>	The difference of the present value of total assets and present value of total liabilities.

ABBREVIATIONS

CBA	Central Bank of the Republic of Armenia
GDP	Gross Domestic Product
GNDI	Gross National Disposable Income
NSS	National Statistics Service
IMF	International Monetary Fund
UNO	United Nations Organization
CIS	Commonwealth of Independent States
ECB	European Central Bank
USA	United States of America
FRS	Federal Reserve System
NMC	National Mortgage Company
FDI	Foreign Direct Investment
RF	Russian Federation
IFRS	International Financial Reporting Standards
MTPL	Motor third party liability insurance
CDA	Central Depository of Armenia
TB	Treasury Bills
EPS	Electronic Payments System

