

## 2 QUANTITATIVE CRISIS ANALYSIS: IDENTIFYING AND DEFINING IMBALANCES

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### ABSTRACT

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Dedicated to the study of the possibility of using quantitative analysis tools to determine macroeconomic imbalances as potential harbingers of the spread of the crisis. It is noted that in modern conditions of a rapid course of crisis situations, it is advisable to use nonlinear models, an example of which is nonparametric models based on the signaling approach, providing for the use of macro-indicators (indicators) characterizing the economy's resistance to crises. To predict the emergence of negative trends in the development of the economy in the future, the authors developed and proposed for use a regression model with performance indicators, which reflects the dependence of the probability of the onset of the period of «crisis» on a number of economic indicators and carried out its approbation for the Ukrainian economy. Forecasting results for 2021–2022 made it possible to determine the deviations of the Ukrainian economy from the trajectory of sustainable development. The authors indicated the corrective measures of economic policy on the part of the macroeconomic regulation authorities in order to suspend the inertial development of the forecast situation.

### KEYWORDS

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Crisis, crisis phenomena, symptoms of crisis phenomena, causes of crisis phenomena, factors of crisis phenomena, channels of transmission of crisis phenomena, macroeconomic imbalances, indicator for determining macroeconomic imbalances, signal approach, regression model.

### 2.1 ESSENTIAL CHARACTERISTICS OF CRISIS PHENOMENA AND CHANNELS OF THEIR DISTRIBUTION

The emergence of the modern world economy inevitably leads to an increase in crisis trends. The magnitude of these trends can vary. Macrolevels are characterized by large volumes of problems that cover the socio-economic system as a whole. Microcrisis captures only a single problem or a group of problems. The crisis is seen as one of the phases of the economic development cycle, it is inevitable, but it performs a progressive function of replacing non-viable elements with more efficient ones. That is why, even if sustainable development is achieved, cyclical-crisis development will not disappear.

However, we can say that the timely identification of pre-crisis factors and the formation of an effective measure of instruments will reduce the negative consequences of crises. In this aspect, it is very important to know the signs (symptoms) of the onset of crisis situations, to anticipate

their occurrence, to prevent their occurrence, and, provided that the crisis is already unfolding, to assess the possibilities of its solution.

We agree with the opinion [1] that «symptoms are the first, external manifestation of crisis phenomena, not always characterizing the true causes of the crisis, but on the basis of which some reasons can be established. Causes are phenomena or events that result in the symptoms and factors of the crisis. The factors are events, or tendencies have been established that indicate the emergence of a crisis». **Table 2.1** shows the classification of factors that determine the emergence and development of crisis phenomena.

● **Table 2.1** Classification of factors that determine the emergence and development of crisis phenomena

Classification feature	Elements of the classification feature
Depending on the residence	Internal External
Depending on the action in time	Permanent Temporary
Depending on the scale of the crisis aggravation	Local Global
Depending on the degree of interconnectedness of factors	Independent Derivatives
Depending on the degree of influence on the development of crisis phenomena	Main Minor
Depending on the area of origin	Economic Social Ecological Political Technological Structural
Depending on the recognition capabilities	Explicit Hidden
Depending on the level of occurrence	Microlevel Macrolevel State Interstate

*Source: developed on the basis of data [2–4]*

The question of determining the distribution channels of crisis phenomena remains relevant. Modern scientific thought identifies two concepts that reveal the essence of the spread of eco-

conomic crises. According to the first, the spread of the crisis between countries is based on fundamental macroeconomic characteristics [5–8], and the second – the crisis is a consequence of globalization, financial integration, externalities, changes in the behavior of investors or other financial agents [9–12]. Analysis of certain concepts allows to identify the following channels of transmission of crisis phenomena (Fig. 2.1).

It is possible to study the nature and causes of the emergence of crisis phenomena, check the operation of certain channels of the spread of the crisis and obtain a mechanism for preventing the crisis using a model test.

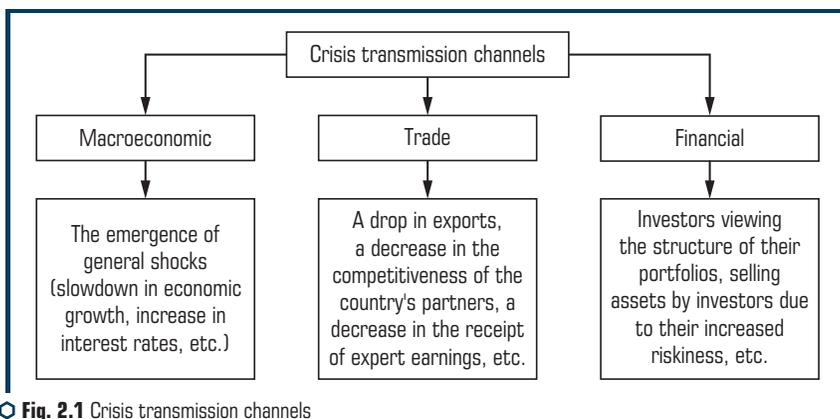


Fig. 2.1 Crisis transmission channels  
Source: developed on the basis of data [13–15]

## 2.2 JUSTIFICATION OF THE ADVISABILITY OF USING NONPARAMETRIC MODELS BASED ON THE SIGNALING APPROACH TO IDENTIFY AND DETERMINE IMBALANCES

The problem of identifying crisis phenomena in the economies of the countries of the world at the moment remains unresolved both in practical and theoretical aspects. There is an opinion widespread in the scientific literature that global imbalances are a prerequisite and cause of crisis phenomena in the world economy [9–12]. And this is natural, because the categories «equilibrium», «imbalances» and «crisis» are inextricably linked in the context of the dualistic nature of cyclical development. Macroeconomic imbalances that can lead to negative social and economic phenomena, it is necessary to identify in time and develop measures to neutralize the negative impact in order to mitigate possible crisis phenomena and their consequences.

The cornerstone of any science, the criterion of the truth of its provisions is the ability to predict with a certain level of reliability the course of future events, taking into account the variety of influencing factors that affect these events. It becomes obvious that the usual linear extrapolation of the past to future events is erroneous, since it can focus on the wrong strategy and erroneous

decisions. Modern conditions of the rapid course of crisis situations require the use of nonlinear models, an example of which is nonparametric models based on the signaling approach. The main advantage of the signaling approach is the assessment of the predictive strength of each indicator individually, which makes it possible to rank the variables. In this case, it is important to determine a set of input variables that are hypersensitive to abrupt changes, and indicative limits of fluctuations of macro indicators (indicators) that characterize the economy's resistance to such changes. With this approach, various numerical characteristics are developed, which make it possible to identify in advance the vulnerability of the economy to the crisis. Within the framework of this approach, two main directions can be distinguished: the construction of the limiting values of indicators – harbingers of the crisis on the basis of various criteria, as well as the development of consolidated indices of financial stability [16, 17]. We share the opinion that the mechanism for describing such models should be intuitive and have a clear economic interpretation to ensure that the results obtained can be used by decision-makers. Also, when choosing mathematical tools, one must take into account the limited amount of data suitable for calculations. This is due to the heterogeneity of statistical information in the context of the countries of the world (differences in units of measurement, calculation methods, etc.) [18].

The world practice of studying crisis phenomena and the mechanism of their prevention testifies to the absence of a generally accepted list of the main macroeconomic indicators that would be used in the monitoring system of crisis recognition. In this regard, it becomes necessary to search for the existing positive practice of constructing early warning indicators in order to assess the feasibility of using it for making managerial decisions. An example of such an effective practice can be considered the European mechanism for the timely recognition of serious imbalances – the Macroeconomic Imbalance Procedure (MIP) (procedure (order) for determining macroeconomic imbalances) [19–21]. The procedure defines a mechanism for identifying potential risks at an early stage and monitoring (monitoring) to prevent the appearance of negative macroeconomic imbalances and to correct the already existing distortions.

MIP as a block of economic management has three components [19]:

- 1) a warning mechanism that facilitates early detection and monitoring of imbalances based on qualitative economic analysis and financial assessments;
- 2) a table of indicators indicating a set of indicators and threshold values used at the initial stage of identifying external and internal imbalances and which are differentiated for the countries of the Eurozone and countries outside it;
- 3) a thorough review, which implies determining the status of a potential imbalance – regulated at an early stage or problematic.

Let's dwell in more detail on financial indicators for revealing macroeconomic imbalances in European practice. The indicators that were selected for the Scoreboard (tables/dashboards) were grouped according to four principles:

- 1) the selected indicators determine the most important aspects of macroeconomic imbalances and loss of competitiveness, which may pose a threat to the normal functioning of the euro;

2) indicators and thresholds on the panel are chosen so as to provide reliable signals about potential imbalances and losses of competitiveness already at an early stage of their occurrence;

3) as we have already noted, the selected indicators should be intuitive and have a clear economic interpretation to ensure that the results obtained can be used by decision-makers. Therefore, the number of such indicators is limited, their choice and the table plays an important role in communication. For this purpose, the table includes a limited number of indicators, their selection and transformation should be of minimal complexity, easily interpreted by third parties, and statistical data for their calculation should be available;

4) to calculate the indicators, high quality statistical data should be used and be comparable for different countries [19, 20].

Thus, the MIP Scoreboard panels/tables provide indicators reflecting external imbalances, internal imbalances and competitiveness positions (**Table 2.2**).

● **Table 2.2** Indicators for determining macroeconomic imbalances and formulas for their calculation

Indicators	Data transformation formulas	Threshold limits of indicator changes
Net international investment position, as % of GDP	$\frac{NIP_t}{GDP_t} \times 100$	-35 %
Private sector credit flow, annual increase as % of GDP	$\frac{PSCF_t - PSCF_{t-1}}{GDP_t} \times 100$	+14 %
Private sector debt, as % of GDP	$\frac{PSD_t}{GDP_t} \times 100$	133 %
Gross external debt, as % of GDP	$\frac{GED_t}{GDP_t} \times 100$	60 %
Total financial sector liabilities, non-consolidated, % year-on-year change	$\frac{FSL_t}{FSL_{t-1}} \times 100 - 100$	16.5 %

Source: based on data from [19]

The selected indicators and the procedure for their calculation are capable of reflecting both a short-term rapid deterioration of the situation and a gradual accumulation of imbalances in the long term [20]. The Procedure (order) for determining macroeconomic imbalances (MIP Scoreboard) describes the procedure for assessing imbalances and determines that these indicators do not serve political purposes and are not political instruments, they need to be taken on their own, but additional information should be taken into account in order to draw broad conclusions. The threshold limits indicated in **Table 2.2** are obtained on the basis of research by European experts and are not very strict in order to avoid a large number of false alarms.

### 2.3 RESULTS OF USING NONPARAMETRIC MODELS BASED ON THE SIGNALING APPROACH TO DETERMINE MACROECONOMIC IMBALANCES

**Tables 2.3–2.7** present the indicators of these indicators in order to determine the macroeconomic imbalances of Ukraine, Poland and Germany (calculations were carried out on the basis of official data from the NBU, the World Bank, and the statistical office of the European Union (Eurostat)). The data in **Table 2.3** give an idea of the external imbalances of countries.

◆ **Table 2.3** Indicator of net international investment position for Ukraine, Poland and Germany, % of GDP

Years	Threshold	Net international investment position, % of GDP		
		Ukraine	Poland	Germany
2006		-17.8	-10.0	15.4
2007		-18.0	-13.0	21.1
2008		-21.4	-20.9	15.4
2009		-28.8	-22.4	21.0
2010		-24.8	-24.5	20.9
2011		-24.7	-25.6	15.5
2012		-28.0	-26.5	22.1
2013	-35 %	-35.1	-27.2	29.5
2014		-37.6	-26.4	31.7
2015		-36.1	-26.0	34.5
2016		-29.1	-22.9	37.9
2017		-24.1	-20.7	43.0
2018		-16.8	-16.8	45.7
2019		-18.0	-12.5	51.1
2020		-13.6	-5.5	53.4

Source: developed on the basis of data [22–24]

Ukraine and Poland show the same trends in the dynamics of the indicator of net international investment position. A negative indicator of the indicator indicates that both countries are active net borrowers and that their national economies are open to capital flows. However, during the analyzed period, Poland never exceeded the threshold value of the given indicator, while in Ukraine it went beyond the limit borders three times (during 2013–2015). In **Table 2.3**, the values of the indicators that have exceeded the corresponding threshold values are highlighted by shading. 2014 became especially indicative for Ukraine, because it was during this period that the annexation of the Autonomous Republic of Crimea took place, an armed confrontation began in eastern Ukraine, political uncertainty took place, which caused a macroeconomic shock. In addition, foreign

investment in Ukraine is mostly carried out according to the model of underdeveloped countries. Ukraine is a place of struggle for the sale of products, and Poland is considered a place of capital investment with the aim of establishing production or with the aim of effectively integrating into the world division of labor. As a result, we can speak of a greater likelihood of macroeconomic imbalances occurring in Ukraine than in Poland, although the countries have significantly improved the indicator indicators since 2016 compared to the beginning of the analyzed period. In addition, the forecast of the indicator for 2021 based on linear and polynomial trends in Ukraine does not show its crossing of the limit value line of  $-35\%$  (Fig. 2.2). The positive value of the indicator of net international investment position in Germany indicates the absence of manifestations of external economic imbalances for the analyzed period. The country is an active net creditor and is gradually improving the value of the indicator.

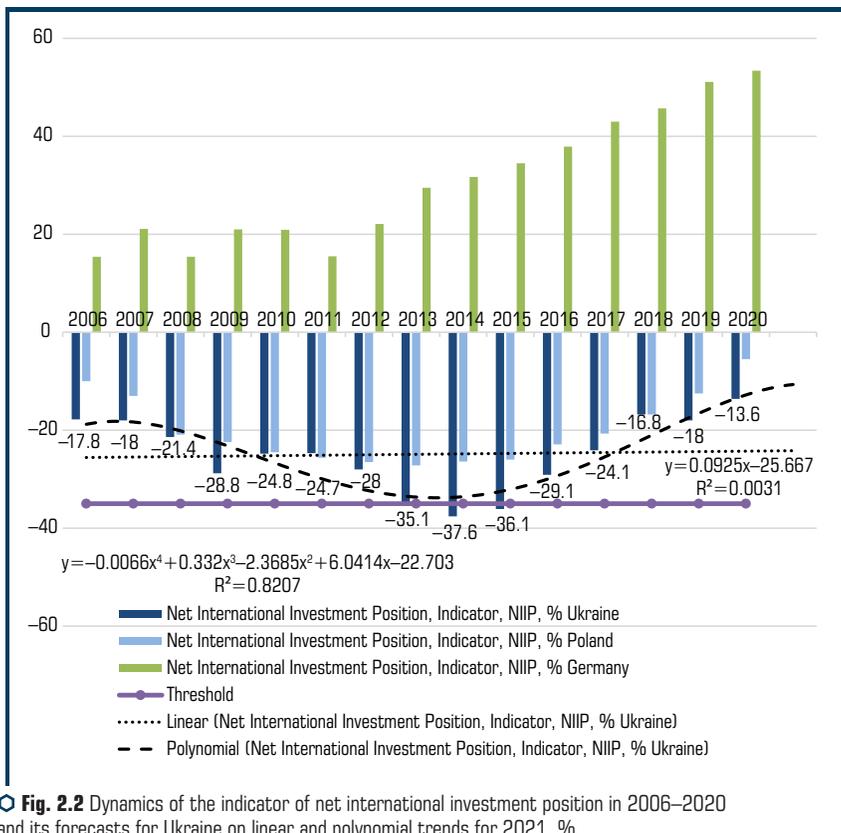


Fig. 2.2 Dynamics of the indicator of net international investment position in 2006–2020 and its forecasts for Ukraine on linear and polynomial trends for 2021, %

Source: developed by the authors

Internal imbalances, according to the results shown in **Table 2.1**, are signaled by such an indicator as the indicator of lending to the private sector of the economy (**Table 2.4**).

Ukraine during the analyzed period cyclically demonstrates a significant excess of the threshold value of the indicator of lending to the private sector of the economy.

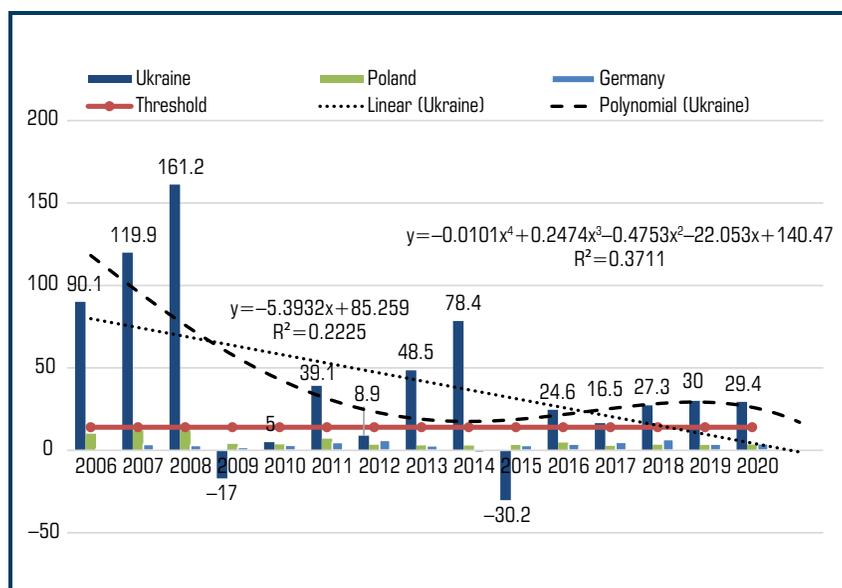
● **Table 2.4** Indicator of lending to the private sector of the economy for Ukraine, Poland and Germany, annual growth in % of GDP

Years	Threshold	Lending to the private sector of the economy, % of GDP		
		Ukraine	Poland	Germany
2006		90.1	10.1	0.9
2007		119.9	12.0	3.6
2008		161.2	12.1	3.0
2009		-17.0	3.9	1.8
2010		5.0	3.6	3.1
2011		39.1	7.1	4.8
2012		8.9	3.4	6.1
2013	+14 %	48.5	3.0	2.8
2014		78.4	2.9	-1.4
2015		-30.2	3.2	3.0
2016		24.6	4.7	3.8
2017		16.5	2.7	4.9
2018		27.3	3.4	6.6
2019		30.0	3.3	3.8
2020		29.4	3.5	4.0

Source: developed on the basis of data [25, 26]

In **Table 2.4**, the values of the indicators that have exceeded the corresponding threshold values are highlighted by shading. So, in 2006–2008, there is a phase of credit expansion and a phase of excessive credit expansion. During these periods, real estate prices are growing rapidly, the level of credit depth is increasing, indicating the transition of the private sector of the economy to unsecured financing. The level of overdue debts is also significantly increasing. In 2008, the credit cycle reaches a phase of «overheating», when it reaches its highest point of development and a rapid decline in lending volumes begins. The phase of the credit crunch begins. At the same time, there is an increase in the level of overdue debts and most loans are issued for the restructuring of existing debts (in 2009). As a rule, the phase of credit contraction in the private sector occurs against the

background of a shortage of working capital among enterprises in the real sector of the economy, which is not covered by bank lending, and a crisis in the financial sector can provoke a crisis in the sector of the real economy. Since 2010, a phase of stagnation begins, followed by a gradual recovery. According to **Table 2.4**, we can say that in 2020 Ukraine on lending to the private sector will again gradually enter the phase of «overheating», which is a signal of the emergence of crisis phenomena and the possibility of a financial crisis. The polynomial forecast for 2021 confirms the cyclical nature of the indicator of lending to the private sector of the economy and entering the «overheating» phase. The linear forecast indicates a drop in the values of the indicator of lending to the private sector of the economy in 2021 to almost a negative level (**Fig. 2.3**). Credit cycles in Poland and Germany are smoother and do not pose a threat of imbalances in the financial sector.



**Fig. 2.3** Dynamics of the indicator of lending to the private sector of the economy in 2006–2020 and its forecasts for Ukraine on linear and polynomial trends for 2021, %

Source: developed by the authors

One of the indicators characterizing internal imbalances in the country is the indicator of gross external debt, which is primarily an indicator of the public sector's solvency (**Table 2.5**).

Most of the developed countries of the world have the largest government borrowings. The leaders among the world's debtors are Japan and the United States, and this is positive evidence that the presence of public debt is a useful stimulating factor in the period of economic growth, if it is aimed at investment purposes, and not covering budget deficits. However, ineffective gov-

ernment borrowing management poses a threat to the economic security of the state. The data in **Table 2.5** indicate that since 2009 Ukraine has exceeded the threshold value of the indicator of gross external debt (shaded values indicate the values of indicators that have exceeded the corresponding threshold values). At the same time, Germany has the opposite trend in the dynamics of this indicator and since 2006 has been bringing its value closer to the threshold value. In order to assess the justification for the growth of external debt, it is advisable to study the dynamics of the GDP of each country, which is presented in our study (**Table 2.6**).

● **Table 2.5** Indicator of gross external debt for Ukraine, Poland and Germany, % of GDP

Years	Threshold	Gross external debt, % of GDP		
		Ukraine	Poland	Germany
2006		50.6	47.3	66.9
2007		56.0	44.5	64.2
2008		56.5	46.7	65.7
2009		88.2	49.8	73.2
2010		86.0	53.5	82.5
2011		77.4	54.7	79.7
2012		76.8	54.4	81.2
2013	60 %	77.8	56.5	78.8
2014		95.8	51.1	75.7
2015		131.0	51.3	72.3
2016		121.7	54.2	69.3
2017		103.9	50.6	65.1
2018		87.7	48.8	61.8
2019		79.2	59.7	59.7
2020		80.8	69.8	57.5

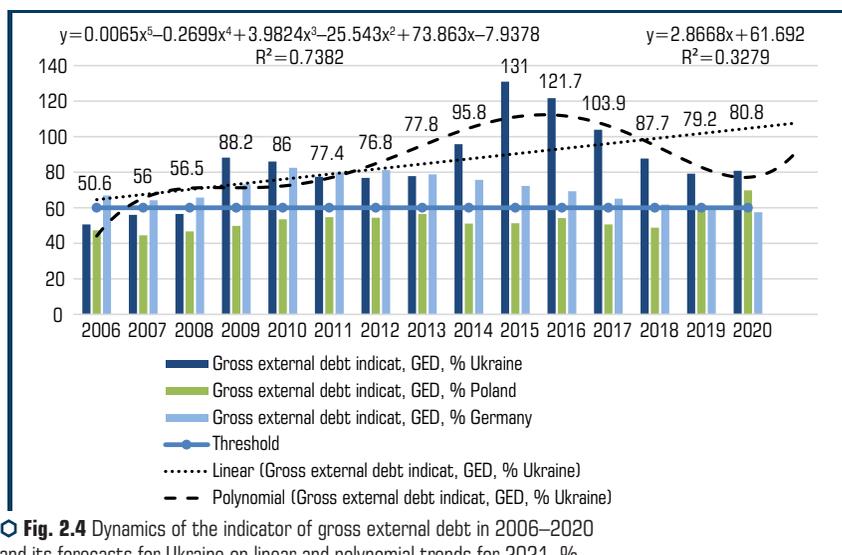
Source: developed on the basis of data [27, 28]

As the data in **Table 2.6** show, Germany directed the increase in gross public debt specifically for investing in economic growth, as evidenced by the growing values of the country's GDP. As for Ukraine, we can assess the level of government of Ukraine's management of public debt as threatening the country's debt security, since it does not lead to sustainable growth in GDP. So, in 2020, the gross external debt of Ukraine increased by 3.2 % compared to 2019, while GDP grew by only 1.2 % [29, 30]. Describing the dynamics of the gross external debt indicator, it should be noted that the forecast for both the linear and the polynomial trend line indicates its further growth in 2021 for Ukraine (**Fig. 2.4**).

● **Table 2.6** The value of the gross domestic product of Ukraine, Poland and Germany for 2006–2020, million USD

Years	GDP, million USD		
	Ukraine	Poland	Germany
2006	107,753	344,622	3,328,000
2007	142,719	429,029	3,427,000
2008	179,992	533,609	3,460,000
2009	117,228	439,738	3,260,000
2010	136,419	479,834	3,400,000
2011	163,160	528,301	3,749,315
2012	175,781	498,524	3,527,143
2013	183,310	521,016	3,733,805
2014	133,503	572,477	3,889,093
2015	91,031	477,812	3,357,586
2016	93,356	472,630	3,469,853
2017	112,190	526,509	3,682,602
2018	130,832	587,409	3,963,767
2019	153,781	595,862	3,861,124
2020	155,582	594,165	3,806,060

Source: developed on the basis of data [29, 31]



○ **Fig. 2.4** Dynamics of the indicator of gross external debt in 2006–2020 and its forecasts for Ukraine on linear and polynomial trends for 2021, %  
 Source: developed by the authors

The next indicator characterizing internal imbalances in the country is the indicator of total liabilities of the financial corporations sector (**Table 2.7**).

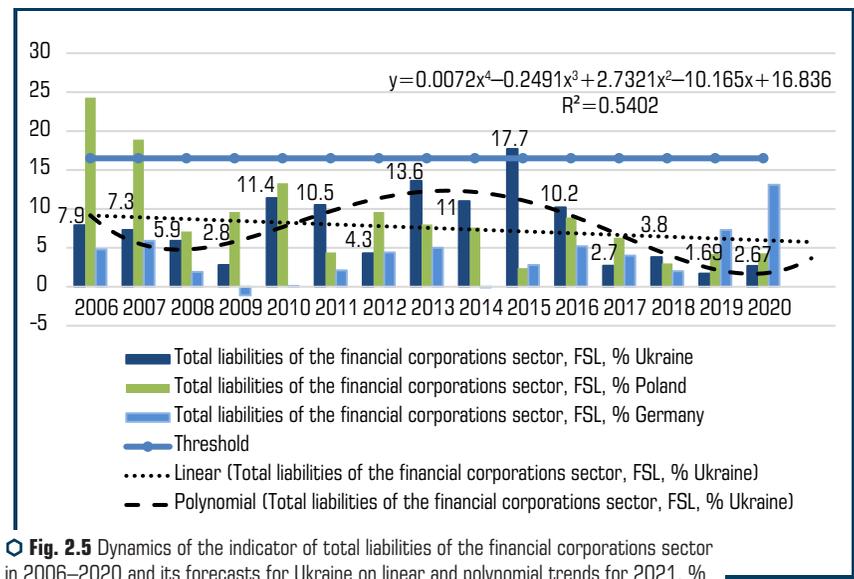
As for Ukraine, in the estimated time period 2006–2020, the indicator value only once, in 2015, exceeded the threshold value of 16.5 %, for Poland the indicator value was above the threshold only in 2006–2007. In **Table 2.7** shading is the indicator values, which are highlighted that have exceeded the corresponding thresholds. In terms of future risks of instability, greater emphasis should be placed not on the rate of change in liabilities, but on the presence of imbalances in the structure of the financial corporations sector. As of 01.01.2021 in Ukraine, depository corporations own 53.97 % of assets and 60.32 % of liabilities. Consequently, the fate of the second financial corporations is practically equal to the share of depository institutions. This testifies to the development of the financial sector in Ukraine as a whole, but emphasizes the role of deposit corporations in ensuring financial stability and economic growth.

The absence of imbalances in Ukraine and a decrease in the values of the indicator of total liabilities of the financial corporations sector in the future is also shown by the forecast along the linear and polynomial trend lines (**Fig. 2.5**).

● **Table 2.7** Indicator of total liabilities of the financial corporations sector for Ukraine, Poland and Germany, change over the year, %

Years	Threshold	Total liabilities of the financial corporations sector, change for the year, %		
		Ukraine	Poland	Germany
2006		7.9	24.3	4.8
2007		7.3	18.9	5.9
2008		5.9	7.1	1.9
2009		2.8	9.6	-1.1
2010		11.4	13.3	0.1
2011		10.5	4.4	2.1
2012		4.3	9.6	4.4
2013	16.5 %	13.6	8.0	5.0
2014		11.0	7.6	-0.1
2015		17.7	2.4	2.8
2016		10.2	8.9	5.2
2017		2.7	6.3	4.0
2018		3.8	3.0	2.0
2019		1.69	4.2	7.3
2020		2.67	4.3	13.1

Source: developed on the basis of data [30, 32, 33]



The private sector debt indicator characterizes the domestic and foreign debt liabilities of the non-financial corporations sector, the household sector and the non-profit organizations sector serving the household sector.

According to **Table 2.8**, it can be concluded that during the periods under consideration, the value of this indicator for Ukraine and Poland does not cause concern, but for Germany from 2006 to 2014 it significantly exceeded the threshold value (shaded values indicate the values of indicators that exceeded the corresponding threshold values). It was during these periods in Germany that the highest values of the indicator of gross external debt were observed. We can draw conclusions about the high level of investment in the growth of the economy of this country during 2006–2014. As for Ukraine, according to the forecast of the polynomial trend, the private sector debt will increase, which is demonstrated by the value of  $R^2$ . This testifies to the ability of the household sector to act as a source of investment in the economy (**Fig. 2.6**).

In general, during 2006–2021 in Ukraine, over the span of three years (2013–2015), simultaneously, three out of five indicators assessing macroeconomic imbalances indicated the presence of crisis phenomena (**Tables 2.3–2.5, 2.7**). This situation can be regarded as a period of «crisis», especially considering the fact that the dynamics of GDP during this period (**Table 2.6**) had a negative character. In other years, there were also signals of imbalances, but a more thorough assessment of crisis exacerbations can only be given by taking into consideration all the indicators of the MIP Scoreboard panel/table.

Table 2.8 Indicator of debt of the private sector of the economy for Ukraine, Poland and Germany, %

Years	Threshold	Debt of the private sector of the economy, % of GDP		
		Ukraine	Poland	Germany
2006		96.5	52.3	215.0
2007		101.8	58.6	224.1
2008		105.2	72.0	237.4
2009		122.9	72.0	250.5
2010		111.3	74.2	244.0
2011		104.5	79.5	237.6
2012		106.6	76.7	239.0
2013	133 %	112.5	75.0	235.1
2014		123.9	74.9	222.6
2015		121.6	79.0	98.9
2016		110.6	81.6	99.3
2017		92.6	76.4	100.1
2018		43.7	76.1	102.4
2019		44.8	74.0	105.4
2020		45.9	72.0	100.4

Source: developed on the basis of data [34–36]

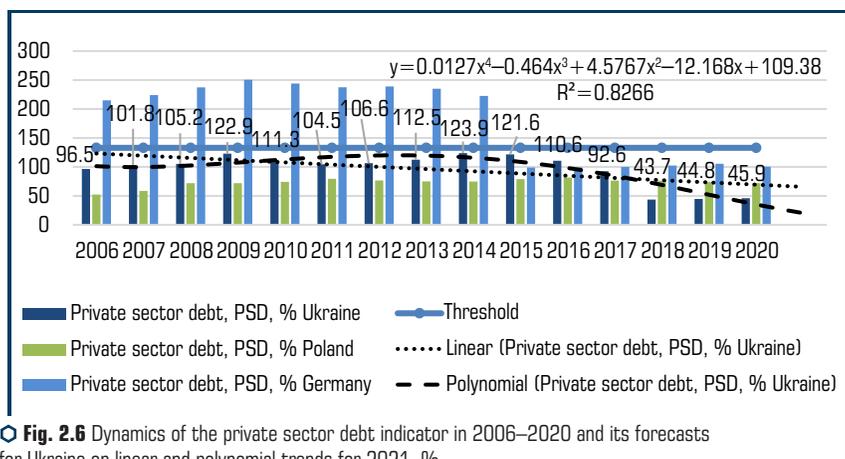


Fig. 2.6 Dynamics of the private sector debt indicator in 2006–2020 and its forecasts for Ukraine on linear and polynomial trends for 2021, %

Source: developed by the authors

## 2.4 JUSTIFICATION OF THE ALGORITHM AND THE RESULTS OF USING A REGRESSION MODEL WITH PERFORMANCE INDICATORS TO PREDICT THE EMERGENCE OF NEGATIVE TRENDS IN THE DEVELOPMENT OF THE ECONOMY IN THE FUTURE ON THE EXAMPLE OF UKRAINE

To predict the emergence of negative trends in the development of the Ukrainian economy in the future, a regression model with performance indicators can be used, reflecting the dependence of the probability of the onset of the «crisis» period on a number of economic indicators. This theoretical model can be written in the form of formula (2.1):

$$Y_t = C_0 + C_1NIIP_t + C_2PSCF_t + C_3GED_t + C_4PSD_t + C_5FSL_t. \quad (2.1)$$

The authors propose to determine the dependent variable  $Y_t$  on the basis of the real effective exchange rate (REER) – the calculated exchange rate, which is an indicator of changes in the price competitiveness of domestic goods in relation to the products of the country's main trading partners [37]. the exchange rate makes it possible to determine the price competitiveness of the country in relation to the countries – major trading partners, because it reflects not only the change in the exchange rate, but also takes into account inflation indicators. REER shows how overvalued or underestimated the national currency. Since Ukraine has a raw material export orientation, the underestimation of its national currency contributes to a decrease in the cost of raw materials on the international market, which poses a threat to the volume of foreign exchange inflows into the country. valuation of the national currency, the cost of imports is high, which contributes to the redistribution of the national income of Ukraine in favor of the countries-trade importers. As a result, the problem of finding funds to finance the negative balance of the current account is intensifying in the national economy, and the revenue side of the budget is shrinking. Therefore, according to the authors, ensuring the optimal dynamics of the REER should be the main guideline in the implementation of macroeconomic policy. The dynamics of the REER in Ukraine is shown in **Fig. 2.7**.

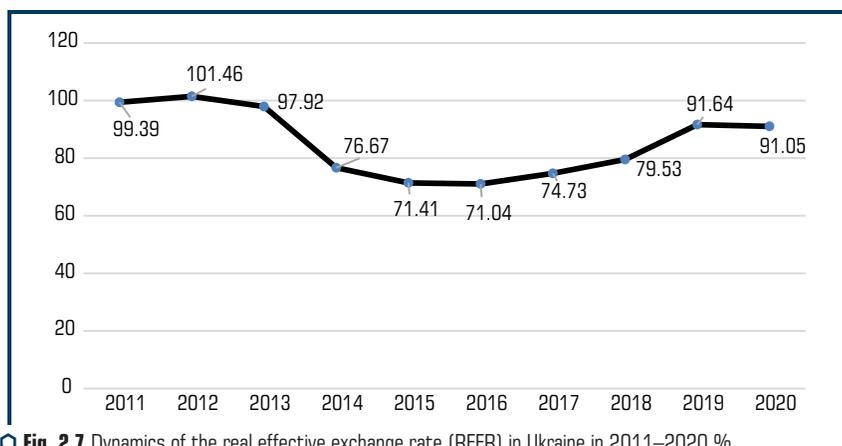
The data presented in **Fig. 2.7** allow to conclude that the dynamics of the REER during 2011–2020 are similar to the dynamics of the analyzed indices/signals of macroeconomic imbalances. It was in 2013–2015. There is a «compression» of the indicator, and as we have already noted, such reasons are not global financial and economic processes, but internal instability.

Let's calculate a certain regression model (2.1) for Ukraine using Microsoft Excel tools. The data for the calculations are presented in **Table 2.9** (the values of the indicators that have exceeded the corresponding threshold values are highlighted in shading).

The simulation results are as follows (2.2):

$$Y_t = 153.377 + 0.445x_1 - 0.157x_2 - 0.77x_3 + 0.168x_4 + 0.585x_5. \quad (2.2)$$

It is necessary to assess the reduced model (2.2) for the significance of the relationship between the reduced dependent and independent factors (**Table 2.10**).



● **Fig. 2.7** Dynamics of the real effective exchange rate (REER) in Ukraine in 2011–2020 %

Source: based on data from [38]

● **Table 2.9** Initial data for calculating the regression model with performance indicators, reflects the dependence of the probability of the onset of the «crisis» period for the Ukrainian economy on a number of economic indicators

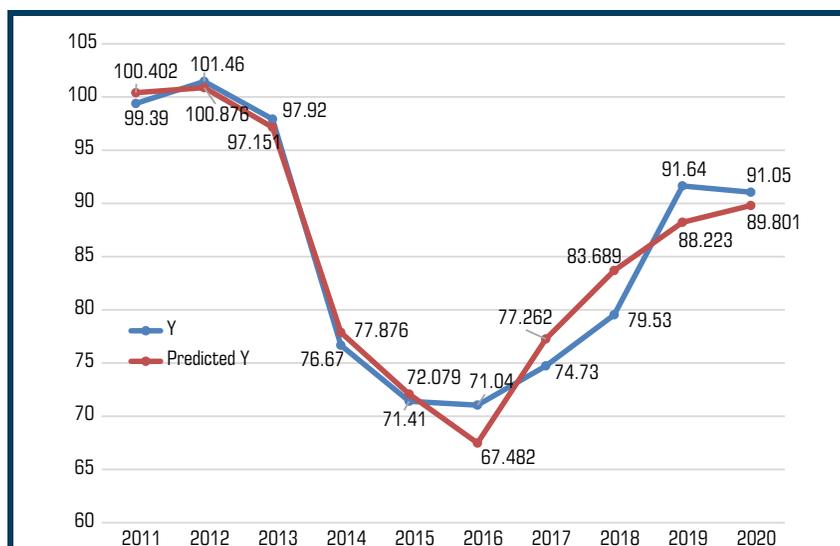
Indicator	Net international investment position	Private sector loan	Gross external debt	Private sector debt	Total liabilities of the financial corporations sector	Real effective exchange rate
Presentation format	% of GDP	annual growth in % of GDP	% of GDP	% of GDP	% change from previous year	%
Legend	<i>NIIP</i>	<i>PSCF</i>	<i>GED</i>	<i>PSD</i>	<i>FSL</i>	<i>REER</i>
Threshold values	-35	14	60	133	16.5	121.4005
2011	-24.7	39.1	77.4	104.5	10.5	99.39
2012	-28	8.9	76.8	106.6	4.3	101.46
2013	-35.1	48.5	77.8	112.5	13.6	97.92
2014	-37.6	78.4	95.8	123.9	11	76.67
2015	-36.1	-30.2	131	121.6	17.7	71.41
2016	-29.1	24.6	121.7	110.6	10.2	71.04
2017	-24.1	16.5	103.9	92.6	2.7	74.73
2018	-16.8	27.3	87.7	43.7	3.8	79.53
2019	-18	30	79.2	44.8	1.69	91.64
2020	-13.6	29.4	80.8	45.9	2.67	91.05

Source: developed by the authors

● **Table 2.10** Assessment of the significance of the indicators of the developed regression model (2.2) with effective indicators, reflects the dependence of the probability of the onset of the «crisis» period for the Ukrainian economy on a number of economic indicators

Indicator	Value
Multiple regression coefficient $R$	0.979345871
Coefficient of determination $R$ -squared	0.959118334
Normalized coefficient of determination $R$ -square	0.908016252
Standard error	3.655754917
Number of observations	10

According to **Table 2.10**, it can be seen that the multiple determination coefficient is 0.959118334, therefore, the effective indicator depends on the factors by 95.9 %. The multiple correlation coefficient 0.979345871 indicates a strong (close) relationship between the indicators. Checking the relevance of the relationship by the  $F$ -criterion shows that  $3.655754917 \leq 5$ . So, the relationship between the indicators that are included in the multivariate regression model is significant (not random). Checking the model (2.2) according to actual data confirms the results of the assessment given in **Table 2.10** (**Fig. 2.8**).



○ **Fig. 2.8** Assessment of the model of indicators of the developed regression model (3.2) with effective indicators reflects the dependence of the probability of the onset of a period of «crisis» for the Ukrainian economy on a number of economic indicators  
 Source: developed by the authors

The selected set of indicators for identifying macroeconomic imbalances provides a basis for building and forming a base of scenarios of possible economic behavior under the influence of external disturbances. In fact, the value of these indicators at the end of the period in the absence of other corrective actions (macroprudential government policies) determine the reaction and stability of the economy during the crisis. The authors carried out forecasting of macro-indicators that allow assessing the spread of crisis phenomena for the Ukrainian economy during the next two years after the analyzed period (**Table 2.11**).

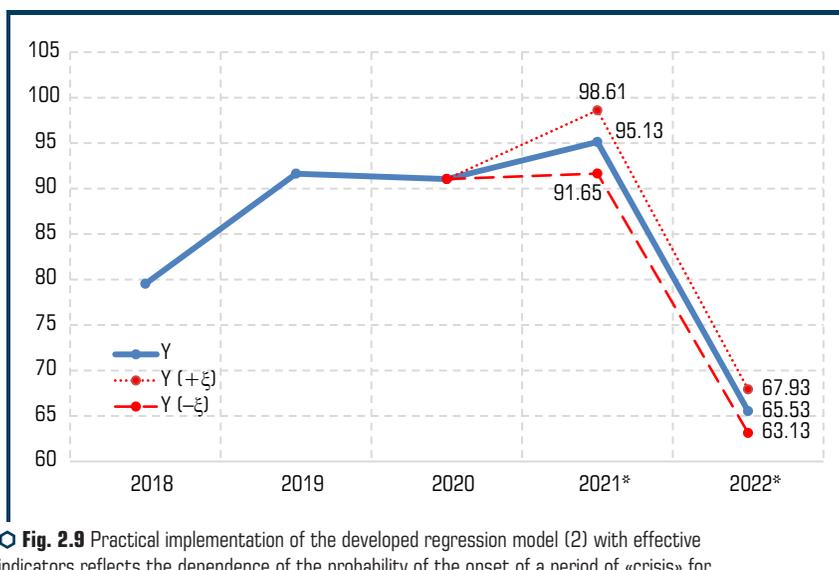
The practical implementation of the economic and mathematical (regression) model with performance indicators reflects the dependence of the probability of the onset of the period of «crisis» for Ukraine on a number of economic indicators is shown in **Fig. 2.9**.

● **Table 2.11** Forecast data of the regression model with performance indicators reflects the dependence of the probability of the onset of the «crisis» period for the Ukrainian economy on a number of economic indicators for 2021–2022

Indicator	Net international investment position	Private sector loan	Gross external debt	Private sector debt	Total liabilities of the financial corporations sector	Real effective exchange rate
Presentation format	% of GDP	annual growth in % of GDP	% of GDP	% of GDP	% change from previous year	%
Legend	<i>NIIP</i>	<i>PSCF</i>	<i>GED</i>	<i>PSD</i>	<i>FSL</i>	<i>REER</i>
Threshold values	<b>-35</b>	<b>14</b>	<b>60</b>	<b>133</b>	<b>16,5</b>	<b>121.4005</b>
2011	-24.7	39.1	77.4	104.5	10.5	99.39
2012	-28	8.9	76.8	106.6	4.3	101.46
2013	-35.1	48.5	77.8	112.5	13.6	97.92
2014	-37.6	78.4	95.8	123.9	11	76.67
2015	-36.1	-30.2	131	121.6	17.7	71.41
2016	-29.1	24.6	121.7	110.6	10.2	71.04
2017	-24.1	16.5	103.9	92.6	2.7	74.73
2018	-16.8	27.3	87.7	43.7	3.8	79.53
2019	-18	30	79.2	44.8	1.69	91.64
2020	-13.6	29.4	80.8	45.9	2.67	91.05
2021	-9.73	17.38	74.35	18.09	5.16	95.13
2022	-10.02	0.12	118.09	6.28	11.13	65.53

Source: developed by the authors

Forecasting results for 2021–2022 (Table 2.11) make it possible to determine the deviations of the Ukrainian economy from the sustainable development trajectory in 2021, as evidenced by the values of the indicators of gross external debt and lending to the private sector of the economy, which deviate from the threshold values (the values of the indicators that have exceeded the corresponding threshold values are highlighted in shading). According to forecasts in 2021, Ukraine will improve the indicator of its net international investment position, but its value will still take a negative value, which means that it will maintain its position as an active net borrower and a consistently high amount of external debt required to equalize the balance of payments. This situation will continue to put pressure on the national currency, causing assessment processes and increasing the private sector's need for additional resources, while reducing the private sector's ability to act as a source of investment in the economy, including through financial intermediaries (financial corporations).



**Fig. 2.9** Practical implementation of the developed regression model (2) with effective indicators reflects the dependence of the probability of the onset of a period of «crisis» for the Ukrainian economy on a number of economic indicators

Source: developed by the authors

The combination of these factors allows the authors to predict the REER at the level of 95.13 %. Strengthening REER in 2021 compared to 2020 worsens the conditions of foreign trade for domestic exporters, mainly due to a decrease in the competitiveness of their goods in foreign markets, and at the same time improves them for importers. As a result, this situation causes an excess of demand for foreign currency over its supply in the domestic foreign exchange market,

again intensifies the assessment of the national currency and will force the National Bank of Ukraine to intervene in the foreign exchange market and look for sources of funds to replenish gold and foreign exchange reserves (again, this is for account of external borrowings). As a result, the forecast for 2022 provides for an increase in the volume of external debt, an increase in the negative value of the net investment position, a reduction in the possibilities of the private sector of the economy, and a strengthening of the REER against the background of the assessment of the hryvnia.

However, the inertial development of the forecast situation can be suspended by corrective measures of economic policy on the part of the macroeconomic regulation bodies, namely:

1) curtailing anti-crisis measures introduced as a result of the COVID-19 pandemic (curtailing such anti-crisis monetary instruments as long-term refinancing and interest rate swap with the NBU);

2) increase in the discount rate, since the real discount rate is 7.5 % lower than its estimated neutral level;

3) restoration of cooperation with the IMF;

4) development of measures aimed at ensuring the protection of the national interests of Ukraine in the context of increased protectionism of other countries, as well as in emergency situations;

5) development of a common Ukraine-EU roadmap for the further development of trade and economic ties and smoothing out the negative impact of measures taken to combat COVID-19.

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