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A CRISIS EARLY WARNING MODEL FOR EURO AREA COUNTRIES

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ABSTRACT

The article summarises the findings obtained in the estimation of an economic crisis early warning model for the euro area countries. These findings show that monitoring five variables that may indicate the emergence of macro-financial imbalances – current account balance, unit labour costs relative to the rest of the euro area, household indebtedness, corporate indebtedness and sovereign risk premium – helps facilitate the early detection of downturns in the euro area countries. As expected, the model points to a widespread euro area-wide increase in the probability of a decline in activity towards the middle of the last decade, just before the start of the Great Recession. Compared with the core euro area economies, the increase in crisis probability was much more pronounced in the periphery countries, driven by a worsening of the current account balance, growing private sector indebtedness and deteriorating competitiveness. In several of these economies, the probability of downturn predicted by the model heightened in 2011-2012, coinciding with the successive sovereign debt crisis episodes. Since then the probabilities of downturn have moderated substantially and are now low in most countries, albeit in some cases still above those observed at the turn of the century.

Keywords: early warning indicators, vulnerabilities, economic crisis forecasting.

JEL classification: C25, C33, E44, E58, G01.

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Introduction

The uneven severity of the Great Recession across economies highlighted the need to gain a better understanding of which are the factors that determine the degree of vulnerability of each country to a hypothetical shock. This need is even more pressing in the context of the euro area, owing to the existing institutional framework, which is characterised by the absence of national sovereignty over monetary policy and the lack of fiscal policy response mechanisms. As the last upturn showed, in the face of asymmetric shocks this may be conducive to the emergence of macro-financial imbalances and may hinder their subsequent correction, since it limits the room for manoeuvre of economic policies. As a result, the global financial crisis of 2007-2008 was exacerbated in the euro area by the subsequent sovereign debt crisis of 2011-2012 and the impact of the downturn was especially acute in the euro area economies that had built up most imbalances.

In any event, both within and beyond the euro area, a high level of consensus has been reached on the importance of the role played by the build-up of macro-financial imbalances as a determinant of the cross-country heterogeneity of the effects of a common shock such as that triggered by the Great Recession. It is, therefore, no surprise that there has been a proliferation of attempts to develop crisis early warning mechanisms, especially among the multilateral institutions that perform regular monitoring of countries' economic situation. The main difficulty in this type of modelling is to detect the variables that may potentially signal the emergence of imbalances and also the levels of these variables that may determine that future downturns are developing.

Thus, in the European ambit, in 2011 the Macroeconomic Imbalance Procedure (MIP) was introduced. The starting point of this oversight mechanism is the Alert mechanism report drawn up annually by the European Commission, which assesses the existence and severity of imbalances that are potentially harmful for macroeconomic stability. This preventive analysis draws on a scoreboard of 14 indicators – relating to the external position of the economy, private sector debt, house prices, the financial system and the labour market – that may be expected to capture the main aspects of existing vulnerabilities. For each variable thresholds are set which, if crossed, denote the presence of risks.

Similarly, the European Systemic Risk Board (ESRB) performs quarterly monitoring of a set of quantitative and qualitative indicators (included in the ESRB Risk Dashboard) to detect any build-up of risk for the financial system. Finally, as the last example, the OECD has proposed a set of more than 70 vulnerability indicators to help detect risks of future crises.[1]

In addition, various studies have attempted to assess how effectively these lists of indicators achieve the purpose for which they were designed, namely to provide sufficient early warning of an approaching crisis. Thus, for example, Kamps et al. (2014) conclude that had the MIP scoreboard indicators been in place before the start of the last downturn, they would have been able to give early warning of the imbalances that were responsible for its severity. The (highly simplistic) approach followed has been to count the number of indicators that crossed the thresholds set in each year analysed.[2]

In other cases, assessing vulnerabilities is rather more complex. In general, the literature uses two empirical proxies:

— In the first, identifying the thresholds (for each of the key crisis prediction indicators) which, if crossed, signal high crisis probability, is crucial. The choice of these thresholds rests on an ad hoc decision as to which type of error is preferred: the model used fails to emit a crisis signal and yet a crisis ensues (type I error); or the model predicts a crisis that fails to materialise (type II error).[3] According to this methodology, the OECD finds that a subset of the more than 70 indicators mentioned above would have predicted past downturns.[4] The IMF obtains similar findings from early warning models that distinguish between different types of crises and between advanced and emerging market economies.[5]

— The second proxy uses a multivariate logistic regression model to estimate the probability of downturn.[6] This type of model may be used

1 See Röhn, Caldera Sánchez, Hermansen and Rasmussen (2015).

2 Thus, for example, in the case of Spain, five of the fourteen scoreboard indicators would have crossed the thresholds set in 2003, six in 2004 and seven between 2005 and 2007.

3 This method – the signalling approach – was originally used for early detection of signals of currency or balance of payment crises in emerging market economies (see, for example, Kaminsky and Reinhart (1999) and Frankel and Rose (1996)). Since the Great Recession, efforts have been geared more towards detecting risks in developed economies.

4 See Hermansen and Röhn (2017). Global risk indicators, such as deviation from their respective trends of global credit (as a proportion of GDP) or of a global house price or stock market index, stand out in particular for their predictive power.

5 See Basu, Chamon and Crowe (2017) who argue that fiscal, balance of payment and "economic" crises (the latter identified as declines in GDP) may each respond to different causes, thus justifying the design of specific early warning tools for each type of crisis.

6 See Martín Machuca (2017) for an analysis of the determinants of balance of payment crisis episodes in euro area economies.

to predict variables that may take a limited number of values (in the case described here, just two, that is, whether or not the downturn materialises) as a function of various independent variables. This is the methodology used here and it has the advantage of permitting statistical contrast analysis of the significance of the indicators.

Specifically, after this introduction, the second section of the article describes the model estimated for early identification of economic crises in the euro area countries and sets out the results obtained. In the third section, these findings are used to analyse which factors have had the most impact, according to the model used, in explaining the crises recorded in the sample period available.

Estimation of a multivariate logistic regression model for early identification of economic crises for the euro area countries

The model, estimated for the whole of the euro area drawing on annual country-level data, predicts the probability of a decline in activity (measured by real GDP) in a specific year. Data for the period between 1990 and 2018 are used for the estimation, for each of the 19 euro area countries. Where complete data are not available, the sample is limited to the time period that is available. This is the case of the countries that joined the euro area most recently (in the middle of the last decade), for which the necessary data for the analysis are only available for the years 2005-2018.

The probability of a contraction in GDP, obtained using a logistic regression model, is linked to economic and financial indicators that, in accordance with the economic literature, may reflect a build-up of vulnerabilities which, in the face of a specific shock, may result in a downturn. In any event, the subset of indicators finally included in the model is selected from among those described above according to their empirical capacity to explain the probability of a decline in GDP. Specifically, there are five indicators in the final specification that capture imbalances in the financial position of the private sector and in public finances and vis-à-vis the rest of the world. All these variables are lagged by one period.

Regarding external imbalances, the model contains two variables: current account balance as a proportion of GDP (specifically, the average in the three years previous to the year considered) and the change in the unit labour costs (ULCs) of the country considered compared with those of its euro area competitors (in terms of the cumulative change in the same period). Persistent external trade deficits will increase a country's external debt, which heightens its vulnerability in face of possible shifts in investor sentiment. This effect is exacerbated in the case of an economy that belongs to a monetary union, as it is unable to use the

exchange rate as an adjustment mechanism. In consequence, the adjustment must be based on either productivity growth or internal devaluation, or in other words on price and wage growth below the levels recorded in the monetary union overall. However, an external deficit is not always a sign of loss of competitiveness; in some cases it may simply reflect optimum allocation of resources when presented with more favourable investment opportunities. The inclusion in the model of relative ULCs is precisely geared to detecting the more benign causes of an external deficit.

Imbalances in the private sector's financial position are a source of vulnerability insofar as rapid growth in households' and non-financial corporations' indebtedness often leads to banking crises.[7] Growing credit to private agents makes for a higher interest burden that may prove difficult to bear in the event of negative income shocks. For this reason, the model includes the household debt ratio (as a percentage of households' disposable income) and the change in the corporate debt ratio (as a proportion of GDP). The last variable included in the model is the 10-year government bond yield spread of the country analysed over the German equivalent. This variable reflects the cost of borrowing for both private and public agents and may also indicate the risk of general government default perceived by the markets. The euro area sovereign debt crisis highlighted the harmful connection between a country's public finances and its banking system. The connection implied that governments might have to issue debt to recapitalise the banks under their jurisdiction; in turn, the higher sovereign risk resulting from the increase in government debt could generate portfolio losses for banks and hamper their wholesale funding.

Table 1 presents the findings obtained from an estimation of the model described. The second column shows the coefficients estimated for each of the explanatory variables. As expected, these indicate that an increase in an economy's ULCs relative to those of the rest of the euro area raises the probability of a decline in its GDP (owing to the loss of competitiveness it entails). A wider spread between a country's government bond yield and the German equivalent (which for a given German bond yield entails higher borrowing costs for both the public and the private sector) also increases that probability. Likewise, higher household or corporate indebtedness raises the probability of downturn, as it reduces the room for manoeuvre that these agents have to address unexpected adverse events. The opposite is true in the case of a build-up of external surpluses, since they favour a decline in the debt assumed with the rest of the world and thus translate into greater economic strength.

As logistic regression models are not linear, the coefficients obtained do not directly reflect the scale of the marginal impact of changes in each of the explanatory

7 See, for example, Borio and Lowe (2002).

Table 1

DETERMINANTS OF PROBABILITY OF DOWNTURN IN THE EURO AREA. FINDINGS OF A LOGISTIC MODEL (a)

	Estimated coefficients		Marginal impacts (in pp) of changes in explanatory variables when at their:					
			Average level	2000 levels	2007 levels	2011 levels	2011 levels (h)	2018 levels
Explanatory variables	Coeff.	(g)						
Current account balance (b)	-0.25	***	-1.7	-1.8	-2.3	-3.1	-4.2	-1.8
Change in relative ULCs (c)	0.11	***	0.7	0.7	0.9	1.3	1.8	0.7
Household indebtedness (d)	0.04	***	0.3	0.3	0.4	0.5	0.7	0.3
Growth in corporate indebtedness (e)	0.07	**	0.4	0.5	0.6	0.8	1.1	0.5
Government bond yield spread (f)	0.51	***	3.3	3.6	4.6	6.1	8.5	3.6
Estimation period	1990-2018							
Number of observations	349							
Adjusted R^2	34.3%							

SOURCE: Own calculations.

a The model is estimated drawing on annual country-level data for the euro area Member States and includes fixed country-level effects.
b Average for the last three years. Lagged by one period.
c Cumulative change in the last three years. Lagged by one period.
d Household debt-to-GDI ratio. Lagged by one period.
e Corporate debt-to-GDP ratio. Lagged by one period.
f Spread between a country's government bond yield and the German equivalent. Lagged by one period.
g ***, ** denote statistical significance at 1% and 5%, respectively.
h For the subset of countries made up of Cyprus, Greece, Spain, Ireland, Italy and Portugal.

variables on crisis probability (although they do reflect the sign of the impact). In this model, the size of the impact will depend both on the level of the variable that records the increase and the level of all the other variables. For example, the impact on crisis probability of an increase in relative ULCs will depend on the level of the ULCs and also on the level of all the other variables entered into the specification. For purposes of illustration, the third column of Table 1 shows the marginal impact on crisis probability of each of the explanatory variables when they are all at their average level. When this marginal impact is assessed on average for all the countries in the sample, a deterioration in the current account balance of 1 pp of GDP in the average of the three years previous to the year considered drives up the probability of a contraction in activity by 1.7 pp.

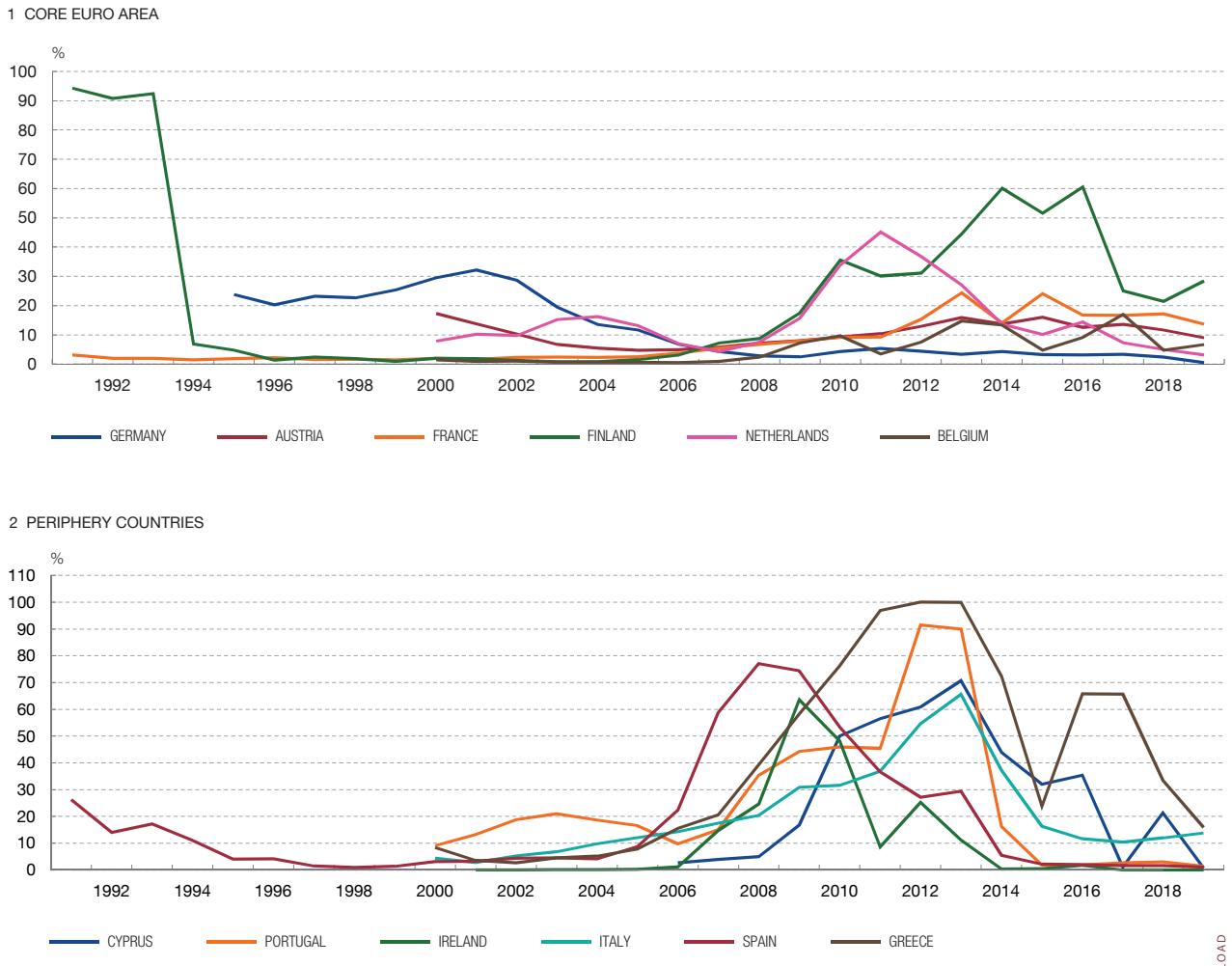
Chart 1 shows the probability of decline in GDP given by the model for each country in the years for which there are data available. As the chart shows, this probability follows an upward path in most euro area countries between the middle of the last decade and 2013, albeit starting from generally low levels.[8] Among the core euro

8 The model also signals very high probabilities of downturn at the start of the 1990s in Finland, which at that time was in the throes of a severe banking crisis. It predicts more moderate (albeit also high) probabilities of contraction in GDP for that period for Spain, despite the downturn in the Spanish economy at that time.

Chart 1

ESTIMATED PROBABILITY OF ECONOMIC CRISIS FOR THE EURO AREA COUNTRIES, 1991-2019

The increase in the probability of a decline in activity was more pronounced in the periphery than in the core euro area countries immediately before the Great Recession. In recent years this probability has decreased substantially.



SOURCE: Own calculations.

area countries, the probability of downturn in this period increased modestly in Germany, Belgium and France, but it rose more significantly in Spain, Greece, Ireland, Portugal and, to a lesser extent, Italy. In the first decade of the century, the growth in this probability in these countries was linked above all to a deterioration of the external balance, an increase in household indebtedness and, in some cases, to more marked relative increases in ULCs than in previous years. However, at the start of the current decade, the most significant factor in explaining this upward path was the growth in risk premia, especially in Greece and Portugal. In these years, the model identifies high probabilities of a decline in GDP in these countries, despite the external balance and ULC adjustments made during the first years of the crisis, owing to the persistently high levels of their risk premia. Since then the probabilities

of downturn have moderated substantially and were, on the data available up to 2018, low in most countries.[9]

One way to assess the goodness of fit of these early warning models is to analyse the downturns observed in the euro area Member States during the period under study.[10] In the case of the model estimated here, taking a threshold of 24% for the estimated probability of contraction in GDP, the model would correctly anticipate 72% of the crises recorded in the sample and would have incorrectly alerted of a downturn in 14% of cases in which there was no subsequent decline in activity (type II statistical error).[11]

Analysis of the impact of economic and financial variables on the probability of downturn

As explained in the previous section, the impact of changes recorded in each of the explanatory variables on the probability of a contraction in GDP is not constant, but depends on the level of each variable (and all the other variables included in the specification). Thus, for example, if household indebtedness is low, an increase in household liabilities of 1% of their gross income would have a smaller impact on the probability of a contraction in GDP than if the increase were to arise against a backdrop of higher household indebtedness. In addition, depending on the starting point, if several imbalances were to build up simultaneously this may give rise to a more than proportional increase in the probability of a downturn compared with a hypothetical situation in which only one of those imbalances were to present deterioration.

Chart 2 illustrates how the probability of a decline in GDP predicted by the model varies according to the level of each of the explanatory variables. For example,

9 In 2019, numerous euro area economies have recorded a significant weakening in activity. The models that predict GDP growth according to a set of short-term monthly indicators have shown increases in the probability of downturn. This deteriorating outlook for activity in the short term has been determined by the gradual intensification of various sources of uncertainty affecting the global economy (such as the trade tensions between the United States and China and the Brexit process). Nevertheless, on the data available up to 2018, the model used in this article has not signalled an increase in the probability of downturn in 2019. This is because in 2019 the above-mentioned factors of uncertainty have not had an appreciable effect on the variables that capture the risk of decline in GDP in the model.

10 As indicated in the introduction, the proportion of events correctly classified as downturn/absence of downturn is the criteria used in the design of models in the other large family of empirical proxies for assessing the validity of early warning indicators.

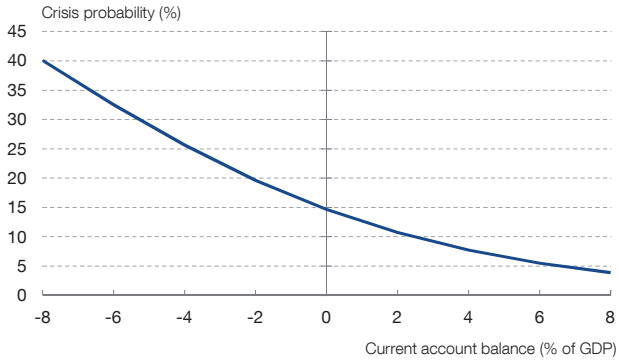
11 The 24% threshold was chosen so as to foresee the bulk of the downturns recorded in the estimation period and, at the same time, minimise the type II error described in the introduction. If the threshold were reduced (raised), the model's capacity to predict future crises would increase (decrease), but the proportion of incorrect alert signals (a recession is predicted but does not occur) would also increase (decrease).

Chart 2

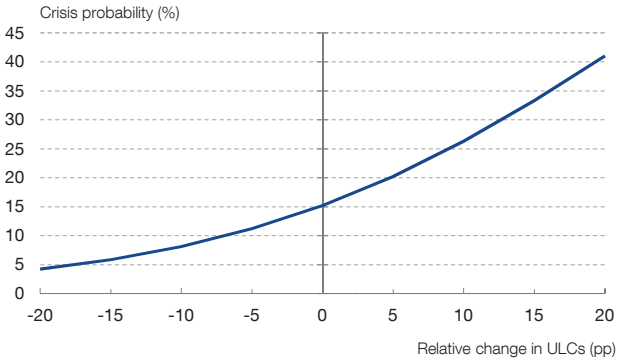
ANALYSIS OF THE IMPACT OF CHANGES IN A COUNTRY'S ECONOMIC AND FINANCIAL SITUATION ON CRISIS PROBABILITY

The impact of changes in the determinants of crisis probability on that probability is uneven; the more adverse the starting point (i.e. a high current account deficit, high private sector indebtedness, higher ULC growth than among competitors, or a high risk premium), the greater the impact.

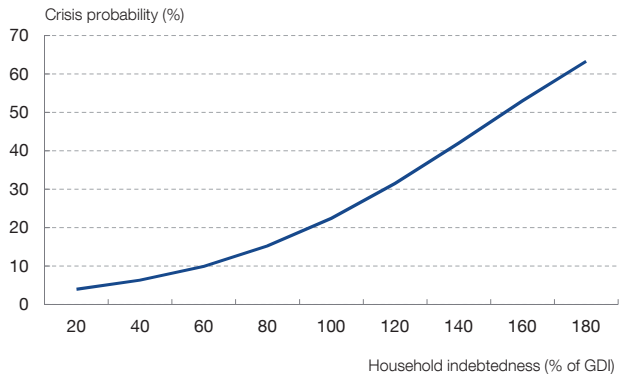
1 AVERAGE CRISIS PROBABILITY AS A FUNCTION OF CURRENT ACCOUNT BALANCE



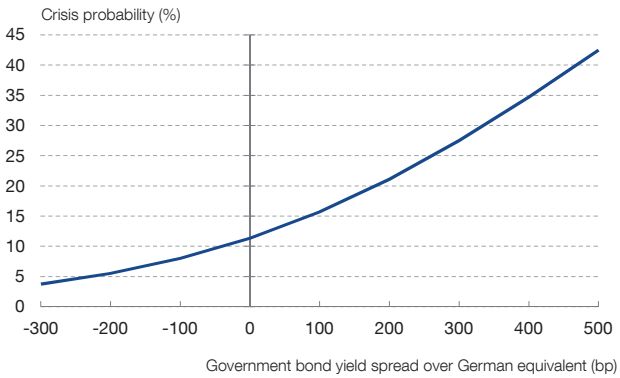
2 AVERAGE CRISIS PROBABILITY AS A FUNCTION OF ULCs RELATIVE TO THE REST OF THE EURO AREA



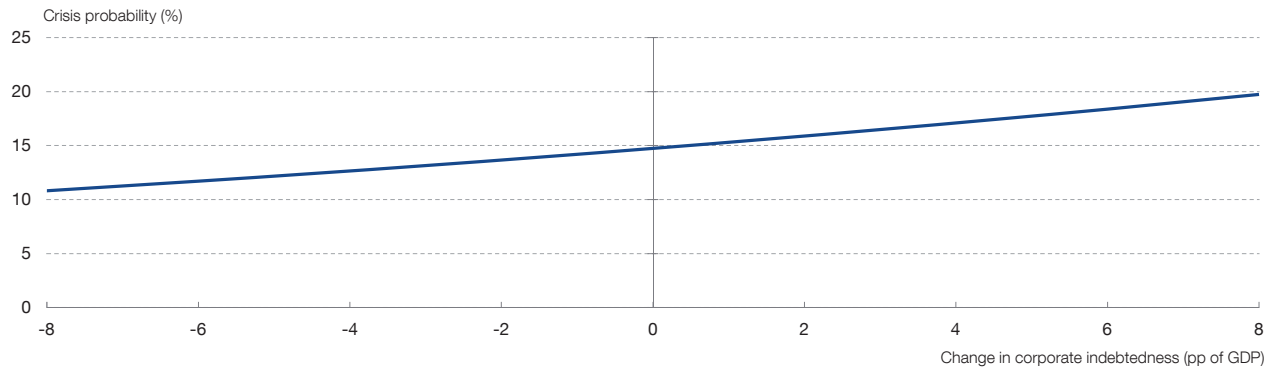
3 AVERAGE CRISIS PROBABILITY AS A FUNCTION OF HOUSEHOLD INDEBTEDNESS



4 AVERAGE CRISIS PROBABILITY AS A FUNCTION OF THE 10-YEAR GOVERNMENT BOND SPREAD OVER THE GERMAN EQUIVALENT



5 AVERAGE CRISIS PROBABILITY AS A FUNCTION OF CHANGE IN CORPORATE INDEBTEDNESS



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SOURCE: Own calculations drawing on the findings of the model presented in Table 1.

Chart 2.1 presents the average probability of downturn according to the level of the external surplus (as a percentage of GDP), once all the other variables included in the model are set, for each year and each country, at their observed levels. As the chart shows, this probability declines as the current account balance improves. But the impact is uneven: the larger the current account deficit, the greater the impact. Thus, on average, an improvement in the external deficit from -8% to -6% of GDP reduces the risk of a decline in activity by 7.5 pp, whereas an increase in the surplus from 6% to 8% reduces it by just 1.6 pp.

Likewise, as Chart 2.2 shows, when ULCs record much more pronounced declines (in cumulative terms over three years) than in the euro area countries overall, the already low crisis probability is relatively little affected by a further decline in those relative costs. Conversely, the greater the loss of competitiveness suffered by the economy, the more marked the impact. In particular, when the change in relative ULCs is -10 pp, a further 5 pp reduction translates on average into a decline of 2 pp in the probability of downturn the following year, whereas when the change is 10 pp, an equivalent reduction of 5 pp in relative ULCs has an impact of 7 pp on that probability.

An increase in the sovereign debt spread over the German equivalent also has a very different impact on the average probability of downturn according to the starting point: the impact is much more pronounced when the spread is wider than when it is narrow (or negative). By contrast, the effect of changes in corporate indebtedness on the probability of a decline in GDP is relatively even and less pronounced than in the case of other variables.[12]

Accordingly, the marginal effects of changes in the explanatory variables on the probability of a decline in GDP presented in the third column of Table 1, which have been assessed assuming that those variables are at their average level, may differ substantially from those recorded under alternative scenarios. For instance, these impacts may be much more pronounced if assessed in the wake of a prolonged build-up of substantial macroeconomic or financial imbalances. For purposes of illustration, the right-hand columns of Table 1 present the marginal impact that changes in the explanatory variables have on the average probabilities of a decline in GDP when those variables are at their 2000, 2007, 2011 and 2018 levels. As the table shows, those marginal impacts were higher in 2007, following the build-up of imbalances observed in many euro area countries during the upturn that preceded the crisis, than at the start of the decade. The estimated impacts were also higher in 2011, even though by then there had been a significant correction in many countries

12 It should be noted that as this variable is inputted into the model as differences rather than levels, comparison with, for example, the findings presented in Chart 2.3 on the household debt ratio is not straightforward.

of the macroeconomic vulnerabilities built up in previous years. The reason for this is the considerable rise in many countries' risk premia, against the backdrop of the sovereign debt crisis. This explains why the 2011 marginal impacts are even higher when calculated for the group of countries most affected by that crisis (see the seventh column of Table 1).[13] In 2018, once debt market tensions had been corrected and the macroeconomic imbalances built up in previous years had shrunk, the marginal effects would be close to those of the early years of the century.

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13 Namely Cyprus, Greece, Spain, Ireland, Italy and Portugal.

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