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Working Papers Liechtenstein Institute No. 70 (2021)

LIECHTENSTEIN-INSTITUT

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Working Papers Liechtenstein Institute No. 70 (2021)
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http://dx.doi.org/10.13091/li-ap-70

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On the structural determinants of growth-at-risk

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June 8, 2021

Abstract

We examine structural differences in growth vulnerabilities across countries resulting from time-varying financial risk. Considering differences in trade openness, financial sector size, the public spending ratio and government effectiveness, our findings suggest the existence of both a *structural gap* as well as a *risk sensitivity gap* when estimating growth-at-risk (GaR) across countries. Hence, structural factors do not only drive level-differences in GaR, but also give rise to differences in the responsiveness of GaR to varying levels of risk. Furthermore, we show that structural factors affect the term structure of GaR, with the impact of structural characteristics varying over the forecasting horizon. A proper understanding of structural factors in the context of the GaR framework is particularly important to facilitate the use of the concept in macroprudential policy.

JEL classification: E27, E32, E44, F43, G01, G20, G28

Keywords: Growth-at-risk; vulnerable growth; structural factors; macroprudential policy

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1 Introduction and motivation

The empirical growth-at-risk (GaR) approach, as originally introduced by Adrian et al. (2019a, 2020), has recently gained traction among policy-makers as an intuitive concept to quantify systemic risk. While standard forecasts usually focus on the expected value of GDP growth, the GaR concept puts a particular emphasis on the probability and magnitude of potential adverse outcomes. By using quantile regression methods, GaR focuses on the downside risk implied by the conditional forecast through the estimation of a particular low quantile (e.g. the 10th percentile) of the projected GDP growth rate distribution over a given time horizon (see Figueres and Jarociński, 2020, for an application to the euro area). In other words, GaR measures the conditional probability that the actual growth rate falls below the GaR threshold calculated in percentage terms (e.g. 10%).

In the last few years, the GaR concept has been extended in various directions. In the original approach, Adrian et al. (2019a) explicitly take into account financial conditions and show that the left tail of the distribution of GDP growth is less stable and more affected by financial conditions than the mean and the upper side of the distribution. Recent empirical studies have also highlighted the term-structure of GaR, i.e. that the sensitivity of downside risks to growth depends on the respective time horizon. This finding does not only imply differing term structures when considering different risk indicators, but also a possible intertemporal trade-off, i.e. lower growth vulnerability at medium and long horizons may come at the cost of lower expected growth (or GaR) in the short term (Adrian et al., 2020). While financial conditions and/or financial stress indicators have turned out to be highly relevant for the conditional GDP growth distribution at relatively short time horizons (i.e. up to one year), risk indicators from the financial cycle literature have also been introduced into the GaR framework. In this context, recent empirical studies indicate that external imbalances, excessive credit growth and house price booms are associated with increasing growth vulnerabilities in the medium term, typically defined as longer time horizons between six quarters and five years (Aikman et al., 2019; Arbatli-Saxegaard et al., 2020; Duprey and Ueberfeldt, 2020). By linking observed financial risk indicators as well as policy indicators to the distribution of projected growth outcomes, the GaR concept is also increasingly used as a measure of systemic risk at the individual country level (see, for instance, Prasad et al., 2019; Adrian et al., 2019b; ESRB, 2019). In this framework, the application of the GaR concept enables policymakers to quantify the probability of adverse scenarios, thereby facilitating an appropriate and timely policy reaction. Consequently, previous studies have already confirmed that such downside risks can at least partially be mitigated by respective policy measures, e.g. by increasing the capitalization of the banking system (Aikman et al., 2019) or by applying other macroprudential or monetary policy instruments (Franta and Gambacorta, 2020; Galán, 2020; Duprey and Ueberfeldt, 2020). Furthermore, by examining the impact of various policy variables on the vulnerability of GDP growth, the GaR concept can also be used as a potential measure for the current stance of macroprudential policy to safeguard financial stability (ESRB, 2019; Suarez, 2021).

While the GaR literature is evolving rapidly, both with respect to theoretical foundations of the GaR approach as well as possible policy applications, our study contributes to this strand of literature by putting a particular emphasis on structural country characteristics and their impact on empirical GaR estimates. The empirical estimation of the effect of various risk indicators and/or policy variables on the projected conditional GDP distribution is typically based on quantile panel estimations covering a range of countries, also to increase the number of observations and thus the accuracy of the estimation. To apply the concept in a policy context at the individual country level, however, it is important to properly understand the impact of structural country characteristics on the respective empirical results. Structural factors can play an important role in at least three dimensions (see also Suarez, 2021). First, countries can differ in their "standard" GaR values, i.e. the average GaR over time. While this *structural gap* could be accounted for by including country fixed effects, it is nevertheless important to understand the drivers behind the cross-country differences in GaR values, particularly from a policy perspective. Second, the effect of varying risk on GDP vulnerability, as expressed by GaR, may differ across countries. Such a *risk sensitivity gap* would become apparent when GaR estimates in individual countries show different reactions to similar changes in the risk indicator due to structural country characteristics.[1] Finally, structural differences across countries could lead to a different effect of policy measures on the respective GaR, which can be referred to as the *policy sensitivity gap*. While some papers take into account selected country properties in their estimations (e.g. Arbatli-Saxegaard et al., 2020, by considering the fixed exchange rate regime in Norway) or discuss this issue as an important area of future research (Suarez, 2021; O'Brien and Wosser, 2021), such structural country characteristics have not been examined systematically so far in the respective strand of literature. This is surprising, as the empirical GaR measure typically does not only fluctuate substantially in the time dimension, but also across countries. A better understanding of the structural factors driving those differences across countries is a

[1] Please note that Suarez (2021) refers to this risk sensitivity gap as the *gap vulnerability to risk*.

prerequisite to extend the use of the GaR concept in the context of policy design and assessment, as such structural factors have to be taken into account when comparing GaR measures (and the corresponding policy reactions) across countries. Our paper aims at filling this important gap in the literature by specifically focusing on the former two issues, i.e. the *structural gap* and the *risk sensitivity gap*. On the one hand, we examine possible drivers of the *structural gap* across countries by including various structural country characteristics in the panel quantile regression. As a result, we are able to shed light on the drivers of structural determinants of GaR across countries which are usually captured by country fixed effects. On the other hand, we examine the interactions between structural characteristics and the respective risk indicator. Thereby, we investigate the impact of differing structural characteristics on the sensitivity of the GaR value with respect to the risk indicator, thus quantifying the respective *risk sensitivity gap* due to specific structural factors.

The literature on potential structural determinants of GaR is very scarce thus far, although earlier studies specifically mention possible effects of structural country characteristics as an important area of future research (see, for instance, Suarez, 2021; O'Brien and Wosser, 2021). With respect to the *structural gap*, we consider trade openness, the public spending ratio, financial sector size and a measure of government effectiveness as potential structural drivers of GaR. By including interaction terms of these structural characteristics with the respective risk indicators, we are also able to estimate the *risk sensitivity gap*, i.e. the impact of the included structural factors on the sensitivity of growth vulnerabilities to the respective risk indicators. While our empirical approach allows us to explicitly estimate the effects of these structural factors on GaR at the individual country level, other structural country properties are still captured by the country fixed effects in the panel estimation.

While there are no papers specifically examining the effect of structural factors on GaR, our hypotheses are based on two related strands of the economic literature. First, the country characteristics that we consider were identified to play a crucial role in explaining the output decline in the global financial crisis and cross-country variation in business cycle volatility (see, among others, Blanchard et al., 2010; Lane and Milesi-Ferretti, 2011; Rose and Spiegel, 2011; Crucini et al., 2011). From an ex post perspective, the financial crisis was associated with high GaR. Characteristics that explain the realized output decline in the financial crisis may therefore also drive GaR estimates. Second, factors that explain heterogeneities in observed business cycle volatility might also help to understand GaR across countries. With respect to trade openness, previous studies suggest a positive link to GDP volatility (see, for instance, Kim et al., 2016), also because higher trade openness is associated with higher degrees of specialization in an economy. On the other hand, the low correlation of tradable sectors to the rest of the economy tends to reduce overall volatility. Nevertheless, the empirical link between the two variables remains positive (di Giovanni and Levchenko, 2009; Loayza and Raddatz, 2007), thus suggesting a negative effect of higher trade openness on GaR. On the contrary, the impact of public expenditures and taxation on output volatility is discussed more controversially in the literature. Posch (2011) finds that the variance of output growth is affected by the level of taxes, whereby the direction of the effect depends on the type of taxes. Collard et al. (2017) argue that larger governments can mitigate volatility arising from technology and preference shocks, but may amplify volatility from expenditure shocks, resulting in a non-linear relationship between the two variables. As a result, the empirical effect remains ambiguous. Carmignani et al. (2011) report a positive link between government size and volatility, while earlier studies find a negative effect of public expenditures or government size on GDP growth volatility (Galí, 1994; Fatás and Mihov, 2001). Regarding the size of the financial sector, empirical studies point to a dampening effect of more developed financial sectors on the volatility of GDP, consumption and investment (Denizer et al., 2002; Manganelli and Popov, 2015), although the effect seems to be less pronounced compared to trade openness and the transmission channel may work via other structural country characteristics (Loayza and Raddatz, 2007). In a similar vein, Beck et al. (2006) find that well-developed financial intermediaries dampen the effect of real sector shocks and thus output volatility. At very high levels of financial depth, however, the effect weakens or even reverses, with high financial depth amplifying consumption and investment volatility (Dabla-Norris and Srivisal, 2013). Finally, government effectiveness is generally found to be negatively linked to GDP volatility (see, for instance, Evrensel, 2010), and is therefore likely to be positively linked to GaR. Summing up, previous literature suggests higher GDP growth volatility with increasing trade openness and decreasing levels of government effectiveness. The empirical effect of the ratio of public expenditures remains ambiguous, and the impact of financial sector size may depend on the respective level of financial development, potentially resulting in a non-linear relationship between the two variables.

Our empirical analysis does not only shed light on whether these hypotheses also hold in the context of the GaR framework, i.e. whether these factors significantly contribute to the *structural gap* in GaR, but we are also able to examine the *risk sensitivity gap* with respect to the included structural country characteristics. We find that structural country characteristics indeed play an important role in shaping cross-country variations in GaR. Both the *structural* *gap* as well as the *risk sensitivity gap* contribute significantly to structural differences of GaR across countries, whereby the magnitude of the effect differs by the respective risk indicator (i.e. financial conditions vs. credit growth) as well as by the respective time horizon. Higher trade openness and larger financial sectors lead to a structurally lower GaR value, particularly at longer time horizons.Higher levels of government effectiveness decrease GDP vulnerability across all time horizons, while the stabilizing role of a high public spending ratio is limited to the short run. The *risk sensitivity gap* seems to be most pronounced with respect to the public spending ratio and trade openness, but play a less significant role in the context of financial sector size and government effectiveness. More precisely, a larger public spending ratio tends to decrease the risk sensitivity, at least in the short run. On the contrary, higher trade openness increases the sensitivity to increasing risk from credit booms both in the short and medium run. At the same time, higher levels of trade openness decrease the risk sensitivity with respect to financial conditions. We also find evidence for non-linearities in the way how financial sector size and government effectiveness affect GaR, at least at some forecasting horizons. However, these effects are relatively small in magnitude compared to the overall effects of the respective structural characteristics (i.e. the structural gap). Overall, our study highlights the importance of structural factors when estimating GaR at the individual country level. We show that both the structural gap as well as the risk sensitivity gap play an important role, with the impact of structural factors varying with different time horizons, i.e. the term-structure of GaR may also be driven by structural country characteristics.

The paper is structured as follows. Section two explains our empirical methodology and introduces a framework to examine both the structural gap and the risk sensitivity gap in the context of panel quantile regressions. Section three shows the empirical results, including our panel quantile estimations, the impact of the structural characteristics on the GaR term structure, and the predicted GaR at the individual country level with and without taking into account structural factors. Finally, section four draws some conclusions and briefly explains the policy implications of our empirical results.

2 Empirical approach

2.1 Data

Our analysis is based on a cross-country unbalanced panel dataset using time series from 24 European economies[2], over the period 1999Q1-2018Q4. The sample includes all European economies for which a country-specific financial stress measure and the credit-to-GDP ratio are available. For these countries, we construct the annualised GDP growth rates using the quarterly seasonally adjusted real GDP provided by Eurostat. The logarithm of these time series, $y_{i,t}$, are then converted into the annualised growth rates of h horizons, where $y_{i,t+h} = \frac{(y_{i,t+h} - y_{i,t})}{h/4}$. This allows for a comparison of the explanatory variables over different time horizons.

In line with previous literature, we include a measure of financial stress as an explanatory variable. In our first model, we use the Composite Indicator of Systemic Stress (CISS) developed by Hollo et al. (2012) and published by the ECB as a measure of European-wide financial stress. The CISS aggregates five market-specific subindices on the basis of weights reflecting their time-varying cross-correlation structure. Thus, the CISS takes account of both the level of individual subindices as well as the number of indicators suggesting high financial stress. Thus, the CISS will react stronger if more indicators show signs of financial stress simultaneously. In the second estimation, we follow a more traditional GaR framework and use country-specific financial stress measures, i.e. the Country-Level Index of Financial Stress (CLIFS), introduced by Duprey et al. (2017). The construction of the index follows the approach of Hollo et al. (2012). Using both the CISS and the CLIFS allows us to check whether the impact of country characteristics on the GaR is already implicitly captured by the country-specific financial stress measures.

While financial stress measures are highly relevant for short-term GaR estimations, credit growth is frequently used as a signal for medium-term financial imbalances. The BIS publishes credit-to-GDP ratios for a wide range of countries. We use the 2-year average of the log differences of the credit-to-GDP ratio as a measure of credit growth.

Finally, for each country, we collect time series of four different structural characteristics: Trade openness, which we define as the ratio of exported goods to GDP; the size of the financial sector, defined as the ratio of gross value added of the financial sector to GDP; the ratio of public expenditures to GDP[3]; and government effectiveness as measured by the Worldwide

[2] Austria, Belgium, Bulgaria, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden.

[3] The data for the first three country characteristics is obtained from Eurostat.

Governance Indicators (WGI) project (Kaufmann et al., 2011). To make the coefficients in our estimations comparable across all explanatory variables, all included factors are standardized with a mean of zero and a standard deviation of one.

2.2 Growth-at-Risk (GaR) methodology

Following Adrian et al. (2019a) we rely on quantile regressions, developed by Koenker and Bassett (1978), to estimate GaR. Because of the multi-country setup, we employ a panel quantile regression framework. A major concern when estimating panel quantile regression is the large number of fixed effects (α_i) for every cross-sectional unit, especially when N is large and T relatively small (Koenker, 2004). However, as T is much larger than N in our case, coefficients can be estimated consistently (Galvao and Montes-Rojas, 2015; Adrian et al., 2020). We follow previous research and include fixed effects for each country resulting into country-specific intercepts at each quantile (τ).[4]

Quantile regressions allow us to estimate the differential effects of the conditioning variables on the distribution of the dependent variable. In our study, we are mainly interested in the effects on the lower part of the distribution of the dependent variable, i.e. the effects on GaR. In our model, the dependent variable, y_{t+h}, is the annualized GDP growth one-quarter to sixteen-quarters ahead ($h = 1, 2, 3, ..., 16$) and the vector of conditioning variables, X_t, includes a constant, current GDP growth, a measure of financial stress and credit growth, as well as the structural characteristics we are mainly interested in. Consider the quantile function

$$\hat{Q}_{y_{i,t+h}|X_{i,t},\alpha_i}(\tau \mid X_{i,t}, \alpha_i) = \hat{\alpha}_{i,\tau} + X_{i,t}\hat{\beta}_\tau \tag{1}$$

where α is the fixed effect, τ denotes quantiles, t the time and i the various countries. For each quantile τ, $\hat{\beta}_\tau$ is estimated by minimising the quantile weighted absolute value of errors:

$$(\hat{\beta}_\tau, \hat{\alpha}_{i,\tau}) = \arg\min_{\alpha_i,\beta_\tau} \sum_{i=1}^{n} \sum_{t=1}^{T-h} \rho_\tau(y_{i,t+h} - X_{i,t}\beta_\tau - \alpha_i) \tag{2}$$

where ρ_τ is the standard asymmetric absolute loss function.

Below, as a measure for GaR, we use the predicted 10^{th} percentile (in line with e.g. Figueres and Jarociński, 2020), hence $\tau = 0.1$.

To assess the effect of structural characteristics on GaR, $X_{i,t}$ includes structural country

[4] For inference we use the (x,y)-pairs bootstrap method developed by Freedman et al. (1981), as employed in e.g. Galvao and Montes-Rojas (2015), with 1000 bootstrap samples.

characteristics which we evaluate in the panel quantile regression. As explanatory variables, we consider various structural factors, such as trade openness, the size of the financial sector, the public spending ratio, and government effectiveness.

In variants of the model, we consider interactions between the financial risk indicators and the included structural characteristics to take account of possible non-linearities. It is well documented that high financial stress leads to a widening of the lower tails of distribution of projected growth (Adrian et al., 2019a). We thus introduce interactions to evaluate whether this form of non-linearity is further reinforced through structural country characteristics. By interacting the structural characteristics with the risk indicators, we allow the effects of the structural factors to vary depending on current financial conditions and observed credit growth.

Note that the coefficients of the structural country characteristics help to detect *structural gaps* indicating whether these structural factors are associated with generally lower or higher GaR. The extent to which non-linearities in the impact of the risk indicators are prevalent is indicative for the existence of *risk sensitivity gaps* highlighting particular sensitivities (i.e. varying responsiveness of GaR) in the face of high financial stress or credit growth.

Including interaction terms, we estimate the following panel quantile regression model:

$$\hat{Q}_{y_{i,t+h}|X_{i,t},\alpha_i}(\tau \mid X_{i,t}, \alpha_i) = \hat{\alpha}_{i,\tau} + X_{i,t}\hat{\beta}_\tau + Z_{i,t} \times FSI_{i,t}\hat{\nu}_\tau + Z_{i,t} \times Credit_{i,t}\hat{\gamma}_\tau \tag{3}$$

where $\alpha_{i,\tau}$ denotes the fixed effects, $Z_{i,t}$ is a subset of vector $X_{i,t}$ comprising structural country characteristics, and $FSI_{i,t}$ and $Credit_{i,t}$ denote financial conditions and credit growth, respectively, which are also elements of $X_{i,t}$.

3 Results

3.1 Main results

First, we consider the CISS measure (Hollo et al., 2012) as a risk indicator, which is an aggregate measure of financial stress that does not vary across countries. The fact that we use one and the same risk indicator across countries permits us a direct interpretation of how the propagation of financial stress to growth vulnerabilities is linked to country-specific structural factors. On the contrary, credit growth is country-specific. All measures in the regression are standardized to facilitate a direct comparison of the various factors in terms of magnitude.

Table 1 shows coefficient estimates for the conditional 10th percentile for different speci-

Table 1: Main results – CISS and credit growth

	Model 1		Model 2	
	$h=4$	$h=12$	$h=4$	$h=12$
	(1)	(2)	(3)	(4)
CISS	-2.386^{***}	-0.103	-2.599^{***}	0.018
	(0.247)	(0.069)	(0.216)	(0.083)
Credit growth	-0.834^{***}	-0.916^{***}	-0.937^{***}	-0.994^{***}
	(0.156)	(0.207)	(0.160)	(0.216)
Current GDP growth	0.029	-0.592^{***}	0.023	-0.559^{***}
	(0.061)	(0.043)	(0.061)	(0.050)
Openness	-0.072	-0.805^{*}	-0.583^{**}	-0.941^{**}
	(0.318)	(0.437)	(0.277)	(0.421)
Financial Sector	-0.245	-3.228^{***}	0.623	-4.118^{***}
	(0.775)	(0.907)	(0.905)	(1.152)
Public Expenditure	0.510^{**}	0.167	0.851^{***}	0.178
	(0.215)	(0.125)	(0.267)	(0.143)
Government Effectiveness	1.536^{***}	2.188^{***}	1.450^{***}	2.085^{***}
	(0.342)	(0.456)	(0.363)	(0.574)
Openness × CISS			0.193	0.042
			(0.186)	(0.101)
Financial Sector × CISS			0.845^{***}	-0.075
			(0.224)	(0.119)
Public Expenditure × CISS			1.022^{***}	-0.114
			(0.258)	(0.083)
Government Effectiveness × CISS			0.019	0.163^{*}
			(0.207)	(0.087)
Openness × Credit growth			-0.647^{***}	-0.397^{*}
			(0.167)	(0.206)
Financial Sector × Credit growth			-0.090	0.274^{***}
			(0.189)	(0.086)
Public Expenditure × Credit growth			-0.098	-0.077
			(0.127)	(0.137)
Government Effectiveness × Credit growth			-0.001	-0.027
			(0.225)	(0.199)
Observations	1,648	1,433	1,648	1,433

Note: The table shows the estimated coefficients of the conditional 10 percent quantile. Columns (1)-(2) show the results from the regression model in equation 1 for the horizons (h) 4 and 12. Columns (3)-(4) show the results from the regression model in equation 3 for the horizons (h) 4 and 12. The measure of financial stress is the CISS. Bounds are computed using 1000 bootstrap samples. The significance level is denoted as follows: *p<0.1; **p<0.05; ***p<0.01.

fications of the panel quantile regression model in which we evaluate structural determinants of GaR. Columns (1)-(2) show results from a parsimonious, linear specification for forecasting horizons $h = 4$ and $h = 12$. These horizons are typically considered to assess short and medium term growth risks. To gauge the role of non-linearities and to assess the prevalence of *risk sensitivity gaps*, we augment the model with interaction terms of structural characteristics and the two included risk indicators (columns (3)-(4)).

Considering the effects of financial stress on the one hand, as measured by the CISS, and credit growth on the other, we observe that the impact of financial stress is particularly significant and pronounced over shorter horizons while the role of credit growth becomes more important as h increases. This pattern is well documented in the literature (see, for instance, Adrian et al., 2020).

Coefficients on structural characteristics in the linear specification shown in columns (1)-(2) give an intuition on the overall effects of openness, financial sector size, public expenditures and government effectiveness. For $h = 4$, we do not observe significant effects of openness and financial sector size on the predicted 10^{th} percentile of the conditional one-year ahead forecast of GDP growth. By contrast, public expenditures and government effectiveness do exert significant effects on short-term growth risks and tend to stabilize the economy. Government effectiveness appears to play a particularly important role: a one standard deviation surge in government effectiveness is associated with an increase in the 10th percentile of projected GDP growth in $h = 4$ by approximately 1.5 percentage points. The two effects broadly confirm the findings of previous literature focusing on the link between government size and output volatility (Galí, 1994; Fatás and Mihov, 2001) on the one hand, and the effect of government effectiveness on the other (Evrensel, 2010).

As h increases, we observe more significant effects of openness and financial sector size. While both characteristics are associated with lower projected GDP growth and thus, higher growth risks, larger financial sectors are particularly detrimental. An increase in financial sector size by one standard deviation is associated with a decrease in the lower tail of projected GDP growth by more than three percentage points. While the effect of trade openness is well in line with the findings of previous literature, which suggests a positive link between GDP volatility and openness (see, for instance, di Giovanni and Levchenko, 2009), the role of large financial sectors is somewhat more surprising, as most empirical studies indicate a dampening effect of more developed financial sectors on GDP volatility (e.g. Manganelli and Popov, 2015). Previous literature also suggests, however, that this effect weakens or even reverses at high levels of financial depth, as large financial sectors may amplify consumption and investment volatility (Dabla-Norris and Srivisal, 2013). Earlier studies thus point to a non-linear link between financial sector size and GDP volatility, which is also consistent with recent findings in the finance-growth nexus literature (see, for instance, Breitenlechner et al., 2015). According to our findings, the negative effect of financial sector size seems to dominate in the GaR framework, although we will argue below that the link between the two variables is also highly non-linear when taking into account various time horizons (see section 3.2 below). With an increasing time horizon, the effect of public expenditures becomes insignificant, thus suggesting that the stabilizing role of higher public expenditures only works in the short term. On the contrary, government effectiveness appears to play an even more important (and still positive) role at a time horizon of three years ($h = 12$).

Next, we add interactions terms of the structural characteristics to the regression model to account for non-linearities in the effects of the explanatory variables on GaR (columns (3)-(4)). For $h = 4$, we observe significant and positive coefficients on interactions with financial stress for financial sector size and public expenditures, indicating that these factors mitigate the adverse effects of financial stress on projected growth vulnerabilities to some extent as risks increase. We also observe a significant and negative coefficient of openness interacted with credit growth. This is to some extent surprising, as credit growth usually plays a secondary role in shaping short-term growth vulnerabilities. After allowing for interactions of the structural characteristics and the risk indicators, however, the coefficient on openness becomes significantly negative. This finding, combined with the significant negative interaction term with credit growth, suggests an overall negative effect of openness for short-term vulnerabilities, at least for countries with buoyant credit growth. A possible explanation for this effect could be that more open economies typically also exhibit higher levels of financial openness, with high rates of credit growth possibly depending on cross-border wholesale funding.

Regarding the role of interactions in shaping medium-term projected growth risks, we observe significantly negative coefficients of the interactions between credit growth and openness as well as financial sector size. While the detrimental effects of openness on growth vulnerabilities become more pronounced with higher credit growth, probably for the same reasons explained above, the negative effect of financial sector size is somewhat mitigated with higher credit growth. In this context, a larger financial sector could be associated with lower dependencies on cross-border funding, thereby mitigating risks linked to higher credit growth. From this perspective, the stabilizing role of more developed financial sectors - as suggested in the literature (e.g. Beck et al., 2006) - becomes more relevant in an environment of high credit growth. The coefficient on the interaction term is, however, relatively small in magnitude, suggesting a limited role of non-linearities assocaited with financial sector size.

In Table 2 we replicate the estimations from above using the CLIFS instead of the CISS as a measure of financial stress. In contrast to the CISS, which is an aggregate measure of financial stress, the CLIFS is country-specific (Duprey et al., 2017). We consider the CLIFS to take into account that structural characteristics may not only affect the transmission of financial stress, but also its country-specific emergence.

Considering columns (1)-(2) and (4) it appears that the overall effects of structural characteristics on projected growth vulnerabilities are not sensitive to the financial stress measure used. Allowing for multiplicative terms in (3), however, we observe some differences in how financial stress and structural country characteristics interact in shaping short-term risks. While we have observed that the effects of financial sector size is mitigated in instances of high financial stress using the CISS, this effect becomes insignificant once we consider the CLIFS. By contrast, considering the CLIFS, the interaction with openness becomes significant, thus indicating that the adverse effects of trade openness diminish to some extent with increasing levels of financial stress. Estimates shown in Table 2 suggest that structural characteristics also affect the transmission of country-specific financial stress and are generally robust to variants of financial stress measures used in the analysis.

Overall, our findings clearly suggest that structural factors play an important role in shaping variations in GaR. Over short-term horizons, we observe stabilizing effects of public expenditures and government effectiveness, with the latter being particularly pronounced. Considering interaction terms with financial stress, we observe that the stabilizing effect of public expenditures is particularly important when financial stress is high, whereas government effectiveness has a predominately linear effect on short-term GDP growth risks. Regarding medium-term growth risks, financial sector size and trade openness play an important and negative role in shaping growth vulnerabilities, while high levels of government effectiveness are still associated with higher GaR levels. Considering interactions with credit growth, we show that the adverse effects of larger financial sectors somewhat diminish with higher credit growth, while the negative effects of openness are further reinforced by increasing levels of credit growth.

The significant effects of structural factors, both with respect to GaR levels as well as the sensitivity of GaR to the underyling risk indicators, point to the prevalence of both a *structural* and a *risk sensitivity gap*. In turn, our results have important macroprudential policy

Table 2: Main results – CLIFS and credit growth

	Model 1		Model 2	
	$h = 4$	$h = 12$	$h = 4$	$h = 12$
	(1)	(2)	(3)	(4)
CLIFS	-1.377^{***}	0.013	-1.543^{***}	-0.017
	(0.270)	(0.062)	(0.295)	(0.082)
Credit growth	-1.287^{***}	-0.937^{***}	-1.485^{***}	-1.058^{***}
	(0.211)	(0.197)	(0.164)	(0.200)
Current GDP growth	0.006	-0.588^{***}	0.041	-0.587^{***}
	(0.076)	(0.040)	(0.068)	(0.040)
Openness	0.023	-0.729^{*}	-0.391	-1.073^{***}
	(0.548)	(0.399)	(0.292)	(0.414)
Financial Sector	0.172	-3.106^{***}	0.949	-4.197^{***}
	(0.871)	(1.016)	(0.997)	(1.156)
Public Expenditure	0.566^{**}	0.118	0.803^{***}	0.184
	(0.257)	(0.112)	(0.236)	(0.127)
Government Effectiveness	2.735^{***}	2.071^{***}	2.719^{***}	2.005^{***}
	(0.613)	(0.548)	(0.630)	(0.517)
Openness × CLIFS			0.607^{***}	0.122
			(0.221)	(0.089)
Financial Sector × CLIFS			0.329	-0.010
			(0.398)	(0.073)
Public Expenditure × CLIFS			0.358^{*}	0.048
			(0.200)	(0.083)
Government Effectiveness × CLIFS			0.294	0.086
			(0.286)	(0.084)
Openness × Credit growth			-0.695^{***}	-0.446^{**}
			(0.164)	(0.219)
Financial Sector × Credit growth			0.089	0.259^{***}
			(0.214)	(0.096)
Public Expenditure × Credit growth			-0.038	-0.144
			(0.131)	(0.152)
Government Effectiveness × Credit growth			-0.031	0.030
			(0.228)	(0.213)
Observations	1,644	1,429	1,644	1,429

Note: The table shows the estimated coefficients of the conditional 10 percent quantile. Columns (1)-(2) show the results from the regression model in equation 1 for the horizons (h) 4 and 12. Columns (3)-(4) show the results from the regression model in equation 3 for the horizons (h) 4 and 12. The measure of financial stress is the CLIFS. Bounds are computed using 1000 bootstrap samples. The significance level is denoted as follows: *p<0.1; **p<0.05; ***p<0.01.

implications. Variations in the *structural gap* suggest that the appropriate macroprudential policy stance may, among other things, depend on structural characteristics, at least in an environment of homogeneous risk preferences across countries. *Risk sensitivity gaps*, as revealed by non-linearities in the effect of the included risk indicators depending on structural country characteristics, suggest that growth risks in some countries react more sensitively to increasing financial risks than in others. Thus, the appropriate reaction of macroprudential policy to variations in financial stress and credit growth may also depend on the respective (structural) country characteristics, as already suggested in theoretical considerations related to the GaR framework (Suarez, 2021). For example, a larger financial sector is, ceteris paribus, associated with generally higher growth risks. Thus, countries with large financial sectors may need a tighter macroprudential policy stance to mitigate possible downside risks to the same extent. However, as the negative effects of financial sector size diminish with higher financial stress (short-term) and credit growth (medium-term), growth risks in these countries will react less sensitively to surges in the respective risk indicators.

In the following sections, we focus our analysis on country-specific measures of financial stress (i.e. the CLIFS), primarily for two reasons. First, using country-specific financial stress measures is more common in previous literature (see, for instance, Adrian et al., 2020; Aikman et al., 2019; Galán, 2020), thus facilitating a comparison of our empirical results to other studies. Second, using the CLIFS instead of the CISS is a more conservative approach to evaluate the effect of structural country characteristics on GaR, as those same factors may be associated with differences in financial stress across countries (i.e. more favourable structural factors could be associated with lower contagion or higher resilience, thus resulting in more favourable financial conditions at the individual country level).

3.2 Term structure of GaR and structural factors

While the focus above is on the distribution of projected GDP growth one year ($h = 4$) and three years ahead ($h = 12$), we now extend our analysis to $h = 1, \ldots, 16$ quarters. Considering the effects of structural country characteristics on GaR for a series of forecasting horizons gives us an indication of how structural factors affect the term structure of GDP growth risks. Thereby, we extend the analysis by Adrian et al. (2020) - who examine how financial conditions affect the term structure of GaR - to structural factors.

We first evaluate how the two risk indicators affect the term structure of GaR. Figure 1 shows the evolution of the estimated coefficients of the CLIFS and credit growth $h = 1, \ldots, 16$

quarters ahead, based on the estimation of regression model 3. While we discuss these in more detail below, estimates using the CISS are shown in the Appendix A in Figures A.1 and A.2. The grey area indicate the 90% confidence intervals. As expected, the CLIFS has the most adverse effects in the short-term, while the negative impact of credit growth is economically and statistically significant negative for all time horizons. This is consistent with the existing literature (see, for instance, Adrian et al., 2020; Aikman et al., 2019).

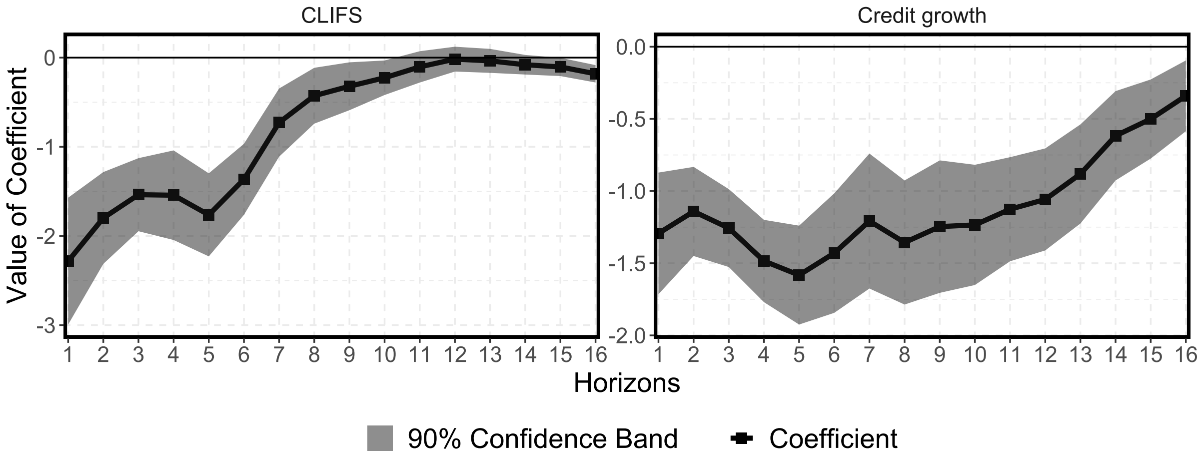

Figure 1: Estimated coefficients of the risk indicators from 1 to 16 quarters ahead, using the CLIFS as the financial stress measure.

Note: The figure shows the estimated coefficients of the risk indicators in the GaR estimation ($\tau = 0.1$) 1-to 16 quarters horizons ahead. The black line represents the estimated coefficients, the grey area shows the 90% confidence intervals; bounds are computed using 1000 bootstrap samples.

In a similar vein, Figure 2 presents the evolution of the structural characteristics' coefficients for 1 to 16 quarters ahead. The black line shows the coefficients of the respective structural country characteristics. In addition, we show the coefficients of the structural factors plus the interaction term with financial stress (green line) and credit growth (blue line) evaluated at the 90^{th} percentile of financial stress and credit growth, respectively. While the black (solid) line can be interpreted as a measure of the *structural gap*, the green and blue (dashed) lines point to the additional existence of *risk sensitivity gaps* in the case of strong deviations from the black line.

As already discussed above, higher public expenditures mitigate growth risks in the short run, as the respective coefficients are significantly positive from $h = 2$ to $h = 7$ (upper left panel in Figure 2). While we do not observe a risk sensitivity gap associated with increasing credit growth, higher financial stress can be mitigated to some extent by a high public spending ratio, once again pointing to a stabilizing role of larger public sectors in the short run.

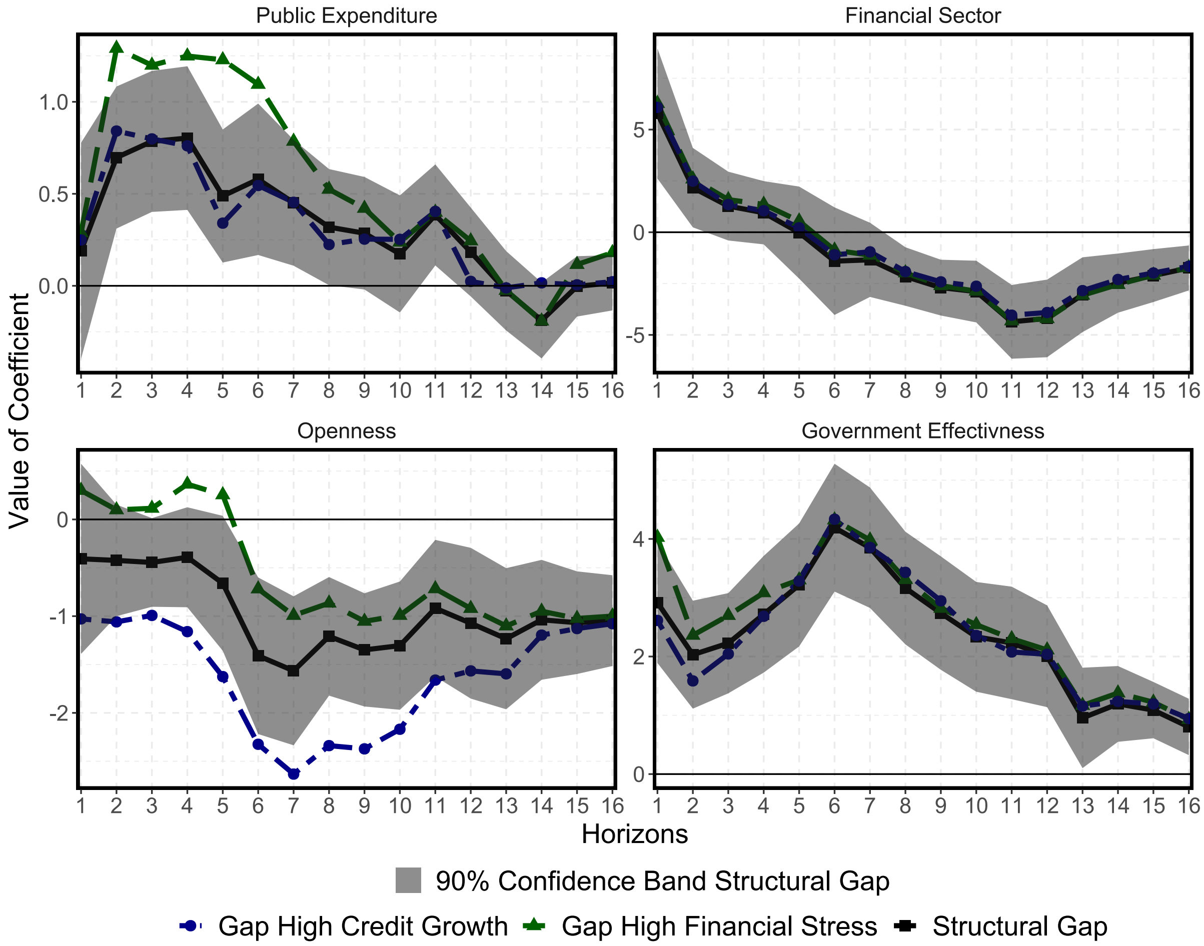

Figure 2: Estimated coefficients for structural characteristics from 1 to 16 quarters ahead, using the CLIFS as the financial stress measure.

Note: The figure shows the estimated coefficients of the structural characteristics in the GaR estimation ($\tau = 0.1$) 1 to 16 quarters ahead. The black line represents the estimated coefficients, the grey area shows the 90% confidence intervals; bounds are computed using 1000 bootstrap samples.

Interestingly, the effect of the size of the financial sector strongly depends on the forecasting horizon, as evident in the upper right panel. In the very short run, larger financial sectors tend to stabilize future growth, but exercise strong detrimental effects on GaR in the medium run. Non-linearities therefore do not only seem to play an important role in the finance-volatility nexus, as suggested by the literature (Dabla-Norris and Srivisal, 2013), but also with respect to the GaR term structure. Interestingly, interactions with financial stress and credit growth do not play an important role in quantitative terms[5], indicating that financial sector size is an important determinant of the *structural gap*, but less so of the *risk sensitivity gap*.

[5] As shown in Table 2, the interaction term is still statistically significant. Due to the large structural gap driven by financial sector size, however, the relatively small coefficient on the interaction term (i.e. the risk sensitivity gap) is hardly visible in this graphical illustration.

The effects of openness are shown in the lower left panel of Figure 2. Non-linearities associated with increasing risk indicators are most pronounced with respect to openness. Notably, however, the impact of the two risk indicators - i.e. financial stress and credit growth - go into opposite directions. While openness mitigates short run risks in the face of high financial stress from $h = 3$ to 5, short to medium run growth risks are amplified when credit growth is high. The figure clearly shows that trade openness is an important factor for both the *structural* as well as the *risk sensitivity gap*.

Finally, for government effectiveness shown in the lower right panel, we see that this variable is a stabilizing factor for projected GDP growth, irrespective of the forecasting horizon. As interactions terms do not play an important role, higher levels of government effectiveness are associated with a positive *structural gap*, but do not affect the *risk sensitivity gap* at the individual country level.

Overall, considering a series of forecasting horizons, we document that structural country characteristics do strongly affect the term-structure of GaR from the short to the medium run. However, the effects of structural characteristics across different forecasting horizons draw a rather heterogeneous picture. While public expenditures tend to affect projected growth risks in the short run, openness is more important at higher forecasting horizons. Government effectiveness has pronounced effects over a forecasting horizons of at least three years. Financial sector size has mitigating effects over the short run, but amplifies growth risks over the medium run.

3.3 Predicted GaR with and without structural factors

To get an impression how structural factors affect growth vulnerabilities across countries, we run in-sample model evaluations with and without consideration of structural country characteristics. Figures 3 and 4 show predicted GaR 3-years ahead[6], estimated with and without the structural factors. The black (dashed) line is the realized annualized growth rate, the blue line represents the predicted GaR without taking into account structural characteristics, while the green line specifically considers structural factors. To facilitate the interpretation of the figures, the predicted GaR is shifted forward to align growth predictions with realizations for the respective quarters.

[6]For the sake of brevity, we only focus on the GaR with a time horizon of three years. This perspective is probably more interesting for policy-makers, as such a medium-term view may allow for a specific and appropriate policy reaction to increased systemic risks. We repeat the same analysis for GaR estimates one year ahead in the Appendix, also confirming that structural factors are important determinants of GaR, both with respect to the structural gap as well as the risk sensitivity gap.

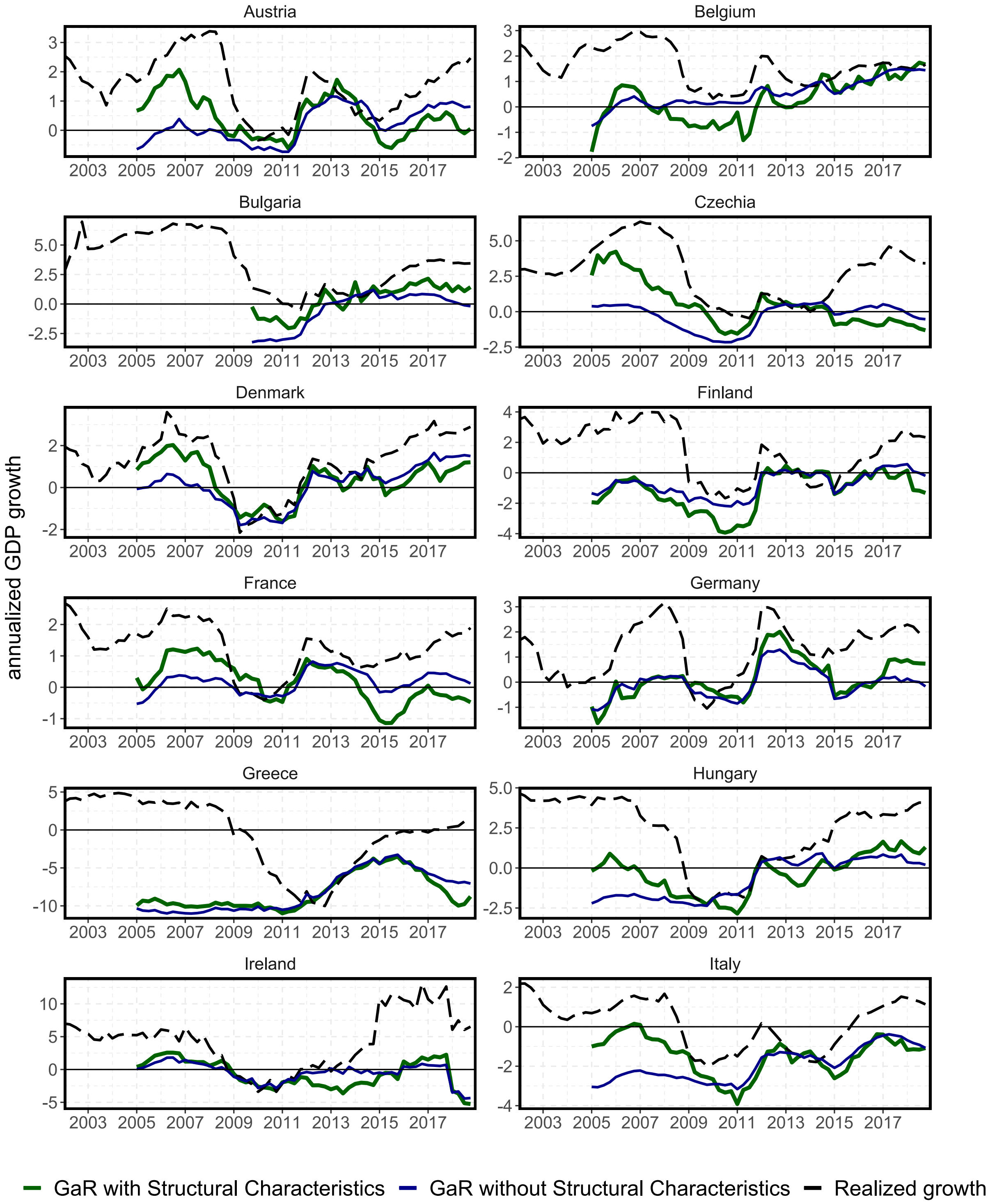

Figure 3: Predicted GaR 3-years ahead with and without structural characteristics

Note: The figure shows the predicted GaR ($\tau = 0.1$) for a 3-year forecasting horizon, estimated with and without the structural factors, together with realized GDP growth.

While Figures 3 and 4 reveal the importance of structural factors when estimating GaR, a detailed discussion of individual countries would clearly go beyond the scope of the paper.

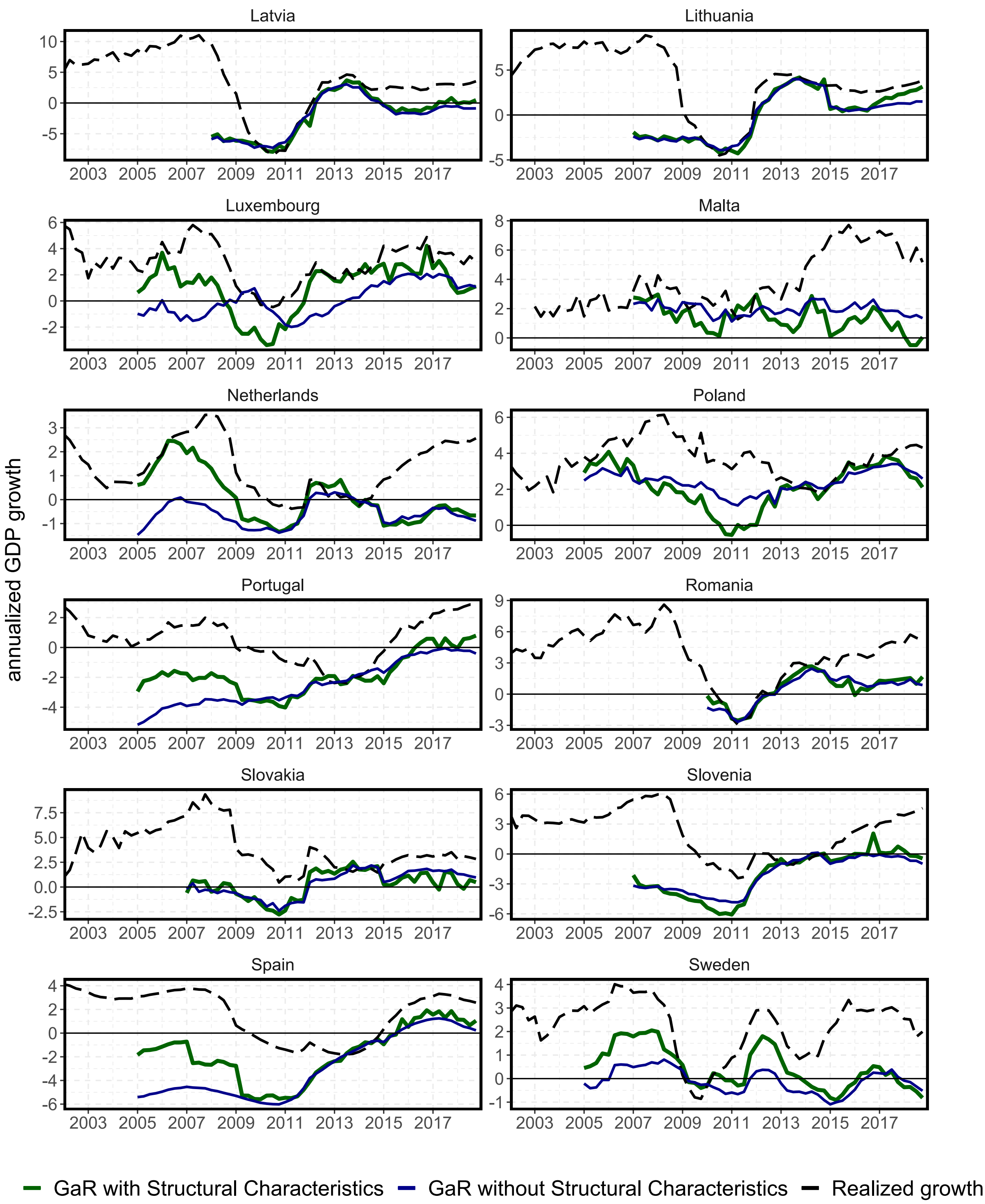

Figure 4: Predicted GaR 3-years ahead with and without structural characteristics

Note: The figure shows the predicted GaR ($\tau = 0.1$) for a 3-year forecasting horizon, estimated with and without the structural factors, together with realized GDP growth.

Generally, the effect of structural characteristics is both country and time specific. While e.g. in Sweden, GaR values tend to be lower when structural characteristics are taken into account, the opposite holds true for e.g. Malta. Moreover, it appears that in several countries models incorporating structural characteristics predict higher values of GaR (e.g. Austria, Czech Republic, Hungary, Italy, Netherlands, Luxembourg, Portugal, Spain, Sweden) in the early 2000s. However, in the run-up to the global financial crisis, the wedge between predictions from models with and without country characteristics appears to shrink, indicating that structural conditions may have become more similar across countries.

4 Conclusion

The analysis in this paper aimed at understanding the cross-country variation in growth vulnerabilities associated with financial stress and credit growth by putting a particular focus on the role of structural country characteristics. Our findings document that structural factors play an important role in the way how financial factors affect the projected distribution of future growth outcomes. By focusing on differences in trade openness, financial sector size, the public spending ratio and a measure of government effectiveness, we show that these structural factors do not only lead to structural differences in GaR at the individual country level, but also give rise to different reactions to varying levels of risk. Thus, our findings suggest the existence of both a *structural gap* in GaR due to structural country characteristics, as well as a *risk sensitivity gap*, with structural differences across countries also leading to different degrees of responsiveness to varying risk. Furthermore, our empirical results also show that the various structural factors play a significant role in the context of the term structure of GaR, with the impact of the structural characteristics varying with the respective time horizon.

Our findings have important policy implications, in particular for macroprudential surveillance and the calibration of the respective policy tools. Taking into account structural country characteristics in the transmission of financial risks, both in terms of GaR levels as well as sensitivity to the examined risk factors, may also facilitate the use of the concept to assess the macroprudential policy stance at the individual country level. To make the GaR framework more readily usable in a policy context, further research is necessary both in examining possible other structural determinants of GaR and also in investigating the impact of the third structural factor, the *policy sensitivity gap*, i.e. differences across countries with regard to the sensitivity of GaR to policy measures. This latter task of examining structural differences of GaR sensitivity to policy measures is particularly challenging both because of the multidimensional toolbox used in macroprudential policy across countries and the limited experience of applying many of those instruments, as macroprudential policy is a rather new field relative to other policy areas, such as fiscal or monetary policy.

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Appendix A: Additional tables and figures

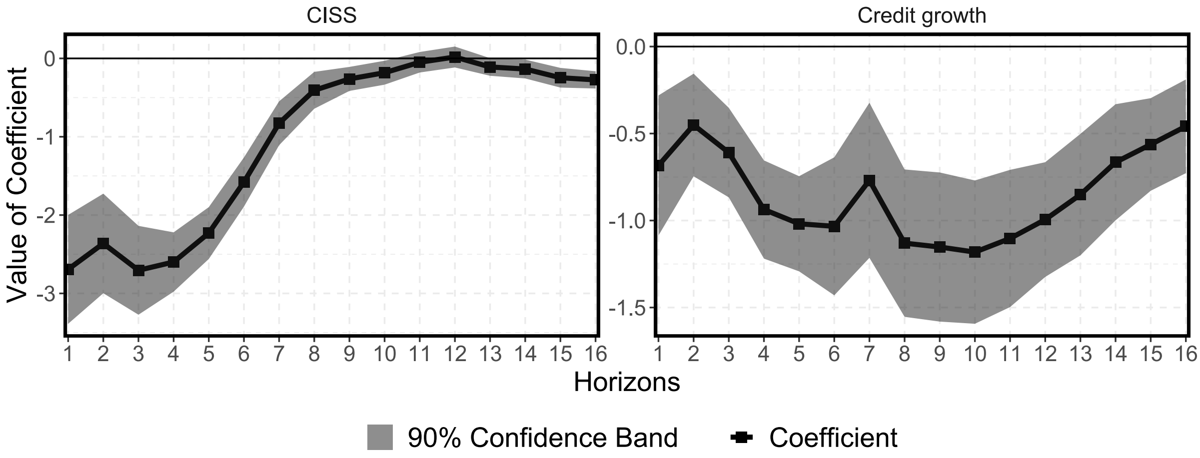

Figure A.1: Estimated coefficients of the risk indicators from 1 to 16 quarters ahead, using the CISS as a financial stress measure.

Note: The figure shows the estimated coefficients of the risk indicators in the GaR estimation ($\tau = 0.1$) 1-to 16 quarters ahead. The black line represents the estimated coefficients, the grey area shows the 90% confidence intervals; bounds are computed using 1000 bootstrap samples.

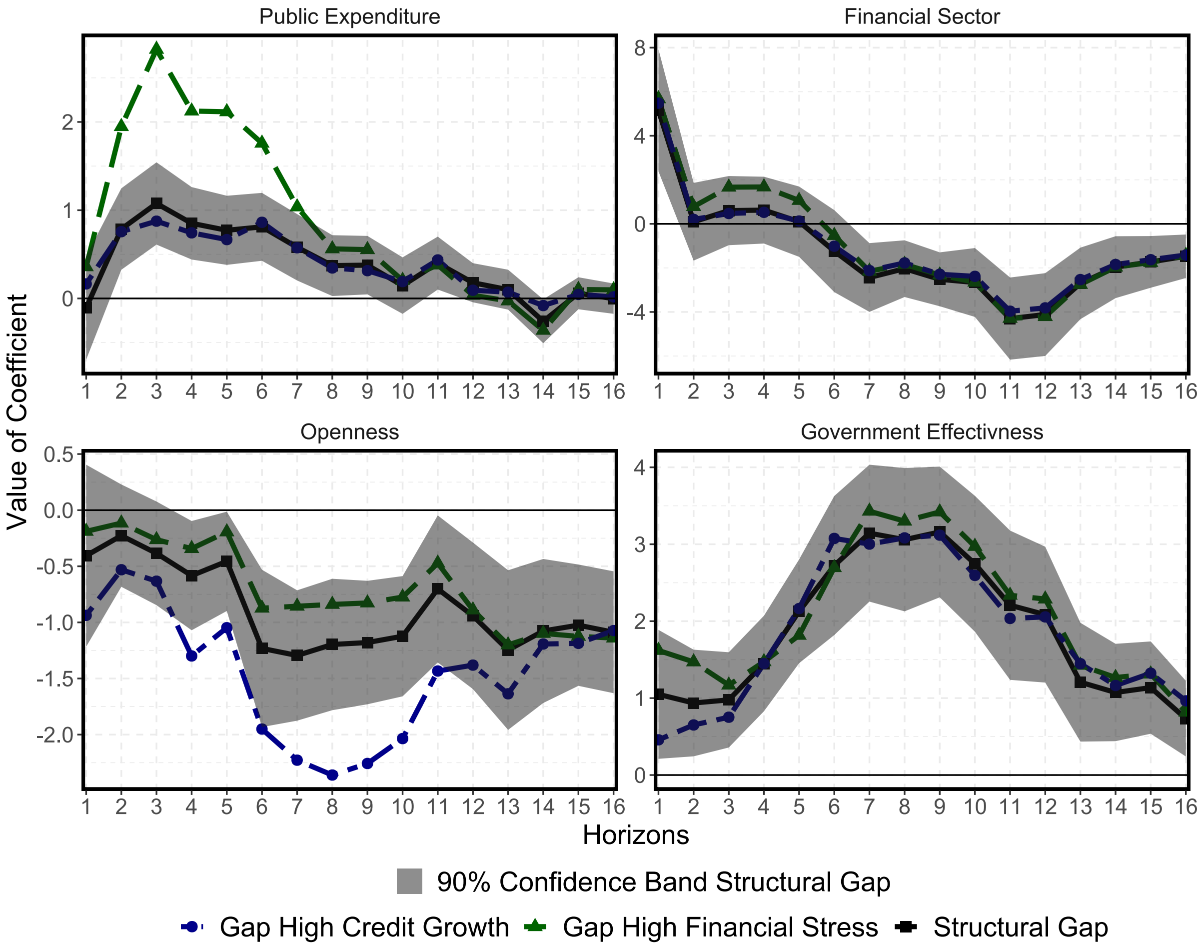

Figure A.2: Estimated coefficients for structural characteristics from 1 to 16 quarters ahead, using the CISS as a financial stress measure

Note: The figure shows the estimated coefficients of the structural characteristics of the GaR ($\tau = 0.1$) 1 to 16 quarters ahead. The black line represents the estimated coefficients, the grey area shows the 90% confidence intervals; bounds are computed using 1000 bootstrap samples.

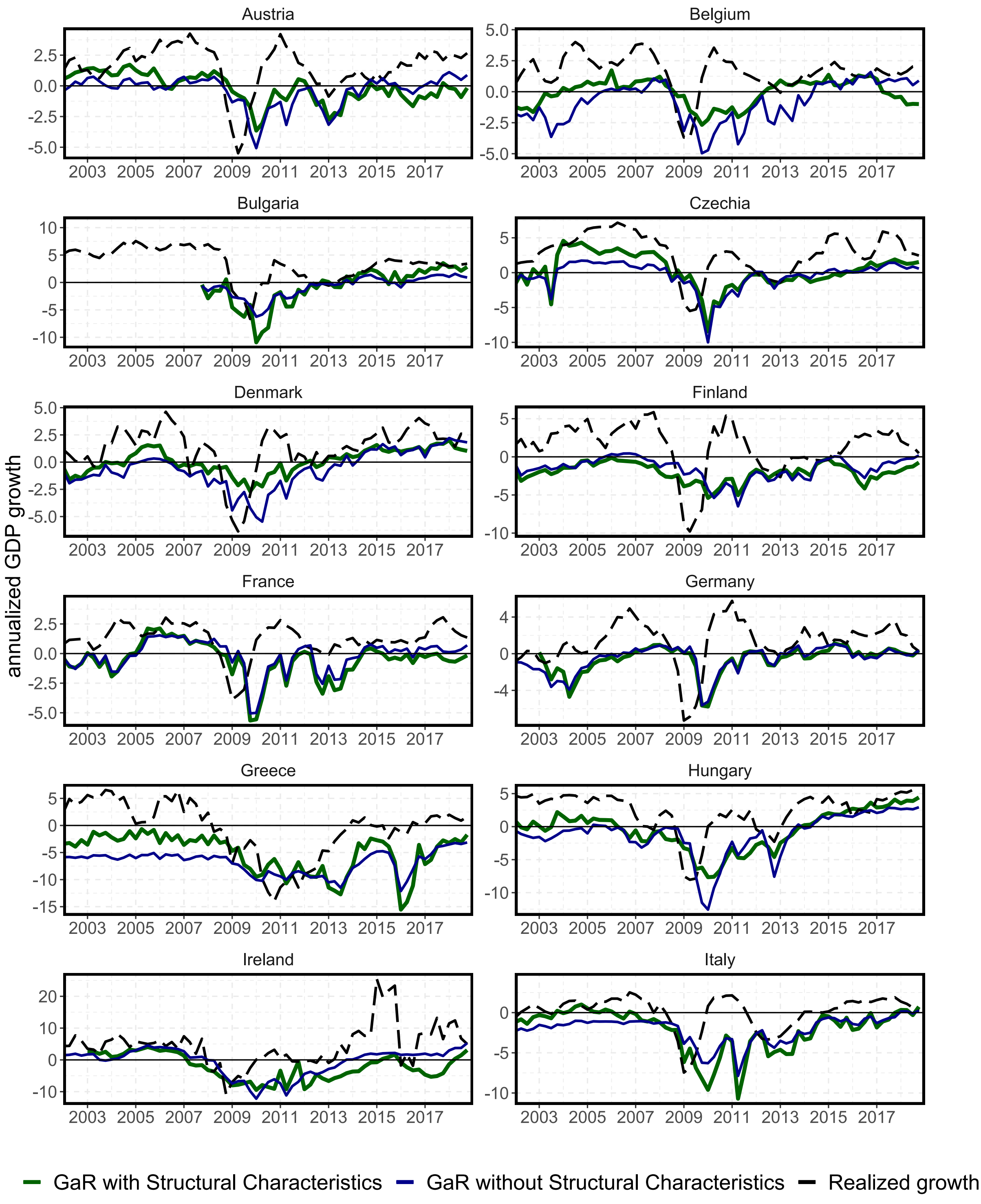

Figure A.3: Predicted GaR 1-year ahead with and without structural characteristics

Note: The figure shows the predicted GaR ($\tau = 0.1$) for a one year forecasting horizon, estimated with and without the structural factors, together with realized GDP growth.

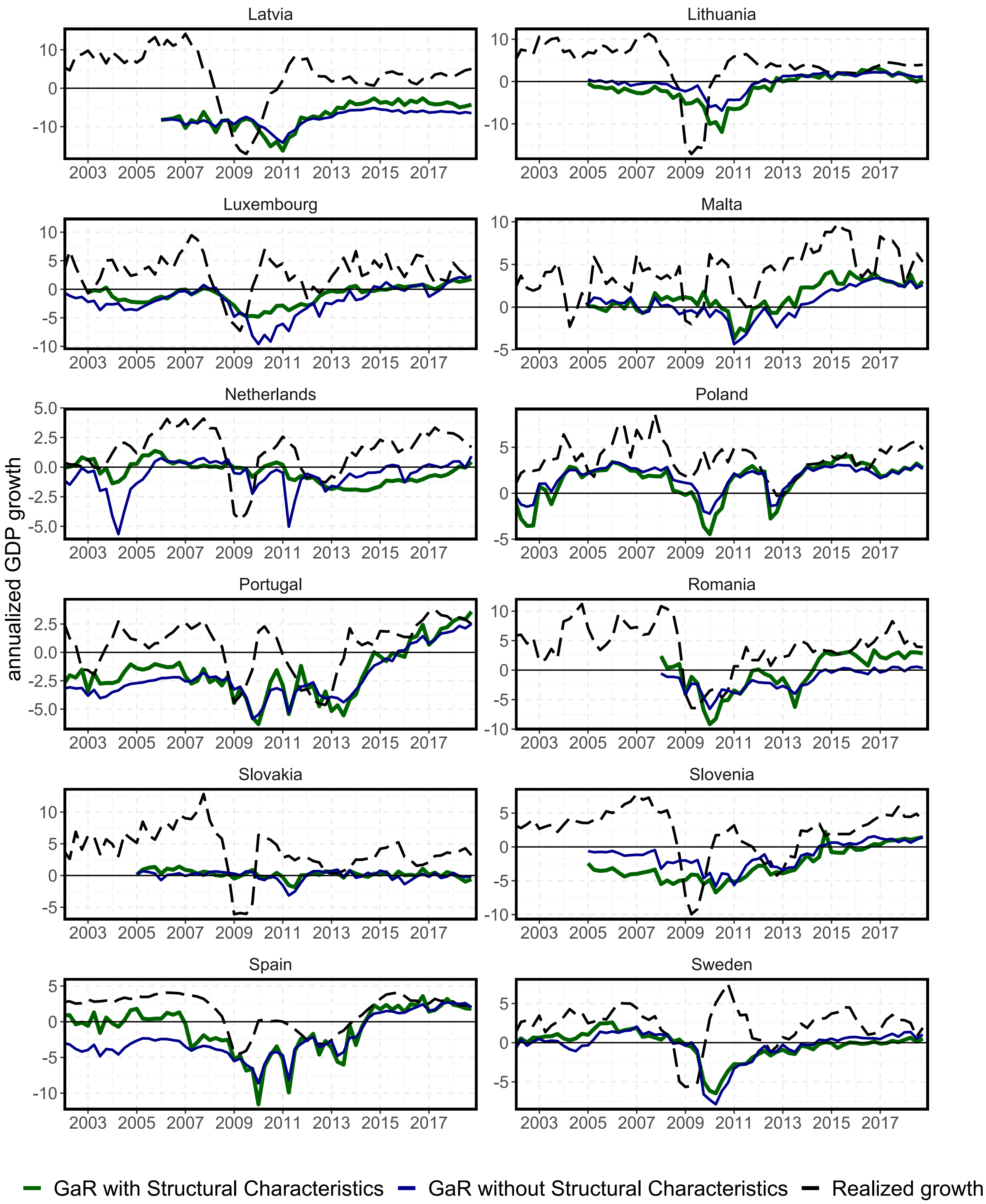

Figure A.4: Predicted GaR 1-year ahead with and without structural characteristics

Note: The figure shows the predicted GaR ($\tau = 0.1$) for a one year forecasting horizon, estimated with and without the structural factors, together with realized GDP growth.