"Does economic complexity reduce the probability of a fiscal crisis?"

José E. Gómez-González, Jorge M. Uribe and Oscar M. Valencia

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Abstract

Higher economic complexity of a country reduces the probability of suffering a fiscal crisis between 46% and 57%. Along with institutional factors, complexity is shown to be sufficient to describe the risk of facing episodes of fiscal distress. On the contrary, the role of variables frequently emphasized by the literature and policy markets, such as the debt-output ratio, real growth, inflation, terms of trade or fiscal balance, is very modest or insignificant. Development strategies that aim for greater economic complexity also promise to reduce countries' fiscal vulnerability.

JEL classification: E02, E44, E62, F34.

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José E. Gómez-González: Lehman College, City University of New York, New York, USA. Email: jose.gomezgonzalez@lehman.cuny.edu

Jorge M. Uribe: Universitat Oberta de Catalunya, Barcelona, Spain. Email: juribeg@uoc.edu

Oscar M. Valencia: Fiscal Management Division, Inter-American Development Bank, Washington, USA. Email: oscarva@iadb.org

1. Introduction

We study whether the ability of a country to export more diversified and less ubiquitous goods (therefore with greater economic complexity) reduces the probability of suffering a fiscal crisis. We rely on survival analysis to assess this probability and on a comprehensive dataset of fiscal distress episodes for 172 countries[1] from 1995 to 2020. The answer is yes, broadly and significantly. The point estimate of the effect in our baseline model indicates that an increase of one-point in the economic complexity index of Hidalgo and Haussmann (2009) reduces the probability of experiencing a fiscal distress episode approximately in half (between 46%-57% depending on the preferred specification and the estimation method). This probability is between 39% and 46% when only emerging markets are considered, and it reaches 73% when the assumption of constant proportional hazards is relaxed in our duration analysis.

A one-point increment is a high bar for any country, since only a few managed to improve their economic complexity index by that order of magnitude during the period analyzed[2]. In any case, half of this variation has been recorded multiple times over the years, by quite a few emerging economies in a matter of a decade or less, making it a realistic policy objective to safeguard fiscal stability in the medium term. This is especially relevant for emerging and low-income developing countries which, as we show in section 4.1, suffer disproportionately from fiscal vulnerability.

Our estimates are robust after controlling for institutional factors, such as the rule of law or regulatory quality, which also show a high predictive power on future fiscal distress of countries, orthogonal to the effect of economic complexity; control for macroeconomic indicators typical in the literature of sudden stops and sovereign debt pricing, such as real gross domestic product (GDP) growth, investment, inflation, terms of trade and consumption; control for natural resource rents, the debt-GDP ratio, and the implicit interest paid on debt during a given year, and even controlling for fiscal balances (among other variables). Indeed, across all specifications, economic complexity and institutional factors retain their statistical and economic significance and are the most important contributors to explaining future periods of fiscal distress.

[1] 80.81% emerging and low-income developing countries and 19.19% advanced economies.

[2] Notorious examples are Brazil (from 0.84 to 0.03); China (from 0.32 to 1.30); Korea (from 1.04 to 1.95); Malasya (0.42 to 1.12); Romania (0.41 to 1.27); Uganda (-1.22 to -0.47) and Vietnam (-0.92 to 0.18). Panama managed to go from 0.00 to 1.00 from 1997 to 2012 in 5 years only.

We are the first to propose and quantify the effect of economic complexity on the probability of suffering a fiscal crisis (indeed, to the best of our knowledge, we are also the first to directly model the survival probability of a country before experiencing a fiscal crisis). However, the economic mechanisms through which this effect takes place are multiple and have been solidly documented in previous literature. At the country level, higher complexity has been shown to be associated with higher future economic growth (e.g. Hidalgo and Haussmann, 2009; Haussmann et al., 2014; Tachella et al. 2018; Nepelski and De Prato, 2020). Furthermore, the growth path led by higher complexity tends to be also more stable, as complexity has also been shown to be associated with lower output volatility (Güneri, B. & Yalta, 2021). At the micro level, there is compelling evidence that a higher level of complexity of a company's product basket is associated with reduced fluctuations in its output (Maggioni et al., 2016). Higher growth with lower volatility is a combination naturally associated with the stabilization of fiscal budgets and the ability to successfully navigate turbulent times without enduring fiscal distress episodes.

On the contrary, the lack of productive diversification can be detrimental to macroeconomic stability in general and to fiscal stability in particular. On the one hand, countries that rely heavily on the production of ubiquitous basic goods have incomes that fluctuate with the prices of these goods in international markets (Deaton, 1999; Lo et al., 2022). On the other hand, countries dependent on sectors such as tourism are vulnerable to global economic cycles that lead to a substantial reduction in tourism demand at times of low global economic activity (Aronica et al., 2021). They are also vulnerable to situations such as the one due to the pandemic, which caused the global demand for tourism to drop sharply in 2020. Moreover, an economy's ability to produce complex goods, which relies on complex networks that bring in different types of know-how and capabilities together, may lead it to be more resilient to external shocks and thus, might help reduce its risk of facing a fiscal crisis.

Making a comparison with investments in financial assets, having a more diversified asset portfolio allows risk to be mitigated, generating more stable income for investors over time. In the same way, housing more complex production structures allows countries to have more stable incomes and governments to face less fluctuating tax revenues. Following this line of reasoning complexity could be expected to be associated with a lower cost of sovereign debt, and a lower risk premium. This seems to be the case according to Özmen (2019), who shows that, after controlling for relevant macroeconomic factors, global factors and institutional indicators, economic complexity has a significant and negative effect on the spreads of Credit Default Swaps, for both emerging and advanced economies.

This study also contributes to the recent literature on fiscal crises that has developed the measures that we use to proxy for fiscal distress episodes, explained in detail in section 2 (i.e., Medas et al., 2018, and Moreno et al., 2022). Our research question differs from those in the extant literature, since we are not concerned with forecasting fiscal crises, using a large set of variables, but with estimating determinants of the probability of entering into an episode of fiscal distress years ahead and, in particular, with evaluating the role of economic complexity as a source of long-term fiscal resiliency for countries. We also contribute in this subject by showing that in the short run, when complexity and institutions are more or less fixed, is better to keep track of the interest paid by countries on debt, than to excessively focus on the debt to GDP ratio, which is not even significant to explain the probability of suffering a fiscal crisis. This result is in line with recent claims in the literature that the debt/GDP ratio shows a time-varying and country-dependent effect on borrowing costs, making it difficult to use as an anchor to establish fiscal rules (Furmer and Summers, 2020; Caselli et al., 2022).

Our contribution is timely, since current macroeconomic discussions between policymakers and academics are focusing on fiscal imbalances, fears for the effect that growing public debt balances may have on fiscal and macroeconomic stability, and the effects of higher interest rates on debt burdens in an environment of high and persistent inflation (Caselli et al., 2022). Interest on fiscal issues is supported by the fact that sovereign debt levels around the world are reporting historic highs. The pandemic created an unprecedented fiscal response as the total resources assigned to attend it globally have reached about $12.5 trillion, according to the IMF (Reuters, 2022). While such spending was needed to address the social, health and economic impacts of the crisis, this vast expenditure has caused a profound deterioration of fiscal balances. Implementation of the support packages has led to large fiscal deficits, which have resulted in high financing needs partially covered by most countries taking on additional debt.

Our results have clear policy implications. Having established a strong link between economic complexity and fiscal resilience, the policy challenge is how to improve complexity. How does it evolve? And what can a government do to encourage the emergence of more complex products in the economy that point to more resilient fiscal results? We do not directly address these questions here, but the complexity literature informs us extensively about them. The traditional approach considers complexity along with "relatedness". Relatedness measures how "easy" it is to enter an activity for a specific country or region, while the former offers a measure of the value of that activity. Activities that rank high in both relatedness and complexity are the best "low-hanging fruit" for diversification and therefore, define the boundaries of an efficient diversification frontier, which maximizes complexity and minimizes the difficulty of entering an activity (Haussmann et al., 2014; Balland et al., 2018; Hidalgo, 2021). Nevertheless, this approach to complexity has been subject to criticisms since it can be too simplistic and suboptimal (Alshamsi et al., 2018). Recognizing these limitations, recent work on complexity has emphasized that, ideally, economies should focus on relatively unrelated but connected activities during a window of opportunity that opens at intermediate levels of development, while "leapfrogging" intermediate technologies and thus intermediate stages of development (Lee and Ki, 2017).

Ultimately, complexity is related to the growth of knowledge, and thus policy efforts should also be interested in knowledge diffusion strategies (see Jaffe et al., 1993; Audretsch and Feldman, 1996, 2004). As Balland et al. (2022), supporting economic upgrading by building complex capabilities is a better development strategy than aiming to produce high-priced goods. These latter goods are not exempt from the rapid changes that characterized commodity markets, as a result of changing market conditions, regulations, customer preferences, wars, and pandemics. For this very reason, developing the capabilities to produce complex products is not only a natural path to ensure long-term growth, but also to ensure greater fiscal stability, particularly in the face of large global shocks such as those recently experienced by the global economy.

The rest of this document is organized as follows. In section 2 we present our methods, in section 3 our data and sources, and in section 4 our main results. Section 5 concludes. There is also an online Appendix showing more robustness checks and additional descriptive tables.

2. Methodology

In this section we describe our main variables, economic complexity and fiscal distress, alongside the economic intuition of both. We also briefly introduce the survival analysis framework to estimate the probability of entering into a fiscal crisis, conditional on covariates.

2.1. *Economic Complexity*

We use Hidalgo and Haussmann's (2009) index of Economic Complexity (ECI), which is regularly updated on the web page of the Economic Complexity Atlas of Harvard's Growth Lab. According to these and other authors (see Hidalgo 2021, and Balland et al., 2022) economic complexity indicators measure economic capacity. These indicators are based on dimensionality reduction techniques known as Singular Value Decomposition (SVD) or principal component analysis, which interestingly are also very popular in asset pricing, actuarial science and recently the macroeconomics of big data. Economic complexity metrics can be interpreted as factor-decompositions of a large network of export products[3]. The reasoning that underlies Hausmann and Hidalgo's, (2009) indicator is that the production of complex goods requires a wide set of diverse and exclusive capabilities. Therefore, complex products are not easily reproducible anywhere, i.e., are less ubiquitous, and are by general rule produced by fewer countries. These countries are considered in this framework complex on the basis of their sufficiently large endowments of diverse and exclusive capabilities.

2.2. *Fiscal Crises*

We follow Medas et al. (2018) and Moreno et al. (2022) to define a fiscal distress episode. These authors define it in a broad sense, as a period of sensitive budgetary distress, which results in the government taking exceptional measures. We use these authors' series from 1995 to 2015 and their criteria for defining a fiscal crisis to complete the series from 2016 to 2020. These criteria are four: 1) Credit events. A fiscal crisis is triggered when debt's service is not paid when due, or the creditor incurs any other type of loss, including through debt restructuring. 2) Exceptionally large external official funding. When the country receives significant financial support from the IMF or the European Union. 3) Implicit breach of the internal public debt. That is, either: (i) periods of high inflation (generally associated with

[3] The concept of economic complexity is not limited to export goods. It only manifests through it (see Hidalgo, 2021, for further discussion).

monetary funding of the budget); or (ii) accumulation of internal arrears. 4) Market confidence loss, associated with extreme market pressures represented by: (i) loss of access to the market, sovereign defaults, or interruption of bond issuance; or (ii) very large borrowing costs or sovereign yield spikes.

2.3. Survival Analysis

Our main objective is to evaluate the relation between economic complexity and episodes of fiscal distress. According to our definition of fiscal crises, our dependent variable is binary, taking on the value one when a period of fiscal distress is identified and taking on the value zero otherwise, for each country. We therefore follow a probability approach. The most general way of constructing a probabilistic approach is by using a hazard duration model.

In duration analysis, the dependent variable T, represents the time that takes for something to happen. This random variable is non-negative and can be either discrete or continuous. Duration analysis can be done either by following a fully parametric approach or a semi-parametric approach. To determine which of these approaches is best to follow, researchers use non-parametric analysis of the raw data. These results are shown in the first part of the fourth section. Cases when preliminary analysis indicates that the non-parametric hazard function is highly non-monotonic provide evidence against the use of parametric functions for representing the duration of normal times before a period of fiscal distress occurs. In such cases, the Proportional Hazards (PH) Model of Cox (1972) is preferred.

Under the proportional hazards specification, the hazard rate can be written as

$$\lambda(t, X, \beta, \lambda_0) = \phi(X, \beta)\lambda_0(t), \qquad [1]$$

where λ_0 is the baseline hazard. Note that the effect of time on the hazard rate is captured completely through the baseline hazard. One common specification for the function ϕ, which is followed in this paper, is $\phi(X, \beta) = \exp\,(X\,\beta)$, where X is a vector of covariates and β is the corresponding vector of parameters to be estimated. Under this specification,

$$\frac{\partial log[\lambda(\cdot)]}{\partial X_k} = \beta_k, \qquad [2]$$

for all k. Therefore, the coefficients can be interpreted as the constant, proportional effect of the corresponding covariate on the conditional probability of completing a spell. In the particular case of this study, completing a spell is associated with the moment in which a country enters into a period of fiscal distress.

In the case of specifications which model the baseline hazard explicitly by making use of a particular parametric model, estimation can be done by the method of maximum likelihood. When the baseline hazard is not explicitly modeled, the conventional estimation method is partial likelihood estimation, developed by Cox (1972). The key point of the method is the observation that the ratio of the hazards for any two individuals depends on the covariates but does not depend on duration.

When there is censoring, the censored spells will contribute to the log-likelihood function by entering only into the denominator of the uncensored observations (for instance this is the case of most advanced countries in our sample). Censored observations will not enter the numerator of the log-likelihood function at all.

Ties in durations can be handled by several different methods. In this paper, ties are handled by applying the exact, Efron, and Breslow methods. We try the three of them for robustness purposes. We also compare our baseline results of the PH model with the results of an accelerated failure time model (AFT). AFT models depart from a different assumption than PH models, whereas in a PH model the covariates act multiplicatively on the hazard, in an AFT model the covariates act multiplicatively on time.

3. Data

We rely on a comprehensive dataset of fiscal distress and related macroeconomic, financial, and institutional factors spanning both, emerging (including low income developing countries) and advanced economies. The dataset has an annual frequency from 1995 to 2020, so that it properly accounts for sufficient periods of fiscal distress and related episodes of financial and macroeconomic turmoil in the global economy. For our first set of results (section 4.1), which does not take into account complexity and controls, we consider 172 countries[4]. 139 countries are labeled as emerging economies (80.81% of the total), while 33 countries are advanced (19.19% of the total). In these countries 96 had in place a fiscal rule at the end of the period, which amounts 55.81% of the total (see Table A3 of the online Appendix).

[4] A full list with the names of the countries and other details can be consulted on Table A1 of the Appendix.

Table 1. Variable definition and summary statistics

Indicator	*Abbreviation*	*Source*	*Median*	*Mean*	*Std.Dev*	*Max.*	*Min.*
Population in millions	pop	WEO	37.17	8.07	134.42	1433.78	0.04
Inflation rate, average of the year	inf_avg	WEO	48.09	4.78	944.7	65374.08	-72.73
Real GDP growth	growth	WEO	3.32	3.58	6.39	177.26	-66.66
Log of per capita real consumption	ccon	Penn World Tables	10.63	10.52	2.08	16.64	5.32
Log of per capita domestic sbsorption	cda	Penn World Tables	10.87	10.74	2.11	16.88	5.43
Log of expenditure-side real GDP at current PPPs in mil. 2017US$	cgdpe	WEO	10.82	10.7	2.17	16.85	5.19
Log of output-side real GDP at current PPPs in mil. 2017US$	cgdpo	WEO	10.83	10.7	2.17	16.84	5.21
Log of capital stock at current PPPs in mil. 2017US$	cn	Penn World Tables	11.97	11.91	2.38	18.44	5.49
Chicago Board Options Exchange Volatility Index	vix	Bloomberg	19.48	17.67	5.83	32.7	11.09
Financial openness, Chinn-Ito index	kaopen	Ito's web	0.06	-0.15	1.55	2.32	-1.92
Terms of trade change in %	tot	WEO	110.21	100.44	51.01	1109.28	10.71
Interest expenses as % GDP	interest	WEO (estimate)	1.9	1.46	2.45	17.71	-35.48
Gross debt as % of GDP, general government	debt	WEO	58.02	48.16	45.05	658.22	0
Primary balance as % GDP	primary_balance	WEO	-0.56	-0.66	6.46	126.46	-186.79
Fiscal balance as % GDP	total_balance	WEO	-2.41	-2.47	6.52	125.14	-151.31
Fiscal revenue as % GDP	revenue	WEO	27.88	25.06	14.01	164.05	0.04
Oil rents as % of GDP	oil_rents	World Bank	3.55	0	9.26	71.49	0
Coal rents as % of GDP	coal_rents	World Bank	0.3	0	2.49	69.8	0
Forest rents as % of GDP	forest_rents	World Bank	2.08	0.32	4.17	44.6	0
Mineral rents as % of GDP	mineral_rents	World Bank	0.78	0.01	2.45	39.67	0
Gas rents as % of GDP (gas_rents)	gas_rents	World Bank	0.37	0	2.34	68.68	0
Natural resources rents as % of GDP	rents	World Bank	5.32	0.3	14.42	270.55	-25.82
Historical ethnic fractionalization	frac	HIEF-Harvard	0.52	0.58	0.28	1	0
Voice and accountability	vae	World Bank	-0.05	-0.04	1.07	4.28	-5.78
Political stability and absence of violence	pve	World Bank	-0.08	0.05	1.35	6.5	-7.92
Government Effectiveness	gee	World Bank	-0.08	-0.17	1.11	3.92	-4.27
Regulatory quality	rqe	World Bank	-0.09	-0.18	1.19	6.47	-5.78
Rule of law	rle	World Bank	-0.06	-0.19	1.13	5.84	-4.41
Control of corruption	cce	World Bank	-0.05	-0.27	1.14	5.79	-6.04
Economic Complexity Index	eci	Harvard's Growth Lab	0.02	-0.08	1	2.86	-2.78
Complexity Outlook Index	coi	Harvard's Growth Lab	0.03	-0.02	1	2.97	-3.71

Note: The table shows summary statistics of the variables in our sample, abbreviations as they appear in the results and sources of information.

For the second part of our analysis (section 4.2) we have collected a wide set of variables, inspired by the previous literature on fiscal crises and sovereign debt determinants. The full list of variables, abbreviation and sources are presented in columns from one to three of Table 1, while in columns four to eight are shown the means, medians, standard deviations, maxima and minima of the variables. Our set of variables considers known sources of fiscal distress identified by the previous literature, while all of them are theoretically motivated. For the same reason, we do not include transformations of the original variables in our data (differences, squares, interactions, etc.).

The pair of ECI and the Complexity Outlook Index (COI), which are constructed and regularly updated on the web page of the Atlas of Economic Complexity by Harvard's Growth Lab (see Hidalgo and Haussmann, 2009), completes our data set (last two rows of the table). The ECI and COI are available only for a subset of 128 countries, which are indicated with an asterisk in Table A1 of the online Appendix.

In Figure A1 of the online Appendix we show Pearson's correlation among the set of variables described in Table 1. Proxy variables for institutional quality in a given country depict a high correlation with each other, e.g. government effectiveness, regulatory quality, rule of law, control of corruption, etc. There are also almost perfect correlations between the aggregate demand proxies, such as domestic absorption and real consumption. For this reason we usually select only one variable within each group to conduct a given regression in our results sections. In any case, including one or several variables does not change our results regarding the effect of economic complexity (see Table A5 of the online Appendix).

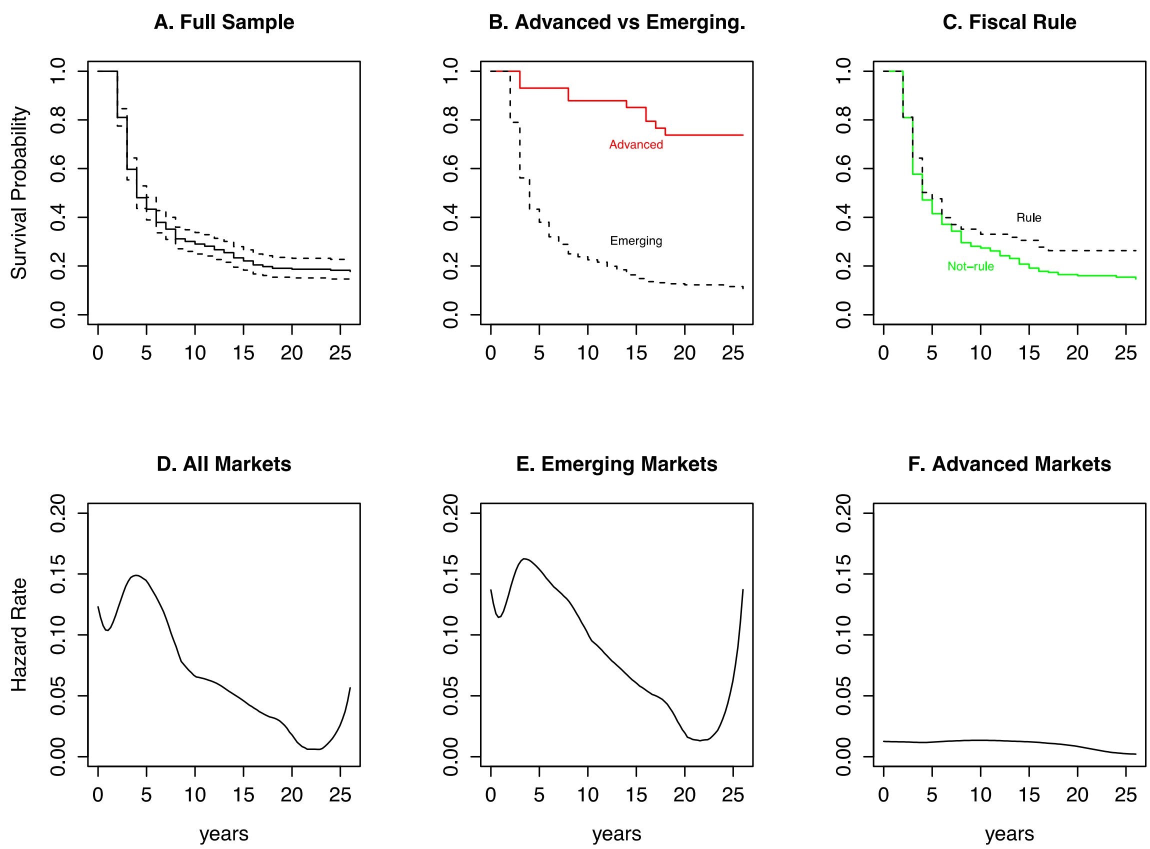
4. Results

Our main results are divided into two sections: in the first one we work with the full data set (even including countries that lack information on economic complexity or other covariates) and conduct a preliminary survival analysis. In the second part, we estimate the proportional hazard model and several robustness checks, including restricting the dataset to emerging economies only, changing the estimation method to handle ties in the data, and fitting an accelerated failure time model rather than a PH model. Our main results always hold.

4.1. *Survival estimates*

Regarding our dependent variable, i.e., fiscal crises, we handle two different types of events: Event 1 refers to fiscal distress episodes, and Event 0 to episodes of non-fiscal crisis. There are 1694 observations in the event of "crisis" in our dataset and 1754 observations in the event of "non-crisis". These observations are associated with 478 individuals. In principle, there are more individuals than countries, because each country can contribute to several fiscal crisis episodes. The average duration before a country enters into a fiscal crisis event is 4.9 years, while the average number of years a country is in the non-crisis state equals 13.29 years. The maximum number of years in both cases is 26, since our sample period runs from 1995 to 2020. This means two things: there are countries that never faced an episode of fiscal distress during the sample period (mostly advanced economies) and there is at least one country that started in 1995 without a fiscal crisis, and stayed out of the fiscal crisis during the whole sample, only to entering it in 2020 (this country is Chile). The minimum number of years between two fiscal crises is 2 by construction, and for such a reason the minimum of Event 1 in our sample is 2 (all this information is repeated in Table A3 of the online Appendix).

Figure 1. Survivorship to fiscal crises and hazard ratios



Note: Panel A to C of the figure show estimated survival probabilities (Kaplal-Meier) using individuals in the full sample, comparing advanced with emerging markets and countries with and without fiscal rule at the end of 2020. Panels D to F shows non-parametric hazard of the full sample, emerging and advanced economies, respectively.

On the top of Figure 1, Panels A to C, we can observe the Kaplan-Meier estimates for different individuals of the survivorship function. In Panel A it can be noticed that there is a significant share of individuals that enter into a crisis after year 2, while there is also a large number of individuals that do not enter a crisis episode even at period 26.

In Panel B of the figure we differentiate advanced from emerging countries. The differences in the survival (to crisis) probabilities are obvious and, for this reason, we will perform two separate analyses in the next section: 1) the main analysis including the whole sample of countries and 2) a restricted analysis using only emerging markets. As can be observed in the figure, the probability of surviving (i.e. not entering into an episode of fiscal stress) of advanced economies is much higher.

We also conduct a preliminary assessment of fiscal rules as a way to mitigate crises. In Panel C, it seems that fiscal rules move upwards the survivorship function of the countries that implement them, but the difference is not that large, so we need to conduct inference.

Indeed, to formalize the graphical inspection above we have conducted a formal statistical test (log-rank test) that compares the two functions in the two cases: As expected, the log-rank test indicates that the survivorship of the emerging and advanced countries is statistically different and the test is inconclusive for the case of the fiscal rule (p value is equal to 0.07, which means that the null of equality is rejected at 10% but it is not at 5%). In the latter case, there is also a possible bias due to the fact that emerging countries tend to implement fiscal rules more frequently than advanced countries, thus, in order to prevent a Simpson's paradox from emerging, it is necessary to compare the survivorship functions of emerging and advanced economics in different groups. For advanced economies, the log-rank statistic of the difference between implementing and not implementing a fiscal rule is 0.1 (p-value=0.7), while it is 1.7 (p-value=0.2) for emerging economies. In both cases, the null of equality cannot be rejected, meaning that fiscal rules' implementation does not reduce the probability of a future fiscal crisis. For this reason fiscal rules will not be considered in the following analysis.

In panels D to F of Figure 1 we show the no-parametric (Epanechnikov) kernel estimates of the hazard, which are useful to determine whether a monotonic function (i.e. exponential, Weibull) would suffice to model the duration until fiscal distress episodes are observed, or when it would be more appropriate to include covariates in the form of a proportional hazards model. Panel D shows the kernel for the whole sample, Panel C for emerging economies only, and Panel F for advanced economies only. It can be observed that, while in the case of advanced economies a monotonic function could be fitted to the data, in the case of emerging countries, and consequently the total sample, the non-monotonic behavior is significant and it merits the use of more sophisticated survival models of the hazard.

Noticeably, there is a growing risk at the end of the period of entering the fiscal crisis state for emerging countries (also for the total sample, in which emerging countries are included). This contrasts with the case of advanced economies for which the hazard tends to disappear for the end of the sample. This observation justifies our approach to the subject and confirms the importance for policy debate of understanding the sources of possible increments in the probability of living through a fiscal crisis, especially for emerging countries.

4.2. *Modeling the risk of facing a fiscal crisis*

In Table 2 we present the results for our baseline model 1 (M1) in column 2, and seven additional specifications from columns three to eight. M1 considers as predictors: regulatory quality (rqe), the rents perceived by countries (from oil, natural gas and coal) as a percentage GDP (rents), interest payments as percentage of GDP (interest) and the economic complexity indicator (eci). All of these variables are statistically significant. In economic terms, the most notable effects we observe are: an increment of a unit in the regulatory quality indicator estimated by the World Bank, reduces the probability of facing a fiscal crisis by 66%. Considering the maximum of this index is 6.47 and the minimum -5.78, a unitary-change is large but still possible to achieve. Indeed, the standard deviation of the index is 1.19 (see Table 1). On its side, an increment of 1 percentage point in the "interest" variable, increases the probability of a fiscal crisis by 14% and finally, a unitary increment in the economic complexity indicator reduces the probability of a fiscal crisis by 57%. The maximum of this indicator in the sample is 2.86 and the minimum -2.78, with a standard deviation of one (see Table 1, last row). The effect of rents is significant when we use regulatory quality as a proxy for institutional quality but is modest, around 2%. When we replace regulatory quality with the rule of law (rle, model 7) the effects of rents becomes insignificant.

In the third column of the table we can observe the results for the second model, which is basically the same model, with the inclusion of traditional macroeconomic indicators such as real growth, inflation and domestic absorption (cda). Interestingly, most of these variables turn out to be statistically insignificant, except for the log of per-capita domestic absorption, cda. In this case, we have that an increment of 1% in domestic absorption reduces the probability of suffering a fiscal crisis by 17% (recall that being cda in logs, the interpretation of this effects is akin to a log-log specification).

Table 2. Estimation results for the full sample of countries

	1	2	3	4	5	6	7	8
Predictors	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*
rqe	-0.66 *** (-1.02 – -0.31)	-0.73 *** (-1.09 – -0.37)	-0.72 *** (-1.09 – -0.36)	-0.70 *** (-1.07 – -0.33)	-0.99 *** (-1.30 – -0.69)	-0.90 *** (-1.19 – -0.61)		
rents	-0.02 * (-0.04 – -0.00)	-0.02 * (-0.04 – -0.00)	-0.03 * (-0.05 – -0.00)	-0.02 * (-0.04 – -0.00)	-0.02 (-0.04 – 0.00)	-0.02 * (-0.04 – -0.00)	-0.02 (-0.04 – 0.00)	-0.02 * (-0.04 – -0.00)
interest	0.14 *** (0.06 – 0.21)	0.14 *** (0.06 – 0.22)	0.11 * (0.00 – 0.21)	0.12 * (0.02 – 0.21)	0.12 * (0.03 – 0.21)		0.16 *** (0.08 – 0.24)	0.15 *** (0.07 – 0.22)
eci	-0.57 *** (-0.89 – -0.25)	-0.47 ** (-0.81 – -0.13)	-0.48 ** (-0.82 – -0.14)	-0.48 ** (-0.83 – -0.14)			-0.52 ** (-0.84 – -0.21)	-0.72 *** (-1.01 – -0.43)
growth		-0.05 (-0.12 – 0.02)	-0.05 (-0.12 – 0.02)	-0.05 (-0.12 – 0.02)	-0.03 (-0.10 – 0.03)	-0.05 (-0.12 – 0.01)		
inf avg		-0.00 (-0.02 – 0.01)	-0.00 (-0.02 – 0.02)	-0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)	0.00 (-0.01 – 0.02)		
cda		-0.17 * (-0.31 – -0.03)		-0.16 * (-0.30 – -0.01)	-0.22 ** (-0.35 – -0.09)	-0.18 ** (-0.31 – -0.06)		
ccon			-0.15 * (-0.30 – -0.01)					
vix			-0.01 (-0.04 – 0.03)					
primary balance			0.01 (-0.04 – 0.07)					
debt			0.00 (-0.00 – 0.01)	0.00 (-0.00 – 0.01)	0.00 (-0.00 – 0.01)	0.01 * (0.00 – 0.01)		
tot				0.00 (-0.00 – 0.01)	0.00 (-0.00 – 0.00)	0.00 (-0.00 – 0.01)		
rle							-0.78 *** (-1.12 – -0.43)	
vae								-0.47 ** (-0.76 – -0.17)
Observations	234	234	234	234	234	234	234	234
AIC	756.460	755.259	760.827	758.620	764.475	769.037	749.876	761.047
log-Likelihood	-374.230	-370.629	-370.413	-370.310	-374.238	-377.518	-370.938	-376.523

** p<0.05 ** p<0.01 *** p<0.001*

Note: results of a Cox model for the probability of fiscal crises including economic complexity. The variables are defined in Table 1.

The fourth column of the table houses model 3, in which we have changed the proxy for consumption, using this time ccon, which is real per-capita consumption in logs; we have included the vix, the debt/gdp ratio and the government primary balance. Nothing drastically changes and vix, the debt ratio and the government's balance are non-significant. In model fourth we have included terms of trade (tot) as a predictor, following the insights by Hilscher and Nosbusch (2009) that emphasize the role of tot in determining the sovereign yields of emerging markets debt. In our case, it is non-significant, neither in model 4, nor in models 5 and 6 that also consider this variable. In models 5 and 6 we have excluded eci (also interest in model 6) to see the effect on the remaining covariates. As can be seen, the exclusion of eci makes consumption and institutions seem even more decisive. The effect of institutions is such that, in this specification, they can rule out fiscal crises entirely on their own, and the effect of consumption increases between 1 and 5 percentage points compared to model 2.

Interestingly, it is only when the interest variable is excluded in model 6 that the debt/gdp ratio becomes significant. This alerts us to the real possibility of overemphasizing the role of debt thresholds in determining episodes of fiscal distress. In line with this result, Caselli et al. (2022) calibrate the model of debt sustainability designed by Mian et al. (2022), with data before and after the pandemic for different emerging and advanced economies and find that debt-ratios and safe-primary-deficits are likely to vary over time and to be country-dependent. They change according to market conditions, making them very difficult to estimate in practice. Indeed, the theoretical model by Mehrotra and Sergeyev (2021) shows that conditions for sustainability are not closely tied to the debt to GDP ratio and other metrics commonly used in the empirical literature (Reinhart and Rogoff, 2010). Our results echo Furman and Summers (2020) questioning the utility of debt-to-GDP thresholds and anchors, or at least warn researchers and policymakers interested in these ratios, to always considering the effect interest paid before assessing such safe-thresholds. Finally, note that the effect of economic complexity seems to be overestimated when a different institutional control is used (in particular, voice and accountability in the last column) and its effect is increased when we use instead the rule of law (model 7). Nevertheless, even including *all* institutional indicators in our dataset the effect of economic complexity never falls bellow 47% (see Table A5 in the online Appendix).

4.3. The hazard of emerging markets

Acknowledging the documented differences between emerging and advanced economies in section 4.1, we have estimated the same set of models reported in Table 2, using only the information for emerging markets, which reduces the effective sample size of individuals from 234 to 202. Results are reported in Table 3.

It can be observed that all the variables in our baseline specification, model 1, in particular, rqe and eci remain significant (except for rents). The signs of regulatory quality and economic complexity are unaltered with respect to the results previously reported in Table 2. Moreover, due to the smaller variation in the regulatory quality and the economic complexity within emerging economies, the effects of rqe and eci reduce 17 and 12 percentage points, respectively (looking at model 1), and 21 and 8 percentage points, respectively, (looking at model 2). The greater sensitivity of the institutional variable than the complexity variable in the face of sample reduction means that for emerging markets the effect of both is approximately the same (49% versus 45%).

Table 3. Estimation results using only emerging market economies

	1	2	3	4	5	6	7	8
Predictors	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*
rqe	-0.49 * (-0.88 – -0.09)	-0.55 ** (-0.96 – -0.15)	-0.51 * (-0.92 – -0.10)	-0.49 * (-0.91 – -0.07)	-0.69 *** (-1.07 – -0.32)	-0.57 ** (-0.93 – -0.22)		
rents	-0.02 (-0.04 – 0.00)	-0.02 (-0.04 – 0.00)	-0.02 (-0.05 – 0.00)	-0.02 (-0.04 – 0.00)	-0.02 (-0.03 – 0.00)	-0.02 (-0.04 – 0.00)	-0.01 (-0.04 – 0.01)	-0.02 (-0.04 – 0.00)
interest	0.16 *** (0.08 – 0.25)	0.15 *** (0.07 – 0.24)	0.10 (-0.02 – 0.22)	0.12 * (0.02 – 0.23)	0.12 * (0.01 – 0.22)		0.17 *** (0.08 – 0.26)	0.17 *** (0.08 – 0.25)
eci	-0.45 ** (-0.79 – -0.11)	-0.39 * (-0.75 – -0.03)	-0.39 * (-0.75 – -0.03)	-0.40 * (-0.76 – -0.04)			-0.46 ** (-0.79 – -0.13)	-0.58 *** (-0.89 – -0.26)
growth		-0.06 (-0.13 – 0.01)	-0.06 (-0.13 – 0.01)	-0.06 (-0.13 – 0.01)	-0.05 (-0.11 – 0.02)	-0.06 (-0.13 – 0.00)		
inf avg		-0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)	0.00 (-0.01 – 0.02)	0.00 (-0.01 – 0.02)	0.00 (-0.01 – 0.02)		
cda		-0.13 (-0.27 – 0.01)		-0.11 (-0.25 – 0.04)	-0.16 * (-0.29 – -0.02)	-0.12 (-0.25 – 0.02)		
ccon			-0.10 (-0.25 – 0.04)					
vix			-0.01 (-0.05 – 0.02)					
primary balance			0.02 (-0.04 – 0.08)					
debt			0.00 (-0.00 – 0.01)	0.00 (-0.00 – 0.01)	0.00 (-0.00 – 0.01)	0.01 * (0.00 – 0.01)		
tot				0.00 (-0.00 – 0.01)	0.00 (-0.00 – 0.01)	0.00 (-0.00 – 0.01)		
rle							-0.55 ** (-0.95 – -0.15)	
vae								-0.28 (-0.61 – 0.05)
Observations	202	202	202	202	202	202	202	202
AIC	689.335	689.655	693.811	692.308	695.187	698.288	687.719	692.572
log-Likelihood	-340.667	-337.827	-336.905	-337.154	-339.593	-342.144	-339.859	-342.286

* *p<0.05* ** *p<0.01* *** *p<0.001*

Note: results of a Cox model for the probability of fiscal crises in emerging economies including economic complexity. The variables are defined in Table 1.

In general lines, the other analyses reported in the last section remain unaltered, in particular the one related to the debt-ratio and interest. Variations in consumption levels within emerging economies seem to lose relevance as well according to this new set of regressions.

4.4. Estimation, specification, robustness

We have conducted several specifications tests for our baseline models that are reported in Table A4 of the Online Appendix. In particular, for models 1 and 2, concordance statistics range between 69.1% and 70.1% which shows a good fit. On their side, likelihood ratio test (statistic equal to 76.6 and 83.8 for model 1 and 2 respectively), Wald test (61.5, 64.93) and logrank test (666.74, 72.45) all allow to reject the null hypothesis of non-significance of the models at any confidence level above 99.9%.

We also have tested the assumption of constant proportional hazards of Cox models. For model 1 the null hypothesis of constant proportional hazard is not globally rejected (statistic of 5.55 with 4 degrees of freedom, and p-value equal to 0.23, see Table A4 in the Appendix). Indeed, all models pass the test, except for those including "growth" as a predictor.

Real growth of countries has been a traditional determinant of sovereign debt spreads and sudden stops. For this reason, we wanted to test if perhaps modeling our problem within the framework of an accelerated failure time model improves the significance of growth and allows for a better specification of the models including it. From the second to fifth columns of Table 4 we report the results of an AFT model for specification 1 to 4 (including and excluding growth). As mentioned in the methodology, AFT models depart from a different assumption than PH models, whereas in a PH model the covariates act multiplicatively on the hazard, in an AFT model they act multiplicatively on time.

When looking at Table 4 (columns 2-5) an additional note of caution is required, since the effect coefficients have a different interpretation in the two types of models. For instance, the impact of a unitary increment in regulatory quality in the AFT model increases the "survival time" of a country (reduces the probability of crisis) in $71.6\% \ (\approx [exp(0.54) - 1] * 100)$. The effect of eci is even greater, as a one-unit-increment in the index is associated to an increment in the survival time of the country (a reduction of the crisis probability) of $73.3\%(\approx [exp(0.55) - 1] * 100)$. The effect of interest is similar, around 9.52% of reduction in the survival time, which compares with 14% in the PH model; the effect of rents is very similar in both models (≈2% of reduction in the failure probability), so it is the effect of the cda (≈13.88%). Unsurprisingly, at this stage, neither growth nor debt are significant.

Table 4. Different model specifications and estimation strategies

	aft 1	aft 2	aft 3	aft 4	base line	breslow	efron
Predictors	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*
(Intercept)	2.75 *** (2.53 – 2.97)	1.05 (-0.00 – 2.10)	1.02 (-0.18 – 2.21)	1.26 * (0.10 – 2.42)			
rqe	0.54 *** (0.30 – 0.77)	0.57 *** (0.34 – 0.79)	0.58 *** (0.35 – 0.80)	0.55 *** (0.31 – 0.78)	-0.66 *** (-1.02 – -0.31)	-0.56 *** (-0.87 – -0.25)	-0.58 *** (-0.89 – -0.28)
rents	0.02 ** (0.01 – 0.04)	0.02 *** (0.01 – 0.04)	0.03 ** (0.01 – 0.04)	0.02 ** (0.01 – 0.04)	-0.02 * (-0.04 – -0.00)	-0.02 (-0.04 – 0.00)	-0.02 (-0.04 – 0.00)
interest	-0.10 *** (-0.15 – -0.05)	-0.10 *** (-0.14 – -0.05)	-0.07 * (-0.13 – -0.01)	-0.09 ** (-0.14 – -0.03)	0.14 *** (0.06 – 0.21)	0.11 *** (0.05 – 0.17)	0.13 *** (0.07 – 0.19)
eci	0.55 *** (0.34 – 0.77)	0.47 *** (0.25 – 0.69)	0.47 *** (0.25 – 0.69)	0.48 *** (0.26 – 0.70)	-0.57 *** (-0.89 – -0.25)	-0.48 ** (-0.76 – -0.19)	-0.52 *** (-0.81 – -0.23)
Log(scale)	-0.25 *** (-0.37 – -0.12)	-0.28 *** (-0.40 – -0.16)	-0.29 *** (-0.41 – -0.17)	-0.28 *** (-0.41 – -0.16)			
growth		0.04 (-0.01 – 0.09)	0.05 (-0.00 – 0.09)	0.04 (-0.01 – 0.09)			
inf avg		0.00 (-0.01 – 0.01)	0.00 (-0.01 – 0.01)	0.00 (-0.01 – 0.01)			
cda		0.13 ** (0.04 – 0.22)		0.12 ** (0.03 – 0.21)			
ccon			0.12 * (0.03 – 0.21)				
vix			0.01 (-0.01 – 0.03)				
primary balance			-0.01 (-0.05 – 0.02)				
debt			-0.00 (-0.00 – 0.00)	-0.00 (-0.00 – 0.00)			
tot				-0.00 (-0.00 – 0.00)			
Observations	234	234	234	234	234	234	234
AIC	946.450	941.821	946.603	944.970	756.460	1413.035	1380.431
log-Likelihood	-467.225	-461.911	-461.302	-461.485	-374.230	-702.517	-686.215

** p<0.05   ** p<0.01   *** p<0.001*

Note: results of an accelerated failure time model for the survival to fiscal crises (columns 2 to 5) and Cox model results of the probability of fiscal crises with different estimation methods: exact maximum likelihood in the baseline, Breslow's and Efron's estimators in the last two columns. The variables are defined in Table 1.

Results in the first columns of Table 4 do not only reaffirm the positive effect of economic complexity on the fiscal health of countries, and as a protective factor against fiscal crisis, but also emphasize this effect. If the assumption of constant proportional hazards were rejected, the effect of economic complexity would be even larger, and totally comparable to that of institutions.

Finally, in columns six to eight of the table we present the results of our baseline model, changing the estimation method. Our results so far have used an exact partial likelihood approximation to estimate the effects of the probability of entering into a fiscal crisis, which is appropriate to smaller data sets of discrete values. In the table we report, in addition, the estimates using Efron's (column 7) and Breslow's (column 8) approximations. The first one is the most popular in the literature, and the second one works better when dealing with tied death times (i.e. frequent matches in the observed survival times of individuals in the sample). Our main results are unaltered in the three cases, compared to our baseline model. There seems to be a reduction in the effect of both regulatory quality and economic complexity of between 8 to 10 percentage points for the institutional factor (rqe) and between 6 to 9 percentage points for the eci index. Robustness exercises including additional controls from Table 1, and other in Table A8 of the Online Appendix, are presented in Tables A5 and A7 of the same Appendix, respectively.

5. Conclusions

After considering numerous modeling specifications of the survival time before a fiscal crisis is observed (or, similarly, the probability of entering a fiscal distress episode), we document a protective effect of economic complexity against crises. In fact, an increase in economic complexity and, therefore, in the diversification and exclusivity of export products, offers an important shield against future fiscal crises, since it reduces the probability of suffering this type of crisis by half. This number drops when only emerging markets are considered, but is still above 39%. Economic complexity and institutions should be the key policy focus, much more so than macroeconomic indicators, fiscal balances, and terms of trade, but especially more so than debt and its thresholds, which are in fact only significant when the interest paid on the debt is deliberately excluded from the model.

In policy terms, the lessons of our study can be summarized as: 1) invest in increasing the economic complexity of export products. Not only would this have a direct impact on development, but it would also help as a shield against fiscal crises. 2) Do not overemphasize debt thresholds and safe debt levels when assessing the fiscal sustainability of countries, but instead focus on complexity and institutional factors as predictors.

References

Alshamsi, A., Pinheiro, F. L. & Hidalgo, C. (2018) A. Optimal diversification strategies in the networks of related products and of related research areas. *Nature Communications* 9, 1328.

Aronica, M., Pizzuto, P., Sciortino, C. (2021) COVID-19 and tourism: What can we learn from the past? *World Development* 45 (2): 430-444.

Audretsch, D. B., Feldman, M. P. (1996) R&D spillovers and the geography of innovation and production. *American Economic Review* 86, 630–640.

Audretsch, D. B., Feldman, M. P. (2004) in Handbook of Regional and Urban Economics Vol. 4 Ch. 61 (eds Henderson, J. V. & Thisse, J.F.) 2713–2739.

Balland, P. A., Boschma, R., Crespo, J., Rigby, D. L. (2018) Smart specialization policy in the European Union: relatedness, knowledge complexity and regional diversification. *Regional Studies* 53, 1252–1268.

Balland, P.A. Broekel, T., Diodato, D., Giuliani, E., Hausmann,R., O'Clery, N., Rigby, D., (2022). The new paradigm of economic complexity. *Research Policy* 51(3), 104450.

Caselli, F., Davoodi, H., Goncalves, C.,Hong, G.H.., Logerborg, A., Medas, P., Nguyen, A. D. M., Yoo, J. (2022) The return to fiscal rules, International Monetary Fund, Staff Discussion Note 2022/002.

Cox, D.R. (1972). Regression Models and Life-Tables. *Journal of the Royal Statistical Society,* B 34, 187-220.

Deaton, A. (1999). Commodity Prices and Growth in Africa *Journal of Economic Perspectives* 13: 23-40.

Furman, Jason, Summers, L. (2020) A Reconsideration of Fiscal Policy in the Era of Low InterestRates. Unpublished manuscript. Available at https://www.brookings.edu/wp-content/uploads/2020/11/furman-summers-fiscal-reconsideration-discussion-draft.pdf

Güneri, B., Yalta, A. Y. (2021) Does economic complexity reduce output volatility in developing countries? *Bulletin of Economic Research* 73(1): 411-431.

Haussmann, R., Hidalgo, C.A., Bustos, S., Coscia, M., Simoes, A., Yildirim, M. (2014)*The Atlas of Economic Complexity: Mapping Paths to Prosperity*, MIT Press.

Hidalgo, C.A. (2021). Economic complexity theory and applications. *Nature Physics* 3, 92–113

Hidalgo, C.A., Hausmann, R., (2009). The building blocks of economic complexity. *PNAS USA* 106 (26), 10570–10575.

Hilscher, J., and Y. Nosbusch (2010). Determinants of sovereign risk: Macroeconomics fundamentals and the pricing of sovereign debt. *Review of Finance* 14: 235–262.

Jaffe, A. B., Trajtenberg, M. & Henderson, R. (1993) Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics* 108, 577–598 .

Lee, K. & Ki, J. (2017) Rise of latecomers and catch-up cycles in the world steel industry. *Research Policy* 46, 365–375.

Lo, G.D., I. Marcelin, T. Bassene, and B. Sene (2022). The Russo-Ukrainian war and financial markets: the role of dependence on Russian commodities. *Finance Research Letters* 50: Article 103194.

Maggioni, D., Lo Turco, A., Gallegati, M. (2016) Does product complexity matter for firms' output volatility? *Journal of Development Economics* 121: 94-109.

Medas, P., Poghosyan, T., Xu, Y., Farah-Yacoub, J., Gerling, K. (2018) Fiscal crises. *Journal of International Money and Finance* 88- 191-207

Mehrotra, N. R., Sergeyev, D. (2021). Debt Sustainability in a Low Interest Rate World. *Journal of Monetary Economics* 124: 1–18.

Mian, A. R., Straub, L., Sufi, A., (2022) "A Goldilocks Theory of Fiscal Deficits." NBER Working Paper No.w29707, National Bureau of Economic Research, Cambridge, MA.

Moreno-Badia, M.L., Medas, P., Gupta, P., Xiang, Y. (2022). Debt is not free, *Journal of International Money and Finance* 127- 102654.

Nepelski, D., De Prato, G. (2020) Technological complexity and economic development. *Review of Development Economics* 24(2): 448-470.

Özmen, M.U. (2019) Economic complexity and sovereign risk premia. *Economics Bulletin* 39 (3): 1714-1726.

Reinhart, C.M., Rogoff, K.S. (2010). Growth in a time of debt. *American Economic Review* 100 (2), 573–578.

Reuters (2022). IMF sees cost of COVID pandemicrising beyind USD 12.5 trillion estimate. Reuters press note retrieved on January 1, 2022.

Tacchella, A., Mazzilli, D. & Pietronero, L. A (2018) Dynamical systems approach to gross domestic product forecasting. *Nature Physics* 14, 861–865.

Online Appendix

In this appendix to the manuscript "Does economic complexity reduce the probability of a fiscal crisis?" we provide additional information that complement the main tables and figures in the body of the article.

Table A1. Country list and classification

Advanced	Emerging Markets		Low Income Developing Countries
Australia*	Albania*	Pakistan*	Afghanistan
Austria*	Algeria*	Panama*	Bangladesh*
Belgium*	Angola*	Paraguay*	Benin
Canada*	Antigua and Barbuda	Peru*	Bhutan
Cyprus*	Argentina*	Philippines*	Burkina Faso*
Czech Republic*	Armenia*	Poland*	Burundi
Denmark*	Azerbaijan*	Qatar*	Cambodia*
Estonia*	Barbados	Romania*	Cameroon*
Finland*	Belarus*	Russia*	Central African Republic
France*	Belize	Samoa	Chad
Germany*	Bolivia*	Saudi Arabia*	Comoros
Greece*	Bosnia and Herzegovina*	Seychelles	Congo, Democratic Republic of the*
Hong Kong SAR	Botswana*	South Africa*	Côte d'Ivoire*
Iceland*	Brazil*	Sri Lanka*	Djibouti
Ireland*	Bulgaria*	St. Kitts and Nevis	Eritrea
Israel*	Cabo Verde	St. Lucia	Ethiopia*
Italy*	Chile*	St. Vincent and the Grenadines	Ghana*
Japan*	China*	Suriname	Guinea*
Korea*	Colombia*	Syria	Guinea-Bissau
Latvia*	Costa Rica*	Thailand*	Haiti
Lithuania*	Croatia*	The Bahamas	Honduras*
Netherlands*	Dominica	Tonga	Kenya*
New Zealand*	Dominican Republic*	Trinidad and Tobago*	Kiribati
Norway*	Ecuador*	Tunisia*	Kyrgyz Republic*
Portugal*	Egypt*	Turkey*	Lao P.D.R.
Singapore*	El Salvador*	Turkmenistan*	Lesotho
Slovak Republic*	Eswatini*	Ukraine*	Liberia*
Slovenia*	Fiji	United Arab Emirates*	Madagascar*
Spain*	Gabon*	Uruguay*	Malawi*
Sweden*	Georgia*	Vanuatu	Mali*
Switzerland*	Grenada	Venezuela*	Mauritania*
United Kingdom*	Guatemala*		Moldova*
United States*	Guyana		Mozambique*
	Hungary*		Myanmar*
	India*		Nepal
	Indonesia*		Nicaragua*
	Iran*		Niger
	Iraq		Papua New Guinea*
	Jamaica*		Republic of Congo*
	Jordan*		Rwanda
	Kazakhstan*		Senegal*
	Kuwait*		Sierra Leone
	Lebanon*		Solomon Islands
	Libya*		Sudan
	Malaysia*		São Tomé and Príncipe
	Maldives		Tajikistan*
	Mauritius*		Tanzania
	Mexico*		The Gambia
	Mongolia*		Togo*
	Morocco*		Uganda*
	Namibia		Vietnam*
	Nigeria*		Yemen*
	North Macedonia*		Zambia*
	Oman*		Zimbabwe*

Note: The table shows the countries included in our main sample. They correspond to those in Medas et al. (2018) and Moreno et al. (2022), except for 16 countries: 3 Advanced economies (Luxemburgo, Malta and San Marino); 9 emerging countries (Bahrain, Brunei, Equatorial Guinea, Rep. of Marshall Islands, Micronesia, Palau, Swaziland, Tuvalu); and 4 LIDC (Somalia, South Sudan, Timor Leste and Uzbekistan). These countries lacked enough information for our explanatory variables during the sample period. In addition, we include Hong-Kong as a country in the advanced sample. The country series of the Economic Complexity Index are fewer as they are only available for 128 countries, which are marked with an asterisk in front of the country name.

Table A2 Description of events of crisis and non-crisis

statistic	*Event.1*	*Event.0*
Mean	4.9	13.29
Median	3	11
Std	3.97	10
Max	26	26
Min	2	1
sum	1694	1754

Note: the table shows summary statistics for the event of crisis (1) and the event of non-crisis (0) in the sample.

Table A3. Comparative log-rank tests of models

Name	*Emerging*	*Fiscal.rule*
Category 0	44	329
Category 1	434	149
statistic	62.23	3.24
p value	0	0.07

Note: the table shows the number of observations in each category: emerging or fiscal rule are category 0 and advanced or non-fiscal rule are category 1. It also presents a comparative logrank test statistic and its associated p-value.

Table A4. Specification Tests

Indicator	*Model.1*	*Model.2*	*Model.3*	*Model.4*	*Model.5*	*Model.6*	*Model.7*	*Model.8*
Score (logrank)	66.7415	72.4491	75.2525	75.2197	70.1714	67.3997	68.932	63.1802
p.value (logrank)	0	0	0	0	0	0	0	0
Wald test	61.2534	64.9342	66.8948	66.8153	63.521	61.0639	62.5356	59.4112
p.value (wald)	0	0	0	0	0	0	0	0
Concordance	0.691	0.7006	0.7023	0.703	0.6989	0.6968	0.6844	0.6786
s.e	0.0251	0.0261	0.0261	0.0261	0.0259	0.0261	0.0259	0.0265
Likelihood ratio	76.5964	83.797	84.2292	84.4364	76.5805	70.0193	83.1803	72.0091
p.value(lik)	0	0	0	0	0	0	0	0
Schoenfeld resid	5.5526	17.425	21.6198	17.7758	17.6003	20.1955	5.8129	4.7938
p.vale(res)	0.2351	0.0149	0.0172	0.0379	0.0244	0.0052	0.2136	0.3091

Note: the table shows the several specification and adjustments tests. In descending order the score (logrank test), Wald test, Concordance, Likelihood Ratio test and Schoenfeld residuals tests. The Null in the former 4 tests is joint non-significant. The null of the later test is constant proportional hazards.

Table A5 Regressions with additional controls in the data set

	1	2	3	4	5	6	7	8
Predictors	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*
rqe	-0.66 *** (-1.02 – -0.31)	-0.67 *** (-1.03 – -0.31)	0.22 (-0.51 – 0.95)	-0.81 *** (-1.18 – -0.45)	-0.78 *** (-1.16 – -0.40)	-0.70 *** (-1.06 – -0.34)	-0.72 *** (-1.07 – -0.36)	-0.10 (-0.88 – 0.69)
rents	-0.02 * (-0.04 – -0.00)	-0.02 * (-0.04 – -0.00)	-0.02 (-0.04 – 0.00)	-0.02 * (-0.04 – -0.00)	-0.02 * (-0.04 – -0.00)	-0.02 (-0.04 – 0.00)	-0.02 (-0.04 – 0.00)	-0.02 (-0.04 – 0.01)
interest	0.14 *** (0.06 – 0.21)	0.14 *** (0.07 – 0.22)	0.17 *** (0.09 – 0.26)	0.15 *** (0.07 – 0.22)	0.15 *** (0.07 – 0.22)	0.15 *** (0.07 – 0.23)	0.15 *** (0.07 – 0.23)	0.16 *** (0.07 – 0.24)
eci	-0.57 *** (-0.89 – -0.25)	-0.52 * (-0.93 – -0.11)	-0.47 ** (-0.83 – -0.12)	-0.51 ** (-0.84 – -0.19)	-0.50 ** (-0.83 – -0.18)	-0.50 * (-0.93 – -0.07)	-0.53 * (-0.97 – -0.10)	-0.51 * (-1.00 – -0.03)
coi		-0.05 (-0.36 – 0.25)				0.07 (-0.27 – 0.41)	0.12 (-0.24 – 0.47)	0.15 (-0.23 – 0.52)
frac			0.43 (-0.62 – 1.49)					0.29 (-0.80 – 1.38)
vae			-0.14 (-0.63 – 0.35)					0.11 (-0.43 – 0.64)
pve			0.02 (-0.31 – 0.34)					-0.19 (-0.55 – 0.17)
gee			-1.11 * (-2.02 – -0.20)					-0.84 (-1.84 – 0.15)
cce			0.12 (-0.55 – 0.79)					0.07 (-0.61 – 0.76)
pop				-0.00 * (-0.01 – -0.00)	-0.00 * (-0.01 – -0.00)			-0.01 (-0.01 – 0.00)
kaopen					-0.04 (-0.18 – 0.10)			-0.06 (-0.21 – 0.09)
cn						-0.14 * (-0.28 – -0.01)		-0.01 (-0.20 – 0.17)
cgdpo							-0.18 * (-0.34 – -0.03)	
Observations	234	234	234	234	234	234	234	234
AIC	756.460	758.336	756.365	749.368	751.090	756.001	754.387	755.793
log-Likelihood	-374.230	-374.168	-369.183	-369.684	-369.545	-372.001	-371.194	-364.897

** p<0.05 ** p<0.01 *** p<0.001*

Note: model using additional controls in the dataset to estimate the probability of fiscal crises of the countries in our data set, including economic complexity. The variables are defined in Table 1 of the main document and Table A6 of this Appendix.

Table A6. List of variables in the main text and additional variables

Variable	Abbreviation	Source
Population (in millions)	pop	WEO
Gross capital formation (% GDP)	gkf	WEO
Gross fixed capital formation (% GDP)	gfkf	WEO
Inflation Rate (average of the year)	inf_avg	WEO
Real GDP Growth	growth	WEO
Human capital index	hc	Penn World Tables
Per Capita Real Consumption	ccon	Penn World Tables
Per Capita Domestic Absorption	cda	Penn World Tables
Expenditure-side real GDP at current PPPs (in mil. 2017US$)	cgdep	WEO
Output-side real GDP at current PPPs (in mil. 2017US$)	cgdpo	WEO
Capital stock at current PPPs (in mil. 2017US$)	cn	Penn World Tables
TFP level at current PPPs (USA=1)	ctfp	WEO
Real internal rate of return	irr	Penn World Tables
Chicago Board Options Exchange Volatility Index	vix	Bloomberg
Nominal Exchange Rate (end of the period)	trm_end	WEO
Exchange rate, national currency/USD (market+estimated)	xr	WEO (estimated)
Trade Openness: Exports + Imports (% GDP)	openess	WEO (estimated)
Financial openness, Chinn-Ito index	kaopen	https://web.pdx.edu/~ito/Chinn-Ito_website.htm
Terms of trade change (%)	tot	WEO
Merchandise: Country Diversification Index -Exports	diversification	World Bank
Merchandise: Country Concetration Index -Exports	concentration	World Bank
Interest Expenses(% GDP), primary balance - overall balance	interest	WEO (estimated)
Implicit interest rate, (Interest Payment / Debt)	interest_rate2	WEO (estimated)
Gross debt (% of GDP), general government	debt	WEO
Primary Balance (% GDP)	primary_balance	WEO
Fiscal Balance (% GDP)	total_balance	WEO
Fiscal Revenue (% GDP)	revenue	WEO
Domestic Currency Debt (% Total)	p_dd	WEO (October 2019)
Foreign Currency Debt (% Total)	p_fd	WEO (October 2019)
Oil Rents (% of GDP)	oil_rents	World Bank
Coal Rents (% of GDP)	coal_rents	World Bank
Forest Rents (% of GDP)	forest_rents	World Bank
Mineral Rents (% of GDP)	mineral_rents	World Bank
Gas Rents (% of GDP)	gas_rents	World Bank
Natural Resources Rents (% of GDP)	rents	World Bank
Historical Index of Ethnic Fractionalization	frac	HIEF-Harvard
Voice and Accountability, Estimate	vae	World Bank
Voice and Accountability, Percentile Rank (0-100)	var	World Bank
Political Stability and Absence of Violence/Terrorism, Estimate	pve	World Bank
Government Effectiveness, Estimate	gee	World Bank
Regulatory Quality, Estimate	rqe	World Bank
Rule of Law, Estimate	rle	World Bank
Control of Corruption, Estimate	cce	World Bank
Complexity Outlook Index	coi	Harvard's Growth Lab
Economic Complexity Index	eci	Harvard's Growth Lab

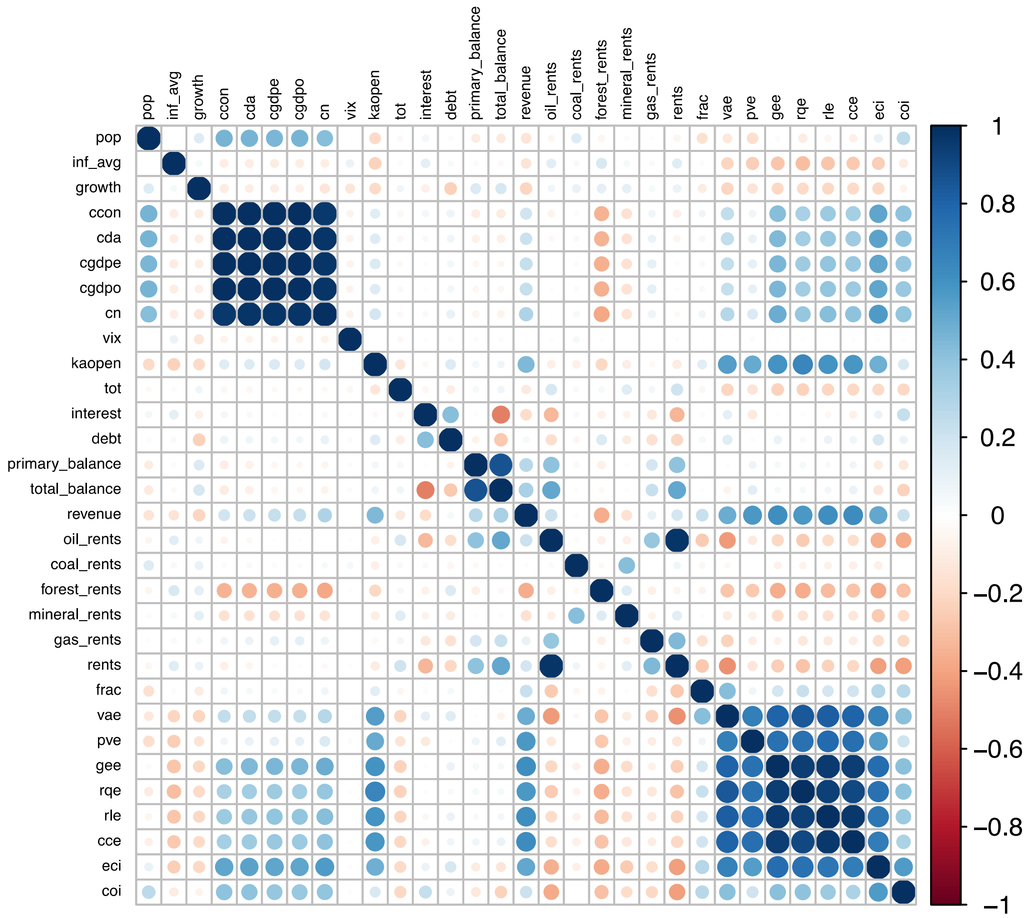
Table A7 Regressions with additional controls using a restricted data set

	1	2	3	4	5	6	7	8	9
Predictors	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*	*Effect*
rqe	-0.46 (-0.97 – 0.06)	-0.45 (-0.96 – 0.06)	-0.45 (-0.97 – 0.07)	-0.46 (-0.96 – 0.03)	-0.45 (-0.98 – 0.08)	-0.55 * (-1.11 – -0.00)	-0.44 (-0.96 – 0.07)	-0.64 * (-1.23 – -0.06)	0.18 (-0.76 – 1.13)
rents	-0.00 (-0.03 – 0.03)	-0.02 (-0.04 – 0.01)	-0.00 (-0.03 – 0.03)	-0.02 (-0.04 – 0.01)	-0.02 (-0.04 – 0.01)	-0.03 (-0.06 – 0.00)	-0.01 (-0.04 – 0.01)	-0.00 (-0.04 – 0.03)	-0.02 (-0.04 – 0.01)
interest	0.16 ** (0.05 – 0.26)	0.16 ** (0.05 – 0.26)	0.15 ** (0.04 – 0.26)	0.19 ** (0.07 – 0.30)	0.16 ** (0.05 – 0.26)	0.16 ** (0.05 – 0.26)	0.15 * (0.03 – 0.26)	0.17 ** (0.05 – 0.28)	0.18 ** (0.06 – 0.29)
change trm	0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)	-0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)	-0.00 (-0.02 – 0.02)	0.00 (-0.02 – 0.02)
eci	-0.66 * (-1.28 – -0.05)	-0.59 (-1.18 – 0.01)	-0.72 ** (-1.21 – -0.22)	-0.45 * (-0.89 – -0.01)	-0.54 * (-0.98 – -0.11)	-0.63 ** (-1.08 – -0.17)	-0.55 * (-0.98 – -0.12)	-0.77 * (-1.43 – -0.12)	-0.40 (-0.88 – 0.08)
concentration	-1.42 (-3.34 – 0.50)		-1.32 (-3.12 – 0.48)					-2.12 * (-4.17 – -0.07)	
diversification	0.50 (-2.73 – 3.74)	-0.30 (-3.23 – 2.63)						0.70 (-2.69 – 4.08)	
p fd				0.01 (-0.00 – 0.02)				0.01 * (0.00 – 0.02)	
kaopen					-0.00 (-0.17 – 0.16)			0.00 (-0.17 – 0.17)	
revenue						0.02 (-0.01 – 0.05)		0.03 (-0.00 – 0.07)	
total balance							-0.01 (-0.08 – 0.06)	-0.06 (-0.13 – 0.02)	
frac									-0.09 (-1.38 – 1.20)
vae									-0.18 (-0.84 – 0.49)
pve									-0.01 (-0.40 – 0.39)
gee									-0.94 (-2.02 – 0.15)
cce									0.23 (-0.62 – 1.08)
Observations	150	150	150	150	150	150	150	150	150
AIC	499.279	499.472	497.373	495.881	499.509	498.286	499.389	498.671	504.049
log-Likelihood	-242.639	-243.736	-242.686	-241.941	-243.755	-243.143	-243.695	-238.336	-242.025

* $p<0.05$ ** $p<0.01$ *** $p<0.001$

Note: model using additional controls in the dataset to estimate the probability of fiscal crises of the countries in our data set, including economic complexity. The variables are defined in Table A7.

Figure A1. Correlation among variables in the dataset



UBIREA
Institut de Recerca en Economia Aplicada Regional i Pública
Research Institute of Applied Economics
Universitat de Barcelona
Av. Diagonal, 690 • 08034 Barcelona

WEBSITE: www.ub.edu/irea • **CONTACT:** irea@ub.edu