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MACROPRUDENTIAL FRAMEWORK: QUANTILE VAR FORECASTING APPLIED TO THE PORTUGUESE ECONOMY

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Abstract

This work project explores the potentialities of Quantile VAR forecasting to study the entire probabilistic distribution of the Portuguese economy, with particular focus on its left tail and associated downside risks. It resorts to Chavleishvili *et al.* (2019) to confirm the nonlinearities and left tail downside skewness of the portuguese growth distribution, as well as the suitability and usefulness of using this method to enlarge the macroprudential policymaking strategy portfolio. It also compares Portugal's framework to the original model's Euro Area's one and suggests further extensions and paths this field can follow to strengthen Economic's role on bringing credibility and reform and to stimulate the economy's underlying growth potential.

Keywords : Macroeconometrics ; Forecasting ; Quantile ; Growth.

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1. Introduction

More than ever, forecasting as a macroeconomic tool is becoming of paramount importance in modern Economics. During the financial crisis, the economic science's actual ability to contribute to greater stability and to shape the living standards and advanced societies' structure organization was intensely questioned. Suddenly, damaging financial shocks were disturbing old commonly accepted laws and conventions, and the economic community not only was unable to predict the dimension and the scope of the problem but had also been unanimous up to that point on ensuring that something like that would not be taking form at all. When the first signals started announcing what was yet to come, it was too late. The phenomenon's consequences were devastating, comprising millions of lost jobs, the failure of several businesses, rising poverty, and an overwhelming amount of wealth destruction. These effects reverberated deeply, triggering political upheaval, and societal unrest and left scars that have yet to heal even after an entire decade of recovery. The economists' role in society was heavily discredited, with public trust in the science falling, as reflected in the 2012 Forbes article "How Economists contributed to the Financial Crisis".

Nowadays, a decennium later, humanity is faced with yet another crisis. However, unlike the previous one, the covid recession was not provoked by economic fundamentals long giving signals that something was going wrong. This time, the cause lied on a completely unexpected exogenous shock whose supervision was not assigned to economic science. Nevertheless, as much as the motives are entirely distinct, the role Economics plays in the way to approach them is quite similar. Central banks all around the globe have yet again enacted a package of bond buying in order to inject liquidity in stale economies so as to soften the slump the economic standstill imposed. Governments, on their behalf,

have used budget resources to formalize support programs helping the most affected citizens to cope with their hardships and, in many cases, even to avoid their materialization, using job furlough schemes to prevent an unemployment crisis. Although in different formats, the same strategy was adopted back in 2008.

This time, authorities were undoubtedly more well prepared, designing measures with the inspiration of past policymaking. However, that was not the only reason the crisis effects were less pronounced. The fact is that coming from an exigent restructuration process, motivated by the previous recent crisis, economies were much sounder, being able to, more or less stoically, face the shock before them. And that is the message this paper upholds: the importance of preemptive analysis and prudential policymaking so as to make possible forward-looking examinations rather than backward-looking reparations. Evidently, that involves carefully looking to the future, studying its opportunities and risks.

In effect, humanity is systematically driven by its prospects, desperately trying to foresee what lies ahead so it manages to be prepared, to adapt, and then, to fulfill its biological ultimate mission, to survive. The vast majority of knowledge fields mirror this anxiety, they are not only vessels of abstract concepts or concrete practical operations trying to solve present problems, but they also all try to contain a very strong predictive component. In Medicine, evolutionary examinations are used to try to guess the evolution of certain diseases; more recently, mRNA technologies are used to try to predict future virus' variants and mutations before they even exist; in meteorology, the weather is studied so the masses can adapt from what to wear to what to do; in Engineering, it is definitely crucial to assess what a certain building can take (weight, pressure, heat) before it collapses, using various scenarios, sometimes in what is very similar to stress tests applied on banking systems; even History, such a past-oriented discipline, recognizes its

main value not only to document but to help to assess future outcomes, using the predicament that history is, in fact, cyclical.

Economics must not escape this task bearing the risk of extinguishing its own purpose in a fast and complex modern world. By doing so, it favours stability, confidence in the institutions and boldens democracy and the rule of law itself. It is possible to do it by using more innovative forecasting strategies, such as untangling the tails of the distributions, the extremes of the probability densities, so as to prepare for what can happen if everything turns out to be wrong if what everyone is working for not to happen, ends up happening after all. Studying point forecasts is excessively simplifying in a world that is increasingly more intricate, fast, and dynamic. Quantile forecasts, in that sense, are much more honest about the true risk of risk existence. And that is precisely the type of model this paper recurs to, scrutinizing the GDP's probability distribution, considering every possible situation, motivated by a previously defined set of important factors.

In this paper, we estimate the term structure of the distribution of predicted GDP growth for Portugal, resorting to a quantile regression, conditional on a financial stress conditions index. To do so, we emulate Chavleishvili *et al.* (2019) with a few tweaks in order to better adapt it to Portugal's context. We conclude that there are indeed nonlinearities worthy of further exploration on the prospective growth distribution, especially on the distribution's left tail, indicating that there may be economic shocks fuelling downside risks to the economy without being detected by median point forecasts. Nevertheless, the lack of significance of some results and the growing possibilities surging on this field suggest that there are some potential extensions and improvements that need to be debated.

Section 2 reviews the main literature on the topic. Section 3 explains the method and the variable selection, introducing the used criteria and thought processes. Section 4 presents

the results and discusses the predictive conclusions and intakes. It also compares the results of the model with the results of Chavleishvili's *et al.* (2019) model, applied to Euro Area country members. Section 5 discusses potential improvements and extensions. Section 6 concludes and section 7 presents the literature and sources used throughout the paper.

2. Literature Review

Quantile forecasting has been a bubbling topic recently, with increasing interest for its use on macroprudential policy. But even though research and application in this field have been gaining steam after the Great Recession, its foundations have been laid before that, slowly evolving before transforming on the current amount of still (progressively less tightened) leashed potential.

In Koenker (2005), the logic of this estimation method is thoroughly explained, emphasizing the opportunity it presents of understanding the effects of different variables and factors on the entire response distribution. The reading of Koenker (2017) was also determinant to totally absorbing the benefits and intricacies of this approach.

Many different and useful papers have been produced tackling the growth distribution of many countries and groups of countries, resorting to the application of this method. In particular, much awareness has been directed towards the relationship between the financial sector and the real structure of the economy, i.e., the impact that the financial system can have on production. Adrian *et al.* (2018) uses Growth-at-Risk analysis of 11 advanced economies to address what he describes as a systematic underestimation of the downside tail risks when initial financial conditions are loose. Nicolò *et al.* (2017) reaches similar conclusions, using US data.

The philosophy of our analysis, in its turn, is shared by Chavleishvili *et al.* (2021). Macroprudential tools emerged as a prevention mechanism against potential new financial shocks. However, the coronavirus pandemic is proof that economic-based fundamentals are merely a drop in the ocean of a myriad of reasons behind prospective economic disturbances. This fact serves as a warning that modern macro-prudential stances are not only a preventive remedy but also immunotherapy of sorts, guaranteeing that even if external agents disrupt what is figured as a stable *statu quo* that the economy is solid and closely knit enough not only to resist but to rebound. It is on this perception of quantile forecasting as a strong macroprudential tool that our analysis is embedded, by trying to assess if and to what extent this mechanism makes sense for Portugal.

Assessments like this have been produced by many Central Banks, as a manner of preparing better for policymaking adjusted for an unpredictable succession of cycles, amending for past mistakes and misjudgments. That is the case, for instance, of Busetti *et al.* (2020) on behalf of the Bank of Italy as a survey of the Italian economy or of Nyholm *et al.* (2021), on behalf of the Bank of Finland as a survey of the Finnish economy. This latter uses household debt as a primary analysis driver, being less broad than the usual type of analysis and specifically directing the scrutiny towards one particular cause. But little information has been divulged about the application of this method to Portugal's economy.

Our analysis is strongly based on Chavleishvili *et al.* (2019), which uses real and financial indicators and found that financial shocks only have an economic impact when the economy simultaneously suffers a real negative shock. As such, this paper builds on the literature delving into quantile forecasting and growth risk, dissecting the adequacy of its use for the Portuguese economic reality, comparing to Chavleishvili's *et al.* (2019)

main results (focused on Euro Area aggregate data), and suggesting potential ways of improving this vast knowledge area.

3. Method

Standard OLS structural VAR focuses on conventional and long-established point forecasts, which correspond to the mean value. Quantile VAR, on the other hand, forecasts the entire probability distribution of future GDP growth, allowing analysis of nonlinearities and state dependence.

Analysing the midpoint behaviour excludes important information about tail shocks, which are precisely the core of cautious macroprudentiality. By recanting it, one only comprehensively understands the economy's dynamics under the regular state of affairs, ignoring the fact that some shocks transform growth prospects, asymmetrically. This means, essentially, that a particular negative shock may hinder growth on the first quantile of its probability distribution whilst leaving the median forecast virtually unaffected. In a case such as that, authorities should be aware that such a shock may cause many consequences should a central scenario not become true. Thus, this new approach serves as an estimation, controlling for downside risks. All in all, this technique provides the tools to assess the likelihood of risk scenarios, escaping the determinism of unifocal central frameworks that embark on the risk of being excessively optimistic.

By doing so, this method also grants the opportunity to scrutinize the pivotal risk factors that may contribute to the disruption of the economy, permitting targeted and therefore much more effective policymaking. The responsible jurisdictions may, thus, outline strategy plans and programs for that specific sector or macro-financial dimension thus narrowing the possibility of a macroeconomic convulsion. Hence why it is such a

desirable device to append to macroprudential surveillance, as a complementary instrument.

In this paper, we have decided to follow the guidelines of Chavleishvili *et al.* (2019), with some alterations to better reflect the Portuguese reality. As such, instead of forecasting the Industrial Production Index as a proxy for product growth, we decided to use OECD's Composite Leading Indicator for Portugal. This decision was motivated by the fact that industrial production may not be significant proxy of Portuguese growth as it may be for the Euro Area in general., bearing in mind Portugal's service-oriented economy (the validity of this decision will be addressed later on). Thus, the reviewed CLI, accounting for the economy as whole, both on the production and the consumption side, is expected to reflect better the macro tendencies of the economy. Similar to Chavleishvili *et al.* (2019), we have used the Composite Indicator of Financial Stress to serve as the financial variable.

From that on, the model consists of a structural quantile VAR (QVAR), in which the financial stress indicator is positioned after the CLI, as an assumption that the real behaviour of the economy can impact the financial markets instantly (since they are sensitive reactor agents), as opposed to the other way around, in which it may take some time before that happens. This Cholesky identification strategy is coherent with all the past research regarding this topic. Specifically, the QVAR(1) model is,

$$Y_{1t} = \omega_1(\theta) \qquad +a_{11}(\theta)Y_{1,t-1} + a_{12}(\theta)Y_{2,t-1} + \varepsilon_{1t}(\theta)$$

$$Y_{2t} = \omega_2(\theta) + a_{021}(\theta)Y_{1t} + a_{21}(\theta)Y_{1,t-1} + a_{22}(\theta)Y_{2,t-1} + \varepsilon_{2t}(\theta)$$

where Y_1 corresponds to the Composite Leading Indicator as a proxy for the product, a_{11} is the coefficient representing the effect of the lagged real variable on its present value and a_{12} resumes the effect of the lagged financial stress variable on the real one. Y_2 represents the financial stress indicator, a_{021} corresponds to the effect of the present real situation on the financial markets, a_{21} represents the impact of the real variable on the financial market and a_{22} corresponds to the effect of the lagged financial variable on its present value. Θ represents the quantile being analysed.

4. Results

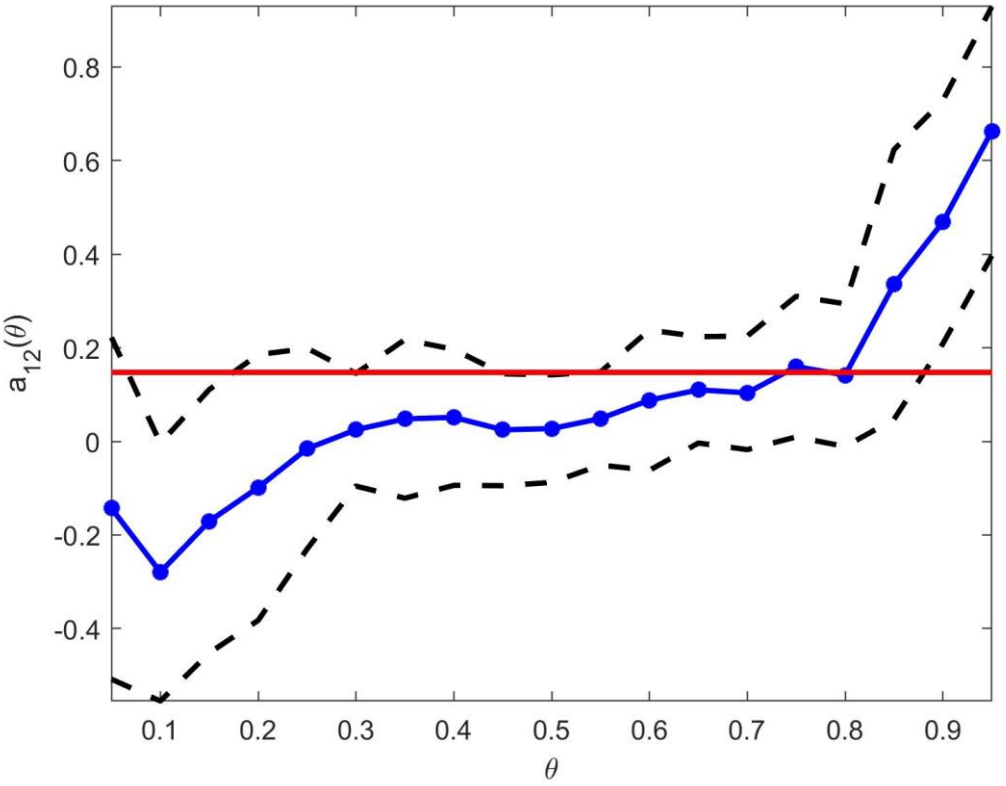

Figure 1-Coefficient of the model, representing the impact of the lagged financial indicator on the real variable (the blue line depicts the parameter estimates and the dotted black lines indicate the 95% confidence interval)

The comparison of QVAR and VAR estimation results displays evidence for the aforementioned necessity to delve into different quantiles of growth forecasting, in order

to assess what awaits the economy in situations of downside risks, casting light on important macro-financial vulnerabilities. Figure 1 attests this by showing a different behaviour of the left tail relative to the one of the mean prediction.

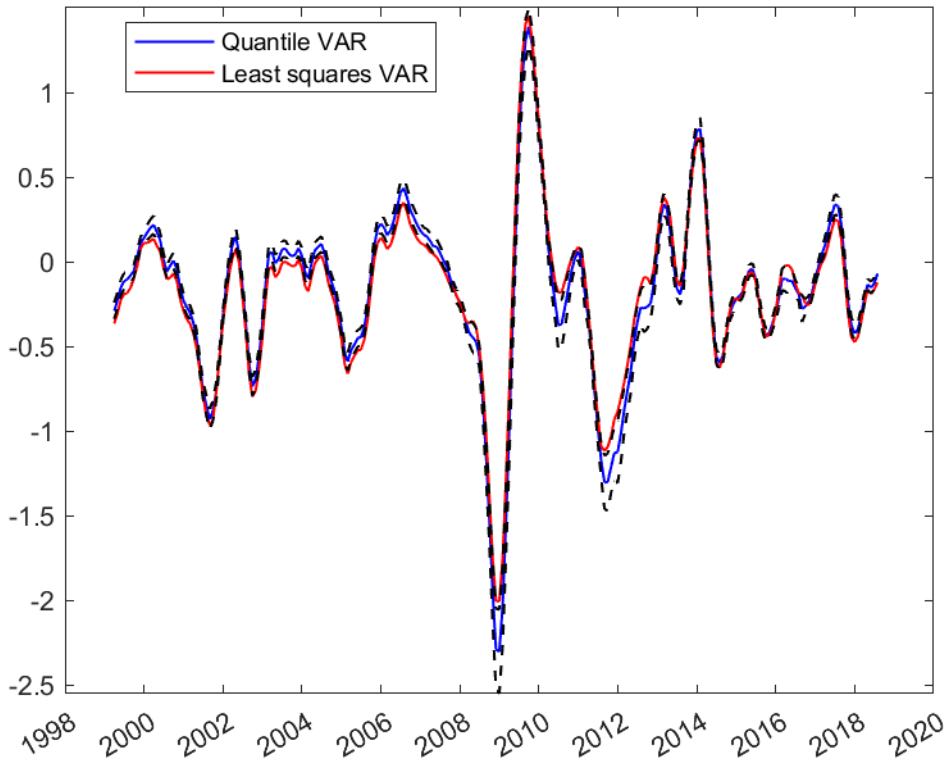

Figure 2- One step ahead CLI indicator forecasting, based on a 10% quantile shock of the financial conditions index (95% confidence interval)

Figure 2 portrays the 10% quantile realization one step ahead forecast of the Composite Leading Indicator, according to both the Quantile VAR and the Least Squares VAR. This corresponds to the simulation of a negative shock to the financial conditions index, to perceive its impact on the real economic indicator. During growth and stability periods, both QVAR and VAR account for very similar growth forecasting, but if the economy behaves more patchily or even with significant underperformance, the results become distinct with lower values for the QVAR analysis. In this sense, both during the Great

Recession and the sovereign debt crisis, hastily disturbing factors of the Portuguese economy, Quantile VAR's negative peak is worse than the OLS's one. This shows that it is more useful for periods where the economy may be struggling, which strengthens the importance of quantile forecasting for the Portuguese economy with robust reassurance as a tool of prudentialism in policymaking. It is for the situations where it would be more needed, that quantile forecasting is more effective.

In figure 3, it is possible to observe the 10% (left graph) and the median quantile forecast (right-graph) for the CLI based on the financial conditions index's median behaviour. The difference between them is whopping, although not significant. This over-dimension of the interval range was something to be expected since when working with the left tail analysis one is working with less information, which erodes significance, fact also applied to Chavleishvili *et al.* (2019), although less so. The steep product drop foreshadowed by the QVAR analysis would be completely overlooked if one attained only to the normal structural VAR case, missing the opportunity to act with anticipation to prevent the unraveling of the following dreadful events.

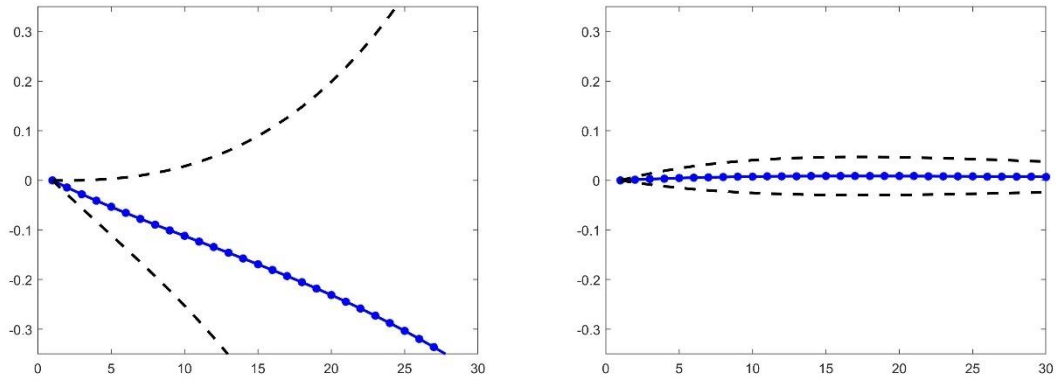

Figure 3-10% quantile (left) and median quantile (right) impulse response functions for the economy's behaviour, after a shock to the financial conditions variable (95% confidence intervals)

Such as in Chavleishvili *et al.* (2019), we also performed different stress testing exercises, applied to study how the economy behaves under a median forecasting scenario versus a scenario encompassing both a 90% quantile projection for the financial indicator and a 10% quantile for the CLI, a proxy for the real economy. This stunt simulates a negative real shock under negative financial conditions. The stressing behaviour is introduced by a sequence of six monthly negative 10% shocks to the real variable and six monthly negative 90% shocks to the financial variable, returning to normality after that. Once again, the graphical depiction confirms the method's validity, displaying a timid growth for the economy under median-centered predictions (equivalent to the typical OLS one) but a continuous slump during 6 months for the quantile measurement setting, with a slight recovery afterward although without fully converging until the end of the time scope of the analysis. Comparing the 2008 and 2012 scenarios with the 2018 one, we can be reassured that the significance of this type of analysis depends on the period under scrutiny: during serene times (2018), the skewness is not as pronounced but the potential for judgement errors based on astigmatic median analysis is higher during troublesome periods of time (2008 and 2012), precisely when they are less convenient for the authorities' agenda.

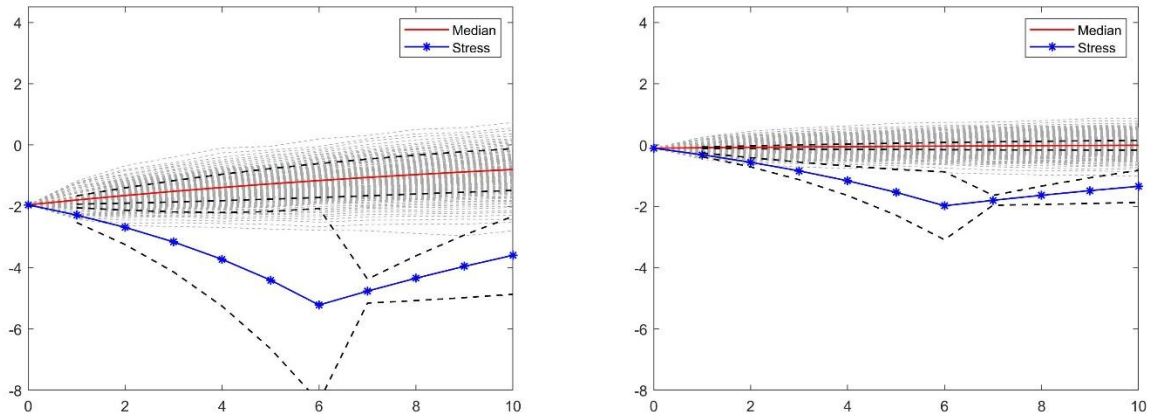

Figure 4-Stress testing exercise, for 2008 (left) and 2012 (right)-95% confidence intervals

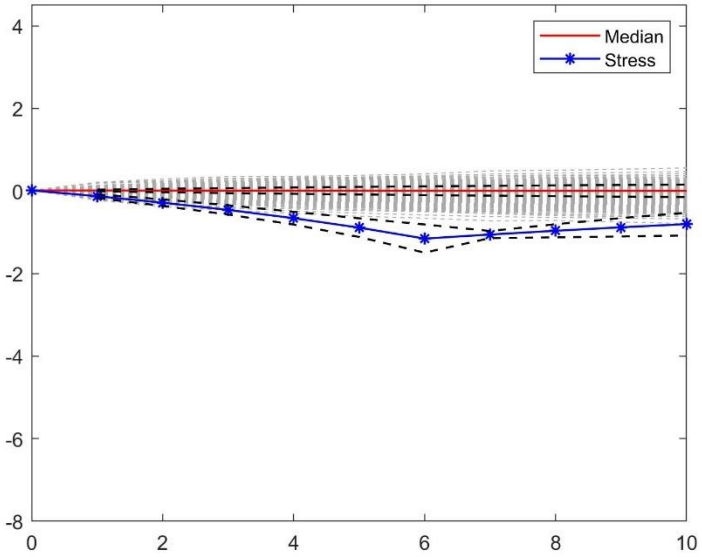

Figure 5-Stress testing exercise for 2018 (95% confidence interval)

Robustness Test

It is possible to proceed to the same analysis but using data on Portugal's Industrial Production Index, to assess in what way the results are different when using a less reliable indicator. It turns out the results are quite different.

It is possible to identify that there seems to be no difference between the Quantile VAR and the Least Squares VAR (figure 6), and the results of the Impulse Response Functions (figure 7) and the stress testing exercises (figure 8) are quite dubious (the non-significance of the results continues to apply). The only difference is in the counterfactual exercise (figure 9). Figure 9 shows three alternative scenarios for the behaviour of the economy at the beginning of the economic crisis triggered by the international great recession. The "Good" scenario consists of six 10% quantile realizations for both variables, which means a combination of favourable financial conditions and a bad real situation; the "Normal" scenario corresponds to 10% quantile realizations for the real

variable (CLI) and median ones for the financial variable, which translates into a bad real economic situation in a context of a normal financial context and the "Bad" scenario is simulated with six 10% quantile realizations for the CLI and six 90% quantile realizations for the financial stress variable, i.e., a bad real economic situation amidst a highly stressing financial reality. All these different scenarios follow Chavleishvili's *et al. (2019)* guidelines and specifications. It is possible to perceive greater difference between the good/medium scenarios and the negative one, precisely during the financial crisis (figure 9). As such, since using this indicator fails even to portray the left tail effect acknowledged by the literature, like in Adrian *et al.* (2019) and detected in our baseline framework (figure 10), the selected approach figures as a good decision.

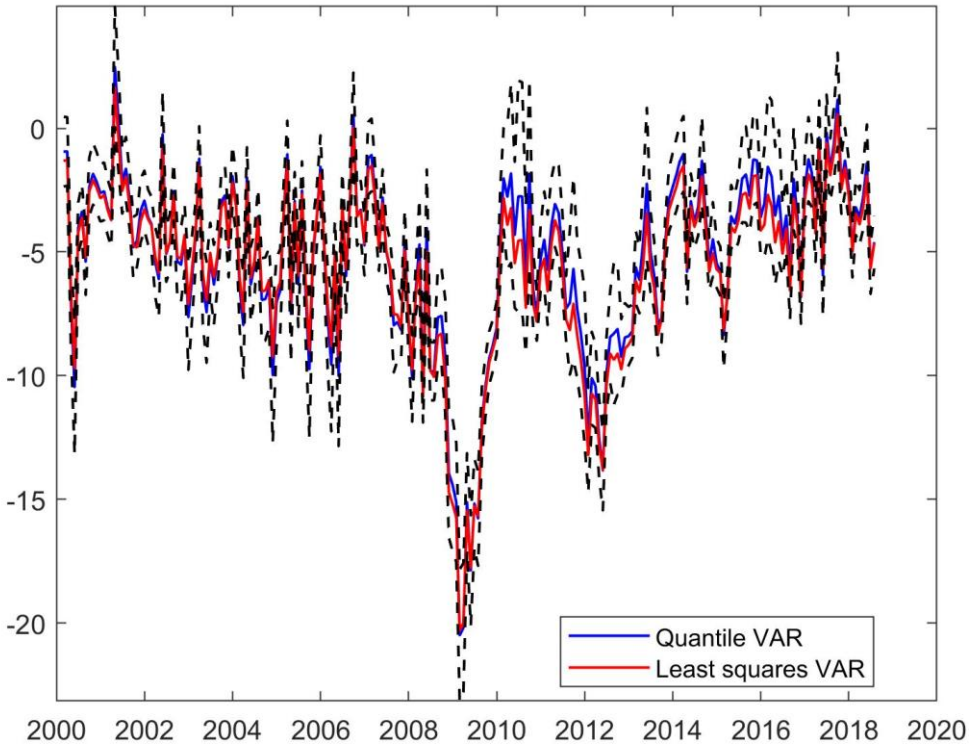

Figure 6-One step ahead IPI indicator forecasting, based on a 10% quantile shock of the financial conditions index (95% confidence interval)

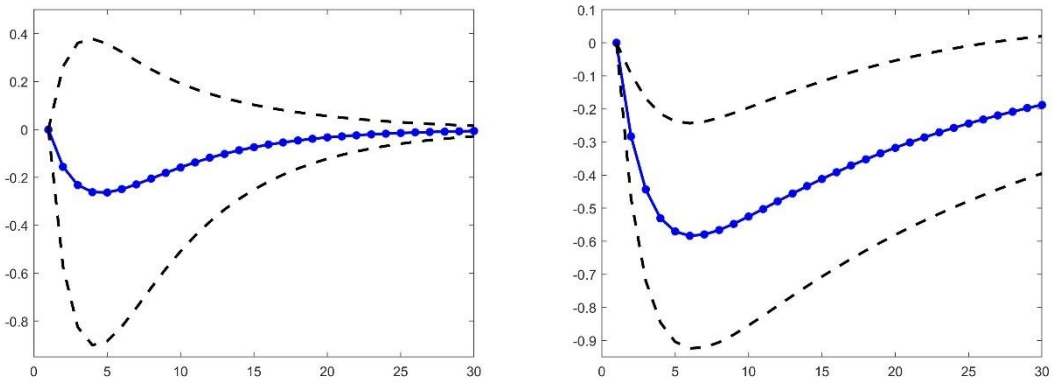

Figure 7-10% quantile (left) and median quantile (right) impulse response functions for the economy's behaviour, after a shock to the financial conditions variable (95% confidence intervals)

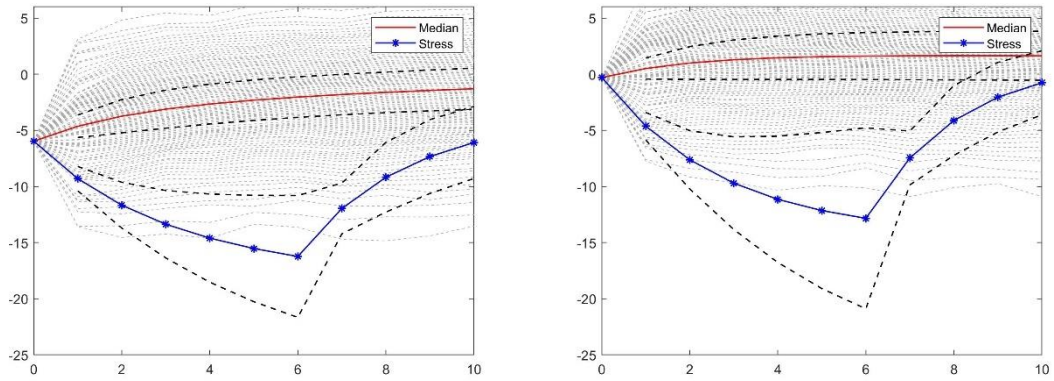

Figure 8-Stress testing exercise, for 2008 (left) and 2018 (right)-95% confidence intervals

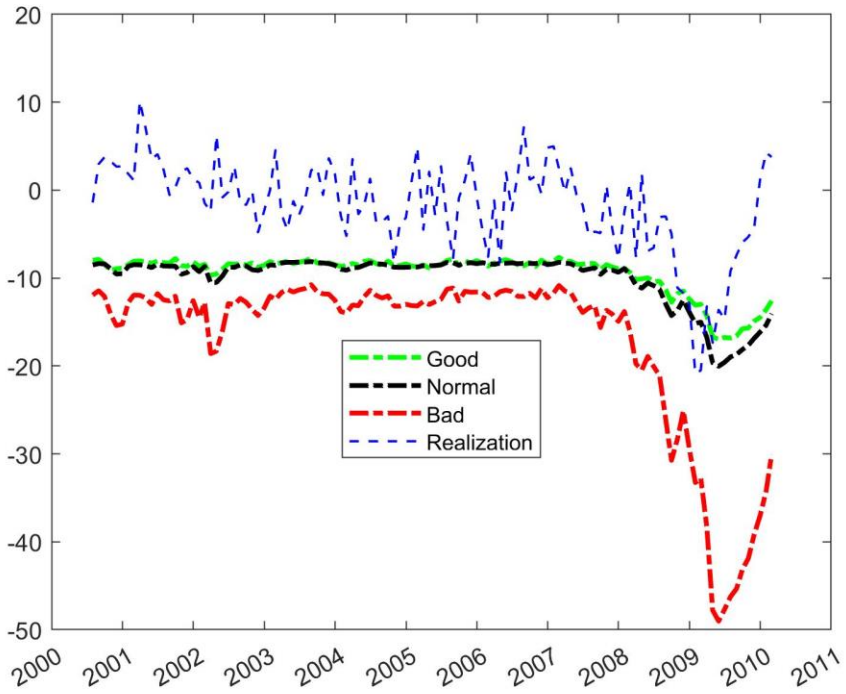

Figure 9-Six month ahead forecast of Portugal's Industrial Production Index, under 3 alternative scenarios

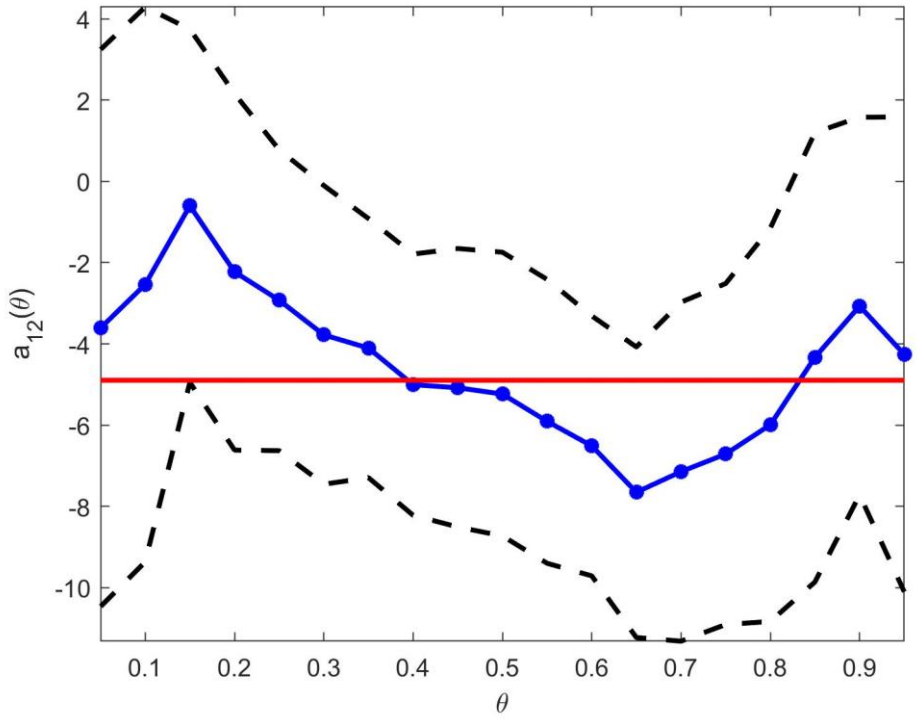

Figure 10-Coefficient of the model, representing the impact of the lagged financial indicator on the real variable (the blue line depicts the parameter estimates and the dotted black lines indicate the 95% confidence interval)

Comparison

Chavleishvili's *et al.* (2019) examination concerned data for members of the Euro Area, which includes Portugal. But it could also be interesting to compare Portugal-only results with them.

It is relevant to note that the CLI indicator is a much smoother variable and, therefore, the tail behaviour may be more restricted than in the series used by Chavleishvili *et al.* (2019).When looking at Figure 11, one can see that the difference between the Quantile VAR and the Least Squares VAR is bigger for the Euro Area than for Portugal's case. In that case, one could assume that Growth at risk analysis seems not to work as well or to be less needed for the Portuguese economy as it is for the total of euro area economies studied since the median quantile forecast seems not to overlook the financial liabilities as much.

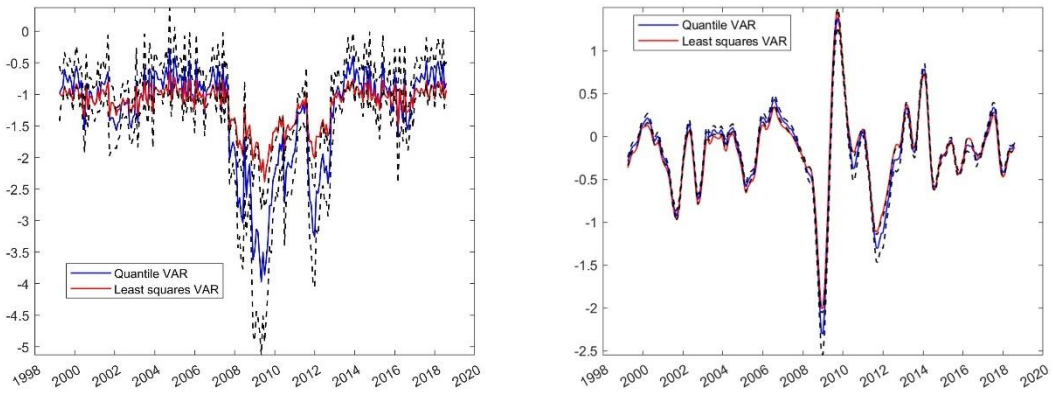

Figure 11- Comparison of the one step ahead CLI indicator forecasting, based on a 10% quantile shock of the financial conditions index (Chavleishvili's et al (2019) on the left and this paper's model on the right)

It is perceptible that in Chavleishvili *et al.* (2019) there is a clear difference between the good and medium scenario relative to the bad one (figure 12), which exacerbates the usefulness of QVAR in interpreting all the dynamics of the economy's distribution. On

this paper's model, that is less evident. As such, this depiction also seems to strengthen the case that QVAR properties are more pronounced for Chavleishvili's *et al.* (2019) setting.

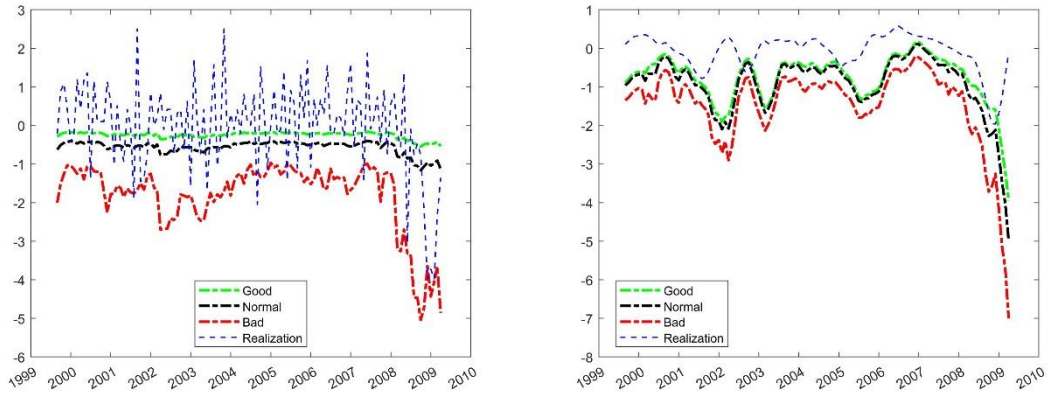

Figure 12-Six month ahead forecast of the Euro Area's Industrial Production Index (left) and Portugal's CLI (right), under 3 alternative scenarios

That could leave space to consider about what are the reasons for Portugal's and the EA's different situations concerning growth-at-risk analysis, where it seems that this method is less proper when utilized for the Portuguese reality. In a country-specific prism, one could argue that this would suggest that Portugal's financial stress index fairs well in comparison to its European counterparts, showcasing less financial vulnerabilities, being that the reason for the difference between quantile VAR and VAR (which underestimates financial weaknesses). Inarguably, this interpretation is incoherent with historic and economic knowledge of the Portuguese economy's financial and banking sector liabilities, especially pre-rescue package reforms, implemented by the Troika institutions.

It is difficult and imprudent to take any type of definite conclusions from this given the different variables used by the two models. It would be necessary to study whether the CLI is a better proxy for the behaviour of the Portuguese economy than the IPI is for the Euro Area's one. And even if the used variable were to be same, the comparison would still be deficient given the different explanatory power of the Industrial Production Index

relative to the different economies being studied. In effect, more than one causal factor may be exerting its influence on this matter and it would not be proper to formulate a conclusion solely based on this data. It requires much more study, either in quantity and diversity of analysis frameworks.

5. Potential Extensions

From the previous analysis, it stays as stated that there are nonlinearities in Portugal's growth distribution worthy of further exploration. Having established the importance and helpfulness of quantile forecasting and simulation for a better and more complete prudential policymaking it is also possible to acknowledge the room for improvement there is, with many of the results having problems of lack of significance, and of conclusions' transposition for the real world and economy. Therefore, it is relevant to reflect on ways to add robustness to this research. For instance, by introducing more and different scopes of analysis to nourish confidence in the economic science and its capacity to provide a more stable state of things as a basis for further and steadier economic development.

As such, introducing a partitions-based analysis as is used by the International Monetary Fund (IMF) on its bilateral macro-financial surveillance program would add a dimensionality the model still lacks as it stands. Whilst the financial skeleton of an economy is instrumental for many of its possible growth paths, it is not capable of serving as a bellwether for its entire growth distribution. In that sense, other country-specific indicators could be added to complement the analysis. As first suggested in Prasad *et al.* (2019) for its Excel-based GAR tool, the inclusion of a "Macro-financial" and an "Other factors of interest" partitions, complementing the financial one, could be of much

interesting use. Resorting to this, it would be possible to identify the main components contributing to emboldening the left tail of the economy's growth distribution, besides the financial aspects. For it to be truly descriptive of the economy's constitution and direction, the main constituents of these partitions would have to be country-specific, i.e., staunchly connected to the country's characteristics and specificities. In that way, authorities would be creating dynamic models of analysis, allowing them to control and define the criteria for which data indicators make sense for the analysis being implemented and which may cease to do so at some point in time. For example, during the current covid pandemic situation, data on infections or mobility may make sense to include on the "Other factors of interest" partition as an economic temperature measuring device for future dynamism of product creation. After health containment initiatives are halted, the inclusion of this type of data information becomes obsolete along with them.

This new approach also makes prudential policymaking more flexible by stopping to be dependent on inflexible composite indicators that quite sometimes struggle to encompass all the economy's stirring tendencies, allowing for rapid introduction and exclusion of variables, both according to circumstances and to the objective of the probe at stake.

In the case of Portugal, it could be suggested to include on its financial partition information about private credit housing and consumption loans, private and corporate bad credit, corporate financial autonomy, foreign exchange reserves, government bond yields, and stock market volatility. Assembled, this information would be enough to trace a portrait of the financial health of the country.

On the macro-financial partition, it would be relevant to aggregate data on exports and imports, public and private debt to GDP, the competitiveness index, inflation, productivity, and the unemployment rate. These would reflect the soundness (or rather lack of it) of the macroeconomic structure of the country.

At last, the "Other factors of interest" category could include all the data relative to the intrinsic attributes of the Portuguese economy, such as its small dimension and openness, as well as its highly external dependability: oil prices and non-energetic commodities prices, which impact fossil fuel prices and, thus, the private economy; the euro area growth, on which Portugal is strongly reliant since those countries are some of its greatest economic partners; tourism revenues, Portugal's biggest sector in which it sustained most of its recent economic recovery; consumer confidence and business sentiment. This category is, essentially, where policymakers could aggregate indicators highly conjuncture-related, like the aforementioned covid ones.

To synthesize information, one could resort to a principal components analysis method, seeing how each individual contributor impacts the object of scrutiny by its relative importance on the partition, or, if needed, by taking it out as an independent one.

Although it has not been referenced throughout this paper, the upside risks of the economy, mainly associated with the right tail of variables like inflation, should also be thoroughly studied, since GDP growth is not the only source of concern for governments and economic and financial authorities. Indeed, recent worries about self-fulfilling inflation spirals have been the main preoccupation and a hot topic of conversation.

Nevertheless, the right tail of the future GDP distribution also hides significant opportunities to equip macroprudential analysis and policymaking. This area of study has been underdeveloped across the globe, where quantile analysis focuses essentially on risks. By using "bonanza tests" as opposed to stress tests, triggering high-quantile shocks to selected variables included on these partitions, resorting to quantile impulse response functions, it would be possible to discover which variables should be the focus of state policies in order to stimulate the opportunity for right tail realizations to be concretized.

6. Conclusion

Portugal is prone to sovereign debt crises, responding to the preoccupation with the sustainability of its public debt. The country has a history of economic and financial fragilities. However, there is a lack of focus on tail shocks, which can lead to a dangerous underestimation of downside risks.

The main purpose of this paper was, thus, to apply a QVAR method to Portugal's context, outlining a tool that can help to better draw a picture of Portugal's many potential futures with the intent of better understanding the many potential presents we may now built to reach the most approximated version of the future we want, avoiding the ones we most dread.

7. References

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