inštitút finančnej politiky

Ministerstvo financií SR / www.finance.gov.sk/ifp

Do Euro Area Expansions Die of Old Age?

Are euro area expansions more likely to enter a recession as they get older? (An Empirical Study)

June 2018

ifp

Economic Analysis 49

Abstract

Are euro area economic expansions more likely to enter a recession as they endure longer? The present analysis empirically addresses this question by applying a Survival Analysis toolkit onto 12 euro area economies' growth cycle data starting in 1951. The key finding is that the risk of experiencing a recession stays essentially the same, as economic expansions age. More specifically, the hazard of a euro area economy experiencing a recession is fundamentally constant in time over the period 1 to 22 years. This finding stands at odds with colloquial speak that the current economic upturn is overdue for a recession because of its duration. In addition, we find that the depth of preceding recessions do not affect the durations of subsequent economic expansions. In the face of the latter finding, future research should focus on covariate-driven approach to growth cycles to identify other factors which affect euro area recession incidence over time.

Author

Sona Muzikarova sona.muzikarova@mfsr.sk

Acknowledgements

The author gratefully acknowledges the feedback and useful comments of Branislav Žúdel (IFP). Any errors or omissions are exclusively the responsibility of the author.

1 Introduction

"It's About Time"

Much colloquial wisdom assumes that as economic expansions mature, they are more susceptible to entering an economic downturn. This is evidenced by economic debates and media headlines at both sides of the Atlantic[1]. The debate, whether economic expansions "die of age" has become especially prominent after the December 2015 exchange between the former US Federal Reserve Board Chair Janet Yellen and a ABC News reporter Rebecca Jarvis:

Jarvis: Historically, most economic expansions fade after this long. How confident are you that our economy won't slip back into recession in the near term?

Yellen: ... I think it's a myth that expansions die of old age. I do not think they die of old age. So the fact that this has been quite a long expansion doesn't lead me to believe that ... its days are numbered.

According to the euro area Business Cycle Dating Committee from the Centre for Economic and Policy Research (CEPR) – the European authority for dating euro area business cycles – we have now entered the sixth consecutive year since the last official recession in 2012. Thus, in Europe, too, many observers have expressed the concern that the current expansion is becoming increasingly fragile as it is becoming older. The current analysis aims to empirically assess the merit of such hypothesis for the euro area.

Recent empirical studies addressing whether euro area expansions "die of age" are limited, and provide mixed results across countries and time periods. The current study focuses on growth cycles[2] of 12 euro area economies, namely, Austria, Belgium, Cyprus, Germany, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands and Portugal, at an annual frequency for a historical period covering 1951 to 2014. To this end, we deploy Survival Analysis, a branch of statistics with origins in epidemiology, which has been applied throughout a wide array of fields. Survival Analysis is used to investigate the risk of exiting a state of interest (i.e. death in biostatistics, recession in economics), depending upon how long one has spent in it (i.e. its duration). In addition, it is concerned with how such risk evolves over time; that is, whether the risk of recession increases as time goes on, or, stays the same. We also briefly investigate, whether the depth of recessions matter for the subsequent lengths of expansions.

The current analysis is organized as follows. Box 1 surveys relevant empirical literature. Section 2 presents the empirical approach and provides a rationale behind the choice of methodology. Box 2 describes data, sources, variable transformations and concept definitions. Section 3 presents the empirical results. Lastly, Section 4 concludes and suggests a general direction for further work.

[1] See for example The Wall Street Journal "Economists Think the Next U.S. Recession Could Begin in 2020" by Ben Leubsdorf, published on May 10, 2018; The Atlantic "Is the Economy Overdue for a Recession?" by Annie Lowrey, published on March 10, 2017; Bloomberg News "That Creaky Old Economic Expansion? Watch It Keep Going" by by Suzanne Woolley, published on April 4, 2017.

[2] This is as opposed to the conventional concept of business cycle most frequently used in the literature, using quarterly frequency and official recession (peaks and troughs) dates

Box 1: Brief Review of Literature

Numerous studies have undertaken the quest to examine duration dependence in economic cycles. Most of them focus on the US business cycle, using quarterly official peak and trough data, as published by the US recession dating authority, the NBER[3]. Several studies also split the business cycle data into pre-war and post-war intervals, and explore the effect of expansions' length on the probability of recession occurrence for these two time periods separately. For example, using the Weibull model, Rudebusch (2016) of San Francisco Federal Reserve finds positive duration dependence in US business cycle data pre-war, but no duration dependence post-war. His earlier work with Diebold (1990) yields a similar result using the non-parametric approach. Sichel's (1991) work provides statistically significant evidence for positive duration dependence for US pre-World War 2 expansions, and post-World War 2 recessions using parametric analysis.

Basic parametric estimations for duration dependence across EU countries, using the Weibull and Cloglog models and official ECRI[4] business cycle data, provide evidence of positive duration dependence only for Germany and at the aggregate EU level (Castro 2008). The same paper uses a discrete-time duration model and includes other explanatory variables, including OECD composite leading indicator, oil prices and private investment, which all help explain the variations in the risk of expansion ending. **Another branch of research has used the Markov-switching model**, and some studies have been additionally successful in including coincident or leading covariates (see Filardo 1994; Layton & Smith 2007).

The current analysis contributes to the existing body of literature in several ways. It focuses on (1) growth cycles (rather than business cycles); (2) at annual frequency (rather than quarterly); and, (3) for 12 euro area countries, covering most of the euro area. Moreover, it makes statistical inferences from aggregate euro area data only, minding that small individual country samples could encourage estimator bias. Third, it uses non-parametric analysis due to the lack of theoretical foundation; but also complements it with viable parametric models to tackle some of shortcomings of the former. Actually, while most authors prefer one approach over another, we find the two approaches to complement each other well, and to additionally serve for cross-checking robustness.

2 Empirical Method

Survival Analysis: A Dual Approach

Survival Analysis is a branch of statistics, which treats a probability of exiting a state of interest, depending upon how long one has spent in it, and, how such probability changes over time. In its classical application, Survival Analysis has typically dealt with the risk of patient death, given a duration of a certain condition or treatment. In later applications, it has concerned itself with questions ranging from product life-spans (the risk of product failure, given its age); labour economics (the risk of losing a job, given the length or employment or *vice versa*, the probability of finding a gainful employment, given how long one has been out of a job); social science and gender economics (the risk of getting a divorce, given the duration of marriage); and, last but not least, macroeconomics (the risk of expansion ending, given its prior length). In any case, it is notable that **Survival Analysis deals with non-negative datasets and skewed distributions.**

[3] NBER – National Bureau for Economic Research – is a business cycle dating authority in the US

[4] ECRI – Economic Cycle Research Institute provides official business cycle dates for selected European countries

What are referred to as "risks" – heritage of the biostatistical jargon – **are essentially probabilities of an event occurring (i.e. death, failure, and recession), conditional on the age** or duration of the variable in question. Besides instant probabilities, we are interested in the overall pattern of how these probabilities change over time. If the risk of an event increases in time, we say we find evidence for positive duration dependence. If the risk of an event decreases in time, we find evidence of negative duration dependence. If the risk stays flat over time, there is no duration dependence, nor evidence that age increases or decreases the risk of such event.

These probabilities can be represented in a multitude of ways, depending on whether we make *a priori* assumptions about their distributions, and also conditional on their usefulness from a standpoint of economic interpretation. We adopt two complementary approaches to assess, whether we find positive duration dependence in euro area expansions.

2.1 Non-Parametric Approach

The non-parametric approach makes no *a priori* assumptions about the underlying distribution of the expansion lengths, and in that way constitutes a full-on "let-the-data-speak" approach. It is advantageous especially if there is no theoretical foundation to guide the choice of the model or functional form.

There is four main – different but interrelated – ways to represent these probabilities (Table 2A). Furthermore, it is sufficient to estimate just one of these functions, and the remaining three can be easily derived. The functions marked with an asterisk are those we are ultimately interested in from the viewpoint of economic interpretation.

Table 2A: Four Related Ways to Represent Expansion Survival Probabilities

Function	Interrelation	Interpretation
*Kaplan-Meier Survivor**	$S(t) = \prod (1 - r/n)$	Probability of expansion surviving to time t
Cumulative Distribution	$F(t) = 1 - S(t)$	Probability of expansion length being equal to time t or less (for each point of time t)
Probability Density	$f(t) = d\,F(t) / d(t)$	Instantaneous probability of surviving at time t, for all expansions
*Hazard**	$h(t) = f(t) / S(t)$	Instantaneous probability of dying at t, for expansions that have survived up to this point

"t" represents the time when the event occurred at least once
"r" represents the number of recessions that occurred at time t
"n" represents the number of subjects known to survive to time t

Source: Buis 2006.

To this end, we estimate an aggregate Kaplan-Meier (KM) survival function for the euro area. The survival function essentially tells us about the probability of economic expansions "surviving" up to any given point of time.

A plot of KM estimator produces a downward sloping step-function, which, by definition starts at probability being equal to one. The subjects "known to survive" at a particular point of time either have not experienced the event of interest, or have been "censored", i.e. have exited the study without experiencing the event. Have there been no censored observations, a standard regression analysis could be considered, but still could prove inadequate due to exclusively positive values and skewed distributions. Furthermore, from the standpoint of economic interpretation, we are more interested in the probability of survival up to a certain point, rather than the expected time of an event a regular regression would yield. Thus, a hazard function produced by Survival Analysis can offer superior understanding of the failure mechanism compared to linear regression.

Another advantage of this approach is the ease with which the estimated survivor function can be re-arranged into the target hazard function. Hazard function is an instantaneous occurrence rate at a specific time interval. The concept is close enough to be interpreted as instantaneous probability of an event for the subjects that survived to a point of time, although technically it is not a probability as it can exceed one (Buis 2006). Thus a more correct interpretation of a hazard rate at time *t* is **a number of times a euro area would be expected to experience recession in a year *t*, if the risk of recession remains constant over that year.**

While the non-parametric approach is advantageous from the perspective of flexibility and economic interpretation, it tells us little about the statistical significance. Moreover, using this method, it is not possible to control for additional risk factors (covariates) that may impact the probabilities of recession over time. In addition, despite possessing low bias in a wide variety of situations, non-parametric estimators suffer from high variance and can require substantial amounts of observations to perform well (Wey et al. 2015). To tackle these shortcomings, we turn to parametric methods to investigate duration dependence in euro area expansions[5].

2.2 Parametric Approach

Maximum likelihood estimation attempts to find parameter values that maximize the likelihood function, given the dataset, or, that make the observed results most probable, given the dataset. This is done iteratively by trying a number of values of the parameters until they converge to a maximum.

The bigger question is what survival probability distribution we assume for our data, and consequently, what shape will our hazard function take on. This may be a tough call, where theory is silent. Notably, a misspecification of the underlying baseline hazard function may yield a biased estimator. To make a feasible model choice, we (1) consult prior applied work; and, (2) look at the shape of the hazard function yielded by the non-parametric analysis. To evaluate the appropriateness of the chosen model *in posterior*, we re-arrange the underlying estimated survivor functions into cumulative hazard functions and plot it against time, in line with e.g. Blossfeld & Rohrwer (1995). If the model is a good fit, the re-arrangement should produce a straight upward sloping line (more in Section 3, forthcoming).

Prior applied works that model duration data have frequently used the fairly flexible Weibull distribution[6]. The constant-hazard assumption (which corresponds to an exponential distribution) may be overly restrictive since it does not allow for, in the words of Bhat (1996), "snowballing" or "inertial" effects. A generalization of the constant-hazard assumption is a two-parameter hazard function, which results in a Weibull distribution for the duration data (Figure 2A, left-hand-side). The hazard rate in this case allows for monotonically increasing or decreasing duration dependence, as indicated by the shape parameter *p*. If *p* exceeds one, this signifies positive duration dependence in the data. In this way, the model is *(1)* consistent with our hypothesis that risk of recession changes in time; and, *(2)* the magnitude of *p* is informative of the magnitude of duration dependence.

[5] The Survival Analysis toolkit also contains semiparametric Cox proportional hazards models, which estimate hazard functions per strata (in our case, by country) under a set of assumptions. This model is not suitable for our analysis due to the small sample sizes at country-level. A sufficient number of observations per strata is required to ensure accurate estimation of conditional models (for more see e.g. Box-Steffensmeier 2006)

[6] See Diebold et al. (1990); Sichel (1991); Castro (2008, 2010); Rudebusch (2016)

Figure 2A left: Weibull model hazard function depends on a=1 and different values of p parameter

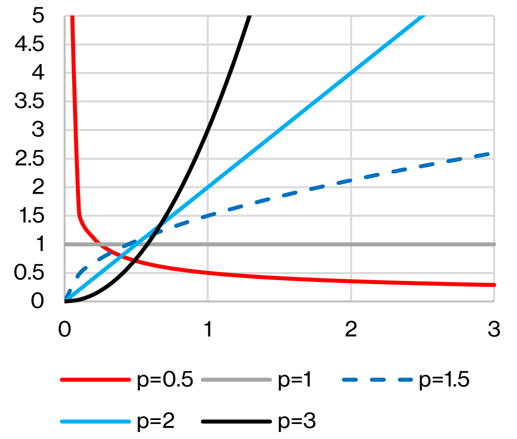
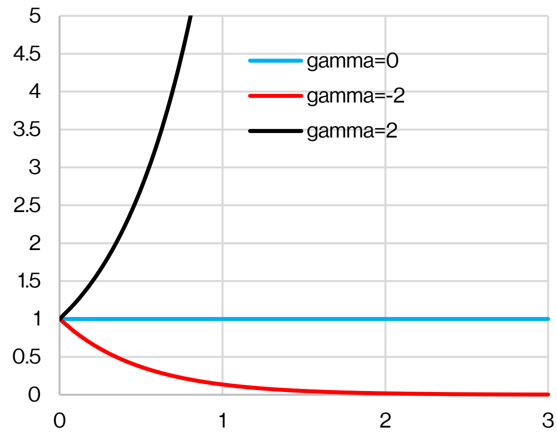


Figure 2A right: Gompertz model hazard function depends on different gamma parameters



Source: IFP based on Buis 2006.

Notes: The null hypothesis of both parametric models is constant hazard (with a=1, p=1 for Weibull; and exp(gamma)=0, gamma=0 for Gompertz). The models are essentially reduced to an Exponential constant-hazard models if we cannot reject the null hypothesis.

The second parametric hazard model we opt for is the Gompertz model, which directly encompasses the time (duration) dependence. The Gompertz law states that the force of mortality or a failure rate increases exponentially over time (Gompertz 1825). Thus, the increasing hazard is consistent with the hypothesis that we aim to test. The Gompertz model in Figure 2A on the right-hand-side is essentially a log-Weibull distribution. It has empirically provided a close fit for adult mortality rates in modern developed countries (Li & Ma 2013, pp.78); but originates in economics (see Prescott 1922; Windsor 1931).

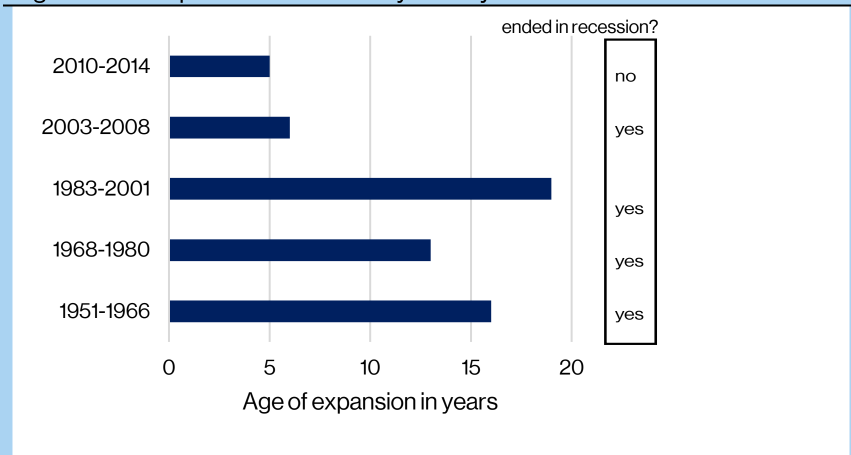
Box 2. Data and Definitions

The raw data for our analysis are expenditure-side real GDP volumes in chained PPP (in mil. 2011 USD) at annual frequency sourced from the Penn World Tables 9.1 (code "rgdpe"). We cover 12 euro area countries, which have identical data coverage from 1950 to 2014, namely, Austria, Belgium, Cyprus, Germany, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands and Portugal. For many euro area newcomers, the historical series start as late as 1990 and for that reason they are excluded.

GDP volumes are transformed into annual growth rates covering the period 1951 to 2014, and resulting in 73 of total observations of economic expansion spells. These expansion spells are then assigned value "1" if they ended in recession, and "0" if they did not. The first variable – the expansion spells – is the "duration variable", while the second, binary variable is the "event variable". This data transformation is required to treat any dataset with Survival Analysis. A sample data for Germany – as they enter the survival model – are shown in Figure B2.

Admittedly, the first expansion spell for each country starts by default in 1951 – since that is when our dataset starts – forcing it to a common starting point for all countries, even though really, the expansion could have started and endured well before the beginning of our dataset in some cases. Similarly, we retain our last, ongoing expansion observations none of which yet ended in a recession. These observations are then censored from the dataset via the standard KM procedure. Despite some degree of bias introduced by the starting and ending point, we retain all data points in the effort to work with as many observations and as much information possible.

Figure B2. Sample data for Germany as they enter the survival model



Sources: Penn World Tables 9.1 and author's calculations.

We examine "growth rate cycles", rather than "business cycles" commonly treated by related literature. This implies simple definitions: an "economic expansion" is defined as a positive annual growth rate, while an economic recession or "the event of interest" is defined simply as a negative annual growth rate. In any case, we are not concerned with neither the fluctuations in *the level* of the economic activity, nor to fluctuations in the economic activity *around the long-run potential level*, merely the fluctuations of the growth rate of economic activity.

3 Empirical Findings

3.1 Non-Parametric Approach

We begin by estimating an aggregate KM survival functions for the euro area as a whole, and by country. The results are presented in Figure 3A below. We can see that a typical euro area expansion has a 62 per cent chance of survival up to 5 years but merely 35 per cent of survival up to 10 years. The step-function flattens after the 10-year mark: a euro area expansion still has about 25 per cent chance of surviving up to year 15.

Figure 3A left: Kaplan-Meier survivor estimate for euro area

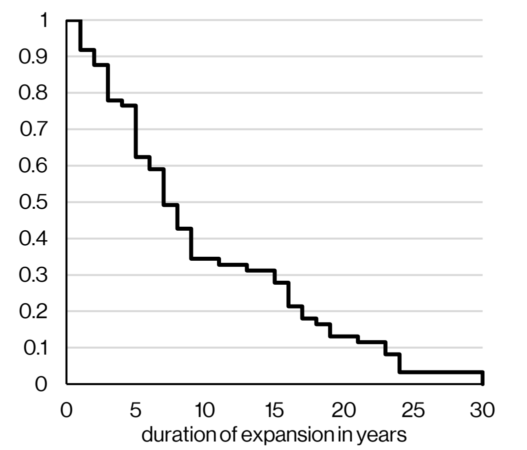
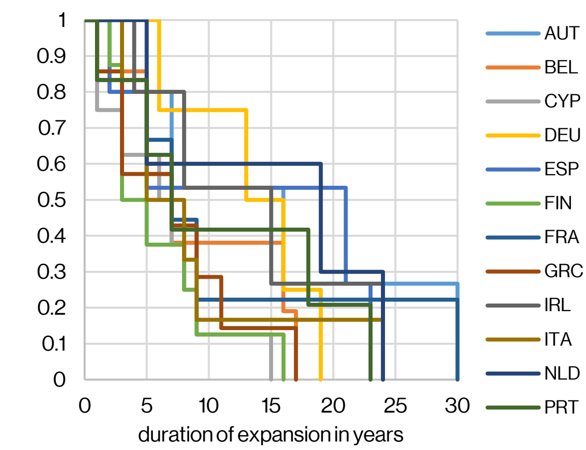


Figure 3A right: Kaplan-Meier survival estimate (by country)



Source: IFP estimations.

The survival probabilities vary rather significantly at country-level. For instance, a typical French and also Austrian expansion still has about 25 per cent chance of survival by year 25. In contrast, Finnish, Cypriot and Greek expansions have the shortest survival probability. Note that at a country-level, we are dealing with rather a few observations per country, as evident from the large size of steps, so the estimated functions may not be well representative of the whole expansion population.

The estimated survival functions can be easily re-arranged into corresponding hazard functions, which we target because of both, economic interpretation and to get a sense of their shape (Figure 3B). With respect to the shape, a flat hazard function signifies constant time-independent hazard, while an upward sloping hazard function is an evidence for positive duration dependence.

Figure 3B left: Kaplan-Meier hazard estimate for the euro area

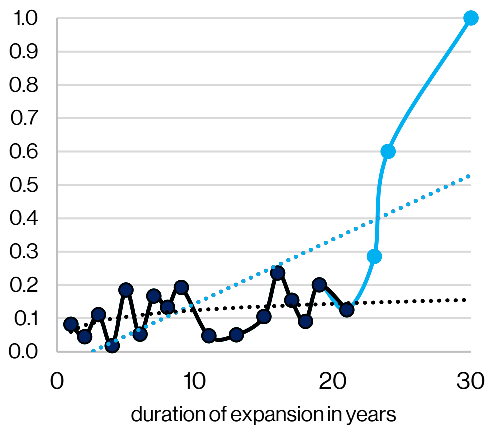
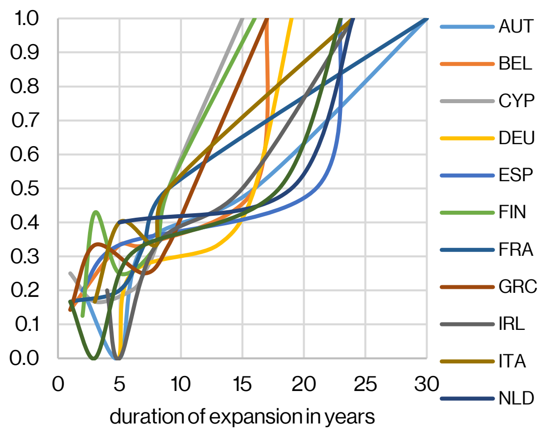


Figure 3B right: Kaplan-Meier hazard estimate (by country)



Source: IFP estimations.

Notes: The black trendline in the LHS chart corresponds to data up to year 22. The blue trendline with clearly positive slope corresponds to full set of data.

The aggregate hazard function for the euro area (Figure 3B, LHS) remains flat, wavering between 0.0 and 0.25, up to year 22. This means that at years 0, 1, 2 ... 22, a typical euro area expansion will end 0.15 times next year if hazard remains constant during that year. **Beyond that, however, the hazard of recession starts increasing rapidly, approaching probability equal to one at year 30.**

Just like in the case of country-level survival functions, the hazard functions vary greatly across countries (3B, RHS). In line with the estimated country-level KM survivor functions, Cyprus' and Finland's hazard rate is equal to 1 at year 15, while Austria's and France's hazard is merely 0.5 in the same year. Given the sample size and the resulting noisiness, however, we are unable to make any statistical inferences at country-level.

3.2 Parametric Approach

To tackle the pitfalls of the non-parametric approach, and to check the robustness of our results, we also estimate several parametric models. We are primarily interested in *(1)* the ability of parametric models to test the statistical significance of the duration dependence; and, *(2)* the possibility to extend the basic model by including covariates.

Fitting a continuous-time basic Weibull duration model with no covariates, we find a statistically significant evidence for a positive duration dependence. The estimated Weibull parameter is equal to 1.32, and within the 1.01 to 1.06 at 95 per cent confidence band. In other words, we can reject the null hypothesis of the Weibull parameter being equal to 1, and the hazard being constant.

The hazard function underlying the basic Weibull duration model is depicted in Figure 3C (LHS). Optical examination reveals that it is increasing more rapidly at year 1 to 10, and visibly flattens thereafter. The hazard function derived from the non-parametric survival function in Figure 3B (LHS) is, on the other hand, flat over year 1 to 22, and increases rapidly thereafter. Moreover, the Weibull model in Figure 3C yields an increasing concave down shape, while the non-parametric model in Figure 3B (LHS) yields an increasing concave up shape.

Figure 3C left: Hazard function underlying Weibull duration model

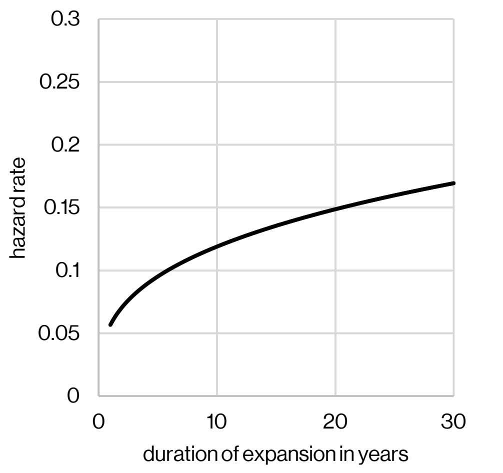
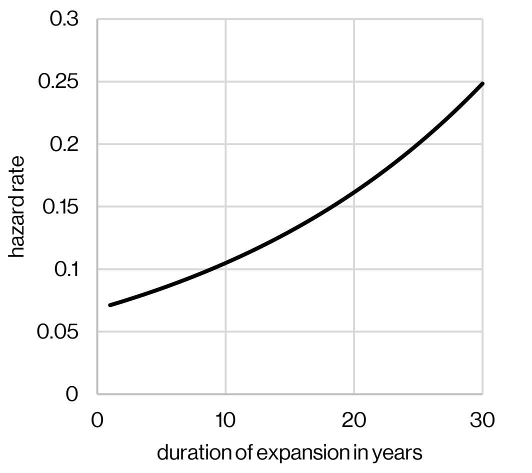


Figure 3C right: Hazard function underlying Gompertz duration model



Source: IFP estimations.

We get a broadly similar result in terms of duration dependence magnitude fitting a continuous-time basic Gompertz model. The gamma parameter comes out at 0.043 with a p-value corresponding to 0.01, so that we can reject the null hypothesis of constant hazard at 95 per cent confidence level. Importantly, the shape of the hazard function underlying the Gompertz model (Figure 3C, RHS) resembles closer the shape of the hazard function underlying the non-parametric model (Figure 3B, LHS).

Finally, fitting a continuous-time basic Weibull duration model with one covariate – the magnitude of recession[7] preceding an expansion – **does not improve the result.** The hypothesis here is that a deeper recession might afterwards trigger a longer expansion/decrease the risk of recession. However, in fact, the estimated *rec_mag* coefficient being close to 1 signifies that the variable does not affect the risk of experiencing recession.

Summing up, whereas the non-parametric estimate of the hazard rate appears flat until the far-end of the function, the parametric approach shows that the hazard rate is significantly increasing in time. We will now reconcile both results by showing that the parametric approach is misleading in our case.

[7] The recession magnitudes are cumulated, where recession lasts for more years. Moreover, absolute values are taken as Survival Analysis deals with non-negative values only.

3.3 Robustness

The estimated survivor function can be used to evaluate the parametric model choice[8] **(i.e. choice of underlying distribution), where theory is silent.** Following Blossfeld & Rohrwer (1995, pp 199-200) and Buis (2006), we re-arrange the estimated survivor function *S(t)* into the corresponding cumulative hazard functions *H(t)* as presented in Figure 3D. If the cumulative hazard function under the exponential distribution comes out as a straight upward-sloping line, then the hazard is constant in time. Also, the optical evaluation of its shape can be informative at different time intervals.

Figure 3D left: Cumulative hazard function under exponential distribution

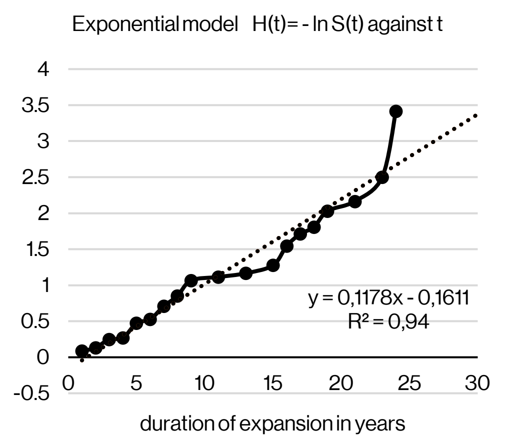
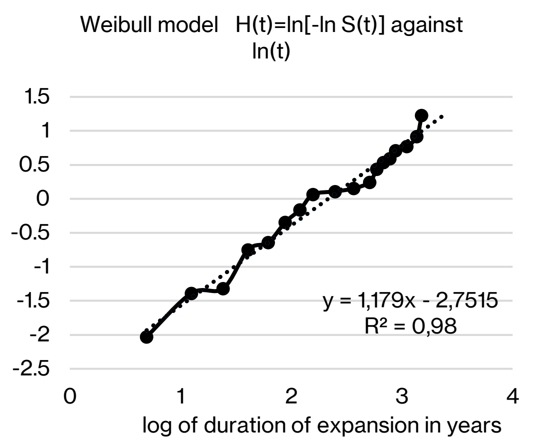


Figure 3D right: Cumulative hazard function under Weibull distribution



Source: Blossfeld & Rohrwer (1995, pp 199-200), IFP calculations.

The robustness check further corroborates our earlier findings. The exponential constant-hazard model is fairly a close fit up to year 22. Nonetheless, the Weibull model fits the data even closer. The reason is that the exponential constant-hazard model is no longer suitable beyond year 22[9]. This finding is broadly consistent with the one yielded by our non-parametric model, and **upholds that the hazard of euro area recession remains constant only at the interval 1 to 22 years.** Table 3D presents the summary of results presented in this section.

Table 3D. Summary Results for Duration Dependence in Euro Area Expansions

Model	Sample Size	Times Recession Occurred	Duration Dependence Magnitude statistics	95 % Confidence Interval	Covariates	Conclusion
Non-parametric	73	65	no statistics	-	n/a	Risk of recession constant at interval 1 to 22 years; then positive duration dependence
Parametric Weibull	73	65	p = 1.32	1.01 - 1.59	n/a	Significant duration dependence of weak magnitude
Parametric Weibull with Covariate Rec_mag	73	65	p = 1.32	1.14 - 1.52	rec_mag hazard ratio = 0.99, z = -0.02 and P>|z| = 0.98	Significant duration dependence of weak magnitude; rec_mag does not help explaining the variation of recession risk
Parametric Gompertz	73	68	gamma = 0.043	0.01 - 0.08 z = -13.17 and P>|z| = 0.00	n/a	Significant duration dependence of weak magnitude

Source: IFP estimations.

[8] Basic model with no covariates.
[9] Note that the last data-point is missing, as the logarithmic transformation of 0 is not defined.

Furthermore, we are going to argue that there are cases when the hazard curve appears to increase in time, but is of no meaningful economic interpretation. To convince the reader in this regard, we propose an experiment, where we roll 200 fair dice, each 64 times, and record a recession each time the number six is observed[10].

The hazard function resulting from this experiment (Figure 3E left) has virtually the same shape as that based on true growth cycle data. It is flat until the "far end" of the curve, where the hazard rate increases sharply and approaches 1. The sudden rise at the "far end" is driven by the small number of dice rolls (i.e. 200), and the fact that with increasing expansion lengths it is estimated with merely a few, very long expansions. Consequently, the volatility of the estimated hazard rate increases, as the number of simulated expansions at risk of recession declines (Figure 3E right).

For instance, in our experiment, there is only one expansion that lasted 42 years and eventually ended up in a recession, thus increasing the hazard rate to 1. In general, the hazard rate would come out completely flat only under such a case scenario, where the number of dice rolls (or expansions) approaches infinity.

Figure 3E left: Simulated hazard function for dice rolls has the same shape as the hazard based on true growth cycle data

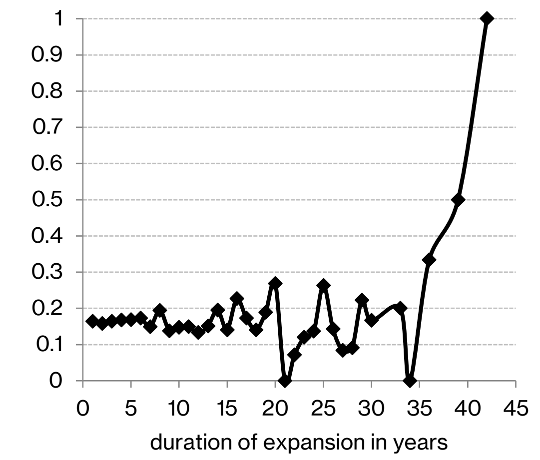
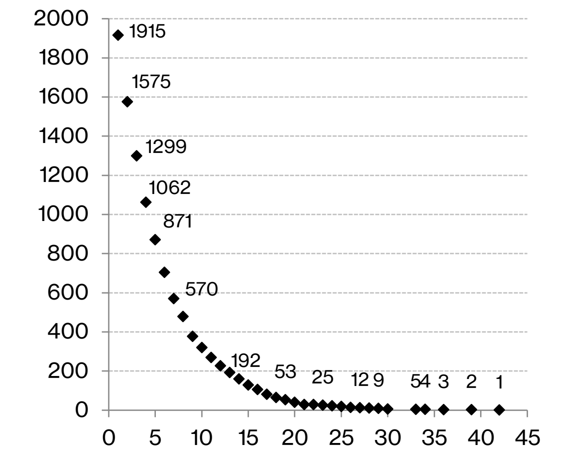


Figure 3E right: Hazard is measured imprecisely at the far end due to the lack of very long expansions (number of expansions at risk by duration)



Source: IFP calculations

4 Conclusions

The current analysis zooms onto the assertion that expansion age increases the risk of recession occurrence. **Its key finding is that the risk of the euro area experiencing a recession does not increase as expansion ages at interval 1 to 22 years.** Notably, the hazard surges rapidly at the far end of the curve, which is driven solely by the lack of observed long-term expansions. In line with that, and driven by these few outliers, the parametric Weibull and Gompertz models yield statistics corroborating weak positive duration dependence of no meaningful economic interpretation.

The main finding of the present analysis stands at odds with the colloquial speak that the euro area is now overdue for a recession because the current expansion is already "old". Admittedly, the estimated individual hazard functions do vary significantly at country level. Moreover, other economic phenomena may influence recession incidence rate. Yet, fitting one such variable – the cumulated magnitude of preceding recessions – does not improve the basic time-dependence

[10] Note that in this setup, there is no duration dependence by construction, as each dice roll is by definition independent of a fair die.

model in a meaningful way. In other words, the cumulated magnitude of preceding recessions does not affect the probabilities of euro area expansions ending over time. It is important to note, however, that the aim of the present analysis is not to build a covariate-driven model for detection of recessions, but to zoom onto whether expansions increasing in length amplify the probability of euro area economy falling into a recession.

In conclusion, euro area expansions do not end because they already last "so long" – at least not for the first 22 years. Chances of being hit by a recession in a particular year of expansion are virtually the same, no matter the duration of the current expansion. Further work should focus on augmenting parametric models with meaningful covariates, which represent additional factors that influence recession incidence in euro area growth cycles, and can be targeted by economic policy.

References

1) Bhat CR (1996): Chapter 6: Duration Modelling, *University of Texas*, Available at: http://www.caee.utexas.edu/prof/bhat/ABSTRACTS/Duration_Modeling_Nov1.pdf

2) Blossfeld HP and Rohwer G (1995): Techniques of Event History Modeling. New Approaches to Causal Analysis, Hillsdale, New Jersey: Lawrence Erlbaum Associates.

3) Board of Governors of the Federal Reserve System (2015): Transcript of Chair Yellen's Press Conference, December 16, 2015, Washington, DC.

4) Box-Steffensmeier JM and Boef SD (2006): Repeated events survival models: The conditional frailty model, *Statistics in Medicine* 25 (20): 3518–3533.

5) Buis M (2006): An introduction to survival analysis, unpublished manuscript, Wissenschaftszentrum Berlin für Sozialforschung.

6) Castro V (2010): The duration of economic expansions and recessions: More than duration dependence, *Journal of Macroeconomics* 32:1, pp. 347-365.

7) Diebold FX and Rudebusch GD (1990): A Nonparametric Investigation of Duration Dependence in the American Business Cycle, *Journal of Political Economy* 98 (6), pp. 596–616.

8) Filardo A (1994): Business-Cycle Phases and Their Transitional Dynamics, *Journal of Business & Economic Statistics,* 12(3), pp. 299-308, https://EconPapers.repec.org/RePEc:bes:jnlbes:v:12:y:1994:i:3:p:299-308.

9) Gompertz B(1825): On the Nature of the Function Expressive of the Law of Human Mortality, and on a New Mode of Determining the Value of Life Contingencies, *Philosophical Transactions of the Royal Society of London*, 115: 513–583. doi:10.1098/rstl.1825.0026. JSTOR 107756.

10) Jarne G, Sanchez-Choliz J, and Fatas-Villafranca F (2007): "S-shaped" curves in economic growth. *A theoretical contribution and an application Evolutionary and Institutional Economics Review*, Vol. 3, Number 2, pp. 239.

11) Jialiang L and Shuangge M: Survival analysis in medicine and genetics, Chapman and Hall/CRC; 1 edition (June 4, 2013), pp. 78.

12) Kaplan EL and Meier P (1958): Nonparametric estimation from incomplete observations, *Journal of American Statistics Association* 53(282): 457–481. doi:10.2307/2281868. JSTOR 2281868

13) Layton AP and Smith DR (2007): Business cycle dynamics with duration dependence and leading indicators, *Journal of Macroeconomics, Elsevier*, vol. 29(4), pp. 855-875.

14) Leubsdorf B (May 10, 2018): Economists Think the Next U.S. Recession Could Begin in 2020, *The Wall Street Journal*, Available at: https://www.wsj.com/articles/economists-think-the-next-u-s-recession-could-begin-in-2020-1525961127

15) Lowrey A (March 10, 2017): Is the Economy Overdue for a Recession?, *The Atlantic*, Available at: https://www.theatlantic.com/business/archive/2017/03/is-the-economy-overdue-for-a-recession/519180/

16) Modis T. (2002): Predictions - 10 Years Later, Geneva, Switzerland: Growth Dynamics. 335. ISBN 2-9700216-1-7.

17) Ohn J, Taylor LW and Pagan A (2004): Testing for duration dependence in economic cycles, *The Econometrics Journal* 7:2, pp. 528-549.

18) Rudebusch GG (2016): Will the Economic Recovery Die of Old Age? *FRBSF Economic Letter,* 2016-02 (February 4).

19) Sichel D (1991): Business Cycle Duration Dependence: A Parametric Approach, *The Review of Economics and Statistics* 73(2), pp. 254–260.

20) Wey A, Connett J and Rudser K (2015): Combining parametric, semi-parametric, and non-parametric survival models with stacked survival models. *Biostatistics*, 2015 16(3): 537-549.

21) Windsor ChP (1931): The Gompertz Curve As A Growth Curve, Department Of Biology, School Of Hygiene And Public Health, John's Hopkins University, *Proceedings Of The National Academy Of Sciences*, Vol. 18 January 15, 1932 Number 1, Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1076153/pdf/pnas01729-0009.pdf

22) Woolley S (April 4, 2017): That Creaky Old Economic Expansion? Watch It Keep Going, *Bloomberg News*, Available at: https://www.bloomberg.com/news/articles/2017-04-04/that-creaky-old-economic-expansion-watch-it-keep-going