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Are there change-points in the likelihood of a fiscal consolidation ending?

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Abstract

Building on a narrative approach to identify episodes of fiscal consolidation, data for a group of 17 industrial countries over the period 1978-2009 and both continuous-time and discrete-time duration models, we find evidence suggesting that the likelihood of a fiscal consolidation ending increases over time, but only for programs that last less than six years. Additionally, fiscal consolidations tend to last longer in non-European than in European countries. Our results emphasize that chronic fiscal imbalances might lead to a vicious austerity cycle, while discipline in the behaviour of fiscal authorities is a means of achieving credible and shorter adjustment measures.

Keywords: *Fiscal consolidation, duration analysis, Weibull model, duration dependence, change-points.*

JEL Classification: *C41, E62.*

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"... The countries in the euro zone shouldn't add any more austerity programs...

.. Such measures could lead to a downward spiral and need to be delayed until the economy recovers...".

- Peter Bofinger (July 20, 2012)

1 Introduction

The most recent financial turmoil that emerged in 2008 led to a quick and aggressive response by monetary authorities with the aim of boosting the economy. However, its deepening and severity associated with the collapse and massive destruction of asset wealth highlighted that large fiscal stimulus programs should be a key additional ingredient of the policy mix. As a result, fiscal authorities in many G20 countries have actively engaged in expansionary fiscal measures with the aim at boosting the economic recovery and implemented comprehensive support packages based on expenditure hikes which, combined with cyclical revenue losses, resulted in sharp increases in budget deficits.

The occurrence of the recent global crisis has, thus, became key for assessing the role that economic policy and, in particular, fiscal policy can play on influencing economic activity (Castro, 2010; Agnello and Schuknecht, 2011; Agnello and Sousa, 2011, 2012; Agnello et al., 2012; Cimadomo, 2012). Indeed, many countries have actively adopted fiscal expansionary measures - especially, aimed at boosting government spending - in reaction to such an extraordinary event.

More recently, the concerns about long-term (un)sustainability of public finances in light of the developments in government bond markets (Schuknecht et al., 2009) have supported, in a relatively consensual way, the view about the need to withdraw such stimulus and the emergence of the implementation of budgetary consolidation measures. This should, in turn, deliver a return to more "normal" fiscal stances and sustain the path of debt growth.

However, while there seems to be an agreement on the long-term benefits of government debt reductions, there is no unified view on the short-term effects of fiscal austerity (Jansen et al., 2008). In fact, apart from the uncertainty about the effect that fiscal retrenchments have on economic performance, some authors started to argue that business cycle de-synchronization is just one of the most visible consequences of the extraordinary challenges faced by some countries (Rafiq and Mallick, 2008; Mallick and Mohsin, 2010). In addition, these interventions can negatively impinge

on the nexus between monetary and financial stability (Granville and Mallick, 2009; Sousa, 2010, 2012; Castro, 2011a; Castro and Sousa, 2012).

In this context, investigating the nature of fiscal consolidations programs is crucial for a timely formulation of policies that can help fine-tuning the trade-off between consolidation of public finances and economic growth. How long is the consolidation program likely to last? How similar (or different) are programs implemented in European countries from those put in place elsewhere? Does the end of a fiscal adjustment depend on its own age? Can we detect the presence of change-points in the duration dependence of fiscal consolidations?

These are questions that gained a renewed momentum in recent times, especially, if one takes into account that there is a great deal of disagreement about the *timing* and the *length* of the fiscal adjustments that are necessary to close the gap in public finances that was brought by the wide range of policies that governments employed in order to deal with the most recent financial crisis. In fact, while among countries of the euro area the tone has been posed on the need to implement fiscal consolidation in a relatively short period of time as a pre-condition for sustainable growth and a credible path for fiscal stance, other countries such as the US and the UK have recognized that fiscal austerity may hurt short-term growth and become counter-productive, and, thus, have allowed for a longer consolidation process. In this work, we aim at providing the answers to the abovementioned questions and challenges.

We start by building on the narrative approach used for the identification of fiscal consolidation (Devries et al., 2011). Therefore, rather than looking at fiscal outcomes, policy actions that are motivated by deficit reduction are assessed by examining accounts and records of what countries were intending to do at the time of publications (such as the OECD Economic Surveys, the IMF Economic Developments reports and the IMF Staff Reports).

Then, we use data for a group of 17 industrialized countries over the period 1978-2009 to investigate whether the likelihood of a fiscal consolidation ending depends on its own age, i.e. whether fiscal consolidation programs are duration dependent. In line with the work of Illera and Mulas-Granados (2002), we use continuous-time and discrete-time duration models and find evidence of positive duration dependence, which implies that the likelihood of fiscal consolidation programs' ending indeed increases over time.

Finally, we assess a dimension that has been typically neglected in this strand of the literature: the existence of breaks in the duration dependence. While the existing works assume that the

behaviour of duration dependence is smooth (i.e. either constant or increasing) over time, we conjecture that the degree of likelihood of a fiscal consolidation ending as it gets older may change after a certain duration. To proceed with such task, we extend the baseline Weibull duration model in order to allow for the presence of a change-point in the duration dependence parameter.

The results indicate that the positive duration dependence is present in fiscal consolidations that last less than six years, but no evidence of duration dependence is found for older consolidations. This represents a remarkable new finding in this field of research and an important contribution to the literature. Indeed, it suggests that countries experiencing fiscal adjustments lasting more than six consecutive years are more likely to become trapped in a vicious cycle of fiscal consolidation. More specifically, in the presence of chronic fiscal imbalances, consolidation measures may become more persistent and, as a result, the time for an exit strategy can be surrounded by high uncertainty. This helps explaining why the probability of consolidation ending declines at a lower pace for programs that last more than six years.

Additionally, our findings show that fiscal consolidations tend to last longer in non-European than in European countries. The need to comply with the Stability and Growth Pact rules and, from an historical point of view, the commitment with respect to the Maastricht criteria for entry to EMU can contribute to describe such feature. In addition, the push towards fast corrections of the budget deficits and the fear to suffer debt-financing crisis on the financial markets have typically led to the launching of discretionary counter-cyclical fiscal measures. This also helps justifying the occurrence of shorter fiscal consolidation programs in European countries.

The rest of the paper is organized as follows. Section 2 reviews the existing literature on the duration of fiscal consolidation. Section 3 presents the econometric model and the empirical methodology. Section 4 describes the data and discusses the results. Finally, Section 5 concludes.

2 Literature Review

There is a relatively large number of works looking at the potential impact of fiscal consolidation on economic growth.

Indeed the argument about the effectiveness of fiscal policy can be dated back to the Keynesian model that predicts that expansionary fiscal policy (i.e. a rise in government spending or a cut in government taxation) boosts disposable income, raises private consumption and partially crowds-out investment via the increase of interest rate. At the empirical level, the evidence seems to confirm

the positive short-term effect of fiscal policy on consumption and output (Fatás and Mihov, 2001; Blanchard and Perotti, 2002; Mountford and Uhlig, 2009).

However, other studies suggest the possibility of Non-Keynesian effects associated with fiscal policy measures. The underlying idea is that a permanent reduction of government spending may lead to an increase in output and consumption, because agents will expect an increase of future income due to the cut of future taxation (Feldstein, 1982; Giavazzi and Pagano, 1990). In this case, fiscal contractions can be "expansionary" as a result of the improvement in household and business confidence and cutting budget deficits could stimulate the economy even in the short-term. In the same line, Alesina and Ardagna (1998, 2010), Miller and Russek (2003) show that growth performance is improved after periods of drastic and decisive spending cuts. Castro (2011b) finds that the growth of real GDP per capita in the EU was not negatively affected by the implementation of fiscal rules and, consequently, the implementation of the Stability and Growth Pact was not harmful from a growth perspective. In addition, Castro (2007) argues that low economic growth, a weak fiscal stance and the timing of parliamentary elections as well as a majority left-wing government are the major causes of excessive deficits. In particular, for EU countries, the constraints imposed by the Maastricht criteria seem to have reduced the probability of excessive deficits. Interestingly, Heim (2010a, 2010b) shows that government deficits crowd out both private consumption and investment. However, while government spending deficits are associated with a complete crowding-out effect (i.e. no net stimulus impact), tax cut deficits result in net negative economic effects. Afonso and Jalles (2011) point to a negative impact of the size of the government on growth and highlight the importance of institutional quality.

From a theoretical point of view, expansionary effects of fiscal adjustments can work via both the demand and the supply side. On the demand side, a fiscal adjustment may be expansionary if agents believe that the fiscal tightening eliminates the expectations about the need of further adjustments in the future (Blanchard, 1990). Similarly, increases in taxes and/or spending cuts that are perceived as permanent help supporting the belief that the stabilization is credible and avoids a default on government debt. As a result, a lower premium on government bonds may be requested and the associated (positive) wealth effect can boost private spending (Alesina and Ardagna, 2010). In addition, the strong negative relationship between government deficits and private spending can operate via credit shortages that are induced by public sector borrowing (Heim, 2010c). On the supply side, expansionary effects of fiscal adjustments work via the labour

market and via the effect that tax increases and/or spending cuts have on the individual labour supply in a neoclassical model, and on the unions' fall-back position in imperfectly competitive labour markets (Alesina and Ardagna, 1998).

Regardless of their impact on GDP, another crucial issue from a policy perspective is whether cutting spending or raising taxes is more likely to result in a stable fiscal stance and subsequent economic growth when a fiscal consolidation is carried out. According to Alesina and Perotti (1995) and Alesina and Ardagna (2010), a fiscal consolidation is successful if the reduction in the debt-to-GDP ratio is sufficiently large and persistent. Alesina and Ardagna (2010) show that tax cuts are more expansionary than spending increases in the cases of a fiscal stimulus. In addition, spending cuts are much more effective than tax increases in stabilizing the debt and avoiding economic downturns. These results are partially attributed to a more substantial monetary stimulus following a fiscal adjustment that is spending-based rather than tax-based. In fact, central banks are less likely to loose monetary policy when revenue-driven measures that raise prices (such as indirect tax hikes) are already in place.

Tackling a more general question dealing with the effect of fiscal policy on the economy, Blanchard and Perotti (2002) find that positive government spending shocks increase output, consumption and decrease investment, while positive tax shocks have a negative effect on output, consumption and investment. Mountford and Uhlig (2009) also point to a negative effect on private investment associated to both taxes and spending increases, but spending increases do not generate an increase in consumption. Moreover, deficit-financed tax cuts are found to be the most effective way to stimulate the economy. Afonso and Sousa (2011) find that unexpected variation in fiscal policy can substantially increase the variability of housing and stock prices. Afonso and Sousa (2012) show that government spending shocks generally have a small effect on GDP and lead to important crowding-out effects. Using narrative approaches, Ramey (2009) challenges the positive effect of government spending shocks on private consumption. Romer and Romer (2010) also find that an increase in taxation has a small negative effect on GDP.

The literature presented so far has typically addressed the impact of fiscal adjustments on the level or the growth rate of aggregate income. Some research has also highlighted that fiscal convergence (in the form of persistently similar ratios of government surplus/deficit to GDP) is systematically associated with higher business cycle synchronization (Darvas et al., 2005). In the same vein, some authors have emphasized that fiscal consolidations impact on the trade-off between

economic growth and income inequality (Mulas-Granados, 2005).

However, the sharp increase in deficits and quick debt build up that have been recently observed in many developed countries - as a result of the fiscal response to the most recent financial turmoil - are now calling for a return to "normal" times via the implementation of fiscal austerity. This brings a new question into the scene: what is the *nature* (i.e. the *timing* and *length*) of the fiscal consolidation process?

In this context, the duration analysis gains an important relevance. Having flourished in the engineering and medical fields, its use rapidly spread out to other sciences. In economics, it started to be employed in labour economics to assess the duration of periods of unemployment.[1] It has also been widely used in the analysis of the duration of the business cycles phases.[2] For instance, the Weibull model with change-points proposed by Lara-Porras et al. (2005) was adapted by Castro (2012) to the analysis of the duration of the business cycle phases. The author showed that positive duration dependence in expansions is no longer present when they are longer than ten years, giving rise to the presence of a change-point in the duration of economic expansions.

Due to its properties, this kind of analysis is also suitable for studying the duration of fiscal consolidation programs, and some recent studies have started to consider this issue. Molnar (2012) analyses the impact of some economic and political factors on the duration of fiscal consolidation. However, the framework is deterministic and, as a result, the author does not account for duration dependence. Using non-parametric and parametric continuous-time duration models, Illera and Mulas-Granados (2002) assess the duration of fiscal consolidation in the European Union. The authors find evidence of a positive duration dependence in those events, but the emphasis is directed towards the impact of some regressors, such as public debt and a set of political variables, on the length of a fiscal consolidation. Indeed, while the previous studies on fiscal consolidation assume that the magnitude of the duration dependence parameter is the same over the entire duration of the event, we challenge this perspective by assessing whether the degree of likelihood of a consolidation ending changes after a certain time.

[1] See Allison (1982) and Kiefer (1988) for a review of the literature on duration analysis.
[2] See, for example, Sichel (1991), Zuehlke (2003), Davig (2007) and Castro (2010, 2012).

3 Econometric Methodology

3.1 Duration Analysis

We start by assuming that the duration variable is defined as the number of periods over which a fiscal consolidation program is being implemented. If T measures the time span between the beginning of the program and its end, then $t_1, t_2, \ldots, t_n$ will represent the observed duration of the fiscal consolidation. The probability distribution of the duration variable, T, can be specified by the cumulative distribution function, $F(t) = Pr(T < t)$, and the corresponding density function is $f(t) = dF(t)/dt$. Alternatively, the distribution of T can be characterized by the survivor function, $S(t) = Pr(T \geq t) = 1 - F(t)$, which measures the probability that the duration of a fiscal consolidation program is larger or equal to t.

A particularly useful function for duration analysis is the hazard function

$$h(t) = f(t)/S(t), \tag{1}$$

which measures the rate at which fiscal consolidation spells will end at time t, given that they lasted until that moment. In other words, it measures the probability of exiting from a state in moment t conditional on the length of time in that state. This function helps characterizing the path of duration dependence. For instance: (i) if $dh(t)/dt > 0$ for $t = t^*$, there is positive duration dependence in t^*; (ii) if $dh(t)/dt < 0$ for $t = t^*$, then there is negative duration dependence in t^*; and (iii) if $dh(t)/dt = 0$ for $t = t^*$, there is no duration dependence. Therefore, when the derivative of the hazard function with respect to time is positive, the probability of a fiscal consolidation ending in moment t, given that it has reached t^*, increases with its age. Thus, the longer the fiscal consolidation program is, the higher the conditional probability of its end will be.

From the hazard function, we can derive the integrated hazard function

$$H(t) = \int_0^t h(u)du, \tag{2}$$

and compute the survivor function as follows:

$$S(t) = \exp[-H(t)]. \tag{3}$$

While different parametric countinuous-time duration models can measure the magnitude of

duration dependence and the impact of other time-invariant variables on the likelihood of an event ending, the most commonly used functional form of the hazard function is the proportional hazard model

$$h(t, \mathbf{x}) = h_0(t) \exp(\boldsymbol{\beta}' \mathbf{x}), \tag{4}$$

where $h_0(t)$ is the baseline hazard function that captures the data dependence of duration and represents an unknown parameter to be estimated, $\boldsymbol{\beta}$ is a $(K \times 1)$ vector of parameters that need to be estimated and $\mathbf{x}$ is a vector of covariates. The proportional hazard model can be estimated without imposing any specific functional form to the baseline hazard function (the so called "Cox model"). Given the inappropriateness of this procedure (in particular, for studying duration dependence), a popular alternative imposes a specific parametric form for the function $h_0(t)$ (i.e. the "Weibull model").

3.2 The Basic Weibull Model

The Weibull model is characterized by the following (baseline) hazard function

$$h_0(t) = \gamma p t^{p-1}, \tag{5}$$

where p parameterizes the duration dependence, t denotes time, γ is a constant, $p > 0$ and $\gamma > 0$. If $p > 1$, the conditional probability of a turning point occurring increases as the phase gets older, i.e. there is positive duration dependence; if $p < 1$ there is negative duration dependence; finally, there is no duration dependence if $p = 1$. In this last case, the Weibull model is equal to an Exponential model. Therefore, by estimating p, we can test for duration dependence in fiscal consolidation programs.

If we plug the Weibull specification for the baseline hazard function as expressed by equation (5) in the proportional hazard function denoted by (4), we get:

$$h(t, \mathbf{x}) = \gamma p t^{p-1} \exp(\boldsymbol{\beta}' \mathbf{x}). \tag{6}$$

Hence, the corresponding survivor function can be written as:

$$S(t, \mathbf{x}) = \exp\left[-H(t, \mathbf{x})\right] = \exp\left[-\gamma t^p \exp(\boldsymbol{\beta}' \mathbf{x})\right]. \tag{7}$$

This model can be estimated by Maximum Likelihood, and the log-likelihood function for a sample of $i = 1, \ldots, n$ fiscal consolidations is given by

$$\ln L(\cdot) = \ln \prod_{i=1}^{n} f(t_i, \mathbf{x}_i) = \ln \prod_{i=1}^{n} h(t_i, \mathbf{x}_i)^{c_i} S(t_i, \mathbf{x}_i) = \sum_{i=1}^{n} \left[c_i \ln h(t_i, \mathbf{x}_i) + \ln S(t_i, \mathbf{x}_i) \right] =$$

$$= \sum_{i=1}^{n} \left[c_i \left(\ln \gamma + \ln p + (p-1) \ln t_i + \boldsymbol{\beta}' \mathbf{x}_i \right) - \gamma t_i^p \exp(\boldsymbol{\beta}' \mathbf{x}_i) \right], \tag{9}$$

where c_i indicates when observations are censored. If the sample period under analysis ends before the turning point has been observed, then observations will be censored (i.e. $c_i = 0$); when the turning points are observed in the sample period, the observations are not censored (in which case, $c_i = 1$).

3.3 A Weibull Model with Change-Points

While the basic structure of the log-likelihood function for the Weibull model allows us to analyze the presence of duration dependence in fiscal consolidations, we also move a step further in that we assess the extent to which the likelihood of a fiscal consolidation ending as it gets older changes after a certain duration. Thus, we allow for the possibility of a structural break in the Weibull model and conjecture that the parameters of the baseline hazard function (p and γ) can change at a certain point (i.e. the "change-point") in time. In particular, we expect that the degree of duration dependence, p, changes after the event has lasted more than a certain time. Consequently, we do not only expect that the likelihood of a consolidation program ending increases over time, but also that if it has lasted more than a certain time, the likelihood of ending may change significantly after that point (that is, the magnitude of duration dependence may decrease or increase from that point onwards).

We propose a Weibull model for fiscal consolidation with change-points that follows the general model framework developed by Lara-Porras et al. (2005) and Castro (2012) for cases where the Weibull distribution, or the respective parameters characterizing the baseline hazard function, vary over time for different intervals, but remain constant within each interval. For simplicity, let us re-write equation (5) as

$$h_0(t) = \gamma p t^{p-1} = \lambda p (\lambda t)^{p-1}, \tag{10}$$

where $\gamma = \lambda^p$. Hence, the survival function becomes

$$S(t, \mathbf{x}) = \exp\left[-H(t, \mathbf{x})\right] = \exp\left[(\lambda t)^p \exp(\boldsymbol{\beta}'\mathbf{x})\right], \tag{11}$$

Denoting $g(t) = \ln H(t)$ and considering a change point, τ_c, and two intervals, $t_0 < t \leq \tau_c$ and $\tau_c < t \leq t_T$, $g(t)$ can be expressed as

$$g(t) = \ln(\lambda_j t)^{p_j}, \tag{12}$$

with $j = 1, 2$. Due to the fact that the continuity of $g(t)$ in the change-point, τ_c has to be verified, we must impose that:

$$\ln(\lambda_1 \tau_c)^{p_1} = \ln(\lambda_2 \tau_c)^{p_2}. \tag{13}$$

Solving this equation with respect to p_2, we get:

$$p_2 = p_1 \frac{\ln(\lambda_1 \tau_c)}{\ln(\lambda_2 \tau_c)}. \tag{14}$$

Consequently, in the case of the survival time ending in the first interval, we have

$$g(t) = p_1 \ln(\lambda_1 t), \tag{15}$$

and, similarly, for the survival time ending in the second interval:

$$g(t) = p_2 \ln(\lambda_2 t) = p_1 \ln(\lambda_2 t) \frac{\ln(\lambda_1 \tau_c)}{\ln(\lambda_2 \tau_c)}. \tag{16}$$

Considering the i-th spell (or individual), we get

$$g(t_i) = d_i p_1 \ln(\lambda_1 t_i) + (1 - d_i) p_1 \ln(\lambda_2 t_i) \frac{\ln(\lambda_1 \tau_c)}{\ln(\lambda_2 \tau_c)}, \tag{17}$$

where $d_i = 1$ if $t_0 < t \leq \tau_c$, $d_i = 0$ if $\tau_c < t \leq t_T$, and $i = 1, 2, ..., n$ (i.e. the number of spells).

For $H(t_i, \mathbf{x}_i) = \exp[g(t_i) + \boldsymbol{\beta}'\mathbf{x}_i]$, the hazard function is given by

$$h(t_i, \mathbf{x}_i) = dH(t_i, \mathbf{x}_i)/dt_i = g'(t_i) H(t_i, \mathbf{x}_i) = \left[d_i \frac{p_1}{t_i} + (1 - d_i) \frac{p_1}{t_i} \frac{\ln(\lambda_1 \tau_c)}{\ln(\lambda_2 \tau_c)} \right] H(t_i, \mathbf{x}_i), \tag{18}$$

and the corresponding survivor function can be expressed as:

$$S(t_i, \mathbf{x}_i) = \exp\left[-H(t_i, \mathbf{x}_i)\right] \tag{19}$$

Therefore, the log-likelihood function can be written as:

$$\ln L(\cdot) = \sum_{i=1}^{n} \left\{ c_i \left[\ln g'(t_i) + g(t_i) + \boldsymbol{\beta}' \mathbf{x}_i \right] - \exp \left[g(t_i) + \boldsymbol{\beta}' \mathbf{x}_i \right] \right\}, \tag{20}$$

where $g'(t_i) = d_i \frac{p_1}{t_i} + (1 - d_i) \frac{p_1}{t_i} \frac{\ln(\lambda_1 \tau_c)}{\ln(\lambda_2 \tau_c)}$. This model is estimated by Maximum Likelihood, given a particular change-point τ_c. The relevance of the change-point is evaluated by testing whether there is a statistically significant difference between p_1 and p_2, i.e. whether the duration dependence parameter changes significantly between the two sub-periods.

4 Data and Empirical Results

4.1 Data

We use annual data for 17 industrialized countries over the period 1978-2009.[3] Fiscal consolidation episodes are identified using the work of Devries et al. (2011), which is based on a narrative approach. As argued by the authors, the standard statistical approach which focuses on variation in the cyclically adjusted primary budget balance (CAPB) may lead to biased results for two important reasons. First, the CAPB may suffer from measurement error that is potentially correlated with economic developments. Second, it omits periods during which fiscal consolidation programs are followed by adverse shocks and offsetting discretionary measures. For these reasons, we follow Devries et al. (2011), who examine accounts and records of what countries were intending to do at the time of publications (such as the IMF Recent Economic Developments reports, the IMF Staff Reports or the OECD Economic Surveys) to uncover policy actions that are motivated by deficit reduction. This procedure eliminates the endogeneity of the response of fiscal policy to the economy, as it captures policymakers' decisions.

By organizing the data in spells - where a spell represents the number of years that a fiscal consolidation lasts and is denoted by *DurCons* -,[4] we are able to identify 39 consolidation spells. While testing for the presence of duration dependence in fiscal consolidation and change-points in its behaviour, we also allow for differences between European and non-European countries. That is, we test whether there is a significant difference in the average duration of fiscal consolidation, as well as in the duration dependence parameter, p, between these two groups of countries. This

[3] The countries included in our sample are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, the United Kingdom, and the United States.

[4] The variable *DurCons* corresponds to t_i in the model described in the previous Section.

is done by including the dummy D_EC in the model, which takes the value of 1 for European countries and 0 otherwise. Additionally, we estimate separate regressions for each of the groups.

We also take into account the effects of some regressors that are assumed to be time-invariant. For the analysis of the business cycle, Zellner (1990), Sichel (1991), Abderrezak (1998) and Davig (2007) suggest that the duration of the previous business cycle phases may affect the length of the current phase. Therefore, we test whether that might also be the case for fiscal consolidation, by including the variable $DurPrev$ in the estimations.

In addition, we analyze whether the duration of fiscal consolidation becomes gradually longer or shorter over time, by considering a kind of a trend variable, labelled as $Event$, which reports the order or observation number of each event over time and for every single country. This variable is equals to 1 for the first event, 2 for the second, and so on. If the coefficient on this variable is significantly smaller (larger) than zero, phase durations get longer (shorter) over time.

In Table 1, we report some descriptive statistics for the duration of fiscal consolidation programs. The Table shows the number of spells of fiscal consolidations (Obs), for all countries (All), for European countries (EC) and non-European countries (NEC). Interestingly, fiscal consolidations seem to last longer for Non-European countries than for European countries. Whether this difference is statistically significant or not is an issue that we will try to answer with the estimation of the continuous-time Weibull model.

Table 1: Descriptive statistics.

Variable	Obs.	Mean	S.D.	Min.	Max.
$DurCons$					
All	39	4.74	3.31	1	14
EC	31	4.23	2.75	1	10
NEC	8	6.75	4.62	2	14
D_EC	39	0.79	0.41	0	1
$Event$	39	1.77	0.81	1	4
$DurPrev$	22	4.05	2.59	1	10

Notes: Fiscal consolidation programs are identified using the work of Devries et al. (2011). The Table reports the number of episodes (Obs.), the mean duration (Mean), the standard deviation (S.D.), the minimum (Min.) and the maximum (Max.) duration for each spell. The data is annual and comprises 17 industrialized countries over the period 1978-2009.

4.2 The Baseline Model

The empirical evidence that emerges from the estimation of the Weibull model presented in sub-Section 3.2 is summarized in Table 2. We recall that the estimate of p measures the magnitude

of the duration dependence and γ corresponds to the estimate of the constant term.

A one-sided test is used to detect the presence of positive duration dependence (i.e. whether $p > 1$) and the sign '+' indicates significance at a 5% level. The results provide strong evidence of positive duration dependence for fiscal consolidations, that is, the likelihood of a fiscal consolidation ending increases as the program becomes older. Moreover, p is statistically lower than or equal to 2, that is, the statistical analysis of the second-order derivative of the baseline hazard function indicates the presence of decreasing or constant positive duration dependence. Putting it differently, the probability of a fiscal consolidation ending at time t, given that it lasted until that period, increases over time, but at a decreasing or constant rate.[5]

In Column 1, we assume that the population of individual spells is homogeneous, i.e. each fiscal consolidation is under the same risk of ending. Given that this may not be a good description, Column 2 allows for the presence of unobserved heterogeneity or frailty. In statistical terms, a frailty model is similar to a random-effects model for duration analysis: it represents an unobserved random proportionality factor that modifies the hazard function of an individual spell and accounts for heterogeneity caused by unmeasured covariates or measurement errors. In order to include frailty in the Weibull model, the hazard function expressed by equation (6) is modified as follows

$$h(t, \mathbf{x}|v) = vh(t, \mathbf{x}), \tag{21}$$

where v is an unobserved individual-spell effect that scales the no-frailty component. The random variable v is assumed to be positive with unity mean, finite variance (θ) and independently distributed from t and $\mathbf{x}$. The survival function becomes:

$$S(t, \mathbf{x}|v) = [S(t, \mathbf{x})]^v . \tag{22}$$

Since the values of v are not observed, we cannot estimate them. Therefore, we follow Lancaster (1990) and assume v follows a Gamma distribution with unity mean and variance θ. Consequently, the frailty survival function can be written as

$$S(t, \mathbf{x}|\boldsymbol{\beta}, \theta) = [1 - \theta \ln S(t, \mathbf{x})]^{-(1/\theta)} , \tag{23}$$

the frailty hazard function becomes

$$h(t, \mathbf{x}|\boldsymbol{\beta}, \theta) = h(t, \mathbf{x}) [S(t, \mathbf{x}|\boldsymbol{\beta}, \theta)]^{\theta} , \tag{24}$$

[5] See Castro (2010, 2012) for details on the analysis of the second-order derivative of the baseline hazard function.

and the corresponding log-likelihood function can be expressed as:

$$\ln L(\cdot) = \sum_{i=1}^{n} \left\{ c_i \left[\ln \gamma + \ln p + (p-1) \ln t_i + \boldsymbol{\beta}' \mathbf{x}_i \right] - \left(c_i + \frac{1}{\theta} \right) \ln \left[1 + \gamma t_i^p \exp(\boldsymbol{\beta}' \mathbf{x}_i) \right] \right\}. \quad (25)$$

The variance parameter (θ), which measures the presence (or absence) of unobserved heterogeneity, is an additional parameter that needs to be estimated. As θ is always greater than zero, the limiting distribution of the maximum-likelihood estimate of θ is a normal distribution that is halved or chopped-off at the zero-bound. Therefore, the likelihood ratio test (*LR test*) used to detect its presence is a 'boundary' test that takes in account the fact that the null distribution is not the usual chi-squared with one degree of freedom, but rather a mixture of a chi-squared with no degrees of freedom and a chi-squared with one degree of freedom (Gutierrez et al., 2001) The results do not show evidence of unobserved heterogeneity, as corroborated by the p-value of the *LR test* reported at the bottom of Column 2.

Even though the presence of frailty (or "random effects") has not been detected, individual-country effects may still be present, given that the sample consists of 17 countries that may have individual-specific characteristics. Therefore, in Column 3, we add country-dummy variables to the set of regressors. In this case, we test for pooling, i.e. the *LR test* is used to assess whether the model controlling for country-specific effects is preferred to simple pooling. Once again, the p-value of the *LR test* reported at the bottom of Column 3 does not support the existence of country-specific effects.

In Column 4, we add the dummy variable D_EC to the set of regressors in order to analyze if the mean duration of fiscal consolidation is statistically different between European and non-European countries. As can be seen, the coefficient associated to D_EC is highly significant and its sign is positive in magnitude, which suggests that fiscal consolidation programs last longer in Non-European countries. This finding can be related to the traditionally more disciplined fiscal stance of European countries, as a result of the adoption and implementation over time of a set of rules constraining the behaviour of fiscal authorities. For instance, this was the case of the Maastricht criteria for entry in the EMU and the Stability and Growth Pact rules.

In Column 5, we control for the possibility that duration of fiscal consolidation is affected over time and, as a result, we include the trend variable (*Event*) in the model. Although the difference in duration between European and Non-European countries remains significant, the findings do not uncover a change in the duration of fiscal consolidations over time.

Additionally, in Column 6, we analyze whether the duration of the previous phase ($DurPrev$) affects the length of the current phase, but no evidence was found in that direction. This experiment implies a substantial reduction in the number of spells, which helps explaining the lack of statistical significance of the coefficient associated to D_EC.

Table 2: Duration dependence - Basic Weibull model estimation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
γ	0.0821^{***}	0.0793^{***}	0.0062	0.0394^{**}	0.0291	0.0044	0.0724^{***}	0.0864^{***}	0.0324^{*}
	[0.0258]	[0.0252]	[0.0042]	[0.0181]	[0.0183]	[0.0053]	[0.0247]	[0.0321]	[0.0187]
p	$1.5038^{+,d}$	$1.5453^{+,d}$	$2.1614^{+,c}$	$1.6029^{+,d}$	$1.6144^{+,d}$	$1.7478^{+,c}$	$1.3757^{+,d}$	$1.5793^{+,d}$	$1.3884^{+,d}$
	[0.1425]	[0.1733]	[0.2632]	[0.1178]	[0.1177]	[0.2394]	[0.1788]	[0.1440]	[0.1306]
Δp							0.2859^{**}		
							[0.1400]		
θ		0.0467							
		[0.1523]							
D_EC				0.7421^{**}	0.7200^{**}	0.6811			
				[0.3783]	[0.3700]	[0.5272]			
$Event$					0.1720	0.2079			
					[0.2565]	[0.3085]			
$DurPrev$						0.0262			
						[0.640]			
$LogL$	−45.06	−45.05	−34.15	−43.20	−42.94	−23.07	−93.78	−35.15	−8.03
$LR\ test$		0.759	0.149						
$SBIC$	97.46	101.10	71.97	97.39	100.54	61.60	198.56	77.16	20.22
$Spells$	39	39	39	39	39	22	39	31	8

Notes: Heteroscedasticity and serial autocorrelation robust standard errors clustered by country are reported in square brackets; $^{+}$ indicates that p is significantly higher than 1 using a one-sided test with a 5% significance level; d, c, and i indicate decreasing, constant and increasing positive duration dependence, respectively; $\triangle p$ is the estimated difference in the duration dependence parameter between European and Non-European countries; ***,**,* - statistically significant at 1%, 5% and 10% level, respectively. In Column 2, the p-value of the $LR\ test$ for unobserved heterogeneity/frailty gives assesses if the estimated variance (θ) is different from zero. In Column 3, the p-value of the $LR\ test$ analyses the statistical significance of country-specific dummy variables (pooling test), that is, $LR = -2(logL_r - logL_u)$, where r and u correspond to the restricted and unrestricted models, respectively. The Schwartz Bayesian Information Criterion (SBIC) is computed as follows: $SBIC = 2(-logL + (k/2)logN)$, where k is the number of regressors and N is the number of observations (spells).

The results presented so far show that the average duration of fiscal consolidation in European countries is significantly different from the one implemented in Non-European countries. However, one question remains: is this explained by the difference in the magnitude of the duration dependence parameter?

To answer the question, in Column 7, we replace the parameter p by $p+\Delta pD\_EC$, and directly estimate that difference (i.e. Δp) The empirical findings confirm that the duration dependence parameter is higher for European countries. As the estimated coefficient, Δp, is positive and statistically significant, the likelihood of a fiscal consolidation ending increases at a higher rate for these set of countries. Additionally, the estimated duration dependence parameter for the European countries is 1.6616 (= 1.3757 + 0.2859) with a standard error equal to 0.1332, which means that evidence of decreasing positive duration dependence also characterizes consolidation processes.

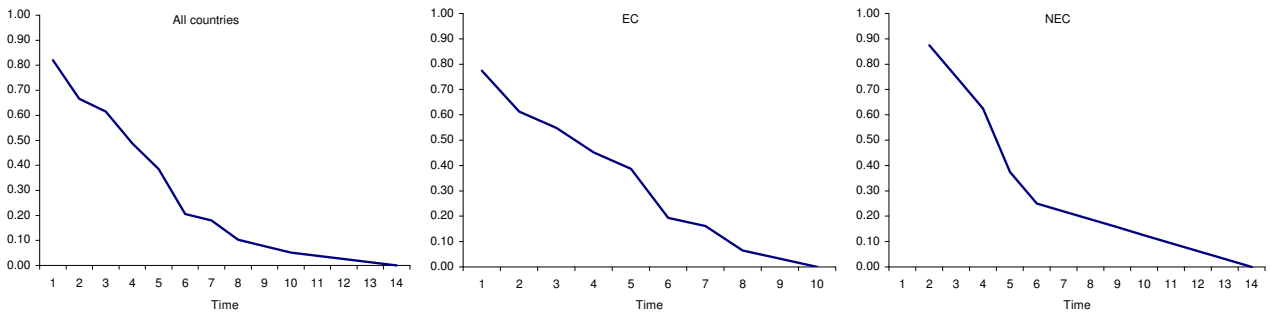
Finally, in Columns 8 and 9, we estimate separate regressions for European countries and Non-European countries, respectively. The results confirm that the duration dependence parameter is larger for European countries (1.5793) than for Non-European countries (1.3884).

4.3 The Model with Change-points in Duration Dependence

The results presented in Table 2 rely on the assumption that the magnitude of duration dependence is time-invariant.

In Figure 1, we plot the survivor functions for all countries and for European versus Non-European countries. It can be seen that the probability (or proportion) of a fiscal consolidation surviving after duration t_i substantially decreases as the program becomes older. The sharp decline is consistent with the existence of positive duration dependence. Moreover, for all countries and Non-European countries, the survivor functions quick fall until $t_i = 6$ and, then, evolve at a slower pace. This highlights the possibility of a break in duration dependence and the need of a more flexible framework allowing for a change-point in the Weibull distribution at $\tau_c = 6$. In fact, the Figure suggests that the magnitude of duration dependence might be lower when fiscal consolidations are longer than six years and the likelihood of a fiscal consolidation ending can significantly change above that period.

Figure 1: Survivor functions.



Another signal of the existence of a break-point in duration dependence is provided by the slope of the survivor functions. In the case of the full sample, the average slope is equal to -0.123 for fiscal consolidations that are shorter than six years and -0.026 for programs that last longer than six years. Putting it differently, when fiscal consolidations have a duration shorter than six years, each additional year of the program increases the likelihood of its ending by 12.3 percentage points, on average. In contrast, when fiscal consolidations have a length longer than six years, each additional year of the program rises the likelihood of its ending by 2.6 percentage points. Similar

results can be found for the sample of European and Non-European countries: (i) in the case of European countries, the difference remains substantial but it is smaller given that the average slope of the survivor function only decreases from -0.116 (in the case of fiscal consolidations that last less than six years) to -0.048 (for programs that have a duration longer than six years); (ii) in the case of Non-European countries, the difference is considerably larger, concerning that the average slope of the survivor function is -0.156 and -0.031 for fiscal consolidations that are shorter and longer than six years, respectively.

In order to test for the presence of differences in the duration dependence parameter, we consider a Weibull model with a change-point. Therefore, we estimate two dependence duration parameters, one for the first period (p_1) and another one for the second period (p_2), and evaluate the statistical significance of the difference between the two ($p_2 - p_1$).[6,7]

The results are reported in Table 3. In Column 1, we estimate a simple equation without covariates. In Column 2, we control for differences in the average duration of fiscal consolidations between European and Non-European countries. In Columns 3 and 4, we account for the possibility that the duration of fiscal consolidation changes over time and depends on the duration of the previous spell.

While we confirm that the duration of fiscal consolidation is typically longer for Non-European countries and there are no significant effects of the duration of previous spells on the duration of a given fiscal consolidation program, the most interesting and remarkable results are the ones related to the duration dependence parameter. In fact, they strongly suggest that the duration dependence parameter is time-varying. In particular, despite the existence of positive duration dependence, the magnitude of the parameter is significantly lower when fiscal consolidation programs are longer than six years: the coefficient associated to $p_2 - p_1$ is negative and statistically significant. Positive duration dependence is still present in consolidations that last less than six years but, when their length is longer, duration dependence is not statistically significant, i.e. the likelihood of ending is no longer dependent on their age. Indeed, while the parameter p_1 is statistically significant in all model specification, p_2 does not seem to exhibit statistical significance.

These results suggest that when countries display chronic fiscal imbalances, the need of consolidation measures becomes a frequent characteristic. Putting it differently, countries will be eventually trapped in a vicious cycle of austerity and, as a consequence, the likelihood of a fiscal

[6] The estimates for the two constant terms are $\gamma_1 = \lambda_1^{p_1}$ and $\gamma_2 = \lambda_2^{p_2}$.

[7] The deltha method is used to compute the respective standard-errors.

consolidation ending declines at a lower pace for programs that are longer than six years.

Finally, we consider separately the two sub-groups of countries (i.e. European and Non-European countries) in Columns 5 and 6. The empirical findings show that the presence of a change-point is significant for Non-European countries, but not for European countries. Even though the estimated difference in the duration dependence parameter ($p_2 - p_1$) is not statistically significant in this group of countries, the evidence still corroborates the existence of positive duration dependence for both consolidations that are shorter or longer than six years: the parameters p_1 and p_2 are positive (1.5217 and 1.7960, respectively) and statistically significant. For Non-European countries, the duration dependence parameter is larger in magnitude for consolidations that last less than six years (3.4083) and the results suggest that it is increasing. However, no evidence of duration dependence is found for longer fiscal consolidation programs.

Table 3: Duration dependence - Weibull model estimation with change-points.

	(1)	(2)	(3)	(4)	(5)	(6)
γ_1	0.1998^{***}	0.2279^{***}	0.2168^{***}	0.1965^{*}	0.2079^{***}	0.1762^{***}
	[0.0183]	[0.0569]	[0.0772]	[0.1029]	[0.0242]	[0.0267]
γ_2	0.2158^{***}	0.2428^{***}	0.2281^{**}	0.2019	0.2010^{***}	0.2095
	[0.0319]	[0.0910]	[0.1089]	[0.1327]	[0.0243]	[0.1532]
p_1	$1.6894^{+,c}$	$1.6884^{+,c}$	$1.6966^{+,c}$	$1.8145^{+,c}$	$1.5217^{+,d}$	$3.4083^{+,i}$
	[0.2205]	[0.2130]	[0.2076]	[0.2945]	[0.1758]	[0.7377]
p_2	1.1876	1.4036	1.4214	1.5578	$1.7960^{+,c}$	0.8253
	[0.2143]	[0.2607]	[0.2661]	[0.4040]	[0.3363]	[0.3374]
$p_2 - p_1$	-0.5018^{**}	-0.2847^{*}	−0.2752	−0.2567	0.2743	-2.5830^{***}
	[0.2290]	[0.1667]	[0.1696]	[0.1717]	[0.2114]	[0.8946]
D_EC		0.6681^{*}	0.6501^{*}	0.6144		
		[0.4014]	[0.3931]	[0.5269]		
$Event$			0.1675	0.1787		
			[0.2581]	[0.3303]		
$DurPrev$				0.0234		
				[0.0661]		
$LogL$	−94.66	−93.27	−93.02	−51.27	−71.53	−19.62
$SBIC$	200.31	201.20	204.37	124.19	153.37	43.41
$Spells$	39	39	39	22	31	8

Notes: Robust standard errors are reported in square brackets. $p_2 - p_1$ is the estimated difference in the duration dependence parameters. The change-point is located at duration equal to six years. $^{+}$ indicates that p is significantly higher than 1 using a one-sided test with a 5% significance level; d, c, and i indicate decreasing, constant and increasing positive duration dependence, respectively; ***,**,* - statistically significant at 1%, 5% and 10% level, respectively.

5 Conclusion

While some continuous-time and discrete-time duration models have successfully detected positive duration dependence in fiscal consolidations (Illera and Mulas-Granados, 2002), the existing works do not consider the possibility of breaks (or "change-points") in the duration dependence.

In this paper, we argue that the likelihood of a fiscal consolidation ending changes as the program becomes older More specifically, we build on a novel database of fiscal consolidation episodes constructed by Devries et al. (2011), and extend the basic Weibull duration model allowing for the presence of a change-point in the duration dependence parameter. Using data for 17 industrialized countries over the period 1978-2009, we confirm the presence of positive duration dependence in fiscal consolidations.

Interestingly, we uncover a change-point in duration dependence. In particular, the magnitude of the duration dependence parameter decreases significantly when a fiscal consolidation program is longer than six years. Additionally, while positive duration dependence is found for those consolidations that last less than six years, when duration is longer than this threshold, fiscal consolidations are not duration dependent. This is a remarkable new finding, as it shows that the likelihood of a fiscal consolidation ending increases at a constant rate with its age. However, when it is running for more than six years, the likelihood of its end no longer depends on the actual duration or age.

From a policy perspective, this result highlights that chronic fiscal imbalances can lead to a vicious austerity cycle, where consolidation measures may need to be implemented over longer time spans. This comes at the cost of high uncertainty about the timing of the consolidation ending and the additional contractionary packages that may be required to achieve a sound and sustainable fiscal stance.

Given the nature of the countries covered in this study, we also compare the characteristics of the duration of fiscal consolidation programs between European and Non-European countries. We find that fiscal consolidations tend to last longer in Non-European countries than in European countries. The results also show the presence of a change-point in the duration dependence parameter for Non-European countries, but not for European countries. In addition, while positive duration dependence is always present in European countries, in the case of Non-European countries, that only happens for fiscal consolidations that last less than six years.

This set of findings for European countries give rise to the role played by the commitment towards the Maastricht criteria for entry in the EMU and the compliance with the Stability and Growth Pact rules. It also in line with the political support regarding relatively quick corrections of the budget deficits and the fear of financing crisis with roots on the unsustainable path of public debt.

While providing valuable information on the duration of fiscal consolidation, the present paper

opens new avenues for further work. For instance, given that the selection of the change-point is exogenously determined by a sensible graphical analysis of the survivor function, an interesting extension of this piece of research would be to incorporate a discrete latent variable in the standard Weibull model. This would make the selection of the change-point endogenous, thereby, representing a challenging and promising approach to be considered in the future.

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