An analysis of duration dependence of government revenue expansions and contractions in Developing Countries

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Abstract

In this paper, we employ the discrete-time duration model to examine whether expansion and contraction phases of government revenue exhibit duration dependence. We hence use an unbalanced panel data of public revenue on 68 developing countries over the period 1980-2009. The analysis also covers the sub-samples of sub-Saharan African and Non sub-Saharan African countries. Our findings suggest that once controlling for frailty and economic variables, the likelihood of public revenue expansion and contraction ending appears to be positively affected by their actual age: government revenue expansion and contraction exhibit in developing countries positive duration dependence.

Keywords: Government Revenue; Discrete-time model; Duration dependence.

JEL Classification: H1; C41 ; H3 ; E6.

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All errors are the responsibility of the author and the views expressed in this paper are those of the author.

1. INTRODUCTION

In today's world, fiscal policy is more than ever a key development policy tool. Developing and low-income countries require considerable mobilization of revenue to attain their development objectives. Many studies have examined the nature of the determinants of public revenue and their effect on macroeconomic indicators (e.g. for private consumption, private investment, or economic growth). However, to our knowledge, none of them has explored the issue of the duration of government revenue cycle phases, namely public revenue expansion and contraction. The purpose of this paper is to use 'survival', 'duration' or 'hazards' analysis to explore whether public revenue expansion/contraction in developing countries exhibits duration dependence. This kind of analysis is required to study the length of time spent by individuals within some state. It models the phenomenon of 'time to event' or 'time failure', which is also known as 'spell length'. Duration analysis has often been used in labour economics to study the duration of periods of unemployment (see for example, Allison, 1982). It has also recently been used to explore issues such as the duration of business cycle expansions and contractions (see. Castro, 2010), or international trade issues such as the duration of EU's imports (Hess et al., 2010).

'Duration' in this study refers to the number of years during which government revenue in a developing country remains either in the expansion or in contraction phases. The overall goal is to estimate the hazard rate, i.e the probability at which the stay in a given phase of government revenue cycle (expansion or contraction) ends at time t after a country stays in that category until t.

This paper explores various key areas of interest. Firstly, we need to determine how the hazard rate varies with the time spells (duration dependence effect) and with the values of relevant covariates, having controlled for the heterogeneity that may stem from country characteristics. Secondly, we will focus both on our full sample of developing countries as well as on the sub-samples of sub-saharan African countries and non sub-Saharan African countries, in order to evaluate whether they exhibit different patterns regarding hazard rate and duration dependence. The hypothesis of state-dependence or path-dependence (see Eblbers, and Ridder, 1982; Heckman 1991; Parsley and Wei, 1993) implies that repeated failures in the expansion or contraction of public revenue, especially over a relatively long period, may build up a positive/negative reputation (i.e it signals some deeply rooted conditions that are favorable or unfavorable to expansions or contractions). According to

Heckman (1981), 'true state dependence[1]' means that the experience of a phase of expansion or contraction of government revenue in any one year raises the risk of being in the same phase in the next year. However, rather than indicating true state dependence, the duration dependence observed in the data may be explained by certain 'unfavourable' characteristics (both observable and unobservable) that justify why certain developing countries leave the phase of expansion earlier or stay longer in the phase of contraction of government revenue (this is known as the 'sorting effect'). Accordingly, the duration of government revenue phases of expansion/contraction may be unrelated to the hazard rate of government revenue expansion or contraction. In such cases, the observed relationship between the hazard rate and the duration of expansions or contractions of government revenue is likely to be spurious and may indirectly hide other causalities (see also Andriopoulou et al., 2011).

The rest of the paper is organized as follows. Section 2 places the paper in the context of existing literature. In Section 3, we explain how we date the phases of public revenue cycles, indicating how we identify peaks and troughs in our dataset. Section 4 outlines the empirical approach whereas section 5, evaluates the empirical results. Section 6 is the conclusion.

2. LITERATURE REVIEW

The determinants of tax revenues in developing countries have been largely explored in the empirical literature. The latter broadly encompasses two main strands. The first strand explores the determinants of tax revenue (or global public revenue) by using cross-section frameworks and ignoring the variation over time. This includes the work of Lotz and Morss (1967), Bahl (1971), Chelliah (1971), Chelliah, Baas and Kelly (1975), Tait Eichengreen and Gratz (1979), Tanzi (1992) and Bird, Martinez-Vasquez and Torgler (2004). The second strand of the empirical literature introduces the time dimension and includes studies that examine the determinants of tax revenue over time. Among these works are those of Tanzi (1981), Leuthold (1991), Stotsky and WoldeMariam (1997), Ghura (1998), Stostky et al. (2004), Adam, Bevan and Chambas (2001), Gupta (2007), Chambas et al. (2008) and Brun et al (2011). Most of these studies, in examining the determinants of tax revenues, also construct a measure of tax effort. Other studies focus more particularly on how tax revenues respond to

[1] Precisely, the term «state dependence» is used in order to define the dependence of the status in t on the status of the dependent variable in t-1, while the term "duration dependence" expresses the dependence of the status in t on the duration spent in this status. Yet the two terms are often used as synonyms in the literature. In this paper, we focus on duration dependence but, indirectly, state dependence is also examined.

business cycles. For example, Velloso and Xing (2010) have recently examined the relationship between tax revenue efficiency and the output gap. Their results suggest a positive and significant effect of these variables, results that are consistent for both advanced and developing countries and for both quarterly and annual data. In addition, during booms, the short run elasticity of tax revenue to output is higher than the long-run elasticity, suggesting that policymakers need to look beyond simple, long-run revenue elasticities and incorporate into their analysis the effects of the economic cycle on tax revenue efficiency, particularly during major economic booms and downturns. Gavin and Perotti (1997) also show evidence that fiscal policy is procyclical in Latin American countries and contracyclical in industrial countries. More specifically, they find evidence that a one-percentage-point increase in the rate of output growth in industrial countries is associated with an increase in the fiscal surplus of about 0.37 percentage points of GDP, whereas the fiscal response in Latin American countries appears to be negligible (that is, not statistically significant). They also explore the nature of fiscal policy in Latin America and industrial countries during good and bad times. Their findings are of two kinds:

-a major asymmetry is found in the fiscal response to output shocks in industrial countries: during good times, budget surplus increases with GDP growth, whereas the magnitude of the positive response of fiscal deficit during bad times is higher - recessions are economically and/or politically more costly than output booms, and the fiscal policy response to them thus needs to be stronger.

-for Latin American countries, the fiscal balance responds positively and significantly to a severe decline of real GDP growth (by more than 10%).

Another study of IMF (2005) also finds empirical evidence for the procyclicality of fiscal policy in advanced, emerging and developing countries. The authors observe evidence that in emerging and developing countries, a one percentage increase in the output gap is associated with a deterioration of cyclically-adjusted fiscal balance by 0.5 percentage point of GDP, whereas the deterioration is of 0.2 percentage point of GDP in advanced countries. In a similar vein, Kun Li and Pablo Lopez-Murphy (2010) examine how imports affect tax revenue downturns in advanced, emerging and developing countries. They argue that positive changes in import-to-GDP ratio are associated with increases in tax revenue-to-GDP ratio. This result is valid for the different groups of countries (advanced, emerging and developing countries) used in their study. In addition, for all these groups of countries, there seems to be no significant response to changes in tax revenues-to-GDP ratio to real GDP growth during bad times. Moreover, an increase in real GDP growth in emerging and developing countries induces a positive change of tax revenue-to-GDP ratio. This effect is not statistically significant for advanced economies. This study is influenced by the work of Gavin and Perotti (1997) and Kun Li and Pablo Lopez-Murphy (2010) and explores whether public revenue expansions and contractions exhibit duration dependence. In the next section, we explain how we date the public revenue phases of expansions and contractions.

3. DATING THE PHASES OF PUBLIC REVENUE EXPANSION AND CONTRACTION IN DEVELOPING COUNTRIES

The identification of specific cycles in economic time series requires precise definitions of expansion and contraction (Cashin 2004). This applies to government revenues in developing countries. According to Harding and Pagan (2002), any procedure or algorithm for extrema identification should follow three fundamental criteria: determining a set of potential turning points; ensuring alternance between maxima and minima; following a set of rules that satisfy the pre-determined criteria of duration and magnitude of phases and cycles, that is, the censoring rules.

The literature on business cycle offers several approaches for identifying the turning points in 'classical cycles'. The most frequently one used is that of the NBER, as developed by Bry and Boschian[2] (BB) (1971). His algorithm evolved from the NBER dating of cycles in U.S. economic activity and has been further adapted by scholars such as King and Plosser (1994), Watson (1994) and Harding and Pagan (2002a). It is worth mentioning that Pagan (1999) has also applied the algorithm to date bull and bear markets in equity prices, and Cashin, McDermott and Scott (2002) have applied it to dating commodity-price cycles.

The empirical literature distinguishes between 'classical cycles' and 'growth cycles'. The former refers to series in level whereas the latter examines series' deviations from trends (Stock and Watson, 1999). Accordingly, the appropriate dating method needs to be chosen, depending on the objectives the researcher is pursuing.

Cashin (2004), in exploring the key features of Caribbean business cycles during the annual period 1963-2003, has used a number of criteria for both classical cycles and growth

[2] The BB procedure essentially identifies the turning points of high frequency series, generally the monthly data of GDP, based on the classical definition of cycle proposed by Burns and Mitchell (1946). Other criteria based on the frequency of the series (the quarterly version of BB's algorithm) and on Okun's rule (any contraction should have a minimum duration of 2 quarters) are also employed (Massmann et al., 2003).

cycles to identify peaks and troughs. For the purpose of this study, we will adapt Cashin (2004)'s method of dating the peaks and troughs of government revenue cycle in developing countries. In particular, we adopt the 'classical growth' method for dating government revenue expansions and contractions in developing countries for two reasons: firstly, it is the most appropriate technique for our study and secondly, results based on the 'growth cycle' technique are sensitive to the chosen de-trending method (Canova, 1998). We will rely on these two definitions:

Definition 1: For annual data, an expansion is defined as a sequence of increases in the government revenue-to-GDP ratio and a contraction, as a sequence of decreases in the government revenue-to-GDP ratio.

Definition 2: A cycle includes one expansion and one contraction, each of them having a minimum of one year.

We will follow Cashin and McDermott (2002) and Cashin (2004) in ruling out any mild interruptions in expansions or contraction. More particularly, we do not consider any potential change of phase that moves the cycle by less than one half of one per cent per year as a turning point. The use of 'classical cycles" leads us to consider expansions/contractions as periods of absolute rise/decline in the global public revenues-to-GDP ratio, rather than as periods of below-trend (above-trend) growth in the series (which is the definition of a "growth cycle").

Therefore, we can identify the dates of different peaks and troughs for developing countries' government revenue-to-GDP ratio phases of expansion and contraction. Our panel dataset is unbalanced, comprising 68 developing countries (of which 42 are Sub-Saharan African countries) and covers the period 1980-2009. The choice of that period was dictated by data availability. For practical reasons, we chose to focus on countries in which the minimum availability of annual data about government revenue is 26 years. That choice is justified by the fact that 'the smaller the samples, the lower are the number of cycles to be identified, making the results obtained by the identification technique used more sensitive, thus rendering any statistical inference practically impossible (Abad and Quilis, 1998). Camacho et al. (2004) also highlight the difficulties in properly identifying the turning points at the beginning and the end of the period of study, on very small samples, with the possible consequence of losing important information. In the table 1, we provide standard descriptive statistics on the duration of expansion/contraction for each country in our sample.

It is necessary to point out the importance here of the phenomenon of the 'censoring' of spells. Survival analysis which based on spell analysis can suffer from left and right censoring, meaning that certain spells start before and finish after the period of study. This is referred to as the left and right censoring status. According to Jenkins (2005), a survival time is censored if all that is known is that it began or ended within some particular interval of time, and thus the total spell length (from entry time until transition) is not known exactly. The right censored spells refers to a spell that does not end within the observation period, whereas the left-censored ones refer to those that have started prior to the beginning date (here, the year) of the observation period and for which the exact length is unknown. In empirical duration analysis, left-censored spells are not taken into account to avoid any restrictive a priori assumption about the duration dependence of the hazard rate. However, these right-censored spells do not matter for the derivation of the sample likelihood. This is why we include in our analysis all right-censored spells, but disregard left-censored spells.

With regard to descriptive statistics tables, in table 1, we report the period of study (minimum of 26 years and maximum of 30 years), the number of expansions and contractions spells (where we exclude the spurious points and the left-censoring spells but include the right-censoring ones), and finally the peaks and troughs. In table 2, we provide the mean, the standard deviation, the minimum and the maximum duration of the expansion and contraction of global public revenue-to-GDP ratio. Regarding the latter, the maximum duration of expansion is 9 years for both the full sample of developing countries and the sub-sample of sub-Saharan African countries (henceforth referred to as SSA) and 7 years for non sub-Saharan African countries (henceforth referred to as Non SSA). The maximum duration of contraction is 8 years for both the full sample of developing countries and the sub-sample of SSA and 7 years for the sub-sample of Non SSA.

A more thorough descriptive analysis is shown in, table 2, which presents descriptive statistics for the durations of public revenue expansion/contraction, while making a distinction between complete and ongoing (incomplete) spells, over the observed period, and figures 1 and 2 plot descriptive survivor functions for the distribution of expansion and contraction duration. From table 2, it appears that in our dataset, all countries do not exhibit an incomplete spell of expansion/contraction. In addition, considering the full sample, we can observe that, on average, complete expansion spells last longer than contraction spells while incomplete contraction spells last more than incomplete expansion spells. The average length of expansion duration appears to be higher than that of contraction duration for the sub-samples of SSA and Non SSA. In terms of duration variability, spells of expansions and contraction display roughly the same standard deviation as the full sample in developing countries, while the variability of these spells (except complete ones) is higher in Non SSA than in SSA.

In figures 1 and 2, we analyze the survivor function of public revenue expansion and contraction duration. Hence, we plot the observed spell lengths in the x-axis and the fraction of observations where the observed spell of expansion/contraction exceeds a given length in the y-axis. Figure 1 suggests that, in developing countries, approximately 44% of all spells of expansion cease during the first year and 87% terminate within the first three years, while 52.9% of all contraction spells terminate during the first year and, 94.44% of all contraction spells end within the first three years. As regards to our two sub-samples, we can observe that the number of expansions spells that cease during the first year in Sub-Saharan African countries (47.1%) is higher than that of non Sub-Saharan African countries (37.7%). The opposite is true for contraction spells (52.29% versus 53.95%). In addition, the number of expansions spells that terminate within the first three years is higher in SSA (89.96%) than in non SSA (81.88%), whereas in the case of contraction, an opposite relationship (96.18% versus 91.45%) can be observed. Therefore, we can conclude that many spells of expansion or contractions last a few years, while a few are 'long-lasting'. Thus, the expansion and contraction of government revenue are often very short-lived.

4. EMPIRICAL APPROACH

4.1 The choice of the model framework: discrete-time or continuous time?

In this section, we lay out the econometric model of the duration of expansions and contractions of government revenue. In duration models, the key issue is the 'hazard rate', which is the probability of experiencing an event (here, expansions or contractions in government revenue) after a certain number of years, which is conditional on not having had experience of the event up to that time. Therefore, in analyzing whether the expansion/contraction of government revenues in developing countries exhibits duration dependence patterns, we need to examine whether the probability of public revenue expansion/contraction duration ending in developing countries depends on the amount of time spent within that spell. The duration variable is then defined as the number of periods (here, years) that a country experiences in a state of expansion or contraction, depending on the phase which is being analyzed. This variable is in our case, continuous. However, the information is available only annually. We have thus grouped (or banded) data and the discrete hazard model should be used. The adoption of this discrete-time framework is based on the fact that whereas duration models have initially been conceived in terms of continuous time-setting, some authors, (e.g. Ohn et al. 2004; Castro 2010, Hess et al., 2011) argue that discrete-time setting is more appropriate when the minimum duration of phases is a small multiple of the reference time unit (a quarter) – which is in fact the case here, as we have annual data. Furthermore, discrete-time duration models have the following advantages:

- they easily allow the inclusion of time-varying covariates within the framework as well as accounting for unobserved individual heterogeneity, even if the number of observations is large.
- they can allow us to easily circumvent the restrictive assumptions of proportional hazards.

Accordingly, in this study, we use parametric discrete-time duration models to examine whether government revenue in phases of expansion or contraction in developing countries produces duration dependence. The work of Jenkins (1995, 2005), Castro (2010), Greene (2003) and Hess et al. (2011) is referenced in relation to this.

One important issue when analyzing discrete-time models is that of spells independence. In order to obtain consistent parameter estimates from our regression, spells must be independent. Also, censoring must occur only at interval boundaries, and must not provide any information about T_i beyond that available in the covariates (see. Hess et al., 2010; Jenkins, 1995). Hence, to ensure conditional independence between spells, we need to account for multiple spells as well as for the dependencies existing among expansions/contractions of government revenue in the same country.

In the next sub-section, we will discuss practical issues related to the implementation of discrete-time models.

4.2 Discussion of the practical issues related to the implementation of the discrete-time method

To estimating the hazard rate of a country's government revenue expansion/contraction, we are confronted with four main challenges:

- the choice of the covariates entering the model;
- the choice of the functional form of the hazard rate P_{it};
- the choice of the functional form of the baseline hazard rate; and

- the choice of whether or not to include unobserved heterogeneity in the model and if so, the choice of the distribution of that 'frailty'.

We will now examine each of these challenges.

4.2.1 The first challenge : Choosing the covariates entering the model

The first challenge is to choose the covariates entering the model. In appendices A and B we provide an overview of all variables, data sources and a list of countries used in our analysis.

- **The dependent variable**

To implement our estimation in Stata, as recommended by Jenkins (1995, 2005) for survival analysis, we need to reorganize our data structure in a person-period format[3]. Accordingly, we will create the following variables:

t indicates the time periods the country is at risk or the length of the spell – number of periods - at which the country experiences government revenue expansion/contraction.

y is a binary dependent variable, which is equal to 1 if the observed spell i ended during the t^{th} year, and 0 otherwise. This variable is often referred to as censoring status. Indeed, as mentioned above (in section 3), we can observe for each spell of government revenue expansion/contraction, the last year in which it occurs, but not necessary the first year it has started. Note however that the terminal period may differ across spells (see table 1). In addition, for the countries that experience several expansions or contractions of government revenue over the observed period, we have the so called 'repeated spells' or 'multi-failure' data. These spells may lead to violations of assumptions about homoscedasticity. To obtain robust standard errors, we need to use inter group correlation for specific countries

- **The explanatory variables**

We follow Gavin and Perotti (1997)'s model in which changes in fiscal outcomes (in percent of GDP) are explained by real GDP growth, terms of trade growth, and lagged fiscal outcomes, and consider the following explanatory variables for our model:

Lagged changes in public revenue (in percent of GDP): the inclusion of this variable in the model aims at capturing a sort of 'state-dependence'. We expect an increase of

[3] See the easy estimation method of Jenkins (1995) and also Jenkins (2005).

the public revenue to-GDP ratio to reduce the likelihood of expansion spells ending, whereas the opposite effect may be obtained for the probability of contraction spells terminating.

Real GDP growth: this variable is introduced in the model with one year lagged values to avoid simultaneity problems. The effect of real GDP growth is ambiguous. Indeed, there is a largely unanimous view among both neoclassical and Keynesian economists, as well as among policymakers for countercyclical fiscal policies, as optimal fiscal policy. In line with that view, we expect real GDP growth to reduce the likelihood of government revenue expansion terminating. However, as the empirical literature demonstrates by providing evidence of procyclical fiscal policies in developing countries, we may obtain an increase of the likelihood of expansion ending following a rise in real GDP growth.

At the same time, either approaches suggest that, in good times, government revenue should increase and that the ratio should decline during bad times. Accordingly, a severe decline in output during bad times is expected to positively affect the probability of expansion ending as well as the likelihood of contraction termination. This suggests (with regard to an unchanged tax base) that public revenue is countercyclical.

Growth rate of terms of trade: An increase of the terms of trade growth rate following an improvement of terms of trade should reduce the likelihood of the expansion duration ending and increase the probability of the duration of contraction being terminated.

Number of previous expansions (contractions): We follow the method of Beck et al., (1998). These authors emphasize that, when dealing with binary time-series cross-section (BTSC) where the temporal dependence is modeled, ordinary logit or probit models may result in overly high inferences (t-statistics that are too high). To circumvent that bias, they suggest adding to the model a variable that picks up the number of previous spells of expansion or contraction of government revenues. This is in line with our intention to take into account the repeated nature of spells and thus to conform with the hypothesis that all spells should be independent and conditional on the covariates. As a result, we include in our specification the variables 'numberexpansions' and 'numbercontractions' that capture respectively the number of previous spells of government revenue expansions and the number of previous spells of government revenue contractions. We expect that the higher the number of previous spells of expansions, the lower the likelihood of expansion ending and, the higher the likelihood of previous contractions spells, the higher the probability of contraction duration ending. However, we can presume that after a long period of revenue expansion, the government will, for several reasons, adopt lax tax policies. In the same way, after several periods of public revenue contraction, the government can decide to implement the appropriate measures to mobilize more revenue, measures which will stop the continuous period of contraction. Therefore, the expected effects may be the opposite of those mentioned above.

The baseline hazard rate: The last regressor to be included in our model is the baseline hazard rate. As explained later, we can model this in the most flexible way by the use of dummy variables that enable the estimation of period-specific intercepts. Indeed, for spells of expansion, we can include dummies for each year up to the end of the seventh year (from 1 year to 7 years) and an additional dummy for longer durations (here the maximum spell length is 9 years, but there is no spell length of 8 years). For spells of contractions that last from 1 to 8 years, we also include dummies for each year up to the eighth year. Additionally, we have created two dummy variables to capture the effects of the recent financial crisis (that started in 2008): dummy2008 and dummy2009 that take respectively '1' for the years 2008 and 2009 and, '0' otherwise.

4.2.2 The second challenge : The functional form of the baseline hazard rate

The second challenge relates to the choice of the functional form of the hazard rate. We rely here on Hess et al. (2010). The most commonly encountered functional specifications (see. Hess et al., 2010) are the normal, logistic, and extreme-value minimum distribution, leading respectively to probit, logit or cloglog models. The logit and cloglog models are similar but differ in the fact that a discrete- time hazard model based on a cloglog assumes proportional hazards, whereas one based on a logit transformation assumes proportional odds (Singer and Willet 2003; Jenkins 2005). Note that the complementary log-log model can be interpreted as the discrete time counterpart of an underlying continuous-time proportional hazard model (see for e.g. Allison, 1982 and Jenkins (1995, 2005). By contrast, the probit specification is decidedly non-proportional (see also Sueyoski, 1995 for an extensive discussion of these model specifications in a duration context). In this paper, we implement the probit, logit and cloglog model and use some criteria described later to choose the model that fits our dataset better.

4.2.3 The third challenge: the choice of the functional form of the baseline hazard rate.

The third challenge relates to the choice of the functional form of the baseline hazard rate. According to the literature, several forms of the baseline hazard rate exist (denoting here, θ_t) : a parametric form of the hazard rate (usually stipulated on the basis of a theoretical framework – for example the weibull model; a specification linear in time: $\theta_t = \alpha_0 + \alpha_1 t$; a polynomial in time: $\theta_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + ... + ...$) and a non-parametric method to estimate the hazard rate (for example piece-wise dummies – one for each particular sub-period of time – where the hazard rate is assumed to be the same within each time-group but different between those groups: $\theta_t = \alpha_0 + \alpha_1 d_1 + \alpha_2 d_2 + ... + ...$; or when it is possible, a fully non-parametric specification with one dummy for each value of t for which the event is reported).

In this paper, as we do not have any theory that dictates the choice of the functional form of the baseline hazard rate (which characterizes the form of the duration dependence), we will model it in a flexible way by the use of a piecewise constant specification with a set of dummy variables for spells of expansions/contractions of government revenues, where the hazard rate is assumed to be the same within each country-spell but different between those spells. As the maximum duration of expansion is 9 years and that of contraction 8 years in the full sample of developing countries, we will proceed to the creation of the dummy variables as follows: a dummy duration-specific intercept is created for every possible duration from 1 to d_max = 9 for expansions spells and d_max = 8 for contractions spells, where d_max is the maximum duration. Hence we have, in the absence of a constant in the model, 9 dummy variables for expansions and 8 dummy variables for contraction; in order to capture the duration dependence in expansion spells duration and the contraction spells duration.

4.2.4 The fourth challenge : the issue of unobserved heterogeneity

The fourth challenge calls for the choice of whether or not to include ‘unobserved country specific effects’ or ’frailty’ in the model. If these are included, the choice of the distribution of unobserved heterogeneity becomes crucial for the ‘frailty’ model. According to the empirical literature (see Jenkins 2005), ignorance of the heterogeneity effect could lead to three major biases: an overestimation of negative duration dependence; unstable coefficients for covariates and biases coefficients for covariates.

In the empirical literature, the Gamma and inverse Gaussian distributions are commonly used for continuous-time model whereas the Gamma Normal (Gaussian) distributions are used to represent the distribution of unobserved heterogeneity in discrete-time model. In other words, when estimating discrete-time models, a sensible approach is to apply conventional binary response panel data models with random effects (see for e.g. Castro, 2010; Hess et al., 2010; Steele F. A., 2011).

In this paper, we subscribe to the usual convention in estimating discrete-time models and assuming that the individual-specific unobserved characteristic (unobserved heterogeneity) follow a log-normal distribution (normally distributed with zero mean and independence of frailty with all observable characteristics): the individual-specific effects are modeled using random effects techniques. Hence, by the use of the maximum likelihood method, we estimate the parameters of the complementary-log-logistic, logit and probit models.

5. EVALUATION OF THE EMPIRICAL RESULTS

In this section, we will discuss the results obtained from the estimation of the baseline specification of explanatory variables using discrete-time cloglog, logit and probit models with random effects (In this way we can take account of unobserved individual heterogeneity or frailty). As mentioned above, the baseline hazard rate is modelled in the most flexible way by the use of dummy variables that enable the estimation of period-specific intercepts. In addition, we exclude all left-censored spells which could lead to misestimating the hazard rate. Given that we have several possible non-parametric models (cloglog, logit and probit models) we need a rule to discriminate between them in order to interpret our results. The empirical literature offers us a means to deal with that issue: when non-parametric models are nested, the likelihood ratio or the wald tests can be used to discriminate between them. Conversely, when they are not nested, these tests become unsuitable and make it difficult to choose one model for interpreting our results. In such a situation, a practical and common approach is to use the Akaike Information Criterion

(AIC): $AIC = -2(\log likelihood) + 2(c + q + 1)$ where c is the number of model covariates (explanatory variables) and q is the number of model-specific auxiliary parameters. This information criterion is proposed by Akaike (1994) and penalizes each log-likelihood to reflect the number of parameters being estimated in a particular model and then comparing them.

Therefore, the preferred model would be the one with the smallest AIC value (which describes the data more accurately) despite the fact that the best-fitting model is the one with the largest log-likelihood. Accordingly, all the choices that will subsequently need to be made for the interpretation of the model's results will rely on the Akaike Information Criterion (AIC).

In tables 4 and 5, we display the results of the estimation of the hazard rate, the latter picking respectively up the likelihood of termination of government revenue expansion duration and the likelihood of the termination of government revenue contractions duration. In these tables, both the duration dependence variables (the dummy variables) and the time-varying explanatory variables are taken into account and the model uses discrete-time cloglog, logit and probit models with random effects to conduct estimates.

The results of the duration dependence variables indicate evidence of positive duration dependence in expansions, except for the spell length of 1 year (see table 3). This means that in these countries, the likelihood of an expansion ending increases with age. In fact, duration dependence increases significantly for the spell length ranging from 2 to 5years, and this become statistically insignificant afterwards. Therefore, the probability of expansion spells ending increases if the country has experienced an expansion of its public revenue for up to five periods (years) and the spells that go beyond 5 years do not significantly affect the likelihood of termination of the government's revenue expansion . An economic interpretation of such results may be that, on average, after 5 consecutive years of government revenue expansion, the governments of these countries need to conduct adequate policy measures (increasing the tax base and/or tax rate) to avoid the ending of that expansion.

Government revenue contractions (table 4) also exhibit positive duration dependence from a 2-years spell length until the last spell (8-year spell length). with the exception of a spell length of 1 year which is not significant in explaining the hazard rate of contraction termination. This means that, except for the 1 year of spell length, the hazard rate of government revenue contraction increases with 2 years or more of contraction spells. Hence, after 1 year of spell length, the governments of these countries take ad-hoc policy measures to reverse the trend of contractions. Thus, the likelihood of expansions and contractions of government revenue occurring in these countries becomes more likely to end as years pass. This means that the likelihood of an expansion ending increases with age. These results remain valid for the two sub-samples.

The results in table 3 reveal that, for both the whole sample of developing countries and the sub-sample of SSA, the probit model appears to exhibit the smallest AIC criterion. Accordingly, we will rely on the probit model for interpreting the results stemming from the different model specifications (columns 3 and 6). The assumption is that the proportional hazard appears not to be valid for the group of the developing countries and the sub-group of SSA. However, for the sub-group of non sub-Saharan African countries, the logit model appears to exhibit the smallest AIC value. The results could thus be interpreted in terms of proportional log-odds of expansion spells ending and contraction spells terminating. It is worth mentioning that there is no spell length of 7 years for the sub-sample of SSA (the maximum spell length is 6 years) and no spell length of 9 years for the Non SSA (the maximum spell length is 7 years). In table 4, the same AIC criterion suggests the choice of the probit model whatever group we consider, for the interpretations of our results.

The relative importance of the frailty (unobserved heterogeneity) is given by the estimates for ρ (rho) displayed in the tables 3 and 4. The "rho" is indeed the ratio of heterogeneity variance to one plus the heterogeneity variance and in a way this indicates how much of the model variance is due to unobserved heterogeneity: rho $= \frac{(sigma\_u)^2}{1+(sigma\_u)^2}$, where "sigma_u" is the standard deviation of the unobserved heterogeneity (this is the country-level random effect standard deviation)**.** If the hypothesis that rho is zero cannot be rejected, then frailty is unimportant. The p-value of the likelihood ratio test associated with the rho is lower than 0.01 in all but one cases, suggesting the strong role played by frailty in all but one model specifications. The only case where the p-value is higher than 10% is that of expansion hazard rate (column 8 of the table 3) where we retain the logit model.

With regard to the results of the explanatory variables in tables 4 and 5, it is necessary to take simultaneity problems into account, along with the delay in processing some economic data. In order to identify their impact on our dependent variable, we include other explanatory variables with one-year lagged values: the public revenue, as a percentage of GDP; the growth rate of real GDP; and a dummy capturing bad times, which is calculated on the basis of one-year lagged values of real GDP growth.

The first regressor is the government revenue as a percentage of GDP. The results, whatever the sample considered, reveal that the coefficient associated with this variable presents a negative sign and has a strong power in anticipating the end of expansions and contractions. In other words, an increase in government revenue (as a percentage of GDP) reduces the likelihood of government revenue expansion ending, whereas a decrease in this ratio increases the likelihood of the duration contraction termination. The growth rate of the terms of trade does not affect significantly the likelihood of government revenue expansion ending. A decrease in the growth rate of real GDP is associated with an increase in the probability of the expansion ending, whatever the sample considered**.** This is suggestive of the countercyclical nature of government revenue during its phases of expansion, if we suppose the tax base will remain unchanged**.** In addition, the higher the number of previous spells of expansion, the lower the likelihood of the expansion terminating. Columns (3), (6) and (9) of table 4 suggest the following:

- A positive growth rate of terms of trade induces a higher likelihood of contraction duration ending. This is in the line with our theoretical expectations.
- For the whole sample and the sub-sample of SSA Countries, an increase in the real GDP growth rate negatively affects the probability of contraction termination. This means that public revenue will be procyclical during its phases of contractions. For non SSA countries, the hazard rate of contractions is not significantly associated with the growth rate of real GDP.
- The number of previous spells appears to exert a negative effect on the likelihood of government revenue contraction termination for the whole sample of developing countries, but not for the sub-samples., where the effect is statistically insignificant.

Does the hazard rate of government revenue expansions/contractions behave differently during bad times and good times?

The results of table 3 show that the probability of expansion ending is lower in bad times than in good times, whereas a decline in real GDP growth rate during the bad times reduces that probability. This reflects a procyclicality of government revenue expansion phases during bad times, with regard to an unchanged tax base. Furthermore, the probability of contraction ending also appears to be negatively affected by a decline in real GDP growth rate during bad times. Phases of revenue contractions appear to be countercyclical (for a fixed tax base).

In table 4, we can see that the behaviour of the hazard rate of government revenue contraction is not statistically different in good times and bad times for the sample of all the developing countries and for the sub-sample of SSA countries but not for non SSA countries, where the likelihood of contraction terminating is lower in bad times than in good times. By contrast, for the sample of all developing countries and for the sub-sample of SSA countries, we can find evidence that an increase of the real GDP growth during bad times induces a higher probability of contraction termination, while a rise in the real GDP growth during bad times is not significantly associated with the likelihood of a contract ending.

6. CONCLUSION

The literature on government revenue has usually focused either on the determinants of tax (or total) revenue or on its effects on macroeconomic indicators such as economic growth, private consumption and investment. This paper departs from the previous by attempting to explore by introducing hazard analysis in government revenue dynamic analysis. More particularly, we use an unbalanced panel of public revenue data on 68 developing countries (of which, 42 sub-Saharan Africans) over the period 1980-2009, to examine whether government revenue expansion and contraction phases exhibit duration dependence. The analysis covers both the full sample of developing countries and the sub-samples of sub-Saharan African and Non sub-Saharan African countries.

The following main conclusions emerge from our study:

- Government revenue expansion and contraction appear to exhibit positive duration dependence.
- An increase in public revenue in year t compare of that of year t-1 reduces the probability of government revenue expansion ending and that of contraction termination.
- Terms of trade growth affects positively and significantly hazard rate of contraction and does not affect significantly the hazard rate of expansion.
- The expansions of government revenue appear to be countercyclical and the contractions of government revenue, procyclical, even during bad times.

Summarizing all these results, we conclude that when taking account of frailty, not only the duration of government revenue expansion and contraction are affected by several economic variables, but they are also affected by the actual age of expansion and contraction.

Regarding precisely the duration dependence aspect, our analysis suggests interest results. On the side of contraction, we obtain that the higher the duration of contraction, the higher its likelihood of ending, suggesting that governments in developing countries, after 1 year of contraction of their public revenue, start finding adequate measures to stop that contraction trend. By contrast, on the expansion side, the probability of expansion ending increases with the length of the expansion lasting from 2 years to 5 years. However, after 5 years, the effect is statistically insignificant on the hazard rate of expansion. This may suggest that the governments in developing countries adopt lax tax policies after 1 year and until 5 years of expansion of public revenue.

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Appendix 1: Variables - Definitions and sources

Variable	Definition	Source	Comments
Lagrevenuegdp	The one-year lagged values of the total government revenue (excluding grants), expressed in percentage of GDP.	The government revenue data stem from the Public Finance Database of CERDI (Centre d'Etudes et de Recherches sur le Developpement International) - France	Author's calculation of the one-year lagged values of the total government revenue (excluding grants), expressed in percentage of GDP.
Growthterms	The growth rate of the net barters terms of trade (in percentage change).	The net barters terms of trade of the World Bank Development Indicators (2011).	Author's calculation of the growth rate the net barters terms of trade.
Lagrealgrowth	The one-year lagged values of the real GDP growth rate.	The real GDP growth rate data come from the World Bank Development Indicators (2011).	Author's calculation of the one-year lagged values of the real GDP growth rate.
Badtimes	This variable describes the "bad times" during the considered period of study.	The real GDP growth rate data stem from the World Bank Development Indicators (2011).	Author's calculation: this variable is computed as the years where one year lagged GDP Growth rate is lower or equal to "the average of one year Lagged GDP Growth rate less than one standard deviation".
Badtimesrealgrowth	This variable captures the value of the one year lagged real GDP growth rate during bad times.	The real GDP growth rate data stem from the World Bank Development Indicators (2011).	Author's calculation: this variable is computed as the combination of the previously computed variables "badtimes" and " realgrowthreta".

Numberexpansions	The number of prior spells of expansions.	Author's calculation based on the data of Public Finance Database of CERDI as well as on the criteria used in Cashin (2004), and described above.	Consider the variable "expansion" that describes for a given country, the spells of expansions. That variable takes the value "1" for all expansion' spells and "0", otherwise. The variable "numberexpansions" that captures the number of previous spells of expansions takes the value "0" for the first spell and then "1" for the following spell, "2" for the third spell, and so one…

Appendix 2: The Different lists of Countries

List of countries of the sample of Developing countries

Argentina, Bahrain, Bangladesh, Belize, Benin, Bhutan, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Chile, Colombia, Comoros, Congo Dem. Rep., Congo Rep., Costa Rica, Cote d'Ivoire, Djibouti, Dominican Republic, Ecuador, Egypt Arab Rep., El Salvador, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Iran, Islamic Rep., Jordan, Kenya, Lesotho, Madagascar, Malawi, Maldives, Mali, Mauritania, Mauritius, Mexico, Morocco, Mozambique, Namibia, Niger, Nigeria, Pakistan, Peru, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Swaziland, Syrian Arab Republic, Tanzania, Togo, Tunisia, Turkey, Uganda, Yemen Rep., Zambia, Zimbabwe.

List of countries of the sub-sample of Sub-Saharan African countries

Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

Table 1: Summary Statistics on the distribution of Government Revenue Expansions and Contractions Spells

Country Name	Period of Data Covering	Number of Expansions' Spells[1]	Mean Expansions	Std Deviation Expansions	Min Expansions	Max Expansions	Number of Contractions' Spells[1]	Mean Contractions	Std Deviation Contractions	Min Contractions	Max Contractions
Argentina	1980-2005	5	2.6	1.67332	1	5	4	1.75	.5	1	2
Bahrain	1980-2007	7	1.857143	.6900656	1	3	8	1.625	.5175492	1	2
Bangladesh	1980-2009	5	1.6	.8944272	1	3	6	1.333333	.5163978	1	2
Belize	1980-2009	6	1.833333	.7527727	1	3	7	1.714286	1.112697	1	4
Benin	1980-2009	7	2.142857	1.069045	1	4	6	1.833333	.7527727	1	3
Bhutan	1980-2009	4	3.25	.9574271	2	4	5	1.8	1.30384	1	4
Bolivia	1980-2009	5	3.2	1.30384	2	5	5	1.6	1.341641	1	4
Botswana	1980-2009	8	2	.9258201	1	4	8	1.5	.9258201	1	3
Brazil	1980-2008	6	2.833333	1.834848	1	5	5	1.4	.8944272	1	3
Burkina Faso	1980-2009	7	2.428571	1.397276	1	5	6	1.5	.83666	1	3
Burundi	1980-2009	6	2.166667	1.602082	1	5	7	1.571429	.9759001	1	3
Cameroon	1980-2009	6	1.666667	.8164966	1	3	8	1.75	1.752549	1	6
Cape Verde	1980-2009	7	2.428571	1.511858	1	5	6	1.333333	.8164966	1	3
Central	1980-2009	6	1.5	.5477226	1	2	5	1.8	.83666	1	3
Chad	1980-2009	7	2.285714	1.496026	1	5	5	1.4	.5477226	1	2
Chile	1980-2009	5	2	1.224745	1	4	4	2.5	1.732051	1	5
Colombia	1980-2009	7	2.142857	1.214986	1	4	4	1.25	.5	1	2
Comoros	1980-2008	7	1.428571	.5345225	1	2	8	1.625	.5175492	1	2
Congo, Dem. Rep.	1980-2009	8	2	1.414214	1	5	6	1.333333	.5163978	1	2
Congo, Rep.	1980-2008	7	2	1.290994	1	4	7	1.285714	.48795	1	2
Costa Rica	1980-2008	5	2.8	1.30384	1	4	4	1.5	1	1	3
Cote d'Ivoire	1980-2009	4	2	.8164966	1	3	5	2.4	2.19089	1	6
Djibouti	1980-2008	5	1.8	.83666	1	3	6	2.5	1.048809	1	4
Dominican	1980-2009	5	3	2.54951	1	7	5	2	.7071068	1	3

Ecuador	1980-2007	7	1.714286	.7559289	1	3	6	1.5	.83666	1	3
Egypt, Arab	1980-2009	3	2.333333	.5773503	2	3	6	2.833333	2.857738	1	7
El Salvador	1980-2009	4	3.75	2.217356	1	6	4	2.25	.9574271	1	3
Ethiopia	1980-2009	4	2.25	1.5	1	4	4	3	2.708013	1	7
Gabon	1980-2009	8	1.875	.6408699	1	3	8	1.5	.7559289	1	3
Gambia, The	1980-2009	9	1.333333	.7071068	1	3	9	1.444444	.7264832	1	3
Ghana	1980-2009	9	1.777778	1.092906	1	4	6	1.166667	.4082483	1	2
Guinea	1980-2009	5	2.6	1.81659	1	5	5	2.2	1.643168	1	4
Guinea-Bissau	1980-2009	7	1.571429	.7867958	1	3	6	2.333333	.8164966	1	3
Iran, Islamic	1980-2009	6	2	1.549193	1	5	7	1.714286	1.112697	1	4
Jordan	1980-2009	6	2.333333	1.75119	1	5	7	1.714286	.7559289	1	3
Kenya	1980-2009	6	2	1.264911	2	4	6	1.333333	.8164966	1	3
Lesotho	1980-2009	6	2.833333	.9831921	1	4	4	2	.8164966	1	3
Madagascar	1980-2007	5	2.2	2.167948	1	6	6	1.666667	.5163978	1	2
Malawi	1980-2009	8	1.75	.8864053	1	3	6	1.833333	.4082483	1	2
Maldives	1980-2009	7	2.142857	1.214986	1	4	7	1.428571	.5345225	1	2
Mali	1980-2009	5	2.2	1.643168	1	5	4	2.25	.9574271	1	3
Mauritania	1980-2009	7	1.428571	.5345225	1	2	7	2	.8164966	1	3
Mauritius	1980-2009	5	1.6	.8944272	1	3	6	1.833333	.7527727	1	3
Mexico	1980-2008	2	3	0	3	3	4	3.75	1.707825	2	6
Morocco	1980-2008	5	3.2	1.643168	1	5	5	2.2	1.643168	1	5
Mozambique	1980-2009	5	2.2	1.643168	1	5	6	1.666667	.8164966	1	3
Namibia	1980-2009	8	2	1.511858	1	5	9	1.333333	.7071068	1	3
Niger	1980-2009	5	2.4	1.341641	1	4	5	2	1.732051	1	5
Nigeria	1980-2009	5	2	1	1	3	8	1.5	.7559289	1	3
Pakistan	1980-2009	6	1.666667	.8164966	1	3	10	1.3	.6749486	1	3
Peru	1980-2009	4	3.25	1.258306	2	5	6	1.333333	.5163978	1	2
Rwanda	1980-2009	6	2.666667	1.36626	1	5	5	2	1	1	3
Sao Tome and	1980-2009	8	1.625	.7440238	1	3	7	1.857143	.6900656	1	3
Senegal	1980-2009	7	2	1.414214	1	4	5	2	1	1	3

Sierra Leone	1980-2009	6	2.166667	.9831921	1	3	7	1.571429	.5345225	1	2
South Africa	1980-2009	5	2		1	3	6	1.5	.83666	1	3
Sri Lanka	1980-2009	5	1.4	.7071068	1	2	7	2	1.527525	1	5
Sudan	1980-2009	5	2.8	.5477226	1	9	7	1.857143	.8997354	1	3
Swaziland	1980-2009	8	1.5	.7559289	1	3	8	1.75	.8864053	1	3
Syrian Arab	1980-2008	9	1.444444	.8819171	1	3	6	1.5	.5477226	1	2
Tanzania	1980-2009	7	2	1.154701	1	4	5	1.4	.5477226	1	2
Togo	1980-2009	7	1.571429	.7867958	1	3	6	2.5	2.738613	1	8
Tunisia	1980-2009	4	1.5	1	1	3	8	1.875	1.246423	1	4
Turkey	1980-2009	4	4.25	2.217356	2	7	5	2	.7071068	1	3
Uganda	1980-2009	5	3.6	3.286335	1	9	3	1.666667	1.154701	1	3
Yemen, Rep.	1980-2009	6	2	1.095445	1	3	7	2.285714	2.21467	1	7
Zambia	1980-2009	7	1.142857	.3779645	1	2	8	2.125	.834523	1	3
Zimbabwe	1980-2009	6	1.333333	.5163978	1	2	7	2.142857	2.035401	1	6

*Note: Standard deviations are in parenthesis - *p-value<0,1; **p-value<0,05; ***p-value<0,01.*
1: Spurious points and Left Censoring Spells are excluded.

Table 2: Descriptive Statistics on the censoring status of the duration of government revenue expansions and contractions

	For the full sample of Developing countries			**For the full sample of Sub-Saharan African countries**			**For the full sample of non Sub-Saharan African countries**		
	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation
Complete Expansions Spells	47	6,06	1,49	28	6,46	1,43	19	5,47	1,42
Ongoing (Incomplete) Expansions Spells	21	5,81	1,40	14	6,29	1,07	7	4,86	1,57
Complete and Ongoing Expansions Spells	68	5,99	1,46	42	6,40	1,31	26	5,31	1,46
Complete Contractions Spells	34	5,68	1,36	24	6	1,38	10	4,9	0,99
Ongoing (Incomplete) Contractions Spells	34	6,5	1,44	18	6,56	1,38	16	6,44	1,55
Complete and Ongoing Contractions Spells	68	6,09	1,45	42	6,24	1,39	26	5,85	1,54

Figure 1: Descriptive Survivor Functions of government revenue expansions and contractions' duration in developing countries

Figure 2: Descriptive Survivor Functions of government revenue expansions and contractions' duration in Sub-Saharan African (SSA) and Non Sub-Saharan African countries (Non SSA)

Table 3: Estimation of the hazard rate of government revenues expansions (Revenue–to-GDP ratio) using the Complementary Log-Logistic (Cloglog), Logistic and Probit functional forms with random effects.

	All Developing Countries			Sub-Saharan African Countries			Non Sub-Saharan African Countries		
	RE Cloglog	RE Logit	RE Probit	RE Cloglog	RE Logit	RE Probit	RE Cloglog	RE Logit	RE Probit
Variables									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagrevenuegdp	-0.0685***	-0.0671***	**-0.0382*** **	-0.0684***	-0.0658***	**-0.0376*** **	-0.0737***	**-0.0725*** **	-0.0429***
	(0.00899)	(0.00915)	**(0.00520)**	(0.0108)	(0.0110)	**(0.00618)**	(0.0170)	**(0.0174)**	(0.0104)
Growthterms	-0.000124	0.00145	**0.00193**	0.00364	0.00746	**0.00574**	-0.00852	**-0.00959**	-0.00562
	(0.00469)	(0.00629)	**(0.00353)**	(0.00557)	(0.00762)	**(0.00422)**	(0.00984)	**(0.0114)**	(0.00658)
lagrealgrowth	-0.0782***	-0.118***	**-0.0619*** **	-0.0748***	-0.111***	**-0.0617*** **	-0.123***	**-0.182*** **	-0.0864***
	(0.0224)	(0.0283)	**(0.0155)**	(0.0259)	(0.0330)	**(0.0182)**	(0.0445)	**(0.0577)**	(0.0309)
Badtimesrealgrowth	0.189**	0.253***	**0.128** **	0.237*	0.322**	**0.176** **	0.204	**0.264* **	0.123
	(0.0846)	(0.0974)	**(0.0501)**	(0.130)	(0.154)	**(0.0824)**	(0.126)	**(0.142)**	(0.0784)
Badtimes	-1.561***	-2.029***	**-1.121*** **	-1.679***	-2.146***	**-1.212*** **	-1.504**	**-2.057*** **	-1.090***
	(0.368)	(0.417)	**(0.229)**	(0.449)	(0.510)	**(0.278)**	(0.646)	**(0.748)**	(0.418)
numberexpansions	-0.231***	-0.307***	**-0.168*** **	-0.257***	-0.349***	**-0.195*** **	-0.167*	**-0.192** **	-0.0963*
	(0.0406)	(0.0489)	**(0.0275)**	(0.0485)	(0.0586)	**(0.0330)**	(0.0853)	**(0.0958)**	(0.0557)
durexp1year	11.20	27.91	**10.29**	11.72	25.54	**10.56**	9.168	**23.90**	8.038
	(1050)	(12283)	**(3516)**	(188.8)	(2506)	**(586.8)**	(5999)	**(4565)**	(433.0)
durexp2year	2.363***	3.166***	**1.829*** **	2.514***	3.333***	**1.934*** **	2.224***	**3.039*** **	1.747***
	(0.196)	(0.248)	**(0.137)**	(0.249)	(0.311)	**(0.171)**	(0.342)	**(0.450)**	(0.248)
durexp3year	1.862***	2.360***	**1.361*** **	1.980***	2.519***	**1.463*** **	1.782***	**2.185*** **	1.266***
	(0.213)	(0.252)	**(0.140)**	(0.284)	(0.331)	**(0.183)**	(0.349)	**(0.422)**	(0.230)
durexp4year	1.555***	2.011***	**1.189*** **	1.434***	1.884***	**1.112*** **	1.859***	**2.300*** **	1.339***
	(0.272)	(0.317)	**(0.179)**	(0.360)	(0.417)	**(0.234)**	(0.427)	**(0.487)**	(0.278)
durexp5year	1.435***	1.660***	**0.944*** **	1.742***	2.022***	**1.160*** **	1.098**	**1.235** **	0.741**
	(0.318)	(0.361)	**(0.202)**	(0.421)	(0.487)	**(0.276)**	(0.506)	**(0.563)**	(0.304)

durexp6year	0.590	0.686	**0.466**	0.432	0.646	**0.430**	0.655	**0.549**	0.478
	(0.817)	(0.887)	**(0.494)**	(1.162)	(1.252)	**(0.697)**	(1.145)	**(1.289)**	(0.693)
durexp7year	0.694	0.694	**0.666**	0	0	**0**	0.651	**0.616**	0.581
	(0.820)	(0.918)	**(0.473)**	(0)	(0)	**(0)**	(0.840)	**(0.921)**	(0.488)
durexp9year	-0.209	0.00425	**0.112**	-0.206	-0.00121	**0.108**	-	-	-
	(0.825)	(0.871)	**(0.459)**	(0.841)	(0.888)	**(0.467)**	-	-	-
dummy2008	1.170***	1.747***	**1.002*** **	0.676	1.075*	**0.681** **	2.325***	**2.739*** **	1.510***
	(0.334)	(0.422)	**(0.224)**	(0.440)	(0.556)	**(0.294)**	(0.531)	**(0.634)**	(0.362)
dummy2009	1.754***	1.962***	**1.055*** **	2.133***	2.475***	**1.381*** **	0.337	**0.290**	0.0644
	(0.376)	(0.463)	**(0.267)**	(0.436)	(0.554)	**(0.323)**	(1.064)	**(1.160)**	(0.651)
Observations - Countries	1623-67	1623-67	**1623-67**	1051-41	1051-41	**1051-41**	572-26	**572-26**	572-26
NonZero Outcomes	208			137			71		
Log Likelihood	-528.96057	-498.56226	**-498.07833**	-332.55732	-312.67934	**-311.10222**	-188.06252	**-177.83785**	-178.83182
Wald Chi2	312.94	309.12	**346.26**	198.81	195.88	**221.11**	123.14	**124.34**	135.70
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	**(0.0000)**	(0.0000)
AIC	1091.921	1031.125	**1030.157**	697.1146	657.3587	**654.2044**	408.125	**387.6757**	389.6636
sigma_u	.8580799	.6599161	**.4499451**	.8880914	.6939827	**.4529634**	.6632685	**.3729162**	.3446748
	(.1880346)	(.1746644)	**(.1016043)**	(.2479229)	(.2104713)	**(.1245927)**	(.279217)	**(.3787607)**	(.1703963)
Rho	.3092097	.1168986	**.168365**	.324085	.1276984	**.1702456**	.2110095	**.0405568**	.1061858
	(.0936137)	(.0546469)	**(.0632364)**	(.1223038)	(.0675657)	**(.0777114)**	(.1401704)	**(.0790435)**	(.0938414)
LR associated to Rho	29.12	8.95	**16.82**	22.38	7.64	**11.95**	4.93	**0.36**	2.20
	(0.000)	(0.001)	**(0.000)**	(0.000)	(0.003)	**(0.000)**	(0.013)	**(0.274)**	(0.069)

*Note: Standard deviations are in parenthesis - *p-value<0,1; **p-value<0,05; ***p-value<0,01.*
"-" means not available.

Table 4: Estimation of the hazard rate of Government Revenue Contractions (revenues –to-GDP ratio) using the Complementary Log-Logistic (Cloglog), Logistic and Probit functional forms with random effects (with control variables).

	All Developing Countries			**Sub-Saharan Africa Countries**			**Non Sub-Saharan African Countries**		
	RE Cloglog	**RE Logit**	**RE Probit**	**RE Cloglog**	**RE Logit**	**RE Probit**	**RE Cloglog**	**RE Logit**	**RE Probit**
Variables									
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Lagrevenuegdp	-0.195***	-0.198***	**-0.108*** **	-0.214***	-0.217***	**-0.116*** **	-0.196***	-0.206***	**-0.114*** **
	(0.0198)	(0.0228)	**(0.0120)**	(0.0281)	(0.0324)	**(0.0167)**	(0.0318)	(0.0375)	**(0.0206)**
Growthterms	0.0174***	0.0199**	**0.0107** **	0.0143*	0.0171*	**0.00955* **	0.0293**	0.0326**	**0.0163* **
	(0.00658)	(0.00815)	**(0.00459)**	(0.00768)	(0.00954)	**(0.00537)**	(0.0127)	(0.0157)	**(0.00914)**
Lagrealgrowth	-0.0910***	-0.119***	**-0.0615*** **	-0.110***	-0.138***	**-0.0737*** **	-0.0407	-0.0764	**-0.0338**
	(0.0285)	(0.0368)	**(0.0207)**	(0.0342)	(0.0436)	**(0.0243)**	(0.0696)	(0.0864)	**(0.0485)**
badtimesrealgrowth	0.112**	0.143**	**0.0750* **	0.197***	0.241***	**0.129** **	-0.0876	-0.103	**-0.0710**
	(0.0547)	(0.0716)	**(0.0396)**	(0.0724)	(0.0936)	**(0.0530)**	(0.136)	(0.179)	**(0.100)**
badtimes	-0.375	-0.503	**-0.277**	0.0600	0.0881	**0.0255**	-1.367*	-1.934**	**-1.041* **
	(0.327)	(0.420)	**(0.237)**	(0.400)	(0.528)	**(0.298)**	(0.804)	(0.970)	**(0.541)**
numbercontractions	-0.118**	-0.135*	**-0.0732* **	-0.119*	-0.138	**-0.0820**	-0.0517	-0.0243	**0.00173**
	(0.0570)	(0.0728)	**(0.0409)**	(0.0676)	(0.0875)	**(0.0499)**	(0.120)	(0.147)	**(0.0819)**
durcont1year	19.57	32.13	**14.15**	21.52	35.87	**14.87**	13.28	28.17	**10.38**
	(323.4)	(5000)	**(2975)**	(543.6)	(15940)	**(3214)**	(373.4)	(6934)	**(778.2)**
durcont2year	4.550***	5.249***	**2.887*** **	4.858***	5.562***	**3.027*** **	4.317***	5.092***	**2.810*** **
	(0.387)	(0.448)	**(0.230)**	(0.544)	(0.623)	**(0.312)**	(0.579)	(0.692)	**(0.372)**
durcont3year	4.071***	4.562***	**2.506*** **	4.385***	4.874***	**2.640*** **	3.828***	4.473***	**2.509*** **
	(0.423)	(0.485)	**(0.252)**	(0.595)	(0.671)	**(0.336)**	(0.660)	(0.798)	**(0.444)**
durcont4year	3.321***	3.590***	**1.925*** **	2.415**	2.571*	**1.349* **	3.400***	3.801***	**1.973*** **
	(0.702)	(0.802)	**(0.441)**	(1.169)	(1.340)	**(0.738)**	(0.853)	(0.987)	**(0.557)**
durcont5year	3.126***	3.511***	**1.950*** **	2.597*	2.512	**1.305**	3.447***	4.124***	**2.301*** **
	(0.748)	(0.881)	**(0.473)**	(1.346)	(1.634)	**(0.884)**	(0.944)	(1.119)	**(0.631)**

durcont6year	3.725***	3.969***	**2.155*** **	4.338***	4.604***	**2.457*** **	3.634***	4.030***	**2.094*** **
	(0.736)	(0.836)	**(0.453)**	(1.063)	(1.248)	**(0.667)**	(1.084)	(1.209)	**(0.667)**
durcont7year	2.917***	3.140**	**1.669** **	2.382*	2.369	**1.161**	4.432***	5.072***	**2.724*** **
	(1.085)	(1.244)	**(0.681)**	(1.443)	(1.779)	**(0.990)**	(1.542)	(1.815)	**(1.056)**
durcont8year	3.381***	3.435**	**1.878** **	3.626***	3.674**	**1.929** **	-	-	**-**
	(1.271)	(1.512)	**(0.810)**	(1.362)	(1.629)	**(0.872)**	-	-	**-**
dummy2008	0.965**	1.070*	**0.642** **	1.092**	1.281*	**0.778** **	0.627	0.675	**0.404**
	(0.429)	(0.558)	**(0.308)**	(0.544)	(0.715)	**(0.395)**	(0.716)	(0.923)	**(0.496)**
dummy2009	2.569***	2.846***	**1.519*** **	2.484***	2.768***	**1.479*** **	3.111***	3.376***	**1.843*** **
	(0.523)	(0.635)	**(0.354)**	(0.667)	(0.806)	**(0.445)**	(1.038)	(1.210)	**(0.689)**
Observations - Countries	1627-67	1627-67	**1627-67**	1058-41	1058-41	**1051-41**	569-26	569-26	**569-26**
NonZero Outcomes	167			112			55		
Log Likelihood	-338.55063	-329.66517	**-327.37578**	-218.82568	-213.08429	**-211.39105**	-111.91304	-108.77807	**-108.65894**
Wald Chi2	189.56	182.87	**211.84**	110.54	106.88	**126.96**	81.20	76.24	**83.66**
	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	(0.0000)	**(0.0000)**	(0.0000)	(0.0000)	**(0.0000)**
AIC	711.1013	693.3303	**688.7516**	471.6514	460.1686	**456.7821**	255.8261	249.5561	**249.3179**
sigma_u	1.473676	1.432029	**.8297128**	1.661944	1.616547	**.8817608**	1.118198	1.062284	**.7110873**
	(.2313097)	(.2659272)	**(.1433496)**	(.3152663)	(.3614349)	**(.1876538)**	(.3403955)	(.4090395)	**(.2401979)**
rho	.5690117	.3839861	**.4077315**	.6267444	.4426873	**.4374128**	.4318607	.2554023	**.3358329**
	(.0769854)	(.0878511)	**(.0834433)**	(.088754)	(.1103234)	**(.1047413)**	(.1493804)	(.1464539)	**(.1506874)**
LR associated to Rho	70.77	34.40	**40.35**	50.92	24.29	**27.75**	14.18	6.16	**8.88**
	(0.000)	(0.000)	**(0.000)**	(0.000)	(0.000)	**(0.000)**	(0.000)	(0.007)	**(0.001)**

*Note: Standard deviations are in parenthesis - *p-value<0,1; **p-value<0,05; ***p-value<0,01.*
"-" means not available.