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A comparison of countries' vulnerability based on Markov Switching Models

Brendan Vannier[1]

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This article aims at assessing the main characteristics of the business cycle of 80 developed and developing countries. By comparing the possibility for these economies to enter or to exit a recession and the associated consequences, it aims at complementing existing literature with regard to scale and/or frequency of the study. Following the usual definition of a recession, an algorithmic classification tends to show that, surprisingly, developed and developing countries face similar probabilities to enter or to exit a recession, respectively around 5% and 18%. This aspect contradicts existing literature, which often advocates a greater volatility of developing countries' business cycle with more frequent recessions. However emerging markets and economies face output per capita losses around twice as important as advanced ones when they undergo a recession. These observations are then tested using a non-linear parametric Markov-Switching Model. If the statistical validity of this method is bound by data availability, it echoes in a really good manner the pattern derived using a non-parametric approach. Estimating the model on the cyclical component of the series, derived using an HP filter, fits the best previous remarks. It also replicates other major characteristics. Indeed while developed countries form a rather homogeneous group, developing countries demonstrate greater heterogeneity. Latin American countries appear as the most vulnerable ones whereas Asian countries perform better than all other groups.

JEL: F43; C32; O57
Keywords: Business Cycles, Economic Growth, Vulnerability, Markov Switching Models.

The author

I thank Professor Daniel Cohen for the numerous useful advices, Mathieu Gex and colleagues at the Banque de France for their constructive remarks, and Mathilde Viennot and Paul Beaumont for insightful discussions.

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A comparison of countries' vulnerability based on Markov Switching Models*

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WORK IN PROGRESS

Abstract

This article aims at assessing the main characteristics of the business cycle of 80 developed and developing countries. By comparing the possibility for these economies to enter or to exit a recession and the associated consequences, it aims at complementing existing literature with regard to scale and/or frequency of the study. Following the usual definition of a recession, an algorithmic classification tends to show that, surprisingly, developed and developing countries face similar probabilities to enter or to exit a recession, respectively around 5% and 18%. This aspect contradicts existing literature, which often advocates a greater volatility of developing countries' business cycle with more frequent recessions. However emerging markets and economies face output per capita losses around twice as important as advanced ones when they undergo a recession. These observations are then tested using a non-linear parametric Markov-Switching Model. If the statistical validity of this method is bound by data availability, it echoes in a really good manner the pattern derived using a non-parametric approach. Estimating the model on the cyclical component of the series, derived using an HP filter, fits the best previous remarks. It also replicates other major characteristics. Indeed while developed countries form a rather homogeneous group, developing countries demonstrate greater heterogeneity. Latin American countries appear as the most vulnerable ones whereas Asian countries perform better than all other groups.

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"All animals are equal, but some animals are more equal than others."
George Orwell, *Animal Farm*, 1945

Introduction

Business Cycles (BC) have been at the center of academic research in macroeconomics since the beginning of the 20$^{\text{th}}$ century. During the past decades, the focus was directed on identifying differences and/or similarities between the ones of Emerging Markets and Economies (EME) and those of Advanced Economies (AE). This is also the aim of this article.

Many definitions of BC are to be found in the economic literature, as this concept underpines several features on which economists do not always conciliate. Burns and Mitchell (1946), when shaping the methodology to measure them at the National Bureau of Economic Research (NBER), identified cycles as:

> *"expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle."*
> Burns and Mitchell (1946, p.3)

As pinpointed by Diebold and Rudebusch (1996), two important features of business cycles are highlighted here: the co-movement of macroeconomic variables and the alternation of two types of episodes. If the latter develop an approach combining both aspects, most researchers have focused on one or the other when trying to study empirically the BC of particular countries or when comparing them. Agénor et al. (2000) build on the first feature and compare the cross-correlations of domestic industrial output with a set of macroeconomic variables. They identify a considerable persistence in EME's output fluctuations and a more important output volatility for EME than for AE, for which there seem to be less variation across countries. Neumeyer and Perri (2005) find, on the same aspect, that EME's Business Cycles are more volatile than developed countries' ones and assess the reaction of real interest rates, consumption and net exports to the cycle.

The second feature, which is at the center of this study, relates to the characteristics of the sequence of expansions and contractions, mainly the average duration of each episode and the related output losses/gains. Two types of approaches have been developed in order to grasp these features. The first one, based on the work developed at the NBER, consists in a non-parametric methodology. It identifies turning points in the cycle based either on the evolution of a set of variables - that is NBER's approach[1] - or by defining a set of rules to characterize GDP growth rates evolution as stated in Harding and Pagan (1999).

[1] This is to be found at: http://www.nber.org/cycles/recessions.html

As Qin (2010) highlights, a major limitation of this approach, even if it is still considered as a reference, is the fact that, beyond a common agreement on their economic relevance, the rules that are chosen lack a theoretical support. Following the work of Neftçi (1982), James Hamilton developed a statistical model to study Business Cycles. Hamilton (1989), (1990) build a regime-switching model in which an unobserved state used to describe the phases of a BC follows a first-order Markov process. Compared to previously mentioned methodology, one of the advantages of this approach is that the different regimes are derived from the data without any particular constraints. Extended afterwards to a multivariate framework by Krolzig (1997), Hamilton's approach has concentrated the focus of numerous researchers. This accrued interest echoes certainly the acknowledgement of the literature towards the consideration of non-linearities when studying time series. Pritchett (2000) advances the fact that single trend growth rate cannot succeed well in capturing the evolution of most countries GDP per capita and advocates the fact that different sequences, defined by particular trends and volatilities, are required to characterize growth episodes. Hausmann et al. (2005) give credit to multi-state models where the switch between different regimes responds to factors that determine the long run equilibrium. Goodwin (1993), studying the BC of 8 Advanced Economies, claims that Markov-Switching Models (MSMs) succeed better in identifying turning points, when compared to other usual methodologies. Starting from the analysis that non-linearity is generally assumed because of the asymmetry in the duration of expansions and recessions, Engel et al. (2005) show that, relatively to linear models, non-linear ones fit better the shape and the variability over time of BC, even if they tend to identify expansions lasting longer than in the reality. When comparing MSM with non-parametric dating algorithms on monthly US variables, Chauvet and Piger (2008) find that, if both come up with good results, MSMs turn out to be a more closely match to NBER BC's dating. The focus on non-linearity has not, however, gained the approval of all the academic milieu and Harding and Pagan (2002), (2003) stand up as the main antagonists. Defending the non-parametric approach, they state that MSM are limited by the validity of the statistical model and that the statistically significant results may differ from the data. They provide, as a reaction, some statistical support to Burns and Mitchell (1946)

Yet, many studies have used MSM to study the BC of AE and, to a lesser extent, of EME. Nalewaik (2006) uses US data on GDP and GDI to study the american BC. An interesting aspect he underlines is the fact that, over time, the low-regime identified by the MSM are less likely to characterize negative growth episodes but rather null growth ones, therefore diverging from a traditional definition of contractions. Chen (2007) uses a Markov Switching Panel Model to identify business cycle turning points in Japan. Studies on MSM and EME are more seldom and can be found mostly on countries with long historical GDP series, such as Moolman (2004) on South Africa and Huang (1999) on Taiwan.

As mentioned earlier, the economic literature on BC witnessed, in the past two decades, an aroused interest in comparing BC at a regional and at the world level. This approach echoes the acknowledgement of globalization as a driver of the interactions and the synchronization process between BC. Studying G7 macroeconomic aggregates, Gregory et al. (1997) show that the world common components are both statistically and economically significant and Bordo and Helbling (2003) assess the role of an increasing integration of markets and the change in the nature of shocks - from idiosyncratic to global - to justify the creation of a world business cycle (see also Kose et al. (2008) for an historical perspective). If these studies focus only on G7 countries, Kose et al. (2003) use a sample of 60 countries to assess the fact that global factors play a major role in explaining the evolution of national aggregates while regional factors tend to have a minor one. They show that the effect of the world factor is more important for developed economies and that less developed economies are less likely to follow the world cycle. More recently, Kose et al. (2012) extended this approach to 106 countries and found that if the cyclical interdependence rose within groups it decreased between them.

Studies of BC between countries and within regions have flourished, echoing precedent claims. MSMs have been widely used to lead these. Regional comparisons have mostly been focusing on Europe and the EuroZone (see notably Banerji and Guha (1999), Krolzig (2002), Artis et al. (2004) and Krolzig and Toro (2005)). In two consecutive papers Anas et al. (2007a), (2007b) use alternatively a Multiple Markov Switching VAR and non-parametric algorithms to study the relationship between cyclical phases of the industrial production in Europe and the US and to measure the degree of diffusion and synchronization of the cycles among the countries. Fewer articles focus however on developing regions. Among the ones using MSM, Mejía-Reyes (2000) finds that there is no common Latin American cycle but only some common regime shifts between particular countries and Girardin (2005) shows that for most East Asian countries three regimes are necessary, as a regime of rapid growth is identified. He identifies features of the major economies of the region, Japan and China, that can be found in neighboring countries.

The comparison of EME and AE has also been largely discussed, even if the use of MSM for such purpose is not widespread. Aguiar and Gopinath (2007) show that, in EME, the Business Cycle is twice as volatile as in AE. They characterize EME's cycle as the compilation of shocks to the trend growth while AE's ones consist in fluctuations over a global trend, thus describing cycles of totally different nature. This claim is confirmed by Lane (2003), who proves that inappropriate pro-cyclical macroeconomic policies have lead to extreme cyclical fluctuations in EME. In the same range, Rand and Tarp (2002) study the nature and the characteristics of short-run macroeconomic fluctuations and show that developing countries differ a lot from developed ones. They experience shorter cycles and represent a more heterogenous group than AE. Jerzmanowski (2006) uses a MSM with transition probabilities determined by the quality of institutions to study particular characteristics of BC. His use of institution in explaining different probabilities helps shed some light on the differences behind the particularities of EME and AE. Focusing on four Latin American countries, Aiolfi et al. (2010) find correlated BC in the region and assess a more volatile and unstable cycle for these countries when compared to advanced ones. Based on the dating algorithm developed by Harding and Pagan (2002), Calderón and Fuentes (2010) study quarterly data for 23 EME and 12 AE and find that while contractions' duration is similar across countries, this is not the case for expansions and EME experience higher output losses(gains) during recessions(expansions). He shows that recessions are deeper and more frequent in EME and especially in Latin America. Altug and Bildirici (2010) compare for 22 countries, both developed and emerging ones, the results of Harding and Pagan (2002)'s algorithm with the results obtained using a MSM and conclude that both approach yield similar dating results. They find that developing countries constitute a rather heterogenous group that differs considerably from developed countries.

This article aims at highlighting differences and similarities between developed and developing countries regarding their vulnerability, observed in this article as the different characteristics related to recessions such as the probability of entering or exiting a recession and the average loss encountered during a contraction. This study focuses on 80 countries at a quarterly frequency, which is a much wider approach than those found in the economic literature. The data used consist only of quarterly real GDP and population. In a first attempt to characterize countries' vulnerability, recessions are determined using a simple dating algorithm. This approach identifies that, contrarily to what is usually said in the literature, developing countries face the same pattern as developed ones, with a probability to enter a recession around 5% and a probability to exit a recession around 18%. Developing countries form however an heterogeneous group. Latin American countries tend to be more vulnerable than others (i.e. with higher entrance probabilities), while Asian countries perform on average even better than developed ones. This echoes the main discussions on their regional performances across past decades, with Latin American countries having encountered several crises while Asian countries have been acknowledged for their strong growth performances. The main difference between the groups is the fact that developing countries tend to lose around twice as much output as developed ones during a contraction. This observation is valid for all developing countries' groups, thus underlying a higher vulnerability. This article then uses a nonlinear parametric approach, a Markov-Switching Model, to study the countries. If some countries have less observations than other countries (which is particularly true for African countries), and thus lead to surprising results, the rest of the results represent faithfully the patterns identified before. The Markov-Switching Model proves to be a useful tool in identifying the recessions and the estimations echoe the previously presented pattern. The estimations derived using the cyclical component of the series, computed using the HP filter, help extending the definition of a recession by considering not only negative growth episodes but all episodes that imply a significantly lower growth than the trend. These results retranscribe close values to those mentioned earlier (an entrance probability around 5,5% and an exit probability around 23,3%) and identify the same observations. Moreover, using a Noise-to-Signal ratio to compare both methodology, we find values under 30%, which comforts the use of MSM estimates in identifying recessions.

This article's main claim is therefore that if developed and developing countries appear to be similarly vulnerable on average, developing countries pay a higher cost when undergoing a contraction.

The article is structured as follows. Section 1 presents the data and derives BC characteristics following a dating algorithm. Section 2 then presents the model and the estimation procedure. Results, analysis and robustness checks are to be found in section 3. Final section concludes and gives some ideas for possible extensions.

1 A first look into the data

1.1 Data

This study's principal contribution to the economic literature stems out from the number of countries that are examined here at a quarterly frequency. Out of the similar approaches I could find, only 22 and 35 developed and developing countries were studied (respectively in Altug and Bildirici (2010) and in Calderón and Fuentes (2010)), while I focus on 80 countries (35 AE and 45 EME).

I use quarterly GDP at constant price in unit of national currency when available. Otherwise, I use a volume index for GDP. The list of countries, as well as the data sources and the sample period can be found in Annex 1. For ten countries[2] longer series were available from the Oxford Economics Database. This database being subject to many critics related to the construction of the series, I compute all estimates for both sources[3][4]. In order to study GDP per capita, I extract population's observations from the World Bank[5], which I then linearize to obtain quarterly values.
As some series are not seasonally adjusted, I use the year-over-year growth rate of GDP (and where it is mentioned of GDP per capita) to eliminate any seasonal effects that might exist at a quarterly frequency.

Results presented in the text are averages over specific groups, which were constructed based on the classification of countries by the International Monetary Fund (IMF). Annex 2 gives the list of countries included in each group.
To test the robustness of the results, some series might have to be removed - due to specific reasons developed later on. When this is the case, the group averages do not consider any longer these serie.[6]

[2]Brazil(1980), Bulgaria(1980), China(1980), Hungary(1991), India(1980), Malaysia(1980), Romania(1980), the Russian Federation(1990), Thailand(1980) and Venezuela(1980)

[3]Oxford Economics offers a GDP serie for Irak starting in Q1-1980. I take it into account when computing groups averages while including Oxford Economics series.

[4]Results in this article are group averages including Oxford Economics series. They are very close to the results without these series and are available upon request.

[5]The World Bank doesn't offer any serie for Taiwan, for which I use a national source.

[6]Per country results are available upon request.

1.2 Recessions and Countries' Vulnerability

Identifying Recessions

Following Arthur Okun's definition when he was at the head of US President Johnson's economic council, a country enters a recession when it faces two consecutive quarters of negative growth. This definition has been used widely by economists and politicians since this date and it is at the center of many dating algorithms. Starting from this approach, the following rule is used in this study to identify recessions and expansions:

Country i is in a recession at quarter t if its growth rate, y_t is such that:

(a) $(y_t < 0$ and $y_{t+1} < 0)$ or $(y_{t-1} < 0$ and $y_t < 0)$ or

(b) $(y_{t-1} < 0$ and $y_t > 0$ and $y_{t+1} < 0)$ or $(y_{t-2} < 0$ and $y_{t-1} > 0$ and $y_t < 0)$ or $(y_t < 0$ and $y_{t+1} > 0$ and $y_{t+2} < 0)$

Case (a) echoes the usual definition of a recession as previously mentioned. Case (b) has been introduced in order to take into consideration trembling effects of recessions. One should point out the fact that, as year-over-year growth rates are used for seasonal adjustment, this algorithm is not following the traditional definition of a recession, which would require a study on quarter-over-quarter growth rates. However comparing the results of both approaches (y-o-y and q-o-q growth rates) for seasonally adjusted series, I find that using y-o-y growth rates give similar results with a constant lag in the identification of recessions.

A underlying aspect of this definition is the fact that it assumes that developed and developing countries face the same kind of recession. Indeed, given the growth potential of a developing country, one could assume that it enters a recession whenever for a long enough period (be it two consecutive quarters in order to replicate the usual definition) its growth rate is inferior to the trend and not necessarily negative. This approach is developed in the third section by using the Markov Switching Models on the cyclical component of the series, which I extract using an Hodrick-Prescott filter.

Simple Probabilities, Average Duration and average Output Loss per Recession

The first characteristics derived from the data are the 'simple' probabilities for each country to be in, to enter and to exit a recession. These are computed using following formula:

$$Pr(\text{Being in a Recession}) = \frac{\text{number of quarters in recession}}{\text{number of observations}} \tag{1}$$

$$Pr(\text{Entering a Recession}) = \frac{\text{number of quarters in which the country enters a recession}}{\text{number of quarters in expansion}} \tag{2}$$

$$Pr(\text{Exiting a Recession}) = \frac{\text{number of quarters in which the country exits a recession}}{\text{number of quarters in recession}} \tag{3}$$

The next characteristic is the average duration of a recession, which can be obtained, for each country, either as the mean over all recessions' durations, or using previously computed probabilities:[7]

$$E[D] = \frac{1}{1 - p_{RR}} \tag{6}$$

The average output loss per recession is derived from each time serie using the quarters identified by the dating algorithm previously mentioned and computing the peak to through loss. However due to the fact that the beginning and the end of a recession might not take place at the same quarter and considering that some series were not seasonally adjusted, I had to go back to each series to identify graphically the best fit taking into account the dates identified by the algorithm.
I then derive the average output loss for each country, as a simple average over all recessions-associated output losses,

$$\text{Simple Average Output Loss} = \frac{\sum_{r=1}^{R} \text{Output Loss of recession } r}{R} \tag{7}$$

where R is the total number of recessions

Multiple-recessions episodes and associated characteristics

For the sake of the analysis, I also look at two types of conditional probability to study the vulnerability of countries: the probability to enter a recession conditionally on the fact that a country exits a recession and the probability to enter a recession conditionally on the output loss experienced during the first quarter of recession.

Multiple recessions and associated characteristics follows the idea of double dips developed notably in Reinhart and Rogoff (2014). I compute the conditional probability using following formula:

$$Pr(\text{Entering a recession}|\text{Exiting one}) = \frac{\text{Number of recession followed by one in } x \text{ quarters}}{\text{Number of recessions}} \tag{8}$$

I then compute the expected rate of arrival of such events, λ, assuming that it follows a Poisson Process according to equation (12) to obtain an atemporal characteristic.

$$1 - e^{-\lambda T} = Pr(\exists \text{ a recession within next } T \text{ trimesters}|\text{Exiting a Recession}) \tag{9}$$

In order to characterize multiple recessions, I consider that different recessions belong to the same episode if they are separated by 8 quarters or less. I also used a gap of 4, 6

[7] Indeed the probability that a recession lasts k quarters is equal to:

$$Pr(D = k) = p_{RR}^{k-1}(1 - p_{RR}) \tag{4}$$

where D is the duration of a recession, and p_{RR} is the probability to stay in a recession.

Summing over all possible durations, i.e. over k, we can derive the expected duration:

$$E[D] = \sum_{k=1}^{\infty} kPr(D = k) = \sum_{k=1}^{\infty} kp_{RR}^{k-1}(1 - p_{RR}) = \frac{1}{1 - p_{RR}} \tag{5}$$

and 10 quarters to check for robustness of this threshold. This choice echoes the results in Fatas and Mihov (2013).
Once the different multiple events are identified, the related output losses can be computed. Due to the seasonality of some series the output loss is once again derived using a peak-to-through approach.

After sorting out these multiple-recession episodes, I compute the probability of having a multiple recession conditionally on the output loss experienced by a country during a recession using following formula:

$$Pr\big(\text{Having an Episode of Recession of type } T \big| \text{Leaving a recession after loosing } x\% \text{ of output}\big) = \frac{\text{Number of Episodes of type } T \text{ beginning with a loss of } x\% \text{ of output}}{\text{Number of Episodes (all types) in which you loose } x\% \text{ of output}} \quad (10)$$

where the type of episode T stands for single episodes, double episodes (the double dips) and episodes gathering three or more recessions.

1.3 Results and Analysis

This subsection presents and analyzes the results of the different characteristics presented before.

Simple Probabilities and Average Duration

Table 1 presents the 'simple' probabilities derived using year-over-year growth rates of GDP as well as the average duration of a recession. Averages are computed over a reduced sample which does not include countries that have never experienced a recession or those that have less than 43 observations (one quarter of the maximum number of observation per country)[8]. Results on the overall sample can be found in the annex 3. A major inconvenient, when reducing the sample, is that many countries of the African groups (Africa, MENA and SSA) are left aside thus reducing the size and the relevance of the groups.

At first, a striking result is the fact that there is no real difference between developed and developing countries: their probability to enter a recession is, respectively, 3,6% and 4,3% and their probability of exiting a recession 21,2% and 21,6%. However, when considering regional results as well as standard deviations among developed and developing averages, we witness a greater heterogeneity between the different developing regions. Latin American countries, as it has already been assessed in the literature, face higher probabilities to enter a recession (4,5%) while Asian countries succeed very well as they have a low probability to enter a recession (around 2,8%) and a relatively high probability to exit one (24,5%). Central and Eastern European countries are characterized by

[8]It must be noted that some countries are not far above the threshold, as a consequence I also computed the averages using a threshold of one third of the maximum number of observations. Unless mentioned the results on a reduced sample use a threshold of one quarter of the maximum number of observations.

Group	Proba. of Being in a Recession	Proba. of Entering a Recession	Proba. of Exiting a Recession	Average Duration
Dvpd	14,6% (5,7%)	3,6% (1,3%)	21,2% (7,0%)	5,4 (2,3)
NA	10,5% (1,7%)	2,6% (0,7%)	21,9% (1,9%)	4,6 (0,4)
EU	17,8% (6,7%)	4,1% (1,6%)	18,5% (7,2%)	6,3 (2,5)
EZ	16,0% (5,3%)	4,0% (1,2%)	20,4% (7,8%)	5,8 (2,7)
English Sp.	12,4% (4,8%)	3,3% (1,7%)	22,6% (4,1%)	4,6 (0,9)
APdvpd	10,6% (5,3%)	3,2% (1,7%)	26,4% (2,5%)	3,8 (0,4)
Dvpg	17,9% (10,4%)	4,3% (2,8%)	21,6% (11,1%)	6,1 (3,6)
LatAm	17,1% (11,2%)	4,5% (3,2%)	25,8% (14,1%)	5,4 (3,6)
APdvpg	9,4% (3,4%)	2,2% (1,0%)	21,2% (3,8%)	4,9 (0,8)
EA	5,5% (0,9%)	1,5% (0,3%)	26,1% (1,1%)	3,8 (0,2)
SEA	9,4% (3,1%)	2,4% (0,9%)	22,7% (4,5%)	4,6 (0,9)
CEE	22,6% (8,2%)	4,9% (2,0%)	15,5% (6,9%)	7,9 (3,8)
Africa	11,9% (4,3%)	3,1% (0,9%)	25,0% (8,0%)	4,4 (1,4)
MENA	16,5% (11,4%)	4,7% (3,4%)	23,9% (4,1%)	4,3 (0,7)
SSA	12,1% (4,5%)	3,2% (0,9%)	25,9% (9,6%)	4,5 (1,6)

Table 1: Probabilities derived using y-o-y GDP growth rates, Reduced sample (Standard deviations into brackets)

a high probability to enter a recession (4,9%) and a rather low probability to exit a recession (15,5%) when compared to other regions, which makes them a vulnerable group. This is mainly due to the fact, that after the dissolution of the USSR, many countries underwent long-lasting recessions. African countries, reputed to be vulnerable and subject to poor growth performances, are however a group that tends to perform well. Indeed their entrance probability is the same as developed countries and their exit probability even better. An assessed feature on these countries is the fact they face fast growing populations. As a result I now turn towards GDP per Capita in order to identify previously invisible recessions. Table 2 presents the same results using GDP per Capita data.

The main observations I made on the previous tables are still holding. Indeed developed and developing countries perform in a similar way: 4,5% against 5,4% for the entrance probability and 17,9% against 18,1% for the exit probability. Developing countries, as previously, form a really heterogeneous group. While developing Asian countries tend to have small entrance probabilities (2,3%), Latin American and African countries face higher entrance probabilities (respectively 6,2% and 7,2%). Looking at exit probabilities, African countries tend to perform well along with some developed Asian countries. Developing central and eastern European countries, on the other hand, display poor exit probabilities. This is also the case for developed countries belonging to the same region which tends to increase the heterogeneity among developed countries. Indeed, when

Group	Proba. of Being in a Recession	Proba. of Entering a Recession	Proba. of Exiting a Recession	Average Duration
Dvpd	19,2% (5,9%)	4,5% (1,5%)	17,9% (6,1%)	6,4 (2,5)
NA	15,7% (1,2%)	3,5% (0,7%)	18,3% (2,3%)	5,5 (0,7)
EU	20,5% (6,5%)	4,6% (1,6%)	16,3% (6,1%)	7,0 (2,6)
EZ	19,4% (5,6%)	4,4% (1,3%)	17,0% (7,0%)	7,0 (3,0)
English Sp.	18,5% (2,9%)	4,5% (1,3%)	18,7% (2,7%)	5,5 (0,8)
APdvpd	15,2% (6,3%)	4,3% (1,9%)	23,4% (3,5%)	4,4 (0,7)
Dvpg	22,8% (13,0%)	5,4% (3,5%)	18,1% (8,4%)	6,7 (3,3)
LatAm	26,2% (13,8%)	6,2% (4,0%)	17,0% (6,0%)	6,8 (3,4)
APdvpg	11,7% (7,2%)	2,3% (1,3%)	17,9% (4,0%)	5,9 (1,2)
EA	6,4% (0,0%)	1,9% (0,0%)	27,3% (0,0%)	3,7 (0,0)
SA	3,0% (0,0%)	0,8% (0,0%)	25,0% (0,0%)	4,0 (0,0)
SEA	13,6% (5,8%)	2,7% (1,1%)	17,1% (2,7%)	6,0 (1,0)
CEER	21,8% (8,5%)	4,6% (2,0%)	15,3% (7,5%)	8,4 (4,2)
Africa	19,1% (11,9%)	5,1% (2,0%)	24,2% (12,3%)	5,1 (2,1)
MENA	25,3% (14,7%)	7,2% (4,5%)	18,3% (3,9%)	5,7 (1,1)
SSA	20,6% (13,5%)	5,5% (2,1%)	26,9% (14,0%)	4,9 (2,3)

Table 2: Probabilities derived using y-o-y GDP per Capita growth rates, Reduced sample (Standard Deviation into brackets)

leaving them aside the standard deviation on the developed group decreases to 4,8%.

Average Output Loss per Recession

Following previous observations, there is no significant difference between developed and developing contries' vulnerability which challenges usual beliefs and previous observations by the economic literature. Another observation often made in the articles tackling this issue is the fact that the cycle for developing countries is much more wide. Therefore I now compare the average GDP per Capita loss experienced by countries when undergoing recessions. Results are presented in table 3.

All	-7,02%	APdvpd	-4,78%	SEA	-10,81%
Dvpd	-5,25%	Dvpg	-8,28%	CEER	-10,29%
NA	-3,56%	LatAm	-7,60%	Africa	-5,11%
EU	-6,45%	APdvpg	-9,73%	MENA	-9,04%
EZ	-6,58%	EA	-5,68%	SSA	-4,97%
English Sp.	-3,79%	SA	-0,59%		

Table 3: Average GDP per Capita loss per recession, Reduced sample

The common pattern, that arises from this table, is that developing countries tend to loose about twice as much as developed countries (-5,25% against -8,28%). The particularly good African results might actually be driven by countries with little observations. Should they be left aside, the average over the developing countries' group rises to -9,43% as the African average rises to -7,16%. When removing countries with too little observations, the size of the 'African countries' group is drastically reduced, which questions the relevance of the results. Removing countries with too little observations does not affect much other averages.

The fact that developed countries tend to lose less than developing ones when they enter a recession can also be illustrated by the repartition of recessions per group and per GDP per Capita loss, which can be found in the following figures. The threshold -2,5% and -6,5% are chosen in order to split the recessions into three groups of the same size.

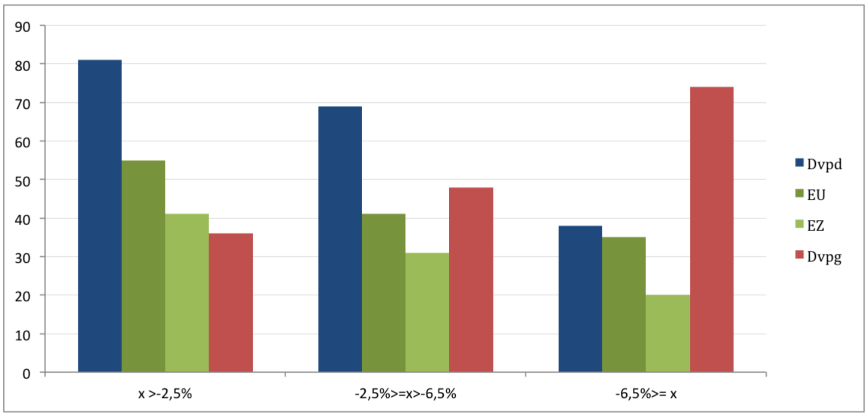

Figure 1: Number of recessions per group and per associated GDPperCapita Loss

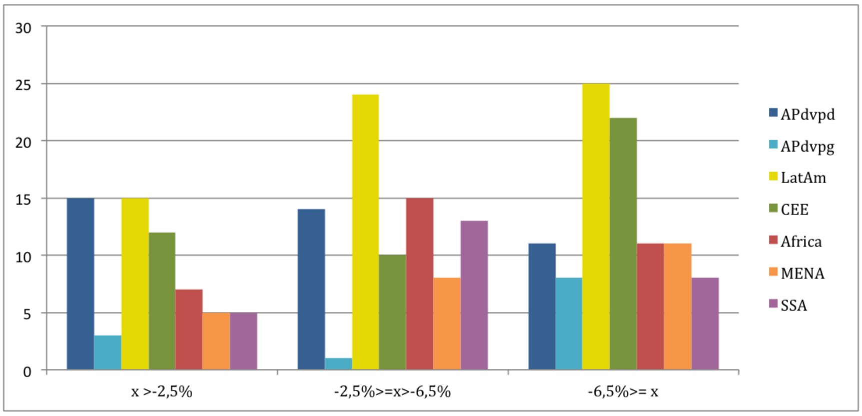

Figure 2: Number of recessions per group and per associated GDPperCapita Loss

Figures 1 and 2 ascertain the fact that developing countries tend to experience harsher recessions during which they lose more GDP per Capita than their developed counterparts. Indeed, for all developed countries' group - overall and regional - we witness a decreasing trend whereas, developing countries experience the opposite pattern. At a regional scale, the trend for developing group does not appear as clear as fpreviously. But developing countries' groups tend nevertheless to experience about twice as many harsh recessions than light ones.

Multiple-recessions episodes and associated characteristics

Considering the fact that, in average, developed and developing countries face similar probabilities to enter and to exit recessions, with nevertheless some regional distinctions among developing countries, we now try to see if these countries differ by looking at multiple-recessions episodes.

Figure 3 and 4 present the group-average instantaneous probability to enter a recession within Q quarters, knowing the country just left one. Values can be found in the annex 4.[9]

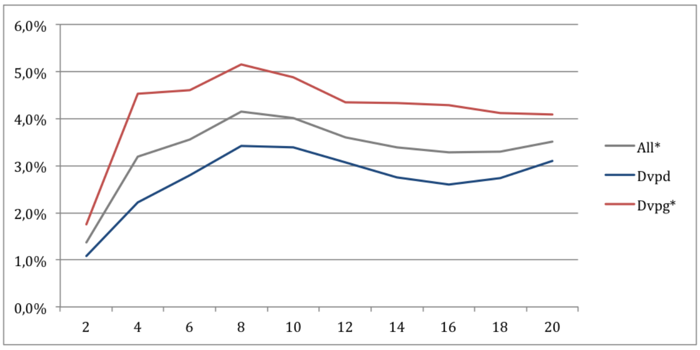

Figure 3: Conditional probabilities for a country to enter a recession knowing it is leaving one - Group Averages

Figure 3 illustrates the fact that, once again, developed and developing countries tend, in average, to behave the same way when they exit a recession, which, for a gap of 2 years, is illustrated by a probability of 3,4% for developed countries and 5,2% for developing ones. The difference between the two (around 1,5% on average) is only minor.

[9]In figures 3 and 4, Irak was left aside from the study as it drastically changed the averages for the developing and MENA countries' groups. Values including or excluding Irak can be found in annex 4.

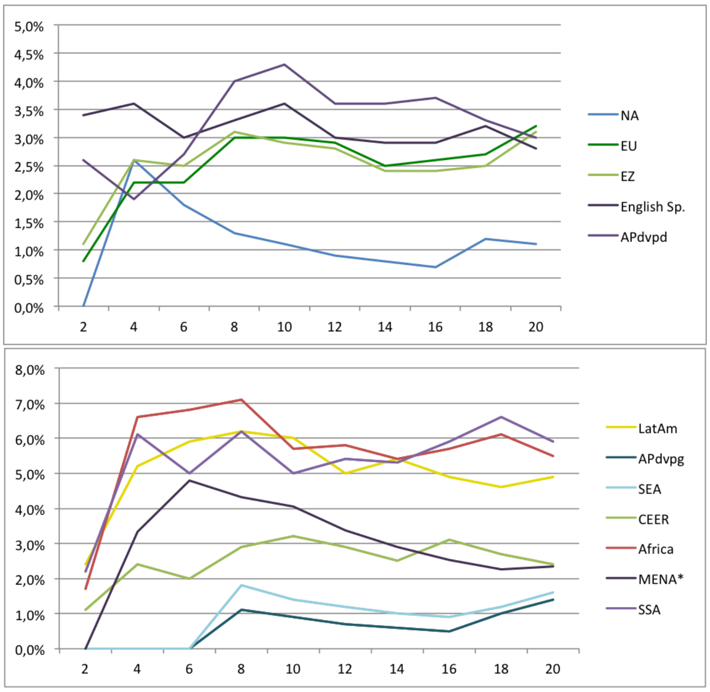

Figure 4: Conditional probabilities for a country to enter a recession knowing it is leaving one - By regions (developed (up), developing (down))

Looking at figure 4, a first remark refers to the heterogeneity of the developed and the developing groups. Leaving developed Asian countries aside, the developed countries' group is far more homogeneous than the developing one.

African and Latin American countries appear as being the most vulnerable countries whereas Asian countries perform even better than the developed countries. When comparing Central and Eastern European countries with other European averages (EU and EZ) we find similar results thus underlying a regional unity.

All these observations tend to reinforce previous observations. Regarding the shape of the curves, we find more similar and marked S-shaped curves for developed groups than for developing ones.

Considering these results I now look at the occurrence and the specificity of this multiple-recessions episodes. The first thing I measure is the total GDP loss of these events. A remarkable fact is that for two thirds of these events when experienced by developed countries, the expansion phase taking place in-between recessions belonging to the same episode tend to recover and overpass the output loss associated with the first recession, while this is rarely the case for developing countries. Moreover for developed countries, 46,2% of these multiple events were experienced during the latest economic and financial crises whereas the figure drops to 17,1% for developing countries. Therefore future data might strengthen the past remark. Another way of explaining this for a double dip is that the through corresponding to the second recession is higher than the peak of the first. I illustrate this in figure 5, where the left figure corresponds to the developed countries' case and the right one to developing countries.

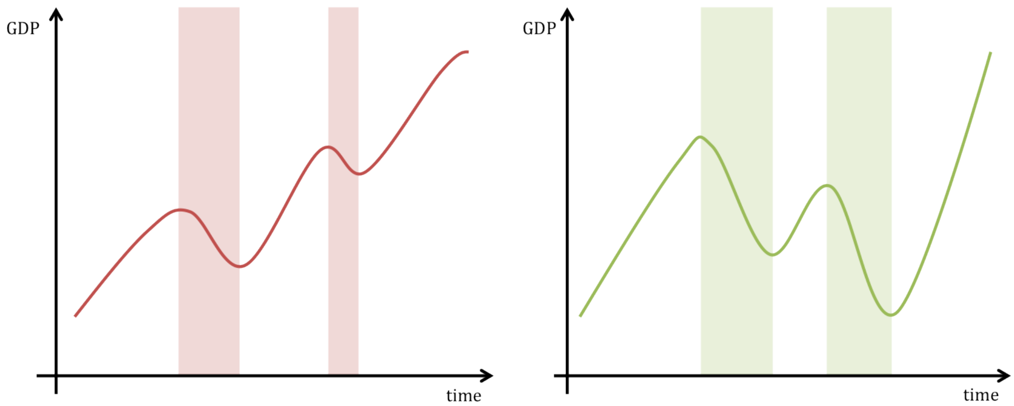

Figure 5: Two cases of Double Dips: the developed countries' (left) and the developing countries' case (right). Shaded areas correspond to recessions

This observation echoes the fact that developing countries tend to face higher output per capita losses when experiencing a recession, thus leaving them more vulnerable to a secondary one.

Table 4 presents the repartition of the different episodes (single recession - double dips - multiple recessions) according to the GDP per Capita Loss experienced in the first recession for all countries.

GDP per Capita Loss of the first recession	Number of: Single Recession	Double dips	Multiple-Recessions
-2,5% $> x$	82,4%	14,7%	2,9%
-2,5% $> x >$ -6,5%	64,4%	25,6%	10,0%
-6,5% $> x$	64,1%	29,1%	6,8%

Table 4: Repartition of the different episodes according to the GDP per Capita Loss of first recession - All countries

Table 5 and 6 present, for developed and developing countries respectively, the conditional probabilities to have an episode (single, double or multiple) conditional on the GDP per Capita Loss experienced in the first recession.

If it seems hard to derive absolute characteristics from these tables, one can still note that developing countries face more double and multiple episodes than developed countries, thus facing higher conditional probabilities to enter a double or multiple episode of recessions.

GDP per Capita Loss of the first recession	Conditional Probability of: Single Recession	Double dips	Multiple-Recessions
-2,5% > x	82,6%	13,0%	4,3%
-2,5% > x > -6,5%	75,0%	18,8%	6,3%
-6,5% > x	76,6%	18,8%	4,7%

Table 5: Probabilities to have a particular episode (single, double or multiple) conditional on the GDP per Capita Loss experienced in the first recession - Developed countries

GDP per Capita Loss of the first recession	Conditional Probability of: Single Recession	Double dips	Multiple-Recessions
-2,5% > x	82,2%	15,6%	2,2%
-2,5% > x > -6,5%	52,4%	33,3%	14,3%
-6,5% > x	43,6%	46,2%	10,3%

Table 6: Probabilities to have a particular episode (single, double or multiple) conditional on the GDP per Capita Loss experienced in the first recession - Developing countries

1.4 Anecdotal evidences: a short summary

This subsection tries to summarize the main informations that have been derived from the data so far.
Using both GDP and GDP per capita data, I find that there is no real difference on average between developed and developing countries' vulnerability. Both groups face a probability to enter a recession of 5% and a probability to exit a recession of 18% using GDP per Capita. Developing countries form however a more heterogenous group with Latin American countries being more vulnerable (with an entrance probability of 6,2% and an exit one of 17,0%) and Asian countries succeeding better than all the other groups (2,3% and 17,9% respectively). African countries form a special group as, due to limited number of observations, their results are less robust.
The main difference between the groups is found on the average output per capita loss encountered during a contraction. On average, developing countries tend to lose around twice as much as developed ones (-8,3% against -5,3%). This is driven by the fact that they experience harsher recessions (half of their recession leads to GDP per Capita losses larger than -6,5%), which is the opposite for developed countries (80% of the recessions they experience leads to losses smaller than -6,50%).
If developed and developing countries tend to have the same probability of entering a recession conditional on the fact they are leaving one (around 4%), the regional differences between developing countries are still valid. The fact that developing countries experience tougher recessions makes them more vulnerable to multiple-recessions episodes. On the other hand, developed countries tend to regain their losses during recoveries such that double dips (and multiple-recessions episode) appear as less damaging.

The following part of the article aims at testing some of these results using a nonlinear parametric framework, which has the advantage of not needing any *a priori* specification on the series. Section 2 presents the model and section 3 the results.

2 A nonlinear univariate model

2.1 A general framework

The Markov-switching autoregressive model proposed by Hamilton (1989) considers the first difference of the observed series as a non-linear process. Nonlinearities stem out from discrete shifts in regimes, characterized by different means. An important point in Hamilton's approach is that the state of the economy is an unobserved latent variable that doesn't need any *a priori* specification. MSM identify stochastic business cycles, with the different regimes identified as the most statistically relevant states given the data. An direct consequence is that there is no reason for the model to identify recessions and expansions. The model is estimated through solving the actual marginal likelihood and maximizing the likelihood function with respect to the population parameters.

Hamilton (1989)'s approach has been extended in several articles, e.g. Krolzig (1997). The most general specification allows for all the coefficients to vary across states:

$$y_t = \nu_{s_t} + \sum_{j=1}^{p} a^j_{s_{t-j}} y_{t-j} + \epsilon^{s_t}_t \tag{11}$$

where y_t represents the growth rate of GDP or GDP per capita; ν_{s_t} regime-specific intercept; p the number of lags considered; $a^j_{s_{t-j}}$ the regime-specific autoregressive coefficient of the j$^{\text{th}}$ lag and $\epsilon^{s_t}_t$ an i.i.d. process with a regime-specific variance σ_{s_t}.

When estimating such a model, one has the opportunity to let or not the different parameters vary across regimes, which makes up a total of 36 possible specifications (when considering 2 and 3 regimes)[10]. To find the best specification, one can use different criteria: Akaike Information Criterion (AIC), Bayes-Schwartz Information Criterion (BIC) and the Hannan-Quinn Criterion (HQC). This approach is used in Altug and Bildirici (2010). Limitations of this approach are twofold. First, given the high number of coefficients to estimate in particular specifications (up to 18 coefficients in a 3-regimes heteroskedastic Markov-switching model with 4 regime-specific Auto-Regressive coefficients), the estimation is most likely unable to converge if there is not enough observations. Second, when choosing the best specification in this framework, the regimes that are identified are the most significant from a statistical point of view. From an economic perspective, they might however not relate to expansions (be it high or low growth episodes) and recessions. I tested the 36 specifications for the 63 countries of my sample and faced, indeed, such obstacles. As a result I limited myself to a Markov-Switching Model in means, with the possibility to take into account regime-specific lag variables. I present the model and its estimation in the next two subsections.

[10] One has the possibility to let the AR coefficients vary or not across regimes, the number of lags is also among the possible choices as well as the heteroskedasticity of the specification.

2.2 A Markov-switching model in mean

Due to the reason previously mentioned, the model, used in this article, follows Hamilton (1989). The equation at the center of the model is the following:

$$y_t = \mu_{s_t} + \epsilon_t \tag{12}$$

$$\text{with } \epsilon_t \sim \mathcal{N}(0,1).$$

y_t represents the year-over-year growth rate of GDP or of GDP per capita; $s_t \in \{1,2\}$ characterizes the regime and μ_{s_t} the regime-specific mean follows:

$$\mu_{s_t} = \mu_1(1 - s_t) + \mu_2 s_t \tag{13}$$

Given the signs of μ_1 and μ_2, we can identify the different regimes: $\mu_1 \leq 0$[11] and $\mu_2 > 0$ give us regime 1 as 'contraction' and regime 2 as 'expansion'. It is however possible that the regime-specific means have the same sign or that one is not statistically different from 0. I discuss this in the third section when broaching the results.

The stochastic process that generates the unobserved regimes is an ergodic Markov Chain defined by following transition probabilities:

$$p_{ij} = Pr(s_{t+1} = j | s_t = i) = Pr(s_{t+1} = j | s_t = i, s_{t-1} = k, ...), \tag{14}$$

$$\text{with } \textstyle\sum_{j=1}^{2} p_{ij} = 1, \quad \forall i \in \{1,2\}.$$

p_{ii} can be interpreted as a measure of the persistence of regime i as it gives information on the probability for the economy to stay in the same regime. It also allows to derive, as seen in previous section, the average duration of regime i: $(1 - p_{ii})^{-1}$.

2.3 Estimation Procedure

The estimation of the model is obtained by using the filtered probabilities of the unobserved state. Let Ψ_{t-1} be the variable containing the past history of y_t such that $\Psi_t = \{y_t, \Psi_{t-1}\}$. Then the filtered probability of the unobserved state at time t, $Pr(s_t|\Psi_t)$, offers an inference about the unknown state given the information available up to time t. Given $Pr(s_{t-1}|\Psi_{t-1})$, $Pr(s_t|\Psi_{t-1})$ derives from:

$$Pr(s_t = j|\Psi_{t-1}) = \sum_{i=1}^{2} Pr(s_t = j|s_{t-1} = i) * Pr(s_{t-1} = i|\Psi_{t-1}), \forall j \in \{1,2\} \tag{15}$$

Then the joint conditional density-distribution of y_t and s_t is given by:

$$f(y_t, s_t = j|\Psi_{t-1}) = f(y_t|s_t = j, \Psi_{t-1}) * Pr(s_t = j|\Psi_{t-1}), \forall j \in \{1,2\} \tag{16}$$

[11] As previously mentioned, Nalewaik (2006) shows that the coefficient for the mean of the regime corresponding to recessions tends, for the US, to converge towards zero.

Summing over j, i.e. all the possible states s_t, we obtain the conditional density of the t^{th} observation on the past information:

$$f(y_t|\Psi_{t-1}) = \sum_{j=1,2} f(y_t, s_t = j|\Psi_{t-1}) \tag{17}$$

This allows us to derive the filtered probability of the state at time t, conditional on the information available at this time:

$$Pr(s_t = j|\Psi_t) = \frac{f(y_t, s_t = j|\Psi_{t-1})}{f(y_t|\Psi_{t-1})}, \forall j \in \{1, 2\} \tag{18}$$

At this stage we can also derive the smoothed probabilities $Pr(s_t|\Psi_T), t = 1, 2, ..., T$, which provides an inference on the unobserved state using all the information in the sample upon time T:

$$\begin{aligned} Pr(s_t = j|\Psi_T) = Pr(s_t = j|\Psi_t) \times \frac{f(y_{t+1}|s_t = j, \Psi_t)}{f(y_{t+1}|\Psi_t)} \\ \times \frac{f(y_{t+2}|s_t = j, \Psi_{t+1})}{f(y_{t+2}|\Psi_{t+1})} \times ... \times \frac{f(y_T|s_t = j, \Psi_{T-1})}{f(y_T|\Psi_{T-1})} \end{aligned} \tag{19}$$

As underlined by Hamilton (1989), we can also derive the sample conditional log-likelihood from the previous computations as:

$$log f(y_T, y_{T-1}, ..., y_1|\Psi_0) = \sum_{t=1}^{T} log f(y_t|\Psi_{t-1}) \tag{20}$$

This can be maximized numerically with respect to the unknown parameters so as to estimate the model.

3 Results

This section presents the results of the estimation of the Markov Switching Models[12]. The aim is to confront previous results with the ones obtained with a nonlinear parametric model, praised by many economists. In order to enable appropriate comparisons, I estimate the MSM on GDP and GDP per capita growth rates. Subsection 1 presents the estimations based on GDP data, while subsection 2 focuses on GDP per capita.

If the previous section presents a Markov-switching model in mean, following Hamilton (1989) I also estimate a model where both mean and variance vary across regimes. The best model is then chosen based on the Akaike Information Criterion (AIC) and the Bayes-Schwartz Information Criterion (BIC). The best specification is given for each serie in the annex 5.

[12] All estimations were made using Matlab following Perlin (2012).

Moreover the economic literature leans to filter the data when studying the Business Cycles in order to focus only on cyclical aspects. The commonly used filter is the Hodrick-Prescott (HP) filter even if its use is heavily debated in the academic world. Cogley and Nason (1995) advance indeed that the HP filter might create BC dynamics where there is none and insist on the need to have stationary results if the filter is used[13]. On the opposite view, Canova (1994), (1998) acknowledge the reliability of this tool in identifying turning points of a cycle. He warns, though, that using it on certain variables might not lead to the best fit but excludes GDP from these variables. He stresses the fact that one should keep in mind when using HP filter, that it tends to constrain a cycle's length to 4-6 years.
I estimate the model for the cyclical components of the series of y-o-y GDP and GDP per Capita growth rates. By applying the filter on y-o-y growth rates, I ensure getting rid of seasonal fluctuations and studying only the cyclical component. The λ of the filter is set to 1600 following Hodrick and Prescott (1997).
A concern rose when using HP filtered data as the MSM might identify recessions where there is none and might as well miss some recessions as identified in the following figure and explained in the next two points:
- Should the country experience not volatile but negative growth then the cyclical component after the HP filter would be close to zero and MSM wouldn't identify a recession.
- Should the country experience a sharp and brief decrease in growth, which still remains positive, then the model would identify a recession where there is none.

Based on these doubts and the fact that there is no *a priori* reason for the estimation to identify expansions and recessions I compute a Noise-to-Signal ratio for each set of estimation so as to assess the concordance of the estimates with the results of the algorithmic approach. Widely used in the literature on Early Warning Systems, this indicator is given by the number of bad signals as a share of possible bad signals divided by the number of good signals as a share of possible good signals. If this number is less than one, then the estimation is useful in predicting recessions. To decide if the model issues a signal or not, I follow Hamilton (1989)'s rules: if the filtered probability of a low-regime is superior to 50% then a recession is signaled. This rule can be strengthened by augmenting the threshold to 75%. Doing so improves slightly the results (the ratio drops by around 8%). I compare the signals issued by the estimated filtered probabilities to the recessions identified following the rule given in the first section.

[13]As the filter is used on year-over-year growth rates, this should not be an issue.

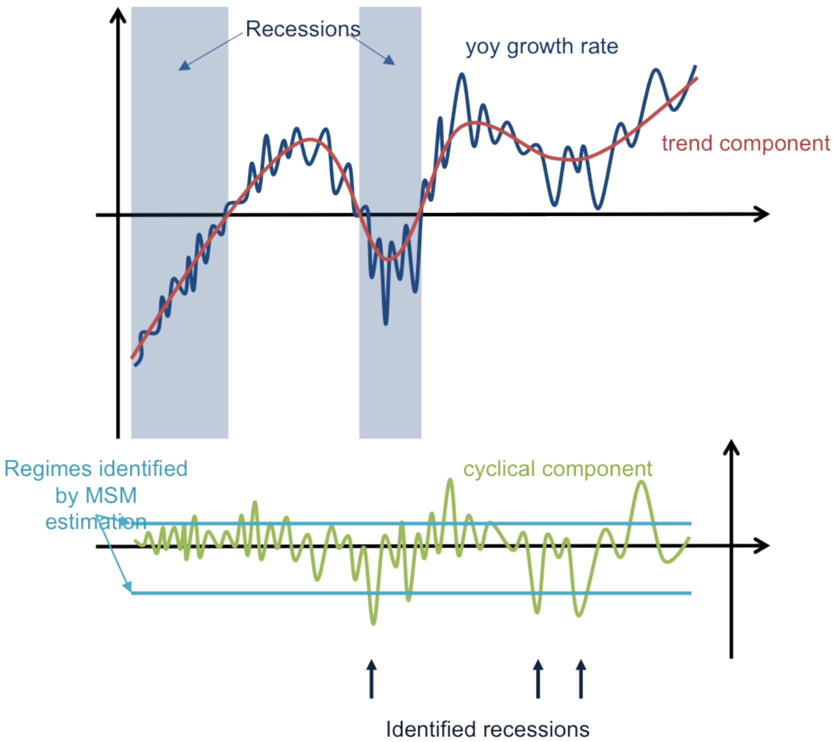

Figure 6: Risk of misidentification of recessions with HP filtered data

The results presented in the rest of this section are group averages excluding the countries for which the estimation process did not converge.

For estimations made on GDP or GDP per capita growth rates, countries for which an expansion and a recession regime were not identified are not taken into account. The later point ensues from the fact that the mean of the two identified regimes exhibit a positive and a negative mean. Should both means be positive and significantly different from zero, the country is left aside. When the lower mean is not negative but not significantly different from zero, the country remains in the sample. Thus I ensure comparing similar approaches.

Results on the cyclical componnts present the aggregates per group when all countries with less than one third of the maximum number of observations are left aside. Indeed for these countries, estimates do not tend to converge and falsify most results.

The list of dropped countries for each type of estimation are given in the annex 6.

3.1 Using quarterly GDP growth rates

3.1.1 Using the MSM specification

The results of the estimation of the Markov Switching Model with GDP data are presented in table 7.

Comparing these results with those obtained in the first section, we find smaller exit probabilities (between 1,5 to 2 times less with an average of 10,6% for developed countries and 13,7% for developing ones) and similar entrance probabilities. Leaving aside the different orders of magnitude for exit probabilities, we find that developing countries form a more heterogeneous group than developed ones, with respect to exit probabilities but not entrance ones. This tends therefore to comfort previous observations. When we look at the volatility of the different regimes, we observe that expansions tend to be less volatile than recessions. The volatility inherent to the recession regimes is even more flagrant for developing countries as the developed results ensue from a high volatility of developed CEE countries. Taking this fact into account, developing countries form, here again, a far more heterogeneous group than developed countries.

Moreover, the loss experienced by developing countries when undergoing a recession is more important than for their developed counterparts. This pattern is all the more true as one removes the developed CEE countries from the developed countries' group.

Looking at regional disparity, we observe that Asian countries form the least vulnerable group when compared to Latin American and Central and Eastern European countries, which echoes what was said in the first section.

These results, if comforting with regard to the previous pattern, are however disappointing when studying the diaggregated results and when considering the orders of magnitude. Moreover if the Noise-to-Ratio associated to this estimation is of only 13%, half of the sample of countries is left aside which questions the relevance of these results.

3.1.2 Using HP filtered data

I now present the results of the estimation of the MSM in mean using the cyclical component of year-over-year growth rates derived using a HP filter. They can be found in table 8.

Using Hodrick-Prescott filtered data, results are much closer to what was found earlier in the data, considering slightly higher exit probabilities. Developed and developing countries tend on average to face the same probability to enter a recession (respectively 5,4% and 6,3%) and the same exit probability (22,9% against 24,2%). This comforts the observation made in the first section.

Concerning regional disparities, we find that developed regions tend to behave in a similar way, while developing countries present stronger regional characteristics. However this pattern is not as strong as it was before and Asian countries do not appear as resistant as they once were. An explanation for this different situation, is the fact that by using cyclical components we enlarge the definition of recessions and identify one as soon as a country faces growth rates lower than the trend.

If the difference between the high and the low regime looks indeed higher for the developing groups when compared to advanced economies, it might not make much sense to conclude on this result. Indeed, as the serie is detrended, it does not identify exactly the output loss experienced during a recession.

Group:	Mean			Variance		Average Duration		Proba. of:	
	Low	High	Difference	Low	High	Low	High	Entering	Exiting
Dvpd	-1,82% (3,42%)	4,31% (1,35%)	6,13% (4,06%)	0,15% (0,30%)	0,04% (0,04%)	12,5 (7,1)	26,5 (13,2)	4,77% (2,17%)	10,58% (4,99%)
NA	-1,67% (0,00%)	3,42% (0,00%)	5,09% (0,00%)	0,03% (0,00%)	0,03% (0,00%)	5,7 (0,0)	49,3 (0,0)	2,03% (0,00%)	17,53% (0,00%)
EU	-2,60% (3,60%)	4,60% (1,37%)	7,20% (4,11%)	0,18% (0,30%)	0,06% (0,05%)	14,6 (9,1)	27,2 (11,2)	4,39% (1,93%)	9,08% (4,03%)
EZ	-3,01% (4,17%)	5,06% (1,53%)	8,07% (4,81%)	0,27% (0,38%)	0,06% (0,05%)	14,1 (7,9)	28,9 (12,2)	4,06% (1,56%)	9,49% (4,48%)
English Sp.	-1,01% (0,60%)	3,58% (0,37%)	4,59% (0,36%)	0,04% (0,01%)	0,03% (0,01%)	6,3 (1,3)	32,5 (12,8)	3,84% (2,06%)	16,60% (3,83%)
APdvpd	-0,41% (0,09%)	3,88% (0,29%)	4,30% (0,21%)	0,03% (0,01%)	0,03% (0,01%)	6,0 (1,6)	25,1 (11,5)	5,03% (2,30%)	17,79% (4,69%)
Dvpg	-3,63% (4,22%)	5,81% (1,66%)	9,44% (4,01%)	0,21% (0,18%)	0,09% (0,07%)	11,3 (10,1)	33,0 (19,5)	4,34% (2,80%)	13,72% (7,22%)
LatAm	-3,74% (4,03%)	5,83% (1,89%)	9,57% (3,76%)	0,19% (0,16%)	0,10% (0,08%)	11,5 (11,5)	34,3 (23,6)	4,97% (3,61%)	13,93% (6,53%)
APdvpg	-2,15% (4,44%)	6,93% (1,51%)	9,08% (3,48%)	0,23% (0,17%)	0,05% (0,03%)	8,8 (5,3)	37,0 (24,1)	3,86% (2,19%)	14,29% (5,15%)
SEA	-3,99% (2,77%)	6,29% (0,92%)	10,28% (2,81%)	0,28% (0,16%)	0,05% (0,03%)	6,2 (1,0)	43,0 (23,3)	2,88% (1,05%)	16,56% (2,70%)
CEE	-4,52% (5,05%)	5,48% (1,31%)	9,99% (5,24%)	0,32% (0,35%)	0,08% (0,06%)	14,6 (9,4)	31,1 (13,8)	4,23% (2,52%)	9,56% (5,10%)
Africa	-3,68% (3,04%)	5,31% (1,58%)	9,00% (4,61%)	0,12% (0,10%)	0,12% (0,10%)	5,1 (2,1)	29,8 (10,5)	3,82% (1,34%)	24,06% (10,19%)

Table 7: Group results of the estimation of the MSM using GDP growth rates data - Only Recessions

Group:	Mean			Variance		Average Duration		Proba. of:	
	Low	High	Difference	Low	High	Low	High	Entering	Exiting
Dvpd	-4,36% (3,21%)	0,85% (0,49%)	5,20% (3,28%)	0,07% (0,10%)	0,04% (0,04%)	4,7 (1,5)	31,5 (30,1)	5,42% (3,53%)	22,95% (6,41%)
NA	-2,89% (0,09%)	0,65% (0,01%)	3,55% (0,10%)	0,02% (0,00%)	0,01% (0,00%)	4,2 (0,4)	20,8 (1,6)	4,84% (0,38%)	23,82% (2,27%)
EU	-4,78% (3,73%)	0,84% (0,50%)	5,62% (3,83%)	0,08% (0,11%)	0,04% (0,04%)	4,9 (1,9)	35,4 (33,0)	5,09% (3,57%)	22,86% (7,44%)
EZ	-5,72% (4,03%)	0,82% (0,55%)	6,54% (4,21%)	0,08% (0,11%)	0,04% (0,05%)	4,3 (1,2)	39,9 (36,0)	4,49% (3,43%)	25,21% (7,00%)
English Sp.	-3,03% (0,16%)	0,58% (0,09%)	3,62% (0,14%)	0,02% (0,01%)	0,02% (0,00%)	4,5 (0,8)	25,2 (5,0)	4,12% (0,80%)	22,91% (3,71%)
APdvpd	-4,64% (1,19%)	0,86% (0,48%)	5,50% (1,43%)	0,12% (0,14%)	0,05% (0,02%)	4,2 (0,8)	29,3 (16,2)	4,32% (1,87%)	24,24% (3,63%)
Dvpg	-5,68% (3,71%)	1,35% (1,44%)	7,02% (3,73%)	0,11% (0,12%)	0,06% (0,06%)	5,8 (6,8)	24,8 (17,4)	6,34% (5,80%)	24,24% (10,02%)
LatAm	-5,71% (3,80%)	1,10% (0,59%)	6,81% (3,95%)	0,10% (0,13%)	0,07% (0,07%)	4,4 (1,0)	26,1 (16,5)	5,49% (3,62%)	24,28% (7,77%)
APdvpg	-6,12% (2,17%)	1,19% (0,08%)	7,31% (2,25%)	0,09% (0,03%)	0,06% (0,03%)	4,6 (1,2)	21,5 (0,8)	4,65% (0,18%)	23,15% (5,99%)
SEA	-5,43% (2,23%)	1,11% (0,15%)	6,54% (2,35%)	0,17% (0,13%)	0,05% (0,02%)	4,9 (1,2)	21,6 (0,7)	4,63% (0,16%)	21,77% (5,71%)
CEE	-6,94% (4,21%)	1,03% (0,50%)	7,98% (4,41%)	0,14% (0,15%)	0,06% (0,06%)	4,9 (2,6)	34,1 (21,8)	4,51% (3,19%)	25,11% (10,43%)
Africa	-4,08% (3,87%)	3,43% (3,23%)	7,51% (3,20%)	0,09% (0,07%)	0,09% (0,07%)	15,5 (16,2)	10,5 (5,5)	15,17% (11,06%)	21,89% (18,40%)

Table 8: Group results of the estimation of the MSM using the cyclical component of GDP growth rates

The Noise-to-signal ratio derived using the estimated filtered probability is of 0,25 which is far below one. (A score of 0 would mean that the indicator (here the fact that the filtered probability of a low regime is above 0,5) is perfect). With 37 countries left aside, the use of these estimations is questionnable and as it was the case in the first section, we now turn to estimates on GDP per Capita that tend to give better results.

3.2 Using quarterly GDP per Capita growth rates

3.2.1 Using the MSM specification

Group estimates are given in following table 9.

Orders of magnitude are similar to the results obtained using GDP data and do not replicate exactly previous results on exit probabilities. Averages on developing countries are close to developed countries' averages with a probability of entering a recession of 4,8% and a probability of exiting it of 14,5%, against 5,7% and 10,4% respectively for developed countries. Probabilities are similar and it seems hard to derive any conclusions regarding the differences between the two groups of countries which comforts our previous observation on this point. Nevertheless it should be noted that the difference between the average developed and the average developing country is now the opposite of earlier (i.e. a smaller entrance probability for developing countries). Regarding developing countries' heterogeneity, Asian and Subsaharan countries have high exit probabilities (16,3% and 21,7%) with regard to other groups while CEE countries tend to behave in average similarly to developed countries (11,7%). Looking at entrance probabilities we find that Asian countries are once again the most resistant ones (with an average of 2,7%) whereas Latin American countries obtain higher values. CEE countries face low entrance probabilities which deviates from former observations. As with GDP data, the main difference between the two groups seems to be in the "loss of growth" when a country moves from a high regime to a low one. Indeed it appears to be twice as important for developing countries (with the exception of African countries due to formerly explained reasons): -5,8% for developed countries, -10,2% for Asian countries, -8,9% for Latin American ones and -10,9% for CEE countries.

When excluding non convergent estimations and estimations for which no recession has been identified, 21 countries are left aside, which is much better than with GDP data. Moreover the Noise-to-Signal ratio takes the value of 20,2%, which comforts the use of these estimates in characterizing recessions.

3.2.2 Using HP filtered data

Table 10 presents the results of the estimation of the MSM using HP filtered data for countries that have a minimum of 58 observations (which is the same threshold as with GDP series).

Group:	Mean			Variance		Average Duration		Proba. of:	
	Low	High	Difference	Low	High	Low	High	Entering	Exiting
Dvpd	-1,56% (2,74%)	4,23% (1,81%)	5,80% (3,62%)	0,12% (0,25%)	0,05% (0,04%)	12,8 (8,8)	22,0 (12,0)	5,66% (2,25%)	10,39% (4,62%)
NA	-1,81% (0,91%)	2,53% (0,27%)	4,35% (0,64%)	0,03% (0,00%)	0,02% (0,00%)	6,5 (0,6)	34,1 (13,7)	3,50% (1,41%)	15,43% (1,47%)
EU	-1,99% (3,17%)	4,49% (1,74%)	6,49% (4,05%)	0,16% (0,28%)	0,06% (0,05%)	15,9 (10,3)	24,1 (11,9)	5,16% (2,27%)	8,33% (3,71%)
EZ	-2,12% (3,56%)	4,69% (1,99%)	6,80% (4,68%)	0,21% (0,34%)	0,05% (0,04%)	15,7 (10,5)	23,9 (13,2)	5,34% (2,33%)	8,70% (4,11%)
English Sp.	-1,43% (0,79%)	2,71% (0,27%)	4,14% (0,64%)	0,04% (0,01%)	0,03% (0,01%)	7,6 (2,8)	25,1 (12,4)	4,83% (1,84%)	14,44% (3,57%)
APdvpd	-1,15% (1,11%)	5,18% (2,05%)	6,33% (2,07%)	0,09% (0,05%)	0,07% (0,03%)	6,5 (1,4)	19,0 (6,8)	5,95% (1,93%)	16,09% (2,89%)
Dvpg	-4,20% (3,82%)	4,75% (1,98%)	8,95% (4,13%)	0,19% (0,18%)	0,09% (0,08%)	11,6 (10,9)	34,8 (27,3)	4,80% (4,07%)	14,54% (8,44%)
LatAm	-3,99% (4,07%)	4,86% (2,58%)	8,86% (3,88%)	0,16% (0,15%)	0,08% (0,08%)	12,7 (12,0)	30,2 (22,6)	6,21% (5,49%)	13,18% (6,79%)
APdvpg	-5,74% (2,23%)	4,44% (1,08%)	10,17% (2,56%)	0,27% (0,16%)	0,05% (0,03%)	6,4 (1,3)	44,4 (22,3)	2,71% (0,96%)	16,31% (3,40%)
SEA	-5,17% (2,29%)	4,78% (1,19%)	9,95% (2,33%)	0,25% (0,15%)	0,06% (0,03%)	6,1 (1,3)	40,4 (21,5)	3,00% (1,04%)	17,02% (3,36%)
CEE	-5,04% (4,75%)	5,89% (1,55%)	10,93% (5,13%)	0,31% (0,34%)	0,11% (0,09%)	13,6 (10,1)	34,1 (13,8)	3,71% (2,13%)	11,74% (7,95%)
Africa	-1,99% (2,73%)	3,65% (1,18%)	5,64% (3,41%)	0,17% (0,24%)	0,06% (0,06%)	11,3 (10,8)	39,8 (47,1)	5,38% (3,09%)	17,64% (12,03%)
MENA	0,81% (0,28%)	3,66% (0,28%)	2,85% (0,56%)	0,35% (0,33%)	0,03% (0,02%)	20,2 (13,9)	77,4 (66,4)	4,89% (4,20%)	9,45% (6,52%)
SSA	-3,39% (2,29%)	3,65% (1,43%)	7,03% (3,38%)	0,08% (0,07%)	0,08% (0,07%)	6,9 (4,5)	20,9 (8,2)	5,62% (2,32%)	21,74% (12,07%)

Table 9: Group results of the estimation of the MSM using GDP per Capita growth rates data

Group:	Mean			Variance		Average Duration		Proba. of:	
	Low	High	Difference	Low	High	Low	High	Entering	Exiting
Dvpd	-4,53% (3,17%)	0,84% (0,48%)	5,37% (3,23%)	0,06% (0,08%)	0,04% (0,04%)	4,7 (1,5)	32,1 (29,5)	5,28% (3,50%)	23,30% (6,23%)
NA	-2,88% (0,05%)	0,65% (0,00%)	3,53% (0,06%)	0,02% (0,00%)	0,01% (0,00%)	4,3 (0,4)	20,8 (1,5)	4,84% (0,36%)	23,56% (2,28%)
EU	-4,91% (3,65%)	0,85% (0,52%)	5,76% (3,75%)	0,07% (0,10%)	0,04% (0,04%)	4,8 (1,7)	36,6 (33,7)	4,95% (3,46%)	23,23% (7,05%)
EZ	-5,67% (3,96%)	0,81% (0,55%)	6,48% (4,15%)	0,08% (0,11%)	0,04% (0,05%)	4,3 (1,2)	40,8 (35,9)	4,38% (3,37%)	24,91% (6,85%)
English Sp.	-3,00% (0,14%)	0,64% (0,11%)	3,63% (0,13%)	0,03% (0,01%)	0,02% (0,01%)	4,3 (0,9)	22,4 (6,6)	4,95% (1,72%)	24,28% (4,67%)
APdvpd	-5,32% (1,72%)	0,85% (0,38%)	6,16% (1,85%)	0,06% (0,03%)	0,05% (0,02%)	3,9 (0,3)	29,0 (14,3)	4,46% (2,29%)	26,13% (2,39%)
Dvpg	-5,97% (3,92%)	1,04% (0,53%)	7,01% (4,07%)	0,09% (0,10%)	0,06% (0,06%)	4,3 (1,3)	27,3 (19,8)	5,52% (3,69%)	26,08% (9,44%)
LatAm	-5,45% (3,81%)	1,20% (0,64%)	6,65% (3,89%)	0,10% (0,12%)	0,07% (0,07%)	4,7 (1,3)	24,9 (17,4)	6,51% (4,80%)	23,47% (8,33%)
APdvpg	-5,92% (3,35%)	0,85% (0,32%)	6,77% (3,40%)	0,09% (0,08%)	0,04% (0,03%)	4,3 (1,0)	32,7 (23,1)	4,65% (3,14%)	24,36% (5,59%)
EA	-6,67% (0,47%)	0,73% (0,16%)	7,40% (0,41%)	0,07% (0,02%)	0,06% (0,01%)	3,6 (0,4)	33,8 (7,2)	3,12% (0,76%)	28,45% (3,46%)
SEA	-7,55% (2,88%)	1,05% (0,19%)	8,59% (2,78%)	0,13% (0,07%)	0,06% (0,03%)	4,6 (1,0)	36,2 (24,8)	3,67% (1,38%)	22,66% (4,76%)
CEE	-8,19% (4,31%)	1,15% (0,51%)	9,34% (4,50%)	0,12% (0,13%)	0,07% (0,06%)	4,4 (2,1)	35,4 (21,5)	4,17% (2,84%)	26,34% (9,49%)
Africa	-4,04% (3,11%)	0,78% (0,34%)	4,81% (3,35%)	0,06% (0,07%)	0,06% (0,07%)	3,6 (1,7)	16,2 (2,6)	6,37% (1,15%)	34,46% (14,48%)
SSA	-4,56% (3,43%)	0,84% (0,37%)	5,40% (3,68%)	0,07% (0,08%)	0,07% (0,08%)	3,4 (1,9)	16,1 (3,0)	6,46% (1,31%)	37,97% (15,19%)

Table 10: Group results of the estimation of the MSM using the cyclical component of GDP per Capita growth rates

As was previously the case, when using HP filtered data, orders of magnitude are closer to those obtained without the model. Averages on developing countries are close to developed countries' averages with a probability of entering a recession of 5,5% against 5,3% for developed countries and a probability of exit of 26,1% against 23,3% for developed countries.

Considering the heterogeneity among developing countries, we find a pattern similar to what was observed with the previous estimation on the cyclical component of GDP series: Latin American face a high probability to enter a low-regime (6,5%) and CEE countries have an entrance probability similar to developed countries (4,2%). Asian countries perform even better than developed ones on both entrance (3,1%) and exit probabilities (28,5%). Latin American and CEE countries' performance on the exit probability (23,5% and 26,3%) is, with regard to other groups, comparable to what it was before. This estimation is therefore really encouraging.

The previous remark on the average output loss using the cyclical component still holds and we do not observe major differences between the different groups. The Noise-to-signal ratio derived using the estimated filtered probability is 21,4% which is again far below one. Therefore this estimation is deemed useful in identifying recessions. Annex 7 presents graphical representations of the filtered probability of 5 countries and compares it to the recessions identified in the first section.[14]

3.3 What we have learned form the estimation of the model

A major issue encountered in the different estimations regards countries with little observations, which is mostly the case for African countries. They exhibit results out of phase with the results of the other countries and do not reflect the previous observations. Another concern is due to the fact that the most statistically significant regimes identified in the process might not include a regime dedicated to recessions.

Estimations using year-over-year growth rates for GDP and GDP per Capita reflect in a good manner the fact that developed and developing countries face in average the same probabilities to enter and to exit a recession. They also represent the heterogeneity that was observed previously: Latin American countries are more vulnerable than other countries, with high entrance probabilities, and Asian countries prove to be once again more resistant, with smaller entrance probabilities and higher exit probabilities. The output loss, represented here by the difference between the mean in the High- and the Low-regime, is also almost twice as high for developing countries as for developed countries, a pattern valid for all the developing countries' groups.

Using the cyclical component of the series, derived using the HP filter, we expand the definition of a recession by not taking into account only consecutive quarterly negative growth rates but by considering episodes in which the growth rates is substantially lower than the trend. This gives results that not only retranscribe the previously mentioned patterns but also gives close values to those observed in the first section.

[14] More countries available upon request.

Conclusion

This article aims at highlighting several figures on the vulnerability of countries regarding their business cycle and thus at identifying the differences and the similarities between developed and developing countries. Business cycles have been at the center of many studies across past decades. The literature on the subject has been based on two major approaches: a non-parametric one following the steps of Burns and Mitchell (1946), whose main defenders are the previously cited Don Harding and Adrian Pagan, and a parametric one based on the nonlinear model developed by James Hamilton - the Markov-Switching Model - which has gained the consideration of many economists as it does not constrain the data by any *a priori* specification but identifies on the opposite the most statistically relevant features of the cycle. The advantage of these two approaches is that little data is required: GDP time series allow to derive the main features of interest.

Recently, comparing developed and developing countries' business cycles has been the key interest of many articles. The economic literature tends to advance the fact that developing countries face a greater volatility of their BC with deeper and more frequent recessions. They are said to form a heterogenous group that differs greatly from developed countries, which are said to be less vulnerable to recessions. Altug and Bildirici (2010) and Calderón and Fuentes (2010), using respectively MSM and Harding and Pagan's dating methodology, illustrate these by studying quarterly GDP on respectively 22 and 35 countries.

This article widens their approach by analyzing the business cycle of 80 countries based on quarterly GDP data. Using a recession dating algorithm, it first derives some observations on the countries by looking at the probabilities to enter and to exit a recession. It also studies the output loss experienced during a contraction and focuses on multiple-recessions episode and on the probability of entering a recession conditional on the country exiting one. If this first approach echoes some major findings of the literature, it also reveals a less common pattern as developed and developing countries tend to exhibit, on average, the same probabilities to enter and to exit a recession. The developing group is more heterogenous as Latin American countries tend to be more vulnerable to recessions as their entrance probability is higher and Asian countries prove to be stronger with low entrance probabilities and higher exit ones. The main difference between developed and developing countries lies in the output loss experienced during a contraction as it is twice as much important for developing countries as for developed ones. This pattern is common among all developing countries. Developed and developing countries also exhibit similar probability to enter a recession conditional on the fact they are exiting another one. However, due to the fact that they experience harsher contractions, developing countries are more likely to experience multiple-recessions events. Indeed developed countries do not experience double-dips or longer types of episodes that are as damaging as for developing countries.

The article then presents the estimates of a Markov-Switching Model in mean, first developed by Hamilton (1989), to test the previous observations. The interest of this nonlinear model is that it finds the most statistically significant regimes in the data without any *a priori* specification, which is a good way to assess the robustness of previous observations. One of its limitations is the fact that it is bound by the validity of the statistical model, which might be concerning with too little observations. This echoes an issue that rose when looking at the results for some African countries, which tend to be out of line with regards to both other results and previously found ones. The MSM was estimated on both GDP and GDP per capita growth rates as well as on their cyclical component obtained with a HP filter. A remark with this type of estimation is the fact that the most statistically significant regimes might not replicate an expansion/recession framework as it is defined from an advanced economy's point of view. Indeed for developing countries, a recession might not only be when consecutively quarterly GDP growth rates are negative but when they are below the trend. If estimates on year-over-year growth rates displayed lower exit probabilities than the previous results, estimates on the HP filtered data replicated similar values as before thus comforting the previous messages.

This article shows that if all countries tend to be put on the same footing at first, developing countries remain more vulnerable as they experience greater losses when undergoing a recession thus weakening them.

If it seems hard to tackle the problem of too little observations for certain countries, this article shows the path for further development in order to confirm and strengthen its main message. Possible improvements include the development of a logit model to provide a statistical backing to the results of the first section. One could also include, in both the MSM estimation and the logit approach, duration coefficients to estimate the probabilities to enter a recession conditional on the time since last one, as to echo some features studied in this article as a first approach.

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Annexes

Annex 1: List of Countries, Data sources and characteristics

Country	Source	1st Value	Last Value	Type	(N)SA
Argentina	NS	Q1-1980	Q4-2013	Constant Prices	NSA
Australia	NS	Q1-1970	Q4-2013	Constant Prices	NSA
Austria	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Belarus	IMF	Q1-1993	Q4-2013	Index	NSA
Belgium	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Bolivia	NS	Q1-1990	Q4-2013	Constant Prices	NSA
Botswana	IMF	Q1-1994	Q4-2013	Index	NSA
Brazil	NS	Q1-1991	Q4-2013	Constant Prices	NSA
Bulgaria	NS	Q1-1996	Q4-2013	Constant Prices	NSA
Canada	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Chile	IMF	Q1-1980	Q4-2013	Index	NSA
China	IMF	Q1-2000	Q4-2013	Index	NSA
Colombia	IMF	Q1-1994	Q4-2013	Index	NSA
Costa Rica	NS	Q1-1991	Q4 2013	Constant Prices	NSA
Croatia	IMF	Q1-1993	Q4-2013	Index	NSA
Cyprus	NS	Q1-1995	Q4-2013	Constant Prices	NSA
Czech Republic	OECD	Q1-1994	Q4-2013	Constant Prices	NSA
Denmark	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Dominican Republic	NS	Q1-1991	Q4 -2013	Constant Prices	NSA
Ecuador	NS	Q1-2000	Q4 -2013	Constant Prices	NSA
Egypt	IMF	Q1-2002	Q4 -2013	Index	NSA
El Salvador	NS	Q1-1990	Q4 -2013	Constant Prices	NSA
Estonia	IMF	Q1-1993	Q4-2013	Index	NSA
Finland	OECD	Q1-1970	Q4-2013	Cosntant Prices	SA
France	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Germany	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Ghana	NS	Q1-2006	Q4-2013	Constant Prices	NSA
Greece	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Hong Kong	NS	Q1-1973	Q4-2013	Constant Prices	NSA
Hungary	NS	Q1-1995	Q4-2013	Constant Prices	NSA
Iceland	OECD	Q1-1970	Q4-2013	Constant Prices	SA
India	OECD	Q2-1996	Q4-2013	Constant Prices	SA
Indonesia	OECD	Q1-1990	Q4-2013	Constant Prices	SA
Ireland	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Israel	IMF	Q1-1980	Q4-2013	Index	NSA
Italy	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Japan	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Kenya	NS	Q1-2000	Q4-2013	Constant Prices	NSA
Latvia	IMF	Q1-1990	Q4-2013	Index	NSA
Lithuania	IMF	Q1-1993	Q4-2013	Index	NSA
Luxembourg	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Malaysia	IMF	Q1-1988	Q4-2013	Index	NSA
Malta	IMF	Q1-1996	Q4-2013	Index	NSA
Mexico	OECD	Q1-1970	Q4-2013	Constant Prices	SA

NS stands for National Source.

Source	Country	1st Value	Last Value	(N)SA	
Morocco	IMF	Q1-1990	Q4-2013	Index	NSA
Mozambique	NS	Q1-2000	Q4-2013	Constant Prices	NSA
Namibia	NS	Q1-2004	Q4-2013	Constant Prices	NSA
Netherlands	OECD	Q1-1970	Q4-2013	Constant Prices	SA
New Zealand	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Nigeria	NS	Q1-1981	Q4-2013	Constant Prices	NSA
Norway	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Paraguay	NS	Q1-1994	Q4-2013	Constant Prices	NSA
Peru	IMF	Q1-1979	Q4-2013	Index	NSA
Philippines	NS	Q1-1981	Q4-2013	Constant Prices	NSA
Poland	OECD	Q1-1990	Q4-2013	Constant Prices	SA
Portugal	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Romania	NS	Q1-1995	Q4-2013	Constant Prices	NSA
Russian Federation	OECD	Q1-1995	Q4-2013	Constant Prices	SA
Serbia	NS	Q1-1996	Q4-2013	Constant Prices	NSA
Singapore	NS	Q1-1975	Q4-2013	Constant Prices	NSA
Slovak Republic	OECD	Q1-1993	Q4-2013	Constant Prices	SA
Slovenia	IMF	Q1-1992	Q4-2013	Index	NSA
South Africa	NS	Q1-1970	Q4-2013	Constant Prices	NSA
South Korea	NS	Q1-1970	Q4-2013	Constant Prices	NSA
Spain	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Sri Lanka	IMF	Q1-1996	Q4-2013	Index	NSA
Sweden	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Switzerland	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Taiwan	NS	Q1-1970	Q4-2013	Constant Prices	NSA
Tanzania	IMF	Q1-2001	Q3-2013	Index	NSA
Thailand	NS	Q1-1993	Q4-2013	Constant Prices	NSA
Tunisia	NS	Q1-2000	Q4-2013	Constant Prices	NSA
Turkey	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Uganda	NS	Q3-1999	Q4-2013	Constant Prices	NSA
Ukraine	IMF	Q1-2002	Q4-2013	Index	NSA
United Kingdom	NS	Q1-1970	Q4-2013	Constant Prices	NSA
United States	OECD	Q1-1970	Q4-2013	Constant Prices	SA
Uruguay	NS	Q1-1997	Q4-2013	Constant Prices	NSA
Venezuela	NS	Q1-1997	Q4-2013	Constant Prices	NSA

NS stands for National Source.

Annex 2: Presentation of the countries in each group studied in the article

- Developed Countries (Dvpd): Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Latvia, Luxembourg, Malta, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Taiwan, the United Kingdom and the United States.
- North America (NA): Canada and the United States.
- European Union Countries (EU): Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithunia, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.
- Eurozone (EZ): Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithunia, Luxembourg, Malta, the Netherlands, Portugal, Slovak Republic, Slovenia and Spain.
- English Speaking Countries (English Sp.): Australia, Canada, New-Zealand, the United Kingdom and the United States.
- Developed Asian and Pacific Countries(APdvpd): Australia, Hong Kong, Japan, New-Zealand, Singapore, South Korea and Taiwan.
- Developing Countries (Dvpg): Argentina, Belarus, Bolivia, Botswana, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Dominican Republic, Ecuador, Egypt, El Salvador, Ghana, Hungary, India, Indonesia, Irak, Kenya, Lithuania, Malaysia, Mexico, Morocco, Mozambique, Namibia, Nigeria, Paraguay, Peru, the Philippines, Poland, Romania, Russian Federation, Serbia, South Africa, Sri Lanka, Tanzania, Thailand, Tunisia, Turkey, Uganda, Ukraine, Uruguay and Venezuela.
- Latin American Countries (LatAm): Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Mexico, Paraguay, Peru, Uruguay and Venezuela.
- Developing Asian and Pacific Countries (APdvpg): China, India, Indonesia, Malaysia, the Philippines, Singapore and Thailand.
- East Asian Countries (EA): China, South Korea and Taiwan.
- South Asian Countries (SA): India and Sri Lanka.
- South-East Asian Countries (SEA): Indonesia, Malaysia, the Philippines, Sri Lanka and Thailand.
- Central and Eastern European Countries (CEE+R): Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Russian Federation, Serbia, Slovak Republic, Slovenia and Ukraine.

- African Countries (Africa): Botswana, Egypt, Ghana, Kenya, Morocco, Mozambique, Namibia, Nigeria, South Africa, Tanzania, Tunisia and Uganda.
- Middle Eastern and North African Countries (MENA): Egypt, Irak, Israel, Morocco, Tunisia.
- Sub-Sahara African Countries (SSA): Botswana, Ghana, Kenya, Mozambique, Namibia, Nigeria, South Africa, Tanzania and Uganda.

Annex 3: Simple Probabilities and Average Durations per country - y-o-y GDP and GDP per Capita data

Group:	Proba. of Being in a Recession	Proba. of Entering a Recession	Proba. of Exiting a Recession	Average Duration
Dvpd	14,6% (5,7%)	3,6% (1,3%)	21,2% (7,0%)	5,4 (2,3)
NA	10,5% (1,7%)	2,6% (0,7%)	21,9% (1,9%)	4,6 (0,4)
EU	17,8% (6,7%)	4,1% (1,6%)	18,5% (7,2%)	6,3 (2,5)
EZ	16,0% (5,3%)	4,0% (1,2%)	20,4% (7,8%)	5,8 (2,7)
English Sp.	12,4% (4,8%)	3,3% (1,7%)	22,6% (4,1%)	4,6 (0,9)
APdvpd	10,6% (5,3%)	3,2% (1,7%)	26,4% (2,5%)	3,8 (0,4)
Dvpg	14,9% (11,6%)	3,8% (3,3%)	22,1% (13,4%)	6,0 (4,0)
LatAm	17,1% (11,2%)	4,5% (3,2%)	25,8% (14,1%)	5,4 (3,6)
APdvpg	5,4% (5,3%)	1,3% (1,3%)	21,2% (10,9%)	4,9 (2,5)
EA	3,7% (2,7%)	1,0% (0,8%)	26,1% (12,4%)	3,8 (1,8)
SEA	9,4% (3,1%)	2,4% (0,9%)	22,7% (4,5%)	4,6 (0,9)
CEE	22,6% (8,2%)	4,9% (2,0%)	15,5% (6,9%)	7,9 (3,8)
Africa	08,0% (8,2%)	2,7% (3,6%)	27,2% (15,1%)	4,1 (2,3)
MENA	13,2% (12,2%)	3,8% (3,6%)	23,9% (10,2%)	4,3 (1,8)
SSA	08,2% (8,8%)	2,9% (4,0%)	28,7% (16,2%)	4,1 (2,4)

Table 11: Probabilities derived using y-o-y GDP growth rates, All sample

Group	Proba. of Being in a Recession	Proba. of Entering a Recession	Proba. of Exiting a Recession	Average Duration
Dvpd	19,2% (5,9%)	4,5% (1,5%)	17,9% (6,1%)	6,4 (2,5)
NA	15,7% (1,2%)	3,5% (0,7%)	18,3% (2,3%)	5,5 (0,7)
EU	20,5% (6,5%)	4,6% (1,6%)	16,3% (6,1%)	7,0 (2,6)
EZ	19,4% (5,6%)	4,4% (1,3%)	17,0% (7,0%)	7,0 (3,0)
English Sp.	18,5% (2,9%)	4,5% (1,3%)	18,7% (2,7%)	5,5 (0,8)
APdvpd	15,2% (6,3%)	4,3% (1,9%)	23,4% (3,5%)	4,4 (0,7)
Dvpg	21,2% (13,6%)	5,2% (3,8%)	18,8% (9,7%)	6,5 (3,6)
LatAm	26,2% (13,8%)	6,2% (4,0%)	17,0% (6,0%)	6,8 (3,4)
APdvpg	8,4% (8,1%)	1,6% (1,5%)	17,9% (8,8%)	5,9 (2,8)
EA	4,3% (3,0%)	1,2% (0,9%)	27,3% (12,9%)	3,7 (1,7)
SA	1,5% (1,5%)	0,4% (0,4%)	25,0% (12,5%)	4,0 (2,0)
SEA	13,6% (5,8%)	2,7% (1,1%)	17,1% (2,7%)	6,0 (1,0)
CEER	21,8% (8,5%)	4,6% (2,0%)	15,3% (7,5%)	8,4 (4,2)
Africa	17,7% (12,3%)	5,4% (3,5%)	25,9% (13,3%)	4,7 (2,3)
MENA	25,3% (14,7%)	7,2% (4,5%)	18,3% (3,9%)	5,7 (1,1)
SSA	18,2% (13,5%)	5,7% (3,9%)	28,5% (14,7%)	4,4 (2,5)

Table 12: Probabilities derived using y-o-y GDP per Capita growth rates, All sample

Annex 4: Group-average conditional probabilities for a country to enter a recession knowing it is leaving one

Group:	Q =									
	2	4	6	8	10	12	14	16	18	20
All	1,6%	3,4%	3,7%	4,4%	4,3%	3,8%	3,6%	3,4%	3,4%	3,6%
All*	1,4%	3,2%	3,6%	4,1%	4,0%	3,6%	3,4%	3,3%	3,3%	3,5%
Dvpd	1,1%	2,2%	2,8%	3,4%	3,4%	3,1%	2,7%	2,6%	2,7%	3,1%
NA	0,0%	2,6%	1,8%	1,3%	1,1%	0,9%	0,8%	0,7%	1,2%	1,1%
EU	0,8%	2,2%	2,2%	3,0%	3,0%	2,9%	2,5%	2,6%	2,7%	3,2%
EZ	1,1%	2,6%	2,5%	3,1%	2,9%	2,8%	2,4%	2,4%	2,5%	3,1%
English Sp.	3,4%	3,6%	3,0%	3,3%	3,6%	3,0%	2,9%	2,9%	3,2%	2,8%
APdvpd	2,6%	1,9%	2,7%	4,0%	4,3%	3,6%	3,6%	3,7%	3,3%	3,0%
Dvpg	2,3%	5,0%	5,0%	5,6%	5,4%	4,8%	4,7%	4,6%	4,4%	4,3%
Dvpg*	1,8%	4,5%	4,6%	5,2%	4,9%	4,4%	4,3%	4,3%	4,1%	4,1%
LatAm	2,4%	5,2%	5,9%	6,2%	6,0%	5,0%	5,4%	4,9%	4,6%	4,9%
APdvpg	0,0%	0,0%	0,0%	1,1%	0,9%	0,7%	0,6%	0,5%	1,0%	1,4%
SEA	0,0%	0,0%	0,0%	1,8%	1,4%	1,2%	1,0%	0,9%	1,2%	1,6%
CEER	1,1%	2,4%	2,0%	2,9%	3,2%	2,9%	2,5%	3,1%	2,7%	2,4%
Africa	1,7%	6,6%	6,8%	7,1%	5,7%	5,8%	5,4%	5,7%	6,1%	5,5%
MENA	4,4%	8,6%	10,2%	10,9%	12,3%	10,3%	8,8%	7,7%	6,8%	6,9%
MENA*	0,0%	3,3%	4,8%	4,3%	4,1%	3,4%	2,9%	2,5%	2,3%	2,4%
SSA	2,2%	6,1%	5,0%	6,2%	5,0%	5,4%	5,3%	5,9%	6,6%	5,9%

Table 13: Probability to enter a recession within Q quarters conditionally on the fact that the country is leaving one (∗ refers to groups leaving aside Irak, which impacts drastically all averages.)

Annex 5: Best Specification for each serie and each country between MSM in mean (MSMm) and MSM in mean and variance (MSMmv)

Country	Serie of growth rates for:			
	GDP	GDPpC	GDP (cyclical)	GDPpC (cyclical)
Argentina	MSMmv	MSMmv	MSMm	MSMm
Australia	MSMm	MSMm	MSMmv	MSMm
Austria	MSMm	MSMm	MSMm	MSMm
Belarus	MSMm	MSMm	MSMmv	MSMmv
Belgium	MSMm	MSMm	MSMm	MSMmv
Bolivia	MSMm	MSMm	MSMm	MSMmv
Botswana	MSMm	MSMm	MSMm	MSMm
Brazil	MSMm	MSMm	MSMm	MSMm
BrazilOE	MSMm	MSMm	MSMm	MSMmv
Bulgaria	MSMmv	MSMmv	MSMmv	MSMmv
BulgariaOE	MSMm	MSMm	MSMmv	MSMmv
Canada	MSMm	MSMm	MSMmv	MSMmv
Chile	MSMmv	MSMmv	MSMmv	MSMmv
China	MSMm	MSMm	MSMmv	MSMmv
ChinaOE	MSMm	MSMm	MSMmv	MSMmv
Colombia	MSMmv	MSMmv	MSMmv	MSMmv
Costa Rica	MSMm	MSMm	MSMm	MSMmv
Croatia	MSMmv	MSMm	MSMmv	MSMm
Cyprus	MSMmv	MSMmv	MSMm	MSMmv
Czech Republic	MSMmv	MSMmv	MSMmv	MSMmv
Denmark	MSMm	MSMm	MSMm	MSMm
Dominican Republic	MSMm	MSMm	MSMm	MSMmv
Ecuador	MSMm	MSMm	MSMm	MSMm
Egypt	MSMm	MSMmv	MSMmv	MSMmv
El Salvador	MSMm	MSMmv	MSMm	MSMmv
Estonia	MSMmv	MSMmv	MSMm	MSMm
Finland	MSMmv	MSMmv	MSMm	MSMm
France	MSMmv	MSMmv	MSMmv	MSMmv
Germany	MSMmv	MSMmv	MSMm	MSMmv
Ghana	MSMm	MSMmv	MSMm	MSMmv
Greece	MSMm	MSMm	MSMm	MSMmv
Hong Kong	MSMm	MSMm	MSMm	MSMmv
Hungary	MSMmv	MSMmv	MSMm	MSMm
HungaryOE	MSMmv	MSMmv	MSMm	MSMm
Iceland	MSMm	MSMm	MSMm	MSMm
India	MSMmv	MSMmv	MSMm	MSMmv
IndiaOE	MSMm	MSMmv	MSMm	MSMmv
Indonesia	MSMmv	MSMmv	MSMmv	MSMmv
IrakOE	MSMmv	MSMmv	MSMmv	MSMmv
Ireland	MSMm	MSMmv	MSMm	MSMmv
Israel	MSMmv	MSMmv	MSMmv	MSMmv
Italy	MSMm	MSMm	MSMm	MSMm
Japan	MSMm	MSMm	MSMm	MSMmv
Kenya	MSMm	MSMm	MSMm	MSMmv
Latvia	MSMmv	MSMmv	MSMmv	MSMm
Lithuania	MSMmv	MSMmv	MSMmv	MSMm

Country	Serie of growth rates for:			
	GDP	GDPpC	GDP (cyclical)	GDPpC (cyclical)
Luxemburg	MSMmv	MSMmv	MSMmv	MSMmv
Malaysia	MSMmv	MSMmv	MSMmv	MSMmv
MalaysiaOE	MSMmv	MSMmv	MSMmv	MSMmv
Malta	MSMm	MSMm	MSMmv	MSMm
Mexico	MSMm	MSMm	MSMmv	MSMmv
Morocco	MSMmv	MSMmv	MSMmv	MSMmv
Mozambique	MSMm	MSMmv	MSMmv	MSMmv
Namibia	MSMm	MSMm	MSMm	MSMm
Netherlands	MSMm	MSMm	MSMm	MSMm
New-Zealand	MSMm	MSMm	MSMmv	MSMm
Nigeria	MSMm	MSMm	MSMmv	MSMmv
Norway	MSMm	MSMm	MSMm	MSMm
Paraguay	MSMmv	MSMmv	MSMm	MSMmv
Peru	MSMm	MSMm	MSMmv	MSMmv
Philippines	MSMmv	MSMmv	MSMm	MSMmv
Poland	MSMm	MSMm	MSMm	MSMm
Portugal	MSMm	MSMm	MSMmv	MSMm
Romania	MSMmv	MSMmv	MSMmv	MSMm
RomaniaOE	MSMm	MSMm	MSMmv	MSMm
Russian Federation	MSMmv	MSMmv	MSMm	MSMm
RussiaOE	MSMmv	MSMmv	MSMm	MSMm
Serbia	MSMmv	MSMm	MSMmv	MSMmv
Singapore	MSMmv	MSMm	MSMmv	MSMm
Slovakia	MSMmv	MSMmv	MSMm	MSMm
Slovenia	MSMmv	MSMmv	MSMm	MSMm
South Africa	MSMm	MSMm	MSMm	MSMmv
South Korea	MSMm	MSMm	MSMm	MSMmv
Spain	MSMm	MSMm	MSMmv	MSMm
Sri Lanka	MSMmv	MSMm	MSMm	MSMmv
Sweden	MSMmv	MSMmv	MSMm	MSMmv
Switzerland	MSMmv	MSMmv	MSMmv	MSMmv
Taiwan	MSMmv	MSMm	MSMm	MSMm
Tanzania	MSMm	MSMmv	MSMmv	MSMmv
Thailand	MSMm	MSMm	MSMm	MSMmv
ThailandOE	MSMmv	MSMmv	MSMmv	MSMmv
Tunisia	MSMm	MSMm	MSMm	MSMm
Turkey	MSMmv	MSMmv	MSMm	MSMmv
Uganda	MSMm	MSMm	MSMm	MSMmv
Ukraine	MSMm	MSMm	MSMm	MSMm
United Kingdom	MSMmv	MSMmv	MSMm	MSMm
United States	MSMmv	MSMm	MSMm	MSMm
Uruguay	MSMm	MSMm	MSMm	MSMm
Venezuela	MSMm	MSMm	MSMmv	MSMmv
VenezuelaOE	MSMm	MSMm	MSMmv	MSMmv

Annex 6: List of countries dropped for group averages of MSM estimates

Using GDP growth rates

DUE TO NON CONVERGING ESTIMATIONS OR ESTIMATIONS FOR WHICH BOTH MEANS' P-VALUE IS SUPERIOR TO 10%:

Belarus, Bulgaria,China,IndiaOE, IrakOE, Israel, Morocco, Mozambique, Namibia, Poland, Tanzania, Uganda.

DUE TO ESTIMATIONS NOT IDENTIFYING RECESSIONS [15]:

Austria, Belgium, Bolivia, Brazil, ChinaOE, Dom Rep, Ecuador, Egypt, France, Germany, Ghana, Hong Kong, Iceland, India, Ireland, Italy, Japan, Kenya, Luxembourg, Malta, Nigeria, Norway, Paraguay, Singapore, Slovakia, South Korea, Sri Lanka, Taiwan, Tunisia, US.

Using the cyclical component of GDP growth rates

DUE TO NON CONVERGING ESTIMATIONS OR ESTIMATIONS FOR WHICH BOTH MEANS' P-VALUE IS SUPERIOR TO 10%:

BrazilOE, Bulgaria, Ecuador, Germany, Indonesia, IrakOE, Israel, Morocco, Namibia, New-Zealand, Paraguay, Serbia, Taiwan, ThailandOE.

DUE TO TOO LITTLE OBSERVATIONS[16]:

China, Ecuador, Egypt, Ghana, Kenya, Mozambique, Namibia, Sri Lanka, Tanzania, Tunisia, Uganda, Ukraine.

Using GDP per Capita growth rates

DUE TO NON CONVERGING ESTIMATIONS OR ESTIMATIONS FOR WHICH BOTH MEANS' P-VALUE IS SUPERIOR TO 10%:

Belarus, Bulgaria, China, Ghana, IrakOE, Israel, Mozambique, Namibia, Poland, Sri Lanka, Tanzania.

DUE TO ESTIMATIONS NOT IDENTIFYING RECESSIONS[15]:

Austria, Brazil, ChinaOE, Ecuador, Egypt, France, India, IndiaOE, Ireland, Japan, Malta, Norway.

Using the cycilcal component of GDP per Capita growth rates

DUE TO NON CONVERGING ESTIMATIONS OR ESTIMATIONS FOR WHICH BOTH MEANS' P-VALUE IS SUPERIOR TO 10%:

Bulgaria, Croatia, Ecuador, IrakOE, Israel, Morocco, Paraguay, Serbia, ThailandOE.

DUE TO TOO LITTLE OBSERVATIONS[16]:

China, Ecuador, Egypt, Ghana, Kenya, Mozambique, Namibia, Sri Lanka, Tanzania, Tunisia, Uganda, Ukraine.

[15] I include countries for wich the mean of the low regime has a p value superior to 10%.

[16] A threshold of one third of the maximum number of observations is chosen here.

Annex 7: Filtered Probability (red) and Recessions identified by the Algorithm (blue)

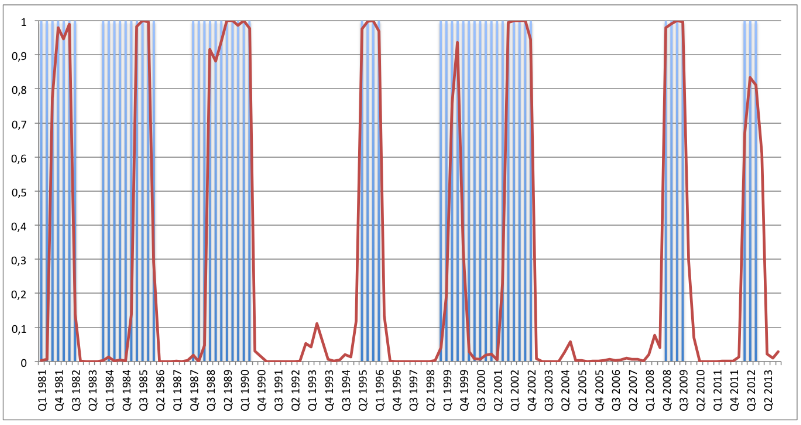

Figure 7: Argentina

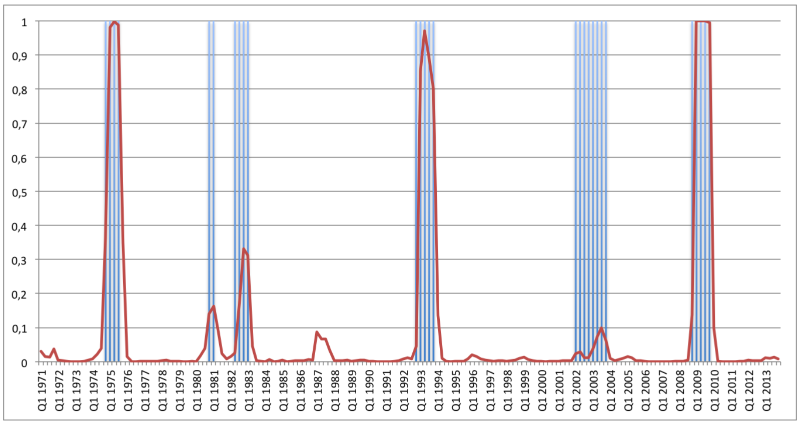

Figure 8: Germany

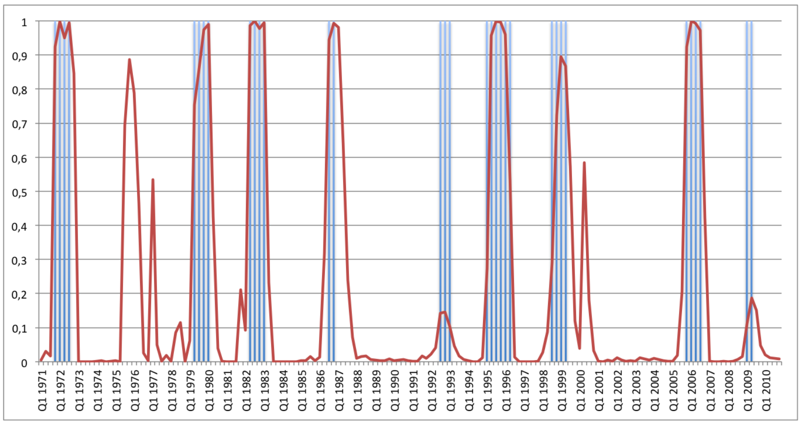

Figure 9: Hong Kong

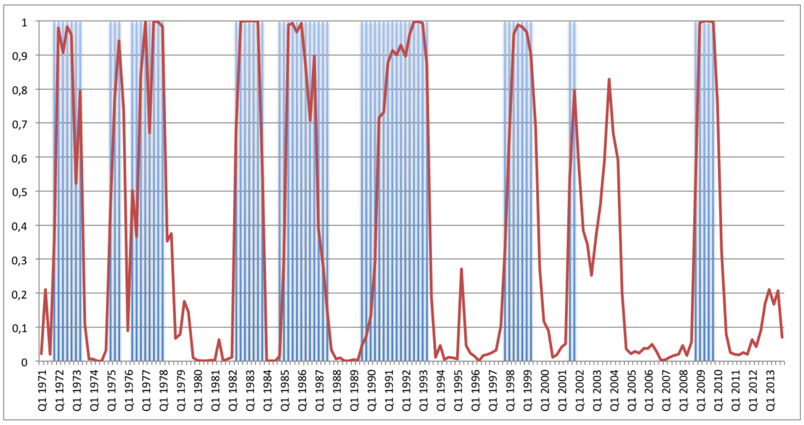

Figure 10: South Africa

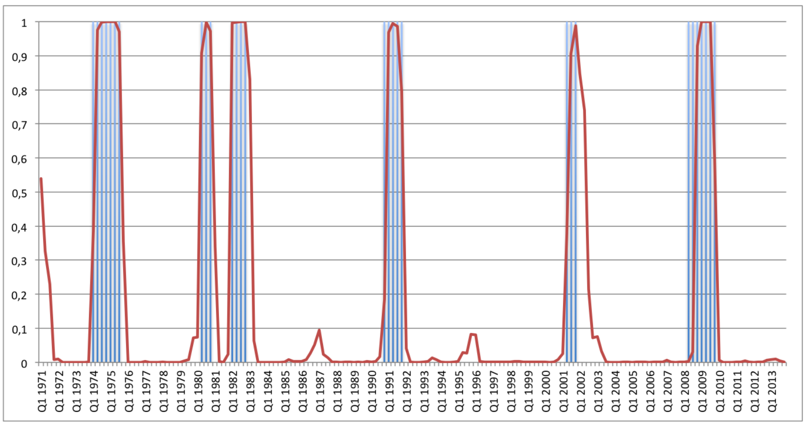

Figure 11: US