**Non-parametric detection Method of multiple breaks**

**in the time series of exchange rates:**

 **Application to MENA countries**

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Abstract
The detection and estimation of behaviour change in economic series consists in locating the moments or certain characteristics of the series change. Changes in the characteristics of these series can be observed at the mean, variance or mean and/or variance level. For example, it may involve detecting the moments of transition from one equilibrium to another in an economic series or locating the transitions of variance and covariance structure of these univariate or multivariate economic series. Changes can generally be transitory or instantaneous

We place this problem in a statistical framework where instantaneous changes are then called ruptures. prediction, etc. Quality control of manufactured products is one of the applications behind failure detection (Shewart.1931) The 1950s are an important step in the evolution of the formalisation of the problem.

Keywords: exchange ratre , reserves , multiple breaks , non parametric Detection method

# 1. Introduction

From the practitioner’s point of view, procedures for the detection of ruptures are of great interest because the process that generates the data being studied is unknown. In addition, economic data are usually non-stationary, and it may be interesting to approximate an unknown process, and may be non-stationary, by stationary local processes; see for example Dalhaus [1997].

Since then the detection of ruptures has aroused a growing interest among the community in can cite the works of Basseville and Nikiforov [1993], Brodsky and Darkhovsky [1993], Csörgö and Horváth [1997], Chen and Gupta [2000]. Articles by Giraitis and Leipus [1992,1990], Hawkins [1977, 2001], Chen and Gupta [2004], Mia and Zhao [1988], and Sen and Srivastava [1975] among others are also of interest

The occurrence of a single break on real data is rather rare, as economic, financial, hydrological, biological, electrotechnical, etc., data present multiple breaks: see for example Schechtman and Wolfe [1985], Braun et al. [2000]. A statistical procedure capable of detecting multiple breaks is therefore of practical interest. It has often been argued that test procedures for single ruptures can be extended to the case of multiple ruptures using the Vostrikova binary segmentation procedure [1981 ], which consists of applying the single rupture detection procedure on the complete sample, then divide the series in half at the point of failure detected, and iteratively apply the break detection procedure on both segments until no break is found.

Two types of fracture detection methods can be distinguished: sequential methods (generally oriented to monitoring) and non-sequential methods (more specifically dedicated to posteriori analysis). The fundamental difference between these two families is the constraint on the detection time. It should be as short as possible for sequential methods, hence a decision has each observation. On the contrary, non- sequential methods (for example for descriptive purposes) are not necessarily constrained by the urgency of detection. Therefore, treatment is performed after the full observation phase. Whereas non-sequential methods are evaluated by their probability of not detecting and their probability of false alarm the assessment of the performance of the sequential methods must also take into account the detection time.

It should be noted, however, that the boundary between these two types of methods is not as clear to the extent that sequential methods can be used on non-sequential problems and vice versa. Examples include Brandt (1983) and Delyon et al (1988) Andre Brecht (1993) where sequential fault detection methods are applied to the segmentation of speech signals. The scope covered by failure detection has expanded considerably. The subjects involved in monitoring are very diverse in nature. Indeed, this may concern industrial infrastructures, hydrological, biological, electrotechnical data, etc., which may be subject to natural vibrations or hazards, etc. Applications to biomedical signals can be oriented surveillance when it comes to monitoring an individual’s physiological state But they can also be oriented analysis when the signal is segmented into stationary areas for a descriptive purpose.

Other applications exist in growing areas such as the exchange rate market and financial markets in general. Rupture detection can be used as a time segmentation method prior to a segment recognition phase. Recent work on the segmentation of an economic series can be found in Benoît Perron (2004), and Delgado and Hidalgo (2000).

##### The purpose of this application is to provide formal and methodological benchmarks on the detection of breaks in financial series, in particular the exchange rate series.

##### In section 2, we first introduce the necessary formalism and then define the type of study approach. We end with a presentation of examples of known methods that are references in the construction literature of advanced warning systems.Section . 3 is devoted to the segmentation method proposed in this application.Section 4 describes the interpretation of the results found. Finally, an annex summarizing all the results found in the form of tables and graphs

##### 2. Formulation de la détection et estimation des ruptures :

Either  a discrete time m-dimensional process that changes abruptly and is characterized by a parameter Ө that remains constant between two breaks.

It is assumed that there are moments  = such that the process is stationary over each time interval with the convention  =0. The homogeneity in the segment, a hypothesis, is thus modelled by the stationarity of the process.

The moments are the moments of change of stationary distribution of the process and are called moments of breaks.

We note  is an observation of the variable .

The detection and estimation of ruptures consists in locating the possible moments of ruptures on a sequence of observations d’observations ( ) of the process Y. The criteria for classifying problems of detection and estimation of ruptures are multiple To retain only those which seem to us the most essential,

Examples include:

Knowledge a priori about segment distributions:

distributions of segments belonging to an unknown family,

distributions of segments belonging to a parameterized family, described by a continuous parameter, no prior information on segment distributions.

Knowledge a priori on the distribution of moments of rupture:

moments of random breaks

deterministic moments

###### We present, respectively, some non-sequential and sequential methods of rupture detection.

###### 2..1. Non-sequential methods

A non-sequential method is the detection and estimation of possible ruptures after a complete observation phase of the process..**..** Two types of methods can be distinguished ;the overall approaches which attempt to estimate the breaks parameters jointly and directly from the observations ( ) of the Y process and on the other hand the local methods which propose to reduce themselves locally to the case of a single possible rupture and to process the signal as it is processed

###### 2..2 Sequential Methods:

A sequential method of break detection is a method which, at each observation moment, makes a decision of absence or presence of a rupture (with a possible delay ,or intrinsic delay ). Sequential methods are better suited to some monitoring problems, although they also apply to other failure detection problems. The theoretical framework of these methods is that of the sequential tests presented for example in [ Siegmund, 1985], [Basseville and Nikiforov, 1993]. the Sequentially is not a concern of this work. We shall mention the principle of two well-known sequential rupture detection algorithms in the literature: the Brandt algorithm [Brandt, 1983 ], and the divergence algorithm [André- Obrecht ,1983] [Basseville and Nikiforov, 1993] [Delyon et al ,1988]

###### 3. Proposed Segmentation Method

###### The purpose of this section is to detail the method for detecting statistical breaks on various united time series proposed in this work. The formalism and ratings are identical to those introduced at the beginning of this part.

###### First, we present the motivations of the proposed approach, which is then described, and finally, we present experiments in detecting breaks in the various economic series, in particular in the exchange rate series.

###### 3.1.MotivationsThe statistical break detection methods discussed above are generally based on a break detection statistic calculated at each moment followed by the extraction of a criterion from which the break moments are estimated rupture must have good properties which are most often guaranteed by comparing observations before and after the current moment. The calculation of the rupture criterion allowing the extraction of the rupture moments is very often the most delicate phase to be implemented.

###### 3.2.PROPSED METHOD :

**3.2.1 Description of the proposed basic method:**

A single break in actual data is rather rare, as economic, financial, l, biological, etc., data have multiple breaks: see for example Schechtman and Wolfe [1985], Braun et al. [2000].

A statistical procedure capable of detecting multiple breaks is therefore of practical interest. It has often been argued that test procedures for single ruptures can be extended to the case of multiple ruptures using the Vostrikova binary segmentation procedure [1981], which consists of applying the single break detection procedure on the complete sample, then divide the series in half at the point of break detected, and iteratively apply the rupture detection procedure on both segments until no further rupture is found.

Recent studies have addressed the problem of comparing global and local detection procedures, and found that the use of local detection procedures to detect multiple ruptures using the binary segmentation method was misleading and led to an overestimation of the number of ruptures

A global approach means that all ruptures are detected simultaneously. These breaks are estimated by minimizing a penalized contrast function J ( ,y) + pen( ) (see [Birge, L., and Massart, P. (2001). Yao, Y.C. (1988). ]).

Here, J ( , y) measures the fit of the model whose sequence of breaks is with the observed series y. Its role is to locate breaks as accurately as possible. To detect breaks in the mean and/or covariance matrix of multivariate series, the contrast function J ( , y) is defined from the logarithm of the Gaussian likelihood function, even if the observations are not Gaussian

The penalty term pen( ) depends only on the K( ) dimension of the model and increases with K( ). The penalty parameter adjusts the compromise between the minimization of J ( , y) (obtained with a large dimension of ) and the minimization of pen( ) (obtained with small dimension of ).

We will see that this approach is also very useful for practical applications, to detect breaks in the mean and/or variance of multivariate series, with the restriction that these series have a common segmentation . An adaptive method is proposed to estimate the number of ruptures.

**3.2 .2THE ADAPTATIVE METHOD**

The proposed method requires careful inspection of the {li} length sequence but is difficult to automate. An alternative approach to selecting the model that provides very good results and is much easier to automate for practical applications.

**The idea of this method is to model the decay of the suite** {}**when there is no break in the series** { } **and to look for which value of K this model adjusts the series of observed contrasts.**

Without a break in the variance, the joined distribution of the sequence {}is very difficult to calculate analytically, but some Monte-Carlo simulations show that this sequence decreases as K + K log (K).

**Algorithme 1**for i = 1, 2, . . .,

model fit:
= K + K log (K) +  ,

to the series, {, K  Ki}, , assuming {}is a series of centered and i.i.d.Gaussian random variables

ajustement du modèle :

= K + K log (K) +  ,

à la série {, K  Ki}, en supposant que {} est une suite de variables aléatoires gaussiennes centrées et i.i.d.,

assessment of the probability that  follows this model also, i.e. estimate the probability
under the estimated model

.=,

Then the estimated number of segments will be the largest value such that the P-value is smaller than a given threshold.  20 20 in numerical examples

**3.2.3 DATA DESCRIPTION**

The model is estimated using monthly data from January 1980 to March 2014 for 7 MENA countries: Tunsia, Algeria, Marroc, Egypt, Turkey, Jordan and Saudi Arabia (a total of 410 observations) for countries. The bulk of the data was provided on the International Monetary Fund (IMF) International FinancialStatistics (IFS) CD-ROM.The results founded using the Matlab software will be discussed in the following section

**4.Analysis and results:**
In this section we confine ourselves to a preliminary analysis of the results provided by the Matlab software by applying the adaptive method described above for the case of Tunisia. The results are provided by the following tables and graphs:

***Case of Tunisia :***

*Table1.A* :Detection of multiple breaks in the mean of the exchange rate series (1980M1-2014M3)

|  |  |  |  |
| --- | --- | --- | --- |
| K | l(K) | p(K) | g(K) |
| 1 | Inf | 5.0e-005 | 1.00 |
| 2  | 6.0  | 3.3e-013  | 9.11 |
|  3  | 1.3  | 1.6e-009  | 2.04 |
|  4  | 0.2  | 9.9e-002  | 0.37 |
|  7  | 0.1  | 1.4e-004  | 0.18 |
|  8  | 0.1  | 3.8e-005  | 0.14 |
| 10  | 0.1  | 3.2e-002  | 0.09 |
| 15  | 0.0  | 1.1e-002  | 0.02 |
| change-points with 8 segments: 16 41 70 206 242 276 383 |
| p-value = 3.81e-005 |
| fitted function: J(K) = 3.315 -0.1053 K log(n/K) |

**Table1.B :Detection of multiple breaks in the variance of the exchange rate series (1980M1-2000M9)**

|  |  |  |  |
| --- | --- | --- | --- |
| K | l(K) | p(K) | g(K) |
| 1 | Inf | 5.0e-005 | 1.00 |
| 2 | 34.2  | 7.3e-006  | 2.10 |
| 5 | 10.6  | 1.9e-005  | 0.60 |
| 9 | 3.7  | 1.3e-001  | 0.24 |
| 13 | 1.7  | 2.9e-002  | 0.19 |
| 17  | 1.4  | 3.6e-001  | 0.15 |
| change-points with 5 segments: 26 206 241 276 |
| p-value = 1.9e-005 |
| fitted function: J(K) = 2509 -9.363 K log(n/K) |

*Tableau1.C* :Detection of multiple breaks in the mean and variance of the exchange rate series (1980M1-2000M9)

|  |  |  |  |
| --- | --- | --- | --- |
| K | l(K) | p(K) | g(K) |
| 1 | Inf | 5.0e-005 | 1.00 |
| 2 | 215.5  | 7.2e-010  | 3.07 |
| 3 | 89.5  | 1.5e-006  | 1.27 |
| 4 | 14.4  | 2.4e-001  | 0.21 |
| 5 | 13.5  | 4.3e-001  | 0.34 |
| 10 | 12.5  | 4.5e-003  | 0.18 |
| 16 | 3.0  | 1.1e-001  | 0.05 |
| change-points withsegments: 15 233 |
| p-value = 1.5e-006 |
| fitted function: J(K) = 2750 -37.06 K log(n/K) |

Figure 1.A : detection of multiple breaks in the mean of the exchange rate series:



Figure 1.B :detection of multiple breaks in the variance of the exchange rate series:



Figure 1.C : detection of multiple breaks in the mean and variance of the exchange rate series:



Figure 2.A : detection of multiple breaks in mean of the series of reserves

Figure 2.B : detection of multiple breaks in the variance of the series of reserves:



Figure 2.C : detection of multiple breaks in the mean and variance of series: of the reserve:



The method applied to 410 observations on the exchange rate over the period January 1980 to March 2014 makes it possible to detect possible breaks in mean, variance and mean and variance.

Table 1.A allows us to detect the sequences of turning points in the series of exchange rates, we see that this series on average is characterized by a number of sequences of breaks K whose length l (K) is zero and a very low P-value.

However, Table 1.B describes the number of breaks and their corresponding dates in terms of the variance which detects a break for the date t = 60 which corresponds to the month of November 1984.

We have considered the 410 observations for the series of exchange rates taken as first difference, algorithm 1 using Matlab software provides us with the figures below.

Figure 1.A below depicts the series with estimated break points represented by a vertical line. We note the absence of breaks in this case.

The one at the top translates the sequence of contrasts which are indicated by the + sign, the fitted function is drawn by a solid line and JK is represented with a circle.

Figure 1.A below depicts the series with estimated break points represented by a vertical line. We note the absence of breaks in this case.

The one at the top translates the sequence of contrasts which are indicated by the + sign, the fitted function is drawn by a sol

 Figure 1.B allows us to see a break at point t = 60 or M11 1984, the middle curve describes the sequence of contrasts, a vertical line in this case indicates the estimated number of segments.

The estimation results for the rest of the countries studied are provided by the following graphs:

***Cas du Maroc :***

Figure 1.A detection of multiple breaks in the mean of the exchange rate series:

 (1980 M1 – 2014 M3)



Figure 1.B detection of multiple breaks in the variance of the exchange rate series (1980 M1 – 2000 M9)



Figure 1.C detection of multiple breaks in the mean and variance of the exchange rate series (1980 M1 – 2000 M9)



***Cas de l’Algerie  :***

Figure 1.A detection of multiple breaks in the mean of the exchange rate series:

 (1980 M1 – 2014 M3)



Figure 1.B detection of multiple breaks in the variance of the exchange rate series (1980 M1 – 2000 M9)



Figure 1.C detection of multiple breaks in the mean and variance of the exchange rate series (1980 M1 – 2000 M9)



***Cas de l’Egypte  :***

Figure 1.A detection of multiple breaks in the mean of the exchange rate series:

 (1980 M1 – 2014 M3)



Figure 1.B detection of multiple breaks in the variance of the exchange rate series (1980 M1 – 2000 M9)



Figure 1.C Détection des ruptures multiples dans la moyenne et la variance de la série de taux de change (1980 M1 – 2000 M9)



***Cas de la Jordanie :***

Figure 1.A detection of multiple breaks in the mean of the exchange rate series:

 (1980 M1 – 2014 M3)



Figure 1.B detection of multiple breaks in the variance of the exchange rate series (1980 M1 – 2000 M9)



Figure 1.C detection of multiple breaks in the mean and variance of the exchange rate series (1980 M1 – 2000 M9)



***Cas de la Turquie :***

Figure 1.A detection of multiple breaks in the mean of the exchange rate series:

 (1980 M1 – 2014 M3)



Figure 1.B detection of multiple breaks in the variance of the exchange rate series (1980 M1 – 2000 M9)



Figure 1.C detection of multiple breaks in the mean and variance of the exchange rate series (1980 M1 – 2000 M9)



***Cas de l’Arabie Saoudite :***

Figure 1.A detection of multiple breaks in the mean of the exchange rate series:

 (1980 M1 – 2014 M3)



Figure 1.B detection of multiple breaks in the variance of the exchange rate series (1980 M1 – 2000 M9)



Figure 1.C detection of multiple breaks in the mean and variance of the exchange rate series (1980 M1 – 2000 M9)



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