ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SOCIAL SCIENCES

THE RELATIONSHIP BETWEEN CURRENCY CRISES AND EXCHANGE RATE REGIMES : A NON-PARAMETRIC APPROACH

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ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SOCIAL SCIENCES

DÖVİZ KURU KRİZLERİ İLE DÖVİZ KURU REJİMİ ARASINDAKİ İLİŞKİLER

YÜKSEK LİSANS TEZİ

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FOREWORD

I would like to express my deep appreciation and thanks for my advisor and ITU Scientific Research Projects (BAP) for providing us with financial support and software facility. Furthermore, I wish to thank my parents, Jolchu Tolubaev and Inobat Tolubaeva for their love, support and understanding. So, dedicating this thesis to my parents would be the best way to express my gratidude and love for them.

June 2010 Chynara TOLUBAEVA

M.A.Economics

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ABBREVIATIONS

CC : Currency crises
ERRC : Exchange rate regime choice
LS : Levy-Yeyati and Sturzenegger
R&R : Reinhart and Rogoff
CART : Classification and Regression Trees
EMPi : Exchange Market Pressure index
OCA : Optimal currency area
EMS : European Monetary System
TN : Terminal node
RER : Real exchange rate

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RELATIONSHIP BETWEEN CURRENCY CRISES AND EXCHANGE RATE REGIMES : A NON- PARAMETRIC APPROACH

SUMMARY

The crisis concept has long been an interest for economists. In this study, by using Classification and Regressin trees analysis which is a non-parametric approach, we are going to study possible relationship between regime choices and currency crises. More precisely, we are investigating whether the path leading to currency crises differs under different regimes. For instance, for a country under fixed exchange regime, the overvaluation of the real effective exchange rates could be considered as one of the causes of crises, but it is hard to find such vulnerability in a country pursuing an independently floating regime. The theoretical literature has been emphasizing the importance of regime choices, whereas it has been undervalued in empirical studies. One of our findings is that the paths leading countries to currency crises under fix, intermediate and floating regimes differ. Hence, by growing a binary classification tree for all regimes mixed in one sample, it becomes hard to detect exact relationship between crises and regime choices. Therefore, in order to get more reliable and significant results observations under each regimes should be analyzed separately. And this can be considered as the contribution of this study to the literature.

DÖVİZ KURU KRİZLERİ İLE DÖVİZ KURU REJİMİ ARASINDAKİ İLİŞKİLER

ÖZET

Bu deneysel çalışmada, Sınıflandırma ve Regresyon Ağaçları (Classification and Regression trees) adlı parametrik olmayan analiz yöntemini kullanarak ülkelerin izledikleri döviz kuru rejimleri ile krize götüren sebepler arasındaki ilişkiyi araştırıyoruz. Örneğin, sabit döviz kuru rejimi altında reel döviz kuru değerlenmekte ve bu o ülkeyi krize sebep sürükleyen önemli faktörlerden biri olabilirken serbest dalgalanma rejimi altındaki bir ülkede böyle bir sorun yaşanmayabilir. Teorik kriz çalışmalarında döviz kuru önemli bir rol oynarken deneysel literatürde bu göz ardı edilmiş, örneklem seçimlerinde kur rejimine dikkat edilmemiştir. Dolayısıyla bu çalışmanın amacı birbirine doğal olarak bağlı olan ancak var olan çalışmalar tarafından işlenmemiş olan bu bağıntıyı -döviz kuru seçiminin kur krizleri ile olan ilişkisini- kurmaktır. Dalgalı, sabit ve ara kur rejimi altında olan ülkelerin kriz ve durgun gözlemlerini bir örneklem içine alarak araştırmak yanlış sonuçlar verebilir. Bu yüzden her rejime ait gözlemleri üç ayrı örneklemlere ayırarak krize uğrama yollarını araştırmak ve istatistiksel ve iktisadi anlamda daha güvenilir sonuçlara ulaştırabilir. Bu da çalışmanın literatüre yaptığı bir katkı olarak değerlendirilebilir.

1. INTRODUCTION

The crisis concept has long been an interest for economists. Specifically affected by the Mexican Tequila (1994), Asian flu (1997), Russian currency market instabilities in 1998 and Argentina (2001) crises, plenty of empirical researches have been done in order to identify the potential causes of speculative attacks which lead to crises. After experiencing the "pain" or cost of entering the crisis period, researchers started analyzing the optimal macroeconomic policies which could prevent from entering, or at least avoid harsh economic consequences of it. Economists such as Krugman (1979) and Obstfeld (1996) have constructed so called "generation models" of currency crises (CC, hereafter) in which they have been focusing on country-specific characteristics as potential causes of crises.

Contrary to Frankel (1999)[1] much of policy makers have been considering an exchange rate regime choice (ERRC, hereafter) to be independent from country-specific vulnerabilities. This was the reason for peg regimes to be of high popularity among countries in post Bretton Woods's period, due to its beneficial effect on taming the inflation. After subsequent financial crises in Europe (1992-93), Latin America (1994-95), and Southeast Asia (1997-98), it has been acknowledged that prior models have become less helpful in explaining the causes of recent crises. Hence, the harsh experience of entering the crisis period has led to renew the models that are capable of detecting the crisis periods as well as avoiding unfavorable economic consequences of it.

Each of experienced crises episodes were of different types, which is attributable to the differentiation of the crises concept inside itself. For instance, Jacobs, Kuper and Lestano (2003) identify three types of financial crises, which are currency crises, banking and debt crises. On the other side, Kaminsky (2003) has distinguished currency crises into six varieties.

[1] Frankel (1999) states that the choice of the regime should be consistent with structural (fundamental), political and financial features of the country

Most of empirical studies analyzed exchange rate regimes and currency crises independently from each other, mainly concentrating on the marginal contribution of various indicators and identification of currency crises periods. Compared to currency crises literature, there are limited numbers of studies which dwell on topics such as: effects of regime switching on economic growth; possibility of optimal regime etc. Being slightly differentiated in terms of methodology and data used, there are only few papers similar to ours, such as Eichengreen and Rose (1998), Haile and Pozo (2006) in which they have tested empirically the particular relevance of exchange rate regimes to currency crises. Thus, the issue of conditional probability of experiencing CC while remaining on particular regime is found in the intersection of two literatures: regime choice and currency crises.

This paper is aimed to contribute to this scarce empirical literature by assessing whether the paths leading to currency crises vary under different regimes. In addition, along with macroeconomic indicators we want to discuss the role of ERRC in making CC. In other words, we claim that inappropriately chosen regime along with country specific vulnerabilities and fragilities may lead a way to a crisis. For instance, it is reasonable to think that, a higher inflation relative to trading partners is worrisome for a fixed regime country but maybe not so much for a floating regime country since the extent of the real exchange rate overvaluation will be much higher in the former country than the latter.

In a study like this, it is important to determine which classification of exchange rate regime to choose. There are two types of classifications, known as *de facto* and *de jure* classifications. Until 2005, most of studies have been using the IMF *de jure* classification which includes official rates, mainly based on regimes announced by governments. However, Calvo and Reinhart (2002), Reinhart and Rogoff (2002), Obstfeld (1996) and Rogoff (1995) observed that even if some countries say that they allow to float/fix, indeed they do not- which seems to be a case of “fear of floating/fixing”. Furthermore, it became known that using IMF *de jure* classification became less reliable and yielding misleading results. For instance, R&R (2004) find that most of floating regime countries in post 80s turns out to be *de facto* pegs or crawling pegs. Therefore, we have been determined in using a *de facto* exchange rate classification. There are two types of *de facto* classifications, constructed by Levy-Yeyati and Sturzengger, 2005 (LS, hereafter) and Reinhart and Rogoff, 2004 (R&R,

hereafter), respectively. In our empirical analysis, we use a Reinhart and Rogoff exchange rate *de facto* classification, which is based on market-determined parallel exchange rate data. The distinguishable feature of R&R classification is that it defines broad range of exchange rate regime categories, which includes many intermediate arrangements, with different degrees of flexibility and commitment by government authorities.

In the analysis, we use a non-parametric Classification and Regression trees (CART) methodology to analyze the occurrence of currency crisis under different regimes. CART being developed by Breiman, Freidman, Stone and Olshen in 1984, has some distinguishable features over standard parametric approaches, specifically when there is a non-linear relationship rather than linear between explanatory variables, such as crises.

The remainder of this paper is organized as follows. Section 2 describes separately the brief overview of empirical and theoretical studies on currency crises and exchange rate regimes, done so far. Section 3 concentrates on methodological issues. Section 4 explains the measurement of Exchange market pressure index (EMPi). The data are described in Section 5. In section 6 we present main results of Classification and Regression Trees (CART). Finally, section 7 concludes the paper.

2. LITERATURE REVIEW

2.1 ERRC literature

This study aims to link two concepts, ERR choice and CC. As the financial globalization and trade linkages have been deepening in late 80s and 90s, the question of “which regime would be appropriate for all times” is gaining greater importance. The theoretical literature on ERRC was initiated by Mundell (1961), in which he proposes the concept of Optimal Currency area (OCA), which explains the choice of regime to depend on country’s structural features such as: the degree of trade integration, openness, size of the economy, and the magnitude of nominal/ real shocks the country is exposed to. Besides of OCA, countries’ political and financial characteristics may be attributable to the regime choice. Stein and Frieden (2001), Levy-Yeyati et al. (2006) have used both political economy variables as potential determinants of regime choice.

The literature on ERRC puts forward three main concepts which may affect the choice of regimes: i) Optimal Currency area (OCA), the idea which was firstly initiated by Mundell; ii) financial view; iii) political view. In financial view, by testing the financial determinants of regime choice they analyze whether existence of currency mismatches and impossible trinity hypotheses are considered to be concerns for regime decision.

In terms of political view, authors present two arguments: “policy crutch” and “sustainability”. They find that weak emerging economies tend to use pegged regimes as a policy anchor with the aim of taming the inflation. From the “sustainability” perspective, political strength is a measure of propensity to peg. In other words, weak governments have difficulties in sustaining pegged regimes due to the deficits in domestic macroeconomic accounts.

Besides there are many other publications on potential determinants of the choice of regimes, but most of them have been investigating in parts and were not successful in a wider perspective, except for the study done by Levy-Yeyati, Sturzenneger and

Reggio (2006), which supports the spirit of theories mentioned in the above. Separately and jointly, authors compare how well and to what extent other approaches are successful in explaining the choice of exchange rate arrangements. A pooled logit regression for 183 countries with 1974-1999 time period was conducted, in which a dependent variable takes a value one if a country is identified as a *de facto* fixed regime, and is marked zero if it is classified as soft, flexible according to the Levy-Yeyati and Sturzenegger *de facto* exchange rate classification. They derive following conclusions: OCA theory is empirically supported in both industrial and non-industrial countries; however, the financial integration induces a more flexible regime in industrial countries, and converse holds in non-industrial economies; in terms of political view, authors come to conclusion that countries' choice of a peg diminishes if the government is weak and incapable to sustain it.

Another empirical analysis is conducted by Levy-Yeyati and Sturzenneger (2003) on the impact of exchange rate regimes on economic growth. Authors study how the choice of the regime affects the growth performance both in developing and industrial countries. Their data span 183 countries over the 1974-2000 periods. In their paper, they use LS exchange rate *de facto* classification, which differs from Reinhart and Rogoff's in terms explanatory variables used. To solve the problem of inconsistency between declared and actual policies, they have constructed a new classification based on Exchange rate and international reserves data for all IMF-reporting countries from 1974-2000 (2003). They find: for industrial countries regimes do not appear to have a significant role; for developing economies less flexible ERR are associated with slower growth and greater output volatility.

2.2 Currency crises literature

Due to the subsequent changes in trade and financial interdependence, the crises models have been changing. The financial crises of Latin America countries in 1960s and 1970s have led to construction of first-generation of crises models (Krugman (1979) and Flood and Garber (1984)). The main cause of first generation models is the inconsistency of expansive monetary policy and fixed exchange rate regime. In countries where capital is freely mobile, against the speculative attacks monetary authorities have two choices: either to hold a pegged regime or increase the interest rate by sustaining the floating regime. This argument is supported by so called "impossible trinity" concept, which states that if a pegged regime country with no capital controls imposes an independent monetary policy at the same time, experiences high risk of its' reserve overloss. The incidence of EMS crises in early 1990s could not be explained by first generation models, which was a turning point for the development of second generation models (Morris and Shin (1995), Obtsfeld (1994 and 1996)). As main sources of fragilities it focuses on countries countercyclical policies in mature economies and self-fulfilling feature of crises. Next third generation models of crises were developed, due to the failure of existing models in explaining the causes of crises, which focuses on imperfect information and moral hazard which result in financial excess problems (Burnside, Eichenbaum and Rebelo (2004), Chang and Velasco (2001)). Further empirical studies can be listed as follows.

By analyzing the data of five currency crises episodes of previous decades, Glick and Rose (1998) could show that currency crises spread with ease across countries which are closely related to each other in terms of international trade linkages. Furthermore, they put emphasis on the fact that currency crises as well as trade linkages tend to be regional, which means that they affect countries in geographical terms. Although, according to the most known two speculative attack models presented by Krugman (1979) and Obstfeld (1996), at first sight it is hard to understand the concept of being "regional" for currency crises, the authors demonstrate that trade linkages seem to be the only way for currency crises to be regional.

Eichengreen et al (1995) define an extensive definition of currency crises. It comprises a large depreciation of a currency and unsuccessful attacks which are neutralized by monetary authorities. They propose idea of an unsuccessful speculative attack which can be measured by sharp loss in international reserves and/or increase in interest rates.

In her paper, Tudela (2001) focuses on the origins of the currency crisis by using the duration analysis, in which she aims to measure the impact of different explanatory variables on countries' probability to leave a tranquil state- exiting to a currency crisis state. Furthermore, she tests whether the duration of time spent in a tranquil period could be a significant determinant of the likelihood of exit to a crisis period. Although most of the recent empirical studies on dating crises were of logit or probit type, she uses a duration analysis as she believes that it is an innovative strategy which is able to detect the time dependency problem among indicators. According to Tudela, merely looking on currency devaluation is not a right way to forecast the crisis when the data is not limited to emerging countries, because speculative attacks on a currency can be prevented by monetary authorities, which results in unsuccessful attacks.

Similar idea was presented by Rose and Frankel (1996). The data is collected for over one hundred developing countries, starting from 1971 until 1992. Their objective was to examine the potential causes of currency crashes by relying on dataset of developing economies. According to authors, currency crash is defined as a depreciation of nominal exchange rate by at least 25 percent, and a 10 percent increase from the previous years' rate of nominal depreciation. The study being limited with developing countries, authors believe that it is sufficient to analyze a depreciation in nominal exchange rate as a key indicator of a currency crash, because due to the lack of data and information it is of great difficulty to measure the policy decisions for most of relevant countries.

Similar to Rose and Frankel (1996), Kumar, Moorthy and Perraudin (1998), Blanco and Garber (1986) use logit models to measure the likelihood for a country with particular economic and financial vulnerabilities to face devaluation. In contrast to Tudela's work, the authors focus only on emerging countries, for which the currency devaluation is considered as a warning signal of a possible currency crisis. In probabilistic estimations such as Logit/Probit, the relative importance of indicators is not emphasized.

A totally different approach was used by Kaminsky, Lizondo and Reinhart (1998), Eichengreen, Rose, and Wyplosz (1995), Kaminsky and Reinhart (1996), who examine the probability of facing a currency crisis and propose the early warning system. This system monitors the movement or behavior of several indicators prior to crisis. A currency crisis is defined to occur when an index computed by signal's approach, which is a weighted average of selected explanatory variables exceeds its mean by more than three standard deviations. Both mean and standard deviations are country specific, and calculated separately for countries experiencing a hyperinflation. Hence, whenever the index exceeds the threshold, the warning system issues a signal, which forecasts that currency crisis may occur within the following 24 months.

There are also country specific papers written on the impact of currency crises. For instance, a case study on Indonesia was prepared by Cerra and Saxena (2000) analyses the Asian currency crises, but specifically focuses on Indonesia, because the authors argue that the clearest case of "crisis contagion" issue is attributable to Indonesia. In their paper, besides of using Markov-switching models, they construct the Market Pressure Index, which is one of the measures of speculative pressure index. The main idea of the paper is that, Indonesia's case does not suit the first and second generation models, because prior to the crisis, most of south East Asian countries exhibited no signs of economic recession. Indeed, due to the high annual economic growth of some countries in South Asia in late 1980s and early 1990s, the title of Asian Tigers was awarded. This challenging side gave rise to new currency models which put emphasis on contagion.

Furthermore, Fratzcher (2000) points out that an importance of a contagion, which is measured by degree of real integration and financial interdependence among neighboring countries, as a macroeconomic indicator is underestimated in explaining the occurrence of crises.

Other closely related set of studies which comprises currency, banking and debt crises is named as financial crises literature. According to Bordo and Eichengreen (2000) and Bordo et al(2001) financial crises episodes include Tequila crisis which has arose due to the Mexican Peso devaluation in 1994; the Asian flu (1997) which has started right after Thailand's currency devaluation etc. There are plenty of different examples of financial crises resulting from different reasons; some of them were due to the currency devaluation, external debt and liabilities, or the collapse of banking sector. Hence, in both empirical and theoretical research financial crises are decomposed into three types: currency crises, banking and debt crises. Indeed, the new phenomenon named "twin crises"- a joint occurrence of banking and currency crises has been widespread. For instance, Glick and Hutchison (1999) analyze the scope and causes of banking and currency crises of 90 industrial and developed countries over the 1975-1997 period. They investigate the possible linkages between these two crises by using the signal-to-noise methodology. As a result of the empirical investigation, they could find that financially liberalized emerging countries with high degree of openness are more prone to face the twin crises. In addition, they arrive at an opinion that occurrence of banking crises is a useful indicator of entering a currency crisis period for emerging markets. However, the converse does not hold.

The most similar work to our paper is done by Haile and Pozo (2006). They empirically test whether exchange rate regime choices affect countries entering the crisis period. Their approach differs from ours in two respects: The first is that they use extreme value theory to date the crisis episodes in contrast to our use of EMP index. And the second is that they classified regimes according to LS classification scheme where as the present paper employs RR scheme. They find that IMF *de jure* classification affects the likelihood of currency crises. In addition, they observe that even if actual exchange rate regime is not pegged, the announced pegged regimes increase the probability of currency crises.

2.3 The link between the regime choice and the currency crisis

The frequency of currency crisis increased significantly in the post-Bretton Woods period (Calvo and Reinhart, 2002). Some observers accuse intermediate exchange rate regimes stating that soft pegs are much more crisis prone than any other regime (Fischer 2001), whereas some of them support the view that crises could have occurred due to the inconsistency of macroeconomic policies with pegged regimes. In addition, according to McKinnon (2002) sometimes due to the moral hazard problems countries with weak banking systems are very vulnerable to speculative attacks, hence should refrain from imposing the flexible exchange rate regimes. Due to the beneficial effects on inflation, pegs regained its popularity in 80s and 90s. However, continuing currency crises which started with Mexican Peso devaluation in 1994 has left suspects on their sustainability. As a result, there has been growing interest in preference of flexible regime arrangements. Furthermore, in late 1990s empirical statistics have revealed that countries around the world are moving towards corner solutions and the “bipolar view” is already taking place. Furthermore, new phenomena such as “fear of floating”, “fear of pegging” and “hidden pegs” have been widespread. According to Levy-Yeyati and Sturzenneger (2003): *Fear of floating*- is associated with countries that announces pegged regime although the de facto exchange rate is floating; Due to the risk of speculative attacks on pegged regimes, *fear of pegging*- is attributable for countries which official seem to be floating, but in fact implying a stable exchange rate; *Hidden pegs*- correspond to countries that want to fix while keeping the door open to a limited exchange rate volatility.

Calvo and Reinhart (2002) investigate whether countries indeed move towards corner regimes as the above mentioned studies suggest by analyzing monthly data for 39 countries from January 1970 till November 1999. They specifically look at movements of nominal exchange rate, foreign reserves and interest rate and compare them across different regimes, since they conjecture that these variables would assess whether a country is moving towards a fix/floating regime. They claim that high variability in both interest rate and foreign reserves is attributable to the variation of nominal exchange rate, because governments most of the time intervene through these two monetary instruments.

3. METHODOLOGY

In an empirical part of this paper, I will apply a relatively new methodology – Classification and Regression Trees (CART). CART is being widely used for the last 10 years. One of the distinguished features of CART analysis is that it constructs decision trees. Being a non-parametric technique CART is able to unveil complex, nonlinear interactions of explanatory variables which is sometimes impossible to be solved by standard parametric approaches.

Let us explain how the classification tree analysis works by illustrating on a simple example. Assume that we have a sample of 35 observations, 20 are of class A type (crises cases) and 15 class B type (tranquil observations). For these observations, assume that we have only two indicators that seem to explain the probability of entering the crisis period (Y= short term debt to GDP ratio and X= depreciation of exchange rate). Figure 1 illustrates the scatter plot of these observations. The observations are taken as a function of X and Y, in order to ease the understanding of the incidence of crises.

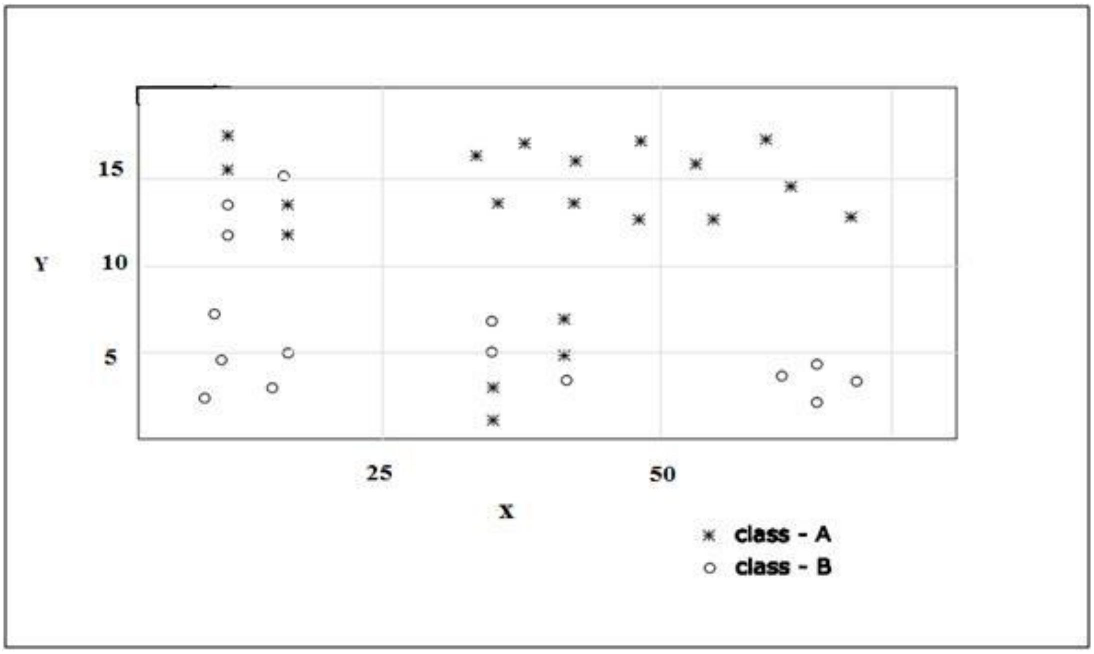

Figure 1 : Distributions of Class A and Class B observations

Before partitioning the sample, we need to define best splitter values for each indicator that will split observations into groups with high homogeneity. As figure 2 illustrates taking X=25, X=50 and Y=10 seem to partition observations into five distinct groups. Figure 3 illustrates the classification tree corresponding to the partitions shown in Figure2. As was early noted, the algorithm starts constructing the tree by asking "yes/no" questions. For this example, the splitting started with Y<10 condition. This node is called a parent node. Due to the nature of the question posed, each parent node will have two child nodes. Observations which satisfy the Y<10 condition are separated to the left, those which do not go to right node. Left node observations are still of heterogeneous distribution, including 4 class A and 12 class B observations, hence we have to find a rule which will be able to partition further.

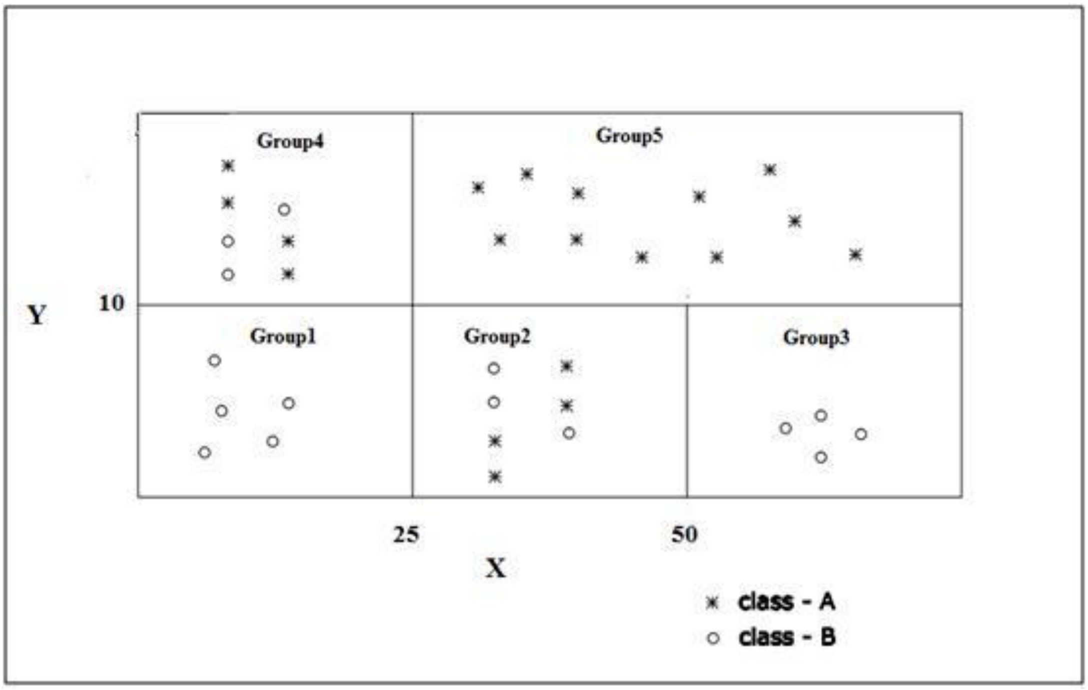

Figure 2 : The partitioning into groups

Observe that, for Y<10 and X>=50, we are left with no class A observations, hence X<50 is a perfect rule.

These observations form Group 3. Including the Group 3, all terminal nodes are blue colored.

Likewise, the algorithm will search for appropriate split value for each indicator, to get terminal nodes as pure as possible. As shown in the above, except for Group 2 and 4, we have isolated remaining observations perfectly. CART will not partition

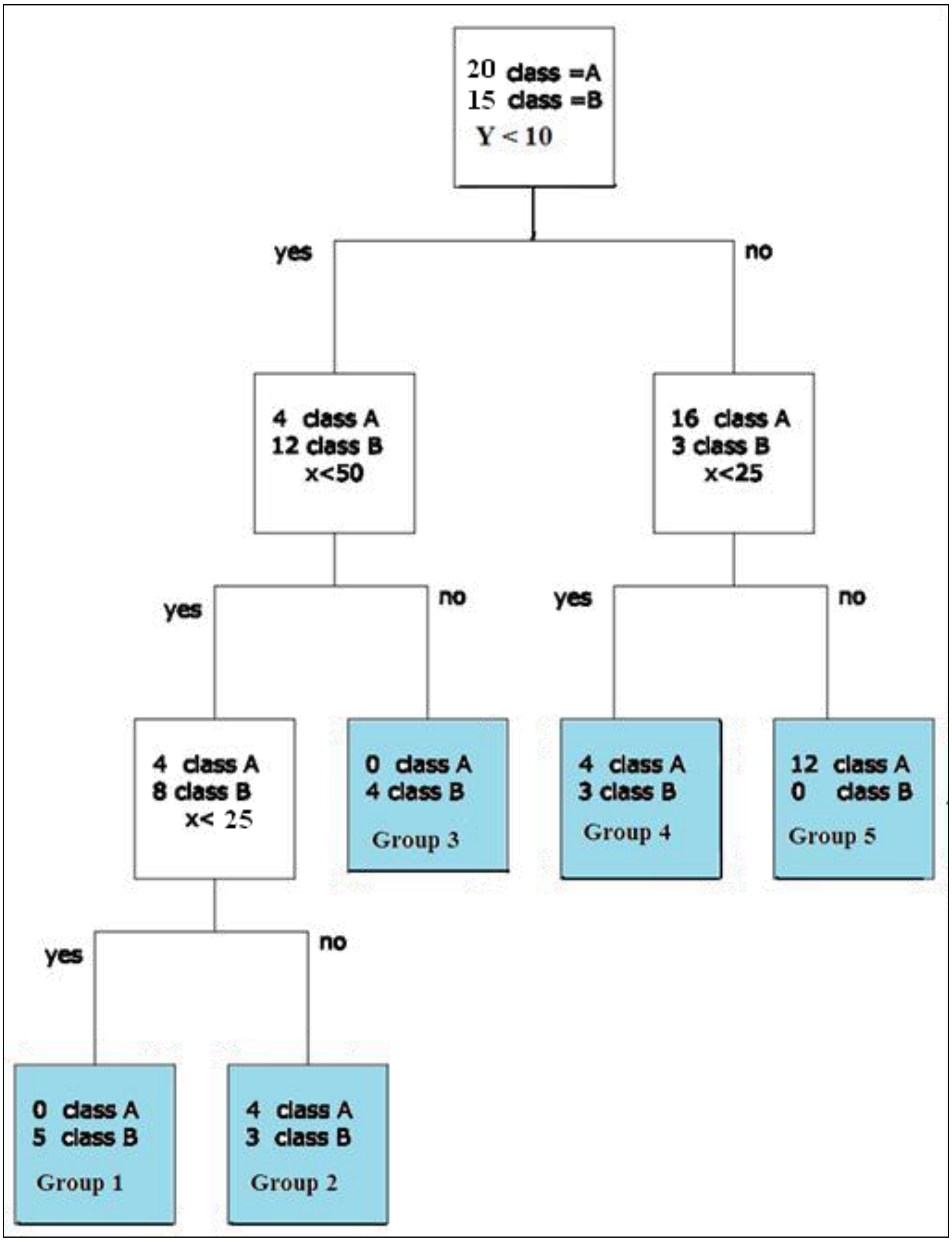

Figure 3 : Classification Tree

observations in Group 2 and 4, because further partitioning will not increase the improvement in purity of groups. This means, further splitting will give a zero change in the degree of homogeneity of observations. Note that this is the step where algorithm stops, because splitting stops whenever there is no further improvement in purity is possible (Asici, 2010).

Once the splitting process is finished, we have to assign classes for each node. Class assignment depends on prior probabilities of each class' observations in a whole sample. In this example, class A (class B) observations make 57% (43%) of the sample. Relying on these probabilities, a group with higher (lower) probability value than the above value will be assigned "crisis" case (tranquil). As a result, due to the probability of having class A observation in Groups 2,4 and 5 is greater than 57, these terminal nodes are said to contain crisis prone observations, whereas Groups 1 and 3 tranquil.

3.1 Advantages and Disadvantages of CART

There are several advantages of CART compared over standard parametric methods. We can list them as follows:

1. CART is a non-parametric technique. This means that, there is no need to check the distribution of both dependent and independent variables used in a model. It is a time-saving feature, because a researcher is exempted from making transformation if the variables are not normally distributed.

2. CART easily deals with a problem of missing values, merely by imposing penalties on it. Hence, CART decision trees will be still generated even if the important predictor variables are not known for all observations.

3. CART is never affected by statistical model problems, such as outliers, heteroscedasticity, correlation between independent variables, autocorrelation etc. For instance, it deals with outliers by isolating them in a single node; CART solves the correlation problem by assigning closely correlated variables into the "surrogates" list. So when a substantial number of observations of main predictor are missing, the algorithm allocates the best surrogates[2] values instead.

4. CART results are invariant to monotone transformations of its independent variables (Timofeev 2004). In other words, if one decides to use logarithmic or squared values of an independent variable, the structure of the tree will not be changed, except for the splitting values.

[2] Surrogates – are variables used as a proxy for the primary splitter. When the primary splitter value is missing, surrogate variables' observations replace the missing values in order to split the sample into left and right within each node. By default, CART produces five surrogates for each primary splitter at each node.

5. While constructing trees, CART automatically eliminates useless, insignificant indicators from being primary splitters.

On the other hand, one of the drawbacks of CART is being a non-probabilistic model. Secondly, CART's algorithm splits only by one variable, which means if a sample contains a complex variable capturing characteristics of one or more indicators, then CART may not perform a correct classification.

One of the applications of CART in economics is done by Asici (2010). He analyzes the power of indicators which might have a particular impact on a countries' decision to exit from a pegged regime to more flexible ones. In his CART model, the dependent variable is a binary EXIT, which takes a value 1 if a country exits and 0 if no exit or realignment inside the regime occurs. Furthermore, once the exit and no exit cases are identified, he classifies exit cases as orderly and disorderly exits according to the output gap variable.

Furthermore, Kaminsky (2003) uses a non- parametric method[3] similar to classification trees, but not exact CART algorithm, in classifying the varieties of crises, and identifying which indicators trigger which type of crises. This new methodology partitions the data according to the characteristics of crises classes. The algorithm works as follows: at first, the observations are grouped into categories, where the tranquil and crises cases are identified. Similar to signal approach, algorithm chooses thresholds, for each indicator, which minimizes the misclassification ratio. The indicator of lowest misclassification ratio will be chosen as a first splitter. Then sample observations are divided into two subgroups: those which satisfy the threshold posed in that indicator, and which do not. For each subgroup the above procedure is repeated by assigning new threshold values for each remaining indicators. By this methodology, observations are classified into groups, of indicators satisfying the particular thresholds, each of them being identified as different types of currency crises.

The CART algorithm is not only used in economics, but it is also widely applied in many clinical research studies, household food security centers etc. For instance,

[3] A methodology proposed by Kaminsky (2003), is a non-parametric alternative to the multiple-regime Markov-process models, initiated by Hamilton (1989).

Lewis (2000) explores CART algorithm in developing a new clinical decision rule, which is ought to be applied in various departments of Harbor-UCLA Medical center. Expected functions of clinical decision rules were: the classification of patients according to treatment or hospitalization; separate into categories of high and low risk diseases etc.

Another application of CART is the study done by Yohannes and Hoddinoff (1999). They study the indicators of Household food insecurity problem in Northern Mali. One of the distinguishing features of CART is that it selects the most relevant indicators and eliminates the least ones in explaining the dependent variable. Making use of this peculiarity, authors apply the algorithm in order to identify which indicators are most significant in providing which households result in being food insecure.

3.2 Steps in CART

According to the type of a dependent variable CART constructs either a classification or regression tree. If a dependent variable is a categorical variable, the classification tree is built, whereas for continuous dependent variable CART builds a regression tree. In our empirical analysis, we will construct three different classification trees, one for each exchange rate regimes (fix, intermediate and float), in which a categorical dependent variable takes a binary value.

After choosing options, CART starts by dividing the sample into two samples, called learning and testing samples. 90% of observations are separated for maximal tree growing; the rest 10% is left for testing the maximal tree in order to reach the optimal tree, the tree with the least misclassification cost. CART grows the biggest tree possible, called the maximal tree. In this step the aim is to reach the purest tree regardless of its representability. Although being the purest tree for the observations used, this tree may not necessarily perform the same when applied to a completely different set of observations. In CART this is done by the testing procedure. The remaining 10% of observations, called testing sample, is used to test the maximal tree. The terminal nodes which do not have the previous purity levels are pruned recursively. The pruning of the maximal tree is stopped when the misclassification cost is minimized. Hence CART algorithm involves two procedures operating exactly in the opposite direction. Maximal tree construction is defined as puritygreedy segment which grows trees of highest homogeneity regardless of the node size; whereas generalization-greedy segment is defined as testing part which favours smaller trees. Once these two segments agree on a tree, the algorithm yields the optimal tree with optimal purity and generality which is later applied to new datasets.

There are three main steps in CART's methodology: i) Choosing Option Settings (by user) ii) Construction of maximum tree (by CART methodology) iii) The testing and the choice of optimal tree (by CART methodology)

3.3 Choosing Option Settings

There are various options in CART's settings menu, according to which the structure of tree changes. Let's have a look at some of the important options, in order to have a better understanding of the way CART works.

3.3.1 Types of splitting rules

Classification trees are built according to splitting rules – rules that split learning sample into small parts. CART performs the algorithm shown in Figure 4 for each variable, where t_{parent} is a parent node and t_{left} and t_{right} are respectively left and right child nodes of a parent node, x – a variable with x^R – is a best splitting value for a variable x.

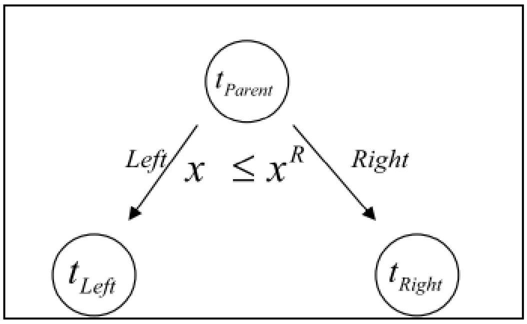

Figure 4 : Splitting algorithm of CART

The important question is to determine the splitting rule which is the most appropriate and will hold for most of the observations of each significant independent variable. The key point is to isolate different types of observations into separate nodes in order to get the purest possible tree. By asking only yes or no questions the process of building a classification tree starts, splitting a whole sample in a root node to smaller and smaller parts. In each step CART searches for a best split, which splits the data into two parts with maximum homogeneity. This process is continued until the maximum homogeneity in terminal nodes is attained.

There are six types of splitting rules in classification part of CART's theory with a specific impurity functions attached to them. We will discuss some of them briefly in here. 1) Gini splitting rule—is a most broadly used splitting criterion, which is set as a default for classification trees, puts emphasis on searching for the largest class and puts it to the right node in order to isolate it from the remaining class observations. According to Timofeev (2004) Gini is the best splitting rule for noisy data. 2) Symmetric Gini—is usually used in the case of cost matrix. 3) Entropy—is used when the target of the research is a rare class of observations. Sometimes it produces even smaller terminal nodes and compared to Gini gives less accurate classification trees. 4) Twoing—is recommended to be used when the dependent variable consists of more than two classes of observations. There are two basic differences between Gini and Twoing rule. The first one is that Twoing rule produces more balanced splits, but takes more time than Gini rule in constructing decision trees. Secondly, whenever the Twoing rule is used, the algorithm will search for two different classes, whose combination will exceed 50% of the data. Lewis (2000) suggests that Twoing and Gini give identical results if the dependent variable is a binary categorical one.

3.3.2 Class assignment

Once the maximal tree is constructed each node should be assigned a predicted class. It is necessary because if one decides to prune the sub tree or some terminal nodes, it will be impossible to know which nodes would be left as new terminal nodes. Furthermore, when the testing sample is applied to the maximal tree, the only way to be able to compute misclassification rates is to assign classes to terminal nodes in advance. The class assignment is done according to the prior probabilities of each class' observations in a whole sample. For instance, assume our sample consists of 100 observations, 60 are tranquil and 40 are crisis observations. Then the probability of being in tranquil (crisis) class is 60% (40%). Hence, the further class assignment of each node is done in the basis of these probabilities. Suppose if we have a terminal node whose 41% of observations are crisis dates, then we assign "crisis class" to that node.

3.3.3 Types of penalties

In CART, at every node, every independent variable competes to become a primary splitter, but the one with high improvement score is awarded a title of a “primary splitter”. Sometimes, there might be a case when a primary splitting variable is missing for one or more observations. In these situations, the surrogate splitting variable’s values replace the missing observations with primary splitter variable being kept in the sample and still preserving its title.

One may think how a variable with no missing values can be treated equally with a variable with lots of missing observations. Hence, in order to solve this problem, CART imposes penalties on variables that have got missing observations. Without penalties, it would have been unfair towards variables with no missing observations, since it is much easier for a variable to attain a higher improvement score with many missing observations. In other words, penalties lower a predictor’s improvement score, preventing it from being chosen as a primary splitter. CART disables the penalty tab as a default option. There are three types of penalties: 1) Missing value penalties 2) High level categorical penalty 3) Predictor specific penalties

Missing value penalties are assigned both for categorical and numerical variables and may take any value between [0,2] interval. For instance, if for a variable X 30% of its observations are missing then the penalty for X should be assigned as 0.3*a, where $a \in [0,2]$. Suppose we have assigned missing value penalty equal to 2. Since the penalty rate and an improvement score are negatively correlated, by assigning 0.3, the improvement score of X will be lowered by 2*30=60%.

High level categorical penalties are imposed only on categorical variables and range between zero and five, inclusive. The concept is very much similar to that of mentioned in the above.

On the other hand, the maximum value that can predictor specific penalties be assigned is 1. Hence, observe that, by setting the penalty rate equal to 1 for a specific variable, one can totally remove that predictor from being included into the algorithm.

3.4 Maximal Tree Construction

Starting with a first variable, all observations of that variable founded in a parent node is split into two child nodes according to the question asked in a parent node. The question is always of the form X>t, where X is an independent variable and t is a splitting value. Observations which satisfy the condition posed in question are separated to the left child nodes and the rest goes to the right child nodes. It is very essential to divide the data into child nodes with a high homogeneity; hence the algorithm searches for the best splitting value which would maximize the homogeneity of child nodes. In CART's theory the maximum homogeneity in child nodes is defined by *impurity function, i(t)*. Impurity functions are used to calculate an improvement score (the decrease in right and left child nodes). Hence, according to the impurity functions, CART repeats the above procedure for all independent variables at the root node until the maximum tree is obtained, i.e. until the sample is split up to the last observations. At the end, CART compares the splitters according to the *improvement scores*, and selects the variable of highest improvement score as a primary splitter. The tree building process continues until there is no any change in improvement scores of predictors, or only one observation left in each terminal node. At the end of this recursive procedure, algorithm yields us a maximal tree. In general, the maximal tree is very big in size with maximum number of terminal nodes as well as minimum degree of impurity measure. Hence, in most of cases, maximal tree is not an optimal tree, and the tree pruning option is applied to get the best final optimal tree with the least misclassification cost. In order to make more apparent explanation, let us explain how misclassification costs are computed on our model. In our sample, we have a total of 924 tranquil and 414 crisis observations. Assume the maximal tree is grown and 68 crisis observations and 27 tranquil observations have been misassigned to nodes. Hence, misclassification cost over a whole sample is found to be 0.1935, which is computed by adding two misclassification rates (68/414 + 27/924 = 0.1935)

3.5 Testing and Optimal tree Selection

As a next segment of an algorithm CART applies the testing phase. Once the maximal tree is constructed, CARTS starts pruning and we will be left with multiple of sub trees of different number of terminal nodes. In a testing procedure, the performance of each sub tree is tested under different subsamples, which are generated by random sampling of the initial dataset. Usually it is very rare not to have misclassified observations in each sub tree, but the point is to select the sub tree with the least misclassification cost and the selected sub tree which will be our optimal tree.

4. EXCHANGE MARKET PRESSURE INDEX (EMPi)

In this section we will construct EMPi to detect crisis and tranquil dates, because in order to analyze the behaviors of crises under different regimes, we will be constructing a sample of observations consisting of crises and tranquil dates.

In currency crises literature, each of economists like Eichengreen et al. (1995, 1996), Asici et al(2007), Kaminsky, Lizondo and Reinhart (1997), Sachs, Tornell and Velasco (1996), Berg (2000) etc. have developed an index based on combination of changes in nominal exchange rates, international reserves and interest rates with purpose of detecting a speculative attack on exchange rate and forecasting CC. Although, the basic concept of this index remains same, sometimes the “names” used are differentiated according to authors’ preference. For instance, some of them prefer using Speculative pressure index (SPI), to the fact that it is widely used in capturing speculative attacks; others are in favor of using Exchange market Pressure index (EMPi), emphasizing the importance of change in exchange rates; Besides, although being rare in number, there are some economists who apply a broader version of an index and use it as an early warning system.

The motivation for constructing such index arose from the idea that speculative attacks on exchange rate regime are not always successful; hence by simply measuring the change in nominal exchange rate one is incapable of capturing all speculative pressures. Thus, it is more than important, to include all three variables stated in the above. As noted in Asici et al (2007), the inclusion of the change in interest rate is crucial and unavailability of interest rate data should not discourage you, because there are other relevant rates such as discount rate, t-bill rate and money market rates that can be used by developing countries instead of interest rates. In addition, the exclusion of interest rate sometimes gives bias results. For instance, in our sample’s Albania February 1997 case, although the index computed by changes in exchange rate and reserves did not exceed the threshold and give a signal, the speculative pressure was detected by an increase in both t-bill and discount rates, which reveals the fact that there is no specific rule regarding which interest rate is more relevant one, therefore, for each country an index should be computed by with different interest rates.

Initiated by Eichengreen et al. (1995) it has become widespread to weight the variables used in index by inverse of their standard deviation. Thus, depending on data availability and weighting preference, different versions of the following index have been used so far:

$$EMPI(\vec{x}) = \vartheta\%\Delta E(\vec{x}) + \varepsilon\%\Delta I(\vec{x}) - \omega\%\Delta R(\vec{x}) \quad \textbf{(4.1)}$$

where the $\vartheta, \varepsilon, \omega$ weights are taken randomly. The index has to be computed separately for countries experiencing hyperinflation; otherwise it overestimates the threshold value and gives bias values. In our study, we are going to pursue Asici et al's (2007) definition of hyperinflation, which is chosen to be at least 150% as an average of last 6 months.

Thus, whenever index exceeds a given threshold, which is usually taken 1.5, 2 or 3 standard deviation over its' mean, EMPI issues a signal. Observe that, since the value of weights taken is controversial, there is no single correct version of EMPi that could be perceived by everyone.

In this paper, we have calculated four different indices for both normal inflation and hyperinflation experiencing countries:

$$EMP_1 = (E_t/\sigma_e) - (R_t/\sigma_r) \quad \textbf{(4.2)}$$

$$EMP_3 = (E_t/\sigma_e) - (R_t/\sigma_r) + (M_t/\sigma_m) \quad \textbf{(4.3)}$$

$$EMP_2 = (E_t/\sigma_e) - (R_t/\sigma_r) + (D_t/\sigma_d) \quad \textbf{(4.4)}$$

$$EMP_4 = (E_t/\sigma_e) - (R_t/\sigma_r) + (T_t/\sigma_t) \quad \textbf{(4.5)}$$

where E_t is the monthly depreciation of nominal exchange rates; R_t is the percentage change in international reserves excluding gold; and D_t, T_t, M_t are monthly changes in discount rate, t-bill rate and money market rate, respectively. For each EMP indices we have used $\mu + 3 * \sigma$ threshold, where mean and standard deviation values are country specific. Once all four indices are computed for each country and month, we check whether

$$EMP_i \geq \mu_{EMPi} + 3*\sigma_{EMPi} \quad \textbf{(4.6)}$$

for i= 1,2,3 and 4.

If the **(4.6)** condition is satisfied, a combined index $\overline{EMPi}$ =1, otherwise it takes value 0. Furthermore, there is one more condition written below, that we have to be aware of:

- EMP= $\overline{EMP}_1$ if none of the interest rates are available;
- EMP^*= max { EMP_2 ,EMP_3 ,EMP_4 } and EMP= $\overline{EMP}*$ if at least one of the relevant interest rates are non-missing.

In our original dataset, at first we had 755 observations which were assigned a value of 1 for EMP. However, the total amount of EMP assembled into the sample was only 349 cases. The reason for this is that, in the procedure of detecting crises and tranquil cases, we have applied a "three year" window. Starting from the first case where EMP gives a value 1, the algorithm eliminates all other possible crises dates within the time period which spans across the preceding 24 months and subsequent 12 months (t-24 to t+12). The important point is that, for an observation to be defined as crises/tranquil case, in addition to EMPi=1/0 condition we need a country to be on the same exchange rate regime for preceding 21 months. Whenever these two conditions hold, an algorithm derives the cases such as tranquil_fix / crisis_fix. For instance, if one of the observations of country A is assigned a "crisis_fix" label, it should be comprehended that at that specific month, country A was using a fixed regime when it faced a speculative attack.

In previous literature, the three-year window method was used by Rose and Frankel (1996), Asici et al (2007), Eichengreen (1996), Tornell (2000) etc. Rose and Frankel (1996) applied this method while investigating the behavior of countries suffering from currency crash. They define an observation to be a currency crash, if the nominal exchange rate increases by at least 25 % and, the depreciation rate exceeds the previous year by at least 10%. They have excluded those crashes which occurred within three years from each other, in order to avoid counting the same crash twice.

Asici et al(2007) conducted a research on probability of exit from pegged regimes for 128 countries. They analyze a pre-exit behavior of endogenous variables that could trigger realignment within the same regime or exit to more flexible regimes, as a defending policy against speculative attacks. Similarly, for each exit and no-exit cases they have applied a three year exclusion window, to refrain from counting cases of re-pegging.

Thus, taking Asici et al (2007) work as a primary reference, for each country we will follow following steps:

- If EMPi is never equal to 1 for a country across the whole sample period, then by having the condition of "21months being on the same regime" satisfied we partition the whole period as many as possible into three year subperiods. Each of these three-year subperiods will be assigned a "tranquil" label.

- If a country has experienced a speculative attack only once, starting from EMPi=1 observation we apply three year window, and move up and down to assign as many as possible three year tranquil episodes.

- If a country has got more than one cases of EMPi=1, we first apply the rule in the above, then partition the time period in between of two EMPi=1 cases as to many "tranquil" observations as we can.

5. DATA

Before detecting the crises and tranquil observations, the important thing is to decide which ERR classification is most appropriate and reliable in explaining the relationship. Levy-Yeyati and Sturzenneger (LVS) 2005; Reinhart and Rogoff (R&R) 2004 have documented that sometimes actual exchange rate regimes may differ from the announced ones, and the usage of announced regimes might lead to misleading results. As was mentioned earlier, there are two different *de facto* classifications: constructed by Levy-Yeyati and Sturzengger, 2005 (LS, hereafter) and Reinhart and Rogoff, 2004 (R&R, hereafter), respectively.

In LS *de facto* classification, exchange rate regimes are defined according to the relative behavior of three classification variables: i) Changes in nominal exchange rate (γ) ii) Volatility of percentage changes of nominal exchange rates (δ) iii) Volatility of international reserves (σ);

Table 1 : LS *de facto* classification (2003)

	Classification Criteria		
	γ	δ	σ
Inconclusive	low	low	low
Flexible	high	high	low
Dirty float	high	high	high
Crawling peg	high	low	high
Fixed	low	low	high

One of their findings is that, the less flexible exchange rate regimes impel higher output volatility as well as slower growth rate in developing economies. Whereas in industrial countries, they could find no significant impact on growth. Furthermore, authors agree on the "hollowing-out" effect, which is related with disappearance of soft regimes and transition to corner regimes such as currency boards, currency union, dollarization or pure floating.

In this study, we will use the *de facto* classification proposed by R&R, in which ERR are defined according to the behavior of "black market" determined parallel exchange rate data. The fine version of this classification consists of 15 exchange rate regime categories, for our study only 13 categories are used, in which corner regimes are defined as dollarization and pure floating regime. Remaining two categories are defined according to countries, for which parallel market exchange rates are missing and, experiencing a high inflation and subsequent depreciation. The latter category is called as “freely falling”- which highlights the fact that local currency continuingly faces a devaluation. In R&R coarse version of the classification, they arrange 13 categories into four subgroups, namely pegs, limited flexibility, managed float, and flexible regimes. The classification is described in details in Table2. To determine whether the occurrence of currency crisis under different regimes follow different paths or not, based on the announced or implicit commitment of monetary authorities, we further divide a fine classification into three subgroups, by combining the limited flexibility and managed float regimes into one category, which we will call as intermediate regimes. Hence, we are left with three broad subgroups; two of them are corner regimes- pegs and pure floating, and a soft peg- intermediate regime.

5.1 Sample

Since the updated R&R classification ends in 2007, our sample spans from 1970 till 2007. Due to the *currency union dummy* variable (until 2005) we have excluded countries which are in currency union area, such as countries that are included in EU etc. Hence, our initial dataset of 1338 observations has been contracted to 1030 observations. Although our crisis dating based on the index constructed by employing monthly variables, due to the lack of availability of data almost all the explanatory variables used in the analysis are annual. The detailed explanation about the explanatory variables can be found in the App. Table 9 and Table 10.

For all empirical studies, dating the incidence of crises is essential to distinguish between tranquil and crises episodes. Hence, we have defined an observation to be “tranquil” period whenever there is no pressure on the currency, while a “crisis” observation to be characterized by the presence of a speculative attack, either successful or not. The sampling is constructed separately for countries with hyperinflation; otherwise the magnitude of inflation overvalues the volatility of

Table 2 : Reinhart & Rogoff De facto regime classification

R&R categories	R&R four way classification	Three way classification
1. No separate legal tender	Peg	Peg
2. Pre announced peg or currency board arrangement	Peg	Peg
3. Pre announced horizontal band that is narrower than or equal to +/-2%	Peg	Peg
4. De facto peg	Peg	Peg
5. Pre announced crawling peg	Limited Flexibility	Intermadiate regimes
6. Pre announced crawling band that is narrower than or equal to +/-2%	Limited Flexibility	Intermadiate regimes
7. De factor crawling peg	Limited Flexibility	Intermadiate regimes
8. De facto crawling band that is narrower than or equal to +/-2%	Limited Flexibility	Intermadiate regimes
9. Pre announced crawling band that is wider than or equal to +/-2%	Limited Flexibility	Intermadiate regimes
10. De facto crawling band that is narrower than or equal to +/-5%	Managed Float	Intermadiate regimes
11. Moving band that is narrower than or equal to +/-2%	Managed Float	Intermadiate regimes
12. Managed floating	Managed Float	Float
13. Freely floating	Pure Float	Float
14. Freely falling		
15. Dual market in which parallel market data is missing		

nominal exchange rates which results in using unreliable data. In order to capture both successful and unsuccessful attacks, a weighted composite of at least two variables--an Exchange Market pressure index (EMPi) is developed (Eichengreen and Rose, 1995)

Our sample consists of 1030 observations, 681 of which are tranquil and 349 ones are crises cases. To avoid from re-counting the same crisis impact we use a three-year exclusion window around crises and tranquil dates. In total of 44 independent variables are used. The total sample includes 172 countries: 138 developing countries and 34 IMF-reported advanced economies, which is based on IMF country classification. For the 1970-2007 period of time, based on observation list 46 countries have not encountered any speculative attack, and 126 countries have experienced at least one speculative attack. The complete list of crises dates for 172 countries are described in details in App. Table 11.

5.2 Variables of Interest

In an empirical part of this paper, by using information on a variety of indicators we want to analyze whether under different regime path of experiencing CC differs or not. In order to investigate the relationship between regime choice and currency crises we shall separately take a look at relevant variables that might have some effect on ERR and CC. Hence, indicators are classified into two basic groups, as determinants of ERR and CC, respectively. We have used lagged values of all indicators, as we believe the endogeneity may be concern.

One of the studies on ERR literature was done by Levy-Yeyati, Sturzenegger and Reggio (2006), in which they test three hypothesis to investigate the determinants of the regime choice question. By using a pooled logit regression for an unbalanced panel data of 183 countries, they test whether, and to what extent, the main theoretical views identified in literature are good in explaining the choice of exchange rate regimes. More precisely, they believe that there are three main approaches which are attributable for the choice of regimes: i) Theory of optimal currency area (OCA), initiated by Mundell (1961) indicates trade linkages, size, openness and the terms of trade real shocks as determinants of ERR; ii) Financial view focuses on changes that accompany financial integration and “impossible trinity concept”; and iii) Political economic view considers peg regimes as a “credibility enhancers” for economies lacking institutional quality and political strength. In each of three approaches, authors have assembled a variety of indicators which seem to capture the closest idea highlighted in theories. Hence, by taking a *de facto* fixed exchange rate regime dummy as a dependent variable, they analyze to what extent the indicators are useful in determining the ERR. Let us briefly explain the main ideas of two theories of exchange rate determination.

5.2.1 *OCA theory*

According to this theory, choice of the regime is related to geographical and trade aspects of each country. This approach basically compares trade gains under pegged regimes against the benefits of more flexible regimes. In other words, OCA theory searches for macroeconomic conditions under which pegging the exchange rate is more suitable. It states that a pegged regime is desirable when there is a high degree of trade integration, and is undesirable when the economy is vulnerable to real shocks, such as terms of trade real shocks. As predicted by theory, these variables are found to affect the exchange rate regime (Klein and Marion, 1994; Edwards, 1991; Frieden et al.,2000; Levy-Yeyati et al.,2006).

Hence, theory identifies country characteristics that would like to peg or exit to a more flexible regime, such as: openness; size of the economy as proxied by log of GDP; the absence of real shocks. In order to check the validity of OCA hypothesis, we use indicators: *Size*- measured by taking the logarithm of GDP in current US dollar; *Openness*- the ratio of import plus export to GDP; and *volatility of terms of trade,* to measure the incidence of real shocks.

5.2.2 *Political view*

Various studies on exchange rate stability have focused on pegged regimes as a nominal anchor for monetary policy, specifically to tame the inflation. However, as Husain et al. (2005) finds that, there are some countries with low inflation and limited capital mobility that tend to adopt pegged regime. This is because; countries with low institutional quality are more prone on relying on fixed regime, because governments use a peg as a defending monetary instrument against the external pressures. On the other hand, Alesina (2006), Wagner (2006) has found a link between political strength and peg regimes, such that weak governments are unable to sustain pegged regimes. In our study, we use three political variables which we believe will fully reflect the political and institutional quality of countries: the number of years the incumbent administration has been in office (*Years in Office*); a Herfindahl index of congressional politics (*Herfgov*); legislative index of electoral competitiveness (*Liec*); *Democracy* indicator as a measure of institutional quality. (Levy-Yeyati,Sturzenegger and Reggio,2006) In previous empirical studies, it has been found that two of the variables (Yearsin Office and Herfindahl Index) are positively correlated with political strength, whereas Liec is a measure of political weakness.

5.2.3 *Determinants of Currency Crises*

Based on currency crises literature we will classify indicators according to three "generation models". The first generation models focus on inconsistency of expansionary macroeconomic policies with fixed exchange rate regimes. According to Kaminsky (2003), potential causes of this type crisis are fiscal deficits and ineffective monetary policies. Variables such as *overvaluation*- a deviation of quarterly Real effective exchange rate from its' HP trend, and *current account deficits* capture the characteristics of these models. Countercyclical government policies are the main reasons for second generation model crises to occur. Relying on literature, we expect variables such as: *export, imports, terms of trade*, large and negative *output gaps*- deviation of real GDP from its' HP trend, real *interest rates* as well as political variables democracy index, weak governments to reflect the focus of these models. The third generation models identify financial excesses, specifically by highlighting the financial maturity and currency mismatches as main reasons of vulnerability. We use six indicators: *domestic credit/ gdp ratio, money supply, bank deposits/ gdp ratio, liquidity of banking sector, domestic credit to private sector and credit provided by banking sector*. One of the types of CC, a sudden-stop approach, which is a consequence of international capital flow reversals, can be measured by fluctuations in world *real interest rate* and central banks' *foreign exchange reserves* (excluding gold).

We have grouped indicators used in this study into five categories: i) external sector ii) financial sector iii) domestic real and public sectors, iv) foreign economy v) political economy variables.

The App. Table 3 describes these variables in detail.[4]

[4] For excellent survey of crisis indicators see Mardi and Demosthenes et al.(2000), chap.4 "Identifying financial crises.

6. RESULTS OF CART ANALYSIS

As a first step we constructed a binary classification tree with possible purest terminal nodes, which takes value 1 if crisis occurred at time t or 0 otherwise, not depending on the type of regime. Next, we built three distinct classification trees for fix, intermediate and float regimes, respectively, by partitioning the whole sample according to regime types. Therefore, by mixing different crises type observations into one sample we expected to find less homogeneous TNs. The latter step was applied, because as it was supported by the results of binary tree model, we believe that the crisis paths under different regimes could not be generalized for all regime types. Before analyzing trees, let us have a look at descriptive statistics of explanatory variables across tranquil and crises observations, given in Table 3.

6.1 *Descriptive Statistics*

The classification trees are constructed with variables that CART founds to be significant and important. Hence, variables with statistically different means across tranquil and crises observations are not assured to be included in the tree. Therefore, in CART analysis, compared to parametric methods, the way the indicators are represented in a model differs. For instance, in parametric methods, while holding all remaining indicators constant at their mean, the displayed statistical significance of marginal effects reveal important to model variables, whereas in CART, for each parent node a variable of highest improvement score is assigned to be a primary splitter, while remaining ones are kept as competitors[5].

Furthermore, a variable may be assigned as a primary splitter more than once with varying splitting values or may not show up even once depending on improvement scores, which is not the case in parametric methods. This feature of CART makes it distinguishable from parametric methods in detecting the non-linear relationship

[5] Competitors –are the variables with improvement scores which are very close to the value of a primary splitter. In other words, competitors are considered as the second better splitter. Five competitors with their improvement scores are displayed by CART as a default option.

between indicators. The mean values across tranquil and crises periods are shown in Table 3.

Table 3 : Descriptive statistics: Tranquil vs. Crises observations

	TRANQUIL		CRISIS	
Variables	mean	obs	mean	obs
Polity variable	1.93	563	2.57	305
Polity variable 2	1.93	563	2.57	305
Real interest rates	6.46	441	9.13***	235
Short term over total debt	115.33	396	101.36	217
Terms of Trade	115.54	528	106.69*	318
Trade balance	-2.57	605	-3.95	319
Volatility of ToT	10.81	530	12.28*	305
Years in office	7.12	532	6.36	302
Change in US feder.funds	-0.15	681	0.06**	349
M2 to GDP	69.92	578	48.06***	316
Growth of M2	18.76	546	21.40**	279
OECD growth	2.56	681	2.98	349
Openness	80.98	599	71.11**	316
Public debt over GDP	3.86	365	4.09*	188
Export to Import ratio	93.07	636	88.66**	336
Overvaluation of RER	-0.74	525	4.47***	290
Autocracy indicator	2.92	541	2.69	294
Budget balance to GDP	-2.83	405	-3.53	264
Bank deposits to GDP	0.47	512	0.43	280
Bank liquid liab.to reserves	13.09	604	12.3	325
Inflation	10.82	568	12.20**	306
Current account balance	-1.63	508	-2.68	287
Capital account balance	1.33	319	0.33**	152
Credit by banking sector	113.21	586	59.38***	319
Credit to GDP ratio	55.87	589	55.19	318
Credit to private sector	97.53	592	46.62***	321
Democracy indicator	4.98	541	5.28	294
Change in OECD growth	-0.34	584	0.01*	309
Herfindahl index	0.78	476	0.78	263
Industrial production	4.24	513	4.41	283
Capital openness	0.44	607	-0.06**	314
Legislative index of compet.	5.83	532	5.73	301
M3to GDP ratio(Financial depth)	93.12	584	48.93***	320
Logarithm of GDP	10.24	625	10.26	321
Long term debt to GDP ratio	48.26	385	48.16	204
Durability of the regime	27.51	566	25.13	304

Table 3 (continued)

	TRANQUIL		CRISIS	
Variables	mean	obs	mean	obs
Financial liberalization	0.5	444	0.45	232
GDP per capita	2.41	603	2.56	319
Real GDP	4.15	611	4.4	316
Output gap	-0.32	574	0.49***	309
Gov.expenditure to GDP	15.69	587	15.7	305
Growth of export	14.24	644	11.77**	336
Growth of import	13.87	636	13.49	336
External debt to GDP	63.17	365	61.45	185
FDI to GDP	2.9	554	1.88**	301
Growth of reserves	3.52	585	1.35***	327

A quick look at the table reveals that a year before crisis, a sharp decrease in mean values of M3 to GDP ratio (indicator of financial depth), reserve growth rate, credit by banking sector is experienced. Furthermore, similar to conventional studies' findings we find that, the decrease in terms of trade, openness, foreign direct inflows, growth of export and capital account balance increase the risk and likelihood of encountering the speculative attack. On the other hand, observe that, the fact that countries which are in crisis period either suffer from higher output gap level, inflation, overvaluation of RER or higher real interest rate is empirically supported by increases in mean values of those particular variables across crises period. In addition, being a measure of real shocks, an increase in volatility of terms of trade is another signal of forthcoming crisis. Therefore, we can summarize that a year before crisis incidence, crisis prone observations compared to tranquil observations encounter with:

- an overvalued real exchange rate,
- less openness,
- higher inflation,
- higher US federal funds rate,
- higher ratio of public debt over GDP,
- lower bank liquid liabilities over reserve assets,
- lower capital account balance,

- lower foreign direct investment to GDP ratio,
- higher output gap,
- lower export growth rate,
- lower rate of international reserve growth,
- higher domestic real interest rates,
- lower terms of trade,
- higher volatility of terms of trade

6.2 *Binary Tree model*

In binary tree model, the CART algorithm classifies all observations into 8 nodes (refer to Figure 5). Only seven indicators are used to split all observations: *OECD growth rate, overvaluation of real exchange rates, change in domestic credit to GDP ratio, change in ratio of trade balance to GDP, ratio of bank liquidities to reserve assets, inflation rate and change in US interest rate*[6]. We have 681 tranquil and 349 crisis observations in our sample. Recall that, in EMP construction we have defined a crises to be of "float type" if the country remains under floating regime for about two years prior to the crisis date (similarly for intermediate and fix regime observations). In our sample, 185 cases are labeled as "intermediate crises", 63 of "float" crises type and 101 observations were labeled as "fix" type crises (Hereafter the fix, intermediate and float type crises will be abbreviated as cr_fix, inter_cr and cr_float, respectively). The unconditional probabilities are presented in the below, see Table 4 and 5.

Observe that CART assigns terminal nodes (TN hereafter) as "crisis" or "tranquil" by relying on the unconditional probabilities presented in the top parent node.

Table 4 : The number of observations under different regimes (Binary tree model)

obs	fix	inter	float	total
crisis	101	185	63	349
tranquil	273	290	118	681
total	374	475	181	1030

[6] CART automatically eliminates useless, insignificant indicators from being primary splitters and does not include into tree.

Table 5 : Unconditional probabilities under different regimes (Binary tree model)

%	fix	inter	float	total
crisis	29%	53%	18%	34%
tranquil	40%	43%	17%	66%
total	36%	46%	18%	100%

For instance, TN with "cr_inter" probability greater than 53% is labeled as "crises under intermediate regime". There might be cases where conditional probabilities of two regimes exceed the threshold. In such cases, *TNs* classes are assigned according to the relative differences between conditional and unconditional probabilities of each three regime type crises. As a result, in our binary model *TNs* 1,2,3 and 6 are labeled as *tranquil* ,*TNs* 4 and 5 as *cr_inter, TN*7 as *cr_float,* and *TN8* as a *cr_fix*. (See Figure 5 for a binary tree representation and App. Table12 for list of countries allocated to TNs). Furthermore, we have demonstrated in a table the routes of each TN (see App. Table 13).

We can summarize results for binary tree model as follows:

Crisis prone TNs:

Interestingly, the data split starts by OECD growth rate and most of crises occurred when the growth rate was higher than 3.77. Since the ratio of crises observations exceeds the unconditional probability level (34%), the TN8 was assigned "crisis" node. Similarly, since the conditional probability of *cr_fix* observations is higher than the threshold (29%), CART has assigned TN8 as "FIX crisis" terminal node.

Previous studies (Edison 2003; Kamin, Schindler, and Samuel, 2001; Eichengreen and Arteta, 2002) have found that higher OECD growth rate strengthens exports, which is as a consequence lowers the probability of currency crises. However, by carefully looking at competitors and surrogates of a top node and TN8, higher overvaluation of RER and change in US federal funds rates are given as best competitor and surrogate, respectively. This indicates that, real exchange rate appreciation can be considered as a proxy for OECD growth rate which is not as least important signal of a forthcoming crisis as was supported by the above studies. In addition, we find that all crises and tranquil observations in TN8 belong to 1973-1990 period, which may be an exceptional case where the conventional belief that 'OECD growth rate decreases the likelihood of CC' might not hold.

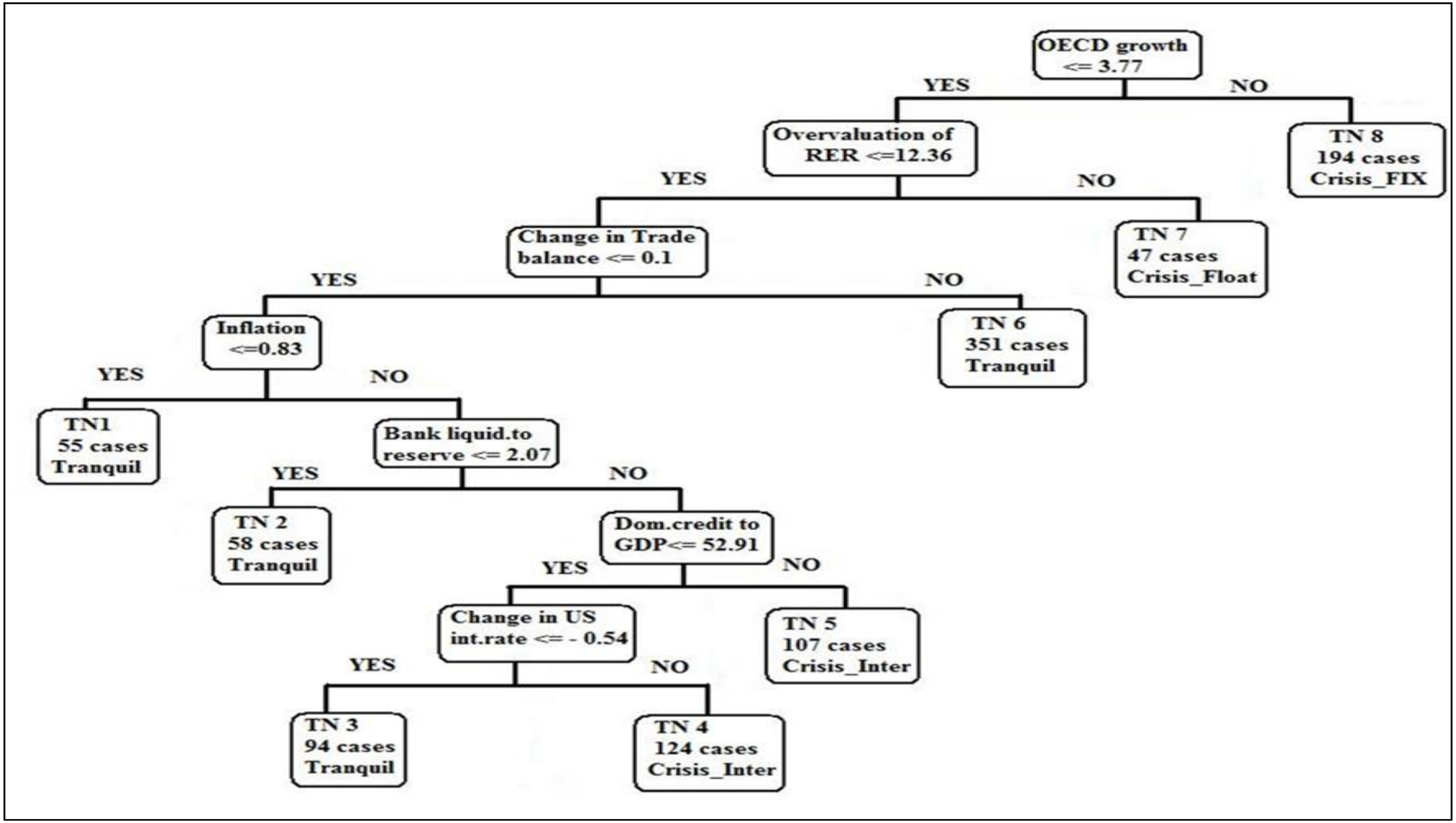

Figure 5 : Tree classification Tree for Binary model

For those observations with low OECD growth rates, the TNs are further defined with classifications based on overvaluation of RER. For the observations for which RER was not appreciated, TNs are further defined by classifications of *change in trade balance* and *inflation*. TN7 is identified as "Crisis_float" by high overvaluation combined with moderate OECD growth. Hence, a higher RER overvaluation in t_{-1} makes crises more likely to occur by increasing the conditional probability from 54% (TN8) to 65%(TN7[7]).

For the observations with no problem of RER appreciation with lower change in trade balance, we examine decrease in probability of crisis incidence, 50% in TN5 and 40% in TN4. In TN5, most of crises occur when there is a higher inflation with higher value of domestic credit to GDP ratio. Whereas, change in US interest rate increases the likelihood of crises when the ratio of bank liquidities over reserve assets is higher than 2.07 and domestic credit/ GDP lower than 52.91 units (TN4[8]).

Tranquil prone TNs

There are four TNs that were classified as tranquil prone nodes (TNs 1,2,3 and 6). Most of tranquil TNs are associated with lower inflation, lower change in US interest rates and lower overvaluation of RER, which supports the conventional fact that lower RER appreciation lowers the likelihood of crises. Furthermore, moderate positive *change in trade balance* combined with lower RER appreciation make crises less likely to occur (TN6[9]). Hence, according to binary tree classification, we shall summarize that the likelihood of crises increase when there is:

- Higher inflation combined with high ratio of domestic credit/ GDP
- Appreciation of RER
- Higher change in US interest rates

After identifying routes leading to CC under different regimes we observe that a binary model was not very successful in separating observations in TNs into three classes of crises (*cr_fix, cr_inter and cr_float*). For instance, in TNs 7 and 8 both

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[7] CART gives *change in overvaluation of RER* as the surrogate for TN7, whereas higher M2growth rate was assigned as a second best splitter after overvaluation.

[8] Real interest rate and volatility of terms of trade are given as surrogates for TN4.

[9] Higher OECD growth rate and higher positive change in export to import ratio are given as surrogates for TN6

conditional probabilities of cr_fix and cr_inter observations exceed the threshold imposed on top parent node, which creates difficulties in assigning the correct class. Therefore, as a second step of our strategy, we have partitioned the sample according to the regime data, and have applied CART analysis to three smaller samples as well. The "fix" subsample contains 101 crisis and 273 tranquil country dates which were under fix regime at least for two year prior to crisis date, whereas "inter" subsample has got a total of 475 observations (185 crisis and 290 tranquil) and "float" contains 63 crisis and 118 tranquil cases. The classification tree based on observations under fix exchange regime is demonstrated in Figure 6. Similarly, in Figures 7 and 8, classification trees of country dates under intermediate and floating regimes are built. Let us have a careful look on each three models separately.

6.3 ***"FIX" Tree model***

Table 6 : Unconditional probabilities of observations under fix regime.

fix	obs	%
crisis	101	27%
tranquil	273	73%
Total	374	

CART has split observations into six TNs using five different indicators: *OECD growth rate, growth of import, change in trade balance, export growth rate and ratio of public debt to GDP*.

Based on unconditional probabilities of cr_fix(27%) and tranquil observations(hereafter, tr_fix) under fix regime (73%) TNs 3 and 4 were classified as crisis prone and TNs 1,2,4 and 5 as tranquil (Figure 6) For detailed information regarding TNs see App. Table 14 and 15.

Findings can be summarized as follows:

Crisis prone TNs:

Similar to binary tree model, splitting starts by *OECD growth* indicator. There are 35 observations for which OECD growth value exceeds 4.18 (TN 17). Change in US federal funds rate higher than 2.28 is given as a best surrogate for TN 6. Again, it is important to note that, crises dates for countries in TN 6 span along 1973-1989

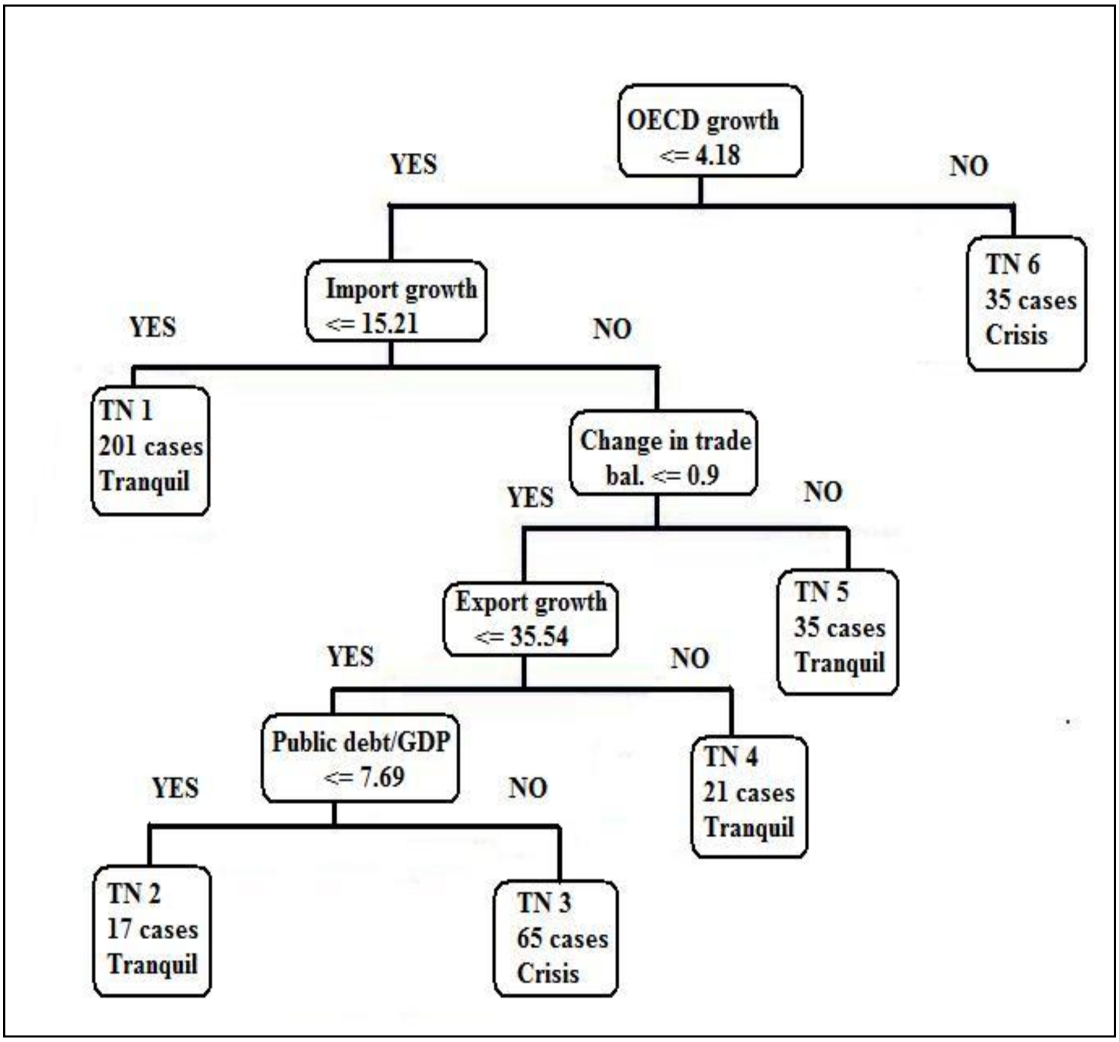

Figure 6 : Tree classification Tree for FIX model

period of time. Hence, we may say *OECD growth* was probably less significant indicator in that period and those countries with high change in US federal funds rate were more likely to experience crisis (74%).

For countries with low OECD growth rates, the next crisis prone TN is associated with higher import growth rate combined with lower change in trade balance, lower export growth rate and higher ratio of public debt/ GDP. However, the conditional probability of experiencing crisis lowers from 74% (TN6) to 54% (TN3[10]).

Tranquil prone TNs:

A lower import growth rate with higher change in trade balance increase the probability of staying in tranquil period (TN5). Furthermore, high growth rate of export, as well as lower ratio of public debt to GDP lowers the risk of crises (TN2).

[10] Higher M2 growth rate with lower change in terms of trade are given as surrogates for TN3.

To sum up, once we restrict our analysis to observations under fix exchange regime, we observe that countries are more prone to experience crises when there is:

- high change in US federal funds rate;
- higher public debt with higher import growth rate and lower export growth rate;

6.4 ***"INTER" Tree model***

Table 7 : Unconditional probabilities of observations under intermediate regimes.

inter	obs	inter
crisis	185	39%
tranquil	290	61%
Total	475	

According to unconditional probabilities given in Table 7, CART has classified observations into nine TNs; five TNs were classified as tranquil whereas remaining four TNs as crises prone observations. The tree built for observations under intermediate regime is shown in Figure 7.

The algorithm has used only six different indicators to be significant and important in splitting observations in this subsample: *overvaluation of RER, OECD growth rate, change in openness, reserve growth rate, changes in inflation and output gap.*

The detailed information of TNs regarding the surrogates, competitors and crises (tranquil) cases is given in App. Table 17. We can summarize results for "INTER" tree model as follows:

Crisis prone TNs:

Splitting of the data starts by overvaluation of RER, indicating that a real exchange rate appreciation is the most important indicator of a forthcoming crisis. Observations of RER overvaluation greater than 12.58 are more crises prone (TN9). For countries with no problem in RER appreciation, the observations are further defined with classifications based on OECD growth rate (TN8)[11].

[11] Change in US federal funds rate greater than 3.14 is given as a surrogate for TN8.

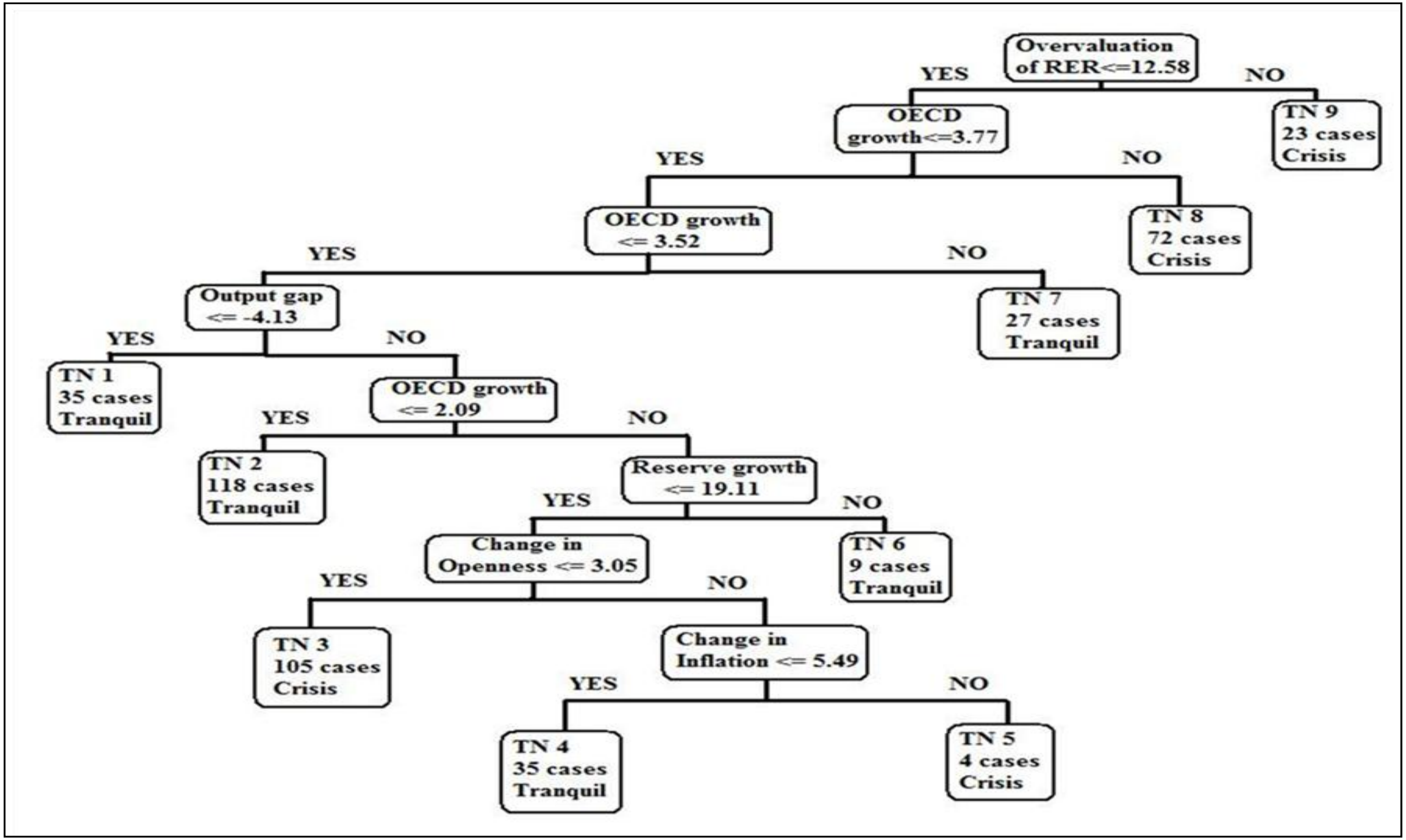

Figure 7 : Tree classification Tree for Inter model

However, compared to TN9, the likelihood of experiencing currency crises decreases from 80% to 68% (TN8).

Furthermore, as seen in TN3 (59%) low reserve growth rate combined with low change in openness lead to crises. The conditional probability increases (100%) for countries with moderate openness level but having high inflation (TN5).

Tranquil prone TNs:

Basically, all of tranquil observations are associated with lower RER appreciation. Characteristics of observations under intermediate regimes having lower probability of entering crisis period are:

- lower output gap;
- higher reserve growth rate;
- lower change in inflation;
- moderate OECD growth rate;

6.5 *"FLOAT" Tree model*

There are a total of 181 observations under floating regimes. Based on unconditional probabilities given in Table 8 CART has split observations into eight TNs; TNs 3,5, and 7 are crisis prone, whereas remaining five TNs are classified as tranquil TNs.

Table 8 : Unconditional probabilities of observations under floating regimes.

float	obs	inter
crisis	63	35%
tranquil	118	65%
Total	181	

The classification tree of "FLOAT" model is described in Figure 8, and detailed information relating the TNs is given in App. Table 19.

Six indicators are chosen to be important in incidence of crises. They are: *change in reserve growth, change in real interest rates, change in M2 growth rate, change in the ratio of short term debt to overall debt, change in capital account to GDP ratio, growth of export and M2.*

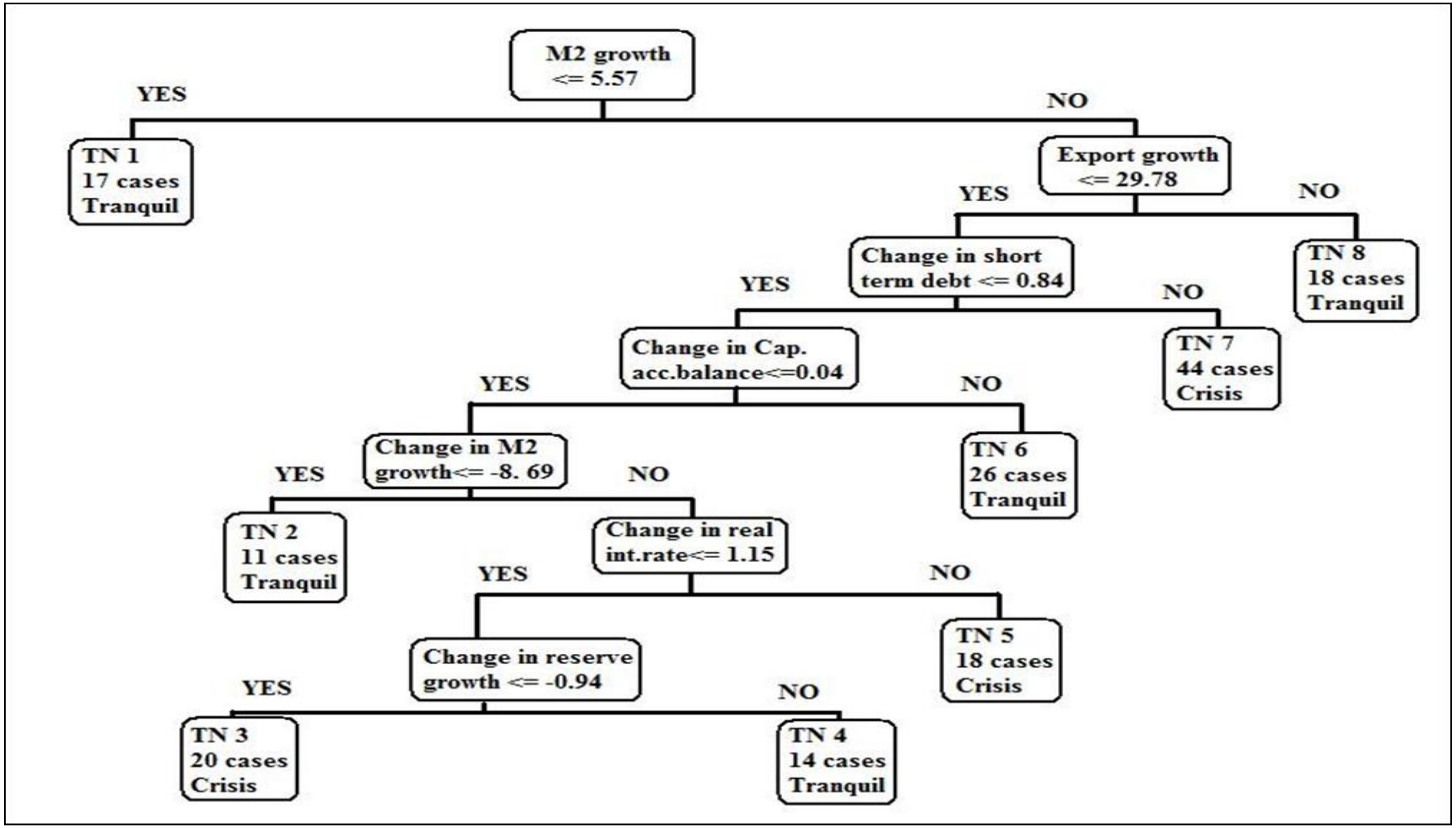

Figure 8 : Tree classification for Float model

Tranquil prone TNs:

In “FLOAT’ model, splitting starts by growth rate of M2. One of the findings of Kamin, Schindler and Samuel (2001) is that they believe that M2 growth rate is a measure of liquidity, whose high values may lead to currency crises. 17 observations for which M2 growth rate was lower than 5.59 were split into tranquil TNs with 100% purity (TN1). Observations which do not satisfy the condition posed in top parent node are classified according to the export growth rate level. Since increasing export growth may be attributable to devaluation of domestic currency, Kaminsky, Lizondo and Reinhart (1998) found that it lowers the likelihood of currency crises.

Observations which empirically support the conventional idea given in the above are grouped into TN8. On the other hand, for the observations for which export growth is lower than 29.78, lower short term debt with higher capital account balance (as a percentage of GDP) compared to TN7 conditional probability of experiencing crises decreases by 37% (TN6).

Crisis prone TNs:

Higher M2 growth rate combined with moderate export growth rate and higher short term debt ratio result in crises (TN7). Furthermore, sharp increase in probability of crises is seen for observations in TN5, which are classified by higher change in both M2 growth and domestic real interest rates[12]. In addition, countries with lower change in reserve growth rate are more vulnerable to currency crises (TN3). Hence, crises observations in “FLOAT” model can be distinguished from tranquil ones in that they have:

- higher changes in ratio of short term debt to total debt
- higher changes in domestic real interest rates
- lower changes in reserve growth rates

[12] High real interest rates signal a liquidity crunch; usually monetary authorities tend to increase domestic real interest rates to fend of speculative attacks.

7. CONCLUSION

The purpose of this paper was to analyze whether the paths leading to crises differ under fix, intermediate and floating regimes. Due to the fact that most of policy makers have been considering exchange rate regime choice to be independent in policy making, there are not many empirical studies which analyze the relationship of ERRC and currency crises. Hence, the findings of this study were aimed to contribute to the scarce literature of possible link between ERRC and CC.
In the first step, by constructing EMPi we have identified crises and tranquil dates for 172 countries starting from the period of Bretton Woods collapse until 2007. As a next step, we have applied a non-parametric approach, CART, to classify the crises and tranquil observations into separate groups as pure as possible. In a latter step, four different classification trees were built. The motivation for constructing separate trees for each type of regimes is attributable to the findings we have reached after analyzing a binary model. Although the overall homogeneity of TNs in binary classification tree was not high, there are some interesting findings worth to mention.According to binary model results, the likelihood of experiencing crises increases in cases of higher inflation, higher overvaluation of RER combined with higher ratio of domestic credit to GDP. Furthermore, as a global economy indicator, higher change in US federal funds trigger crises incidences.

On the other hand, the remaining results indicate that crises paths under fix, intermediate and floating regimes are of different types and separating observations under different exchange regime reveal better results in terms of homogeneity of TNs. For instance, we did not have any TN crises (tranquil) prone with 100% or 0% purity, whereas in sub models we have attained at least one TN in which crises and tranquil observations were separated with 100% homogeneity.

It is found that economies under fix regime with higher public debt, lower growth of export, and higher growth of imports are more vulnerable to crises, whereas peculiar fragilities of countries under intermediate regimes are identified to be higher output gap level and inflation, as well as lower international reserve growth rate. In terms of observations under floating regime, we have found that ratio of short term debt plays a significant role in exiting the tranquil period.

Since CART algorithm chooses indicators based on degree of variable importance, we could not reach to a concrete evidence for the relationship between indicators that were not used in tree construction and CC.

Lastly, we shall summarize that for the majority of observations, crises are likely to occur when overvaluation of RER is high, change in US federal funds rate increase, output gap is higher above the trend, there is an increase in short term debt ratio, monetary authorities rise domestic real interest rates, inflation increases and there is a substantial loss in reserves. Moreover, lower terms of trade and an increase in domestic credit to GDP ratio raises the risk of facing speculative attack.

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App. Table 9 Explanatory variables

Indicator	Interpretation	Effect on CC	References	Sector
Deviation of Real effective exchange rate from its HP trend	A measure for the change in international competetiveness and a proxy for over(under)valuation; Overvalued real exchange rate is expected to produce higher probability of CC	Positive	Kaminsky, Lizondo, and Reinhart (1998);Berg and Patillo (1999); Kamin, Schindler, and Samuel (2001); Edison(2003); Demirguc-Kunt and Detragiache (2000)	External
Export growth	Declining export growth may be attributable to overvaluation of domestic currency; Thus, it is a sign of currency overvaluation.	Negative	Kaminsky, Lizondo, and Reinhart (1998);Berg and Patillo (1999);Edison(2003); Marchesi (2003);	External
Import growth	High growth in import may lead to deterioration of current account and result in CC	Positive	Kaminsky, Lizondo, and Reinhart (1998);Berg and Patillo (1999);Edison(2003); Marchesi (2003);	External
Terms of Trade	Increases in terms of trade strengthen a country's balance-of-payments account; Lowers the probability of crisis.	Negative	Kaminsky, Lizondo, and Reinhart (1998); Kamin, Schindler, and Samuel (2001); Demirguc-Kunt and Detraigache (2000).	External
Ratio of the current account to GDP	Incrreases in the current account surplus are expected to indicate large capital inflows; Lowers the probability of crises.	Negative	Berg and Patillo(1999); Eichengreen and Arteta (2002); Marchesi (2003); Kaminsky, Lizondo, and Reinhart (1998); Kamin, Schindler, and Samuel (2001).	External
Growth of foreign exchange reserves	A decline in foreign reserves is an indicator of an underdevaluation of a currency, but not necessarily of a currency crisis.	Negative	Berg and Patillo(1999);Marchesi (2003); Kaminsky, Lizondo, and Reinhart (1998); Edison (2003).	External
Capital Account openness	An indicator of trade integration level	Ambiguous**	Levy-Yeyati and Stuzenegger, Reggio (2006); Asici et al.(2010);	Financia l
Openness	Another measure of trade liberalization	Negative	Levy-Yeyati and Stuzenegger, Reggio (2006); Asici et al.(2010);	External
Volatlity of Terms of Trade	This indicator measures the extent of real shocks a country exposed to.	Positive	Levy-Yeyati and Stuzenegger, Reggio (2006); Asici et al.(2010);	External
Ratio of external debt to GNP	A primary measure for the level of international debt	Positive	Asici et al.(2010); Rose and Frankel (1996)	External
Current Account bal. to GDP ratio	A measure of vulnerability to external shocks	Negative	Asici et al.(2010); Rose and Frankel (1996)	External
Trade balance		Negative	Asici et al.(2010); Rose and Frankel (1996)	External

App. Table 9 (continued)

Capital Account bal. to GDP ratio		?*	Asici et al.(2010); Rose and Frankel (1996)	External
Exports to Imports ratio		Negative	Asici etl (2010)	External
M2 growth	This indicator is a measure of liquidity; High growth may lead to currency crises.	Positive	Kamin, Schindler, and Samuel (2001)	Financial
M2GDP	A measure of real money supply; The level of liquidity is expected to lower the CC probability	Negative	Asici et al.(2010)	Financial
Ratio of domestic credit to GDP	Very high growth of domestic credit serves as an indicator of the fragility of the banking system.	Positive	Berg and Patillo(1999); Eichengreen and Arteta (2002); Marchesi (2003); Kaminsky, Lizondo, and Reinhart (1998); Kamin, Schindler, and Samuel (2001).	Financial
Domestic real interest rate	High real interest rates signal a liquidity crunch, or have been increased to fend off a speculative attack	Positive	Kaminsky, Lizondo, and Reinhart (1998); Kamin, Schindler, and Samuel (2001); Demirguc-Kunt and Detraigache (2000).	Financial
Ratio of bank reserves to bank assets	In countries where the banking systems are liquid adverse macroeconomic shocks are less efficient in leading to crises.	?	Demirguc-Kunt and Detraigache (2000)	Financial
Bank deposits to GDP ratio	It is one of the sources of third generation currency crises models;	Positive	Kaminsky (2003)	Financial
M3 to GDP ratio	An indicator of financial depth of a country	Positive	Asici et al.(2010)	Financial
Ratio of budget balance to GDP	Countries with higher deficits are more prone to crisis, since deficits increase the vulnerability to shocks; A crude measure of fiscal policy;	?*	Demirguc-Kunt and Detraigache (2000); Eichengreen and Arteta (2002)	Domestic real and public
Ratio of public debt to GDP	High debt level increases the vulnerability to capital inflows reversal.	Positive	Lanoie and Lemarbre (1996); Eichengreen and Arteta (2002); Kamin, Schindler, and Samuel (2001);	Domestic real and public
Growth of industrial production	Increases in growth of industrial production lowers the probability of crisis.	Negative	Berg and Patillo(1999);Marchesi (2003); Kaminsky, Lizondo, and Reinhart (1998); Edison (2003).	Domestic real and public
Inflation rate	Adversely affects the banking system, due to the high nominal interest rates.	?*	Demirguc-Kunt and Detraigache (2000); Lanoie and Lemarbre (1996); Marchesi (2003)	Domestic real and public

App. Table 9 (continued)

GDP per capita	Worsening of countrys' domestic activities tend to increase the likelihood of a banking crisis	?*	Demirguc-Kunt and Detraigache (2000); Lanoie and Lemarbre (1996); Marchesi (2003)	Domestic real and public
Size	It indicates whether country is developed or among developing economies.	Negative	Levy-Yeyati and Sturzenegger, Reggio (2006);	Domestic real and public
FDI to GDP ratio	Expresses the variablity in capital flows.	Negative	Dooley et al.(1995); Asici et al.(2010); Rose and Frankel (1996);	Domestic real and public
Short term debt to total external debt	Debt composition	Positive	Asici et al.(2010); Rose and Frankel (1996);	Domestic real and public
Lont term debt to GDP ratio	Debt composition	Positive	Asici et al.(2010); Rose and Frankel (1996);	Domestic real and public
Output gap	Deviation of Real GDP from its HP trend	Positive	Asici et al.(2010)	Domestic real and public
Ratio of government expenditure to GDP	Macroeconomic characteristics of a country	Negative	Kang(2001)	Domestic real and public
Growth rate of real GDP	Macroeconomic characteristics of a country	?*	Kang(2001)	Domestic real and public
US interest rates	International interest rate increases are often associated with capital outflows.	Positive	Edison (2003); Kamin, Schindler, and Samuel (2001); Eichengreen and Arteta (2002);	Global
OECD GDP growth	Higher output growth strengthens exports	Negative	Edison (2003); Kamin, Schindler, and Samuel (2001); Eichengreen and Arteta (2002);	Global
Herfgov	A polity economy variable, which is a measure of political strength	Negative	Levy-Yeyati and Stuzenegger, Reggio (2006); Asici et al.(2010);	Political

App. Table 9 (continued)

Yearsin office	This variable is positively correlated with government institutional strength	Negative	Levy-Yeyati and Stuzenegger, Reggio (2006); Asici et al.(2010);	Political
Liec	As legislaltures become more competetive, political weakness increases	Positive	Levy-Yeyati and Stuzenegger, Reggio (2006); Asici et al.(2010);	Political
Finlib	Financial liberalization dummy;	Ambiguous**	Asici et al.(2010)	Political
acc	measures for institutionalized autocracy	Negative	Asici et al.(2010)	Political
dem	measures for institutionalized democracy	Negative	Asici et al.(2010)	Political
durab	measure of the durability of the regime's authority	Negative	Asici et al.(2010)	Political
polity	Derived simply by subtracting the AUTOC value from the DEMOC value	Negative	Asici et al.(2010)	Political
polity2	modified version of polity variable	Negative	Asici et al.(2010)	Political

?* The statistical significance of these indicators were not supported by an empirical studies

Ambiguous** The expected sign depends on the maturity of a country

App. Table 10 Explanatory variables

Variable	Definition/Description	Frequency	Source
Overvaluation	Deviation of quarterly real effective exchange rate from HP trend	annual	IFS (REC or REU), otherwise authors calculations (1)
Change in US interest rate	Change in US Federal Funds' Rate	monthly	IFS (line 60b)
Change in Money Supply (M2)	Money and quasi money growth (annual %)	annual	WDI, FM.LBL.MQMY.ZG
Liquid Bank Reserves to Bank Assets	Ratio of liquid Bank Reserves to Bank Assets	annual	DWI; WDI, FD.RES.LIQU.AS.ZS
Exchange market pressure index	Weighted average of depreciation, change in interest rate and reserves	monthly	IFS, 1L.DZF, .AE.ZF... and 60.ZF
Trade Balance	Trade Balance as a percentage of GDP	annual	WDI, NE.RSB.GNFS.ZS
Eximp	Exports to Imports Ratio	annual	WDI, NE.EXP.GNFS.CD, NE.IMP.GNFS.CD
Liquid Liabilities	Liquid Liabilities as a percentage of GDP	annual	World Bank Financial Structure Dataset
Long-term Debt	Long-term Debt as a percentage of GDP	annual	WDI, DT.DOD.DLXF.CD
Public Debt	Public Debt as a percentage of GDP	annual	WDI, DT.DOD.DPPG.CD
Short-term to Total External Debt		annual	WDI, DT.DOD.DSTC.ZS
Terms of Trade	1995=100	annual	WEO (2003), UNCTAD and Ghosh et al.(2003)
Domestic Credit to Private Sector	Domestic Credit to Private Sector as a percentage of GDP	annual	WDI, FS.AST.PRVT.GD.ZS
Domestic Credit/GDP	Net domestic credit (current LCU) is divided by GDP in local currency unit	annual	WDI, FM.AST.DOMS.CN , NY.GDP.MKTP.CN
Domestic Real Interest Rate	Real interest rate (%)	annual	WDI, FR.INR.RINR
Bank Deposits	Demand, time and saving deposits in deposit money banks as a share of GDP	annual	World Bank Financial Structure Dataset
Exports	Growth rate in merchandise export	monthly	IFS line 70.
Imports	Growth rate in merchandise import	monthly	IFS line 71
Reserves	Growth rate in foreign reserves excluding gold	monthly	IFS line IL.d

App. Table 10 (continued)

Growth of industrial production	Industry, value added (annual % growth)	annual	WDI
Oecdgr	OECD gdp growth	annual	OECD statistics
Government expenditure	General government final consumption expenditure (% of GDP)	annual	WDI
Real gdp	GDP (constant 2000 US$)	annual	WDI, NY.GDP.MKTP.KD
Capital account	Capital account balance (%GDP)	annual	WDI, BN.TRF.KOGT.CD; UNCTAD; IFS line 4994..9...
Credit by banking sector	Domestic credit provided by banking sector (% of GDP)	annual	WDI, FS.AST.DOMS.GD.ZS
Finlib	Financial liberalization dummy	annual	Bekeart, Harvey and Lundblad (2005)
acc	measures for institutionalized autocracy	annual	PolityIV dataset 2007
dem	measures for institutionalized democracy	annual	PolityIV dataset 2007
durab	measure of the durability of the regime's authority	annual	PolityIV dataset 2007
polity	Derived simply by subtracting the AUTOC value from the DEMOC value	annual	PolityIV dataset 2007
polity2	modified version of polity variable	annual	PolityIV dataset 2007

IFS: International Financial Statistics International Monetary Fund
WDI: World Development Indicators, World Bank
World Bank Financial Structure Dataset, http://www.worldbank.org/research/projects/finstructure/database.htm
(1) Geometric average of CPI-deflated exchange rate vis a vis US$, DM and yen with equal weights

App. Table 11   Crisis dates for Binary Model

Crisis_Fix							
ARG 02	GRC 92	PRT 96	MLI 73	SWZ 75	BRB 03	CAF 72	JOR 75
AUS 74	GRC97	GBR 72	MLI 79	SWZ 81	BLZ 80	CAF 76	JOR 88
AUT 84	GTM 81	GBR 92	MDA 98	TGO 73	BLZ 85	COG 74	JOR 98
AUT 88	HND 82	BGR 99	MNG 06	TGO 79	BLZ 89	COG 79	KOR 80
BEL 73	IRL 72	BFA 75	MOZ 01	UGA 89	BLZ 98	COG 88	KWT 75
BEL 77	IRL 78	BFA 78	MOZ 06	BHR 94	BEN 73	COG 94	LBN 95
BEL 81	LUX 93	CIV 73	NER 73	BHR 00	BEN 78	CYP 96	MDV 95
BEL 91	MLT 05	CIV 80	NER 79	BHR 04	BDI 76	CYP 00	MDV 01
CRI 78	MEX 76	KEN 75	SEN 73	BRB 81	BDI 83	CYP 04	QAT 96
SLV 98	NLD 86	KEN 81	SEN 80	BRB 89	CMR 74	DMA 79	QAT 00
FRA 91	NLD 91	LTU 99	SVN 07	BRB 93	CMR 79	GAB 75	SAU 78
GAB 79	MDV 07	HKG 97	NPL 75	IND 74	NPL 95	JAM 73	SAU 83
THA 77	THA 84	THA 89	THA 95	ARE 04			

Crisis_Float							
AUS 85	DEU 80	JPN 89	NOR 91	ZAF 01	CHN 89	MWI 90	POL 05
AUS 89	DEU 88	MEX 98	NOR 97	CHE 78	CHN 92	MWI 94	TZA 83
BOL 79	GRC 84	NZL 87	NOR 03	TUR 83	GEO 01	MWI 01	TZA 88
BRA 02	HTI 00	NZL 94	PRY 84	GBR 76	KEN 91	MNG 93	ZWE 97
CHL 85	ISL 06	NZL 97	ZAF 75	GBR 81	MDG 94	NGA 86	DZA 90
DOM 85	ITA 79	NOR 78	ZAF 81	GBR 84	MDG 99	NGA 89	DZA 94
SLV 86	JPN 80	NOR 81	ZAF 84	ALB 97	MWI 78	NGA 99	VEN 86
SLV 90	JPN 86	NOR 86	ZAF 98	CHN 84	MWI 85	NGA 03	

Crisis_Inter							
ARG 81	DNK 82	MLT 91	SWE 02	MRT 88	UGA 95	ISR 91	PAK 00
AUS 82	DNK 86	MLT 94	CHE 84	MRT 92	UGA 00	ISR 98	PHL 79
AUT 73	DNK 91	NLD 73	CHE 91	MRT 97	ZWE 82	JAM 85	PHL 83
AUT 80	DOM 02	NLD 76	CHE 00	MUS 79	DZA 86	JAM 95	PHL 90
BOL 90	FIN 78	NLD 81	TUR 01	MUS 88	BGD 99	JAM 03	PHL 95
BOL 95	FIN 82	NZL 75	ARM 98	MUS 94	BGD 06	KOR 85	SGP 75

App. Table 11 (continued)

Crisis_Inter (continued)							
BOL 98	FIN 86	NZL 78	AZE 99	MUS 05	BWA 84	KOR 97	SGP 78
BRA 97	FIN 89	NZL 84	HRV 99	MOR 85	BWA 90	KWT 78	SGP 91
CAN 76	FRA 73	PRY 89	HRV 07	MOR 90	BWA 98	KWT 82	SGP 97
CAN 84	FRA 80	PRY 93	CZE 96	MOR 05	BWA 05	KWT 87	LKA 77
CAN 92	GRC 74	PRY 98	FJI 06	PNG 94	BDI 87	KWT 94	LKA 84
CAN 98	GRC 78	PRY 03	GMB 00	PNG 97	BDI 90	LAO 95	LKA 88
CHL 93	GTM 98	PER 98	GIN 95	POL 99	BDI 95	LBN 76	LKA 95
COL 79	HTI 91	PRT 77	GIN 05	SVK 06	BDI 00	LBN 81	LKA 00
COL 84	HND 90	PRT 82	HUN 89	SVN 95	CYP 78	MYS 84	LKA 07
COL 90	ISL 87	PRT 86	HUN 93	SDN 92	CYP 89	MYS 89	TTO 96
COL 95	ISL 91	PRT 91	HUN 03	SDN 96	EGY 82	MYS 92	VEN 02
COL 98	ISL 99	ESP 76	KAZ 99	TZA 96	EGY 89	MYS 97	DNK 74
COL 02	IRL 86	ESP 80	KEN 08	TZA 99	IND 88	MMR 96	MLT 82
COL 07	IRL 91	ESP 87	KGZ 03	TUN 77	IND 97	NPL 81	SWE 88
CRI 74	ITA 75	ESP 91	KGZ 07	TUN 81	IND 07	NPL 84	MRT 85
CRI 91	ITA 89	SWE 76	LBY 99	TUN 85	IDN 78	NPL 91	TUN 00
CRI 96	ITA 92	SWE 81	MKD 97	TUN 89	IDN 86	PAK 92	IDN 97
							PAK 95

App. Table 12 Crises observations in crisis prone TNs (Binary model)

TN 4

crisis_fix

BFA 75	COG 94
KEN 75	GAB 75
KEN 81	JOR 75
SWZ 75	KWT 75
SWZ 81	NPL 75
BRB 81	NPL 95
BLZ 98	

crisis_float

ZAF 75	ALB 97
ZAF 81	GEO 01
GBR 81	POL 05
	TZA 88

crisis_inter

BRA 97	GIN 95
COL 95	GIN 05
COL 98	KEN 08
GTM 98	KGZ 07
ITA 75	MRT 97
PRY 98	PNG 94
PER 98	SVK 06
TUR 01	SDN 96
CZE 96	TZA 99
GMB 00	UGA 00
LAO 95	BGD 99
PAK 00	BWA 98
SGP 75	IND 97
LKA 95	LKA 07
LKA 00	

TN 5

crisis_fix

AUT 84	SVN 07
AUT 88	BRB 03
BEL 81	CYP 96
GRC 97	CYP 04
GTM 81	MDV 95
MLT 05	MDV 01
LTU 99	QAT 96
MOZ 01	

crisis_float

DEU 88	ZAF 98
GRC 84	CHN 84
MEX 98	CHN 92
NOR 03	MNG 93

crisis_inter

BOL 98	ESP 76
CAN 84	ESP 87
CAN 92	ESP 91
CAN 98	SWE 81
CHL 93	SWE 88
ISL 99	CHE 84
IRL 91	HRV 99
MLT 91	HUN 03
MLT 94	KAZ 99
PRT 91	LBY 99
MUS 94	EGY 82
MUS 05	IND 07
MOR 05	KWT 87
ZWE 82	MYS 92
BGD 06	SGP 91
	SGP 97

TN 7

crisis_fix

ARG 02
BDI 83
THA 84

crisis_float

ISL 06
NZL 87
NOR 81
PRY 84
MDG 94
MWI 94
MWI 01
NGA 99
ZWE 97
DZA 94

crisis_inter

ARG 81
AUS 82
COL 07
HTI 91
ITA 92
NLD 76
NLD 81
PRT 82
MRT 92
PNG 97
TZA 96
BWA 84
IDN 97
KOR 97
MYS 84
MYS 97
LKA 84
VEN 02

TN 8

crisis_fix

AUS 74	CIV 80	BRB 89
BEL 73	MLI 73	BLZ 80
BEL 77	MLI 79	BLZ 85
CRI 78	NER 73	BLZ 89
IRL 78	NER 79	BEN 73
NLD 86	SEN 73	BEN 78
BFA 78	SEN 80	CMR 74
CIV 73	TGO 73	CMR 79
DMA 79	TGO 79	COG 74
GAB 79	UGA 89	COG 79
IND 74	KOR 80	THA 77
JAM 73	SAU 78	THA 89

crisis_float

AUS 85	DEU 80	CHE 78
AUS 89	ITA 79	CHN 89
BOL 79	JPN 80	MWI 78
CHL 85	JPN86	MWI 85
DOM 85	JPN 89	MWI 90
SLV 86	VEN 86	NGA 86
SLV 90	NOR 78	NGA 89
	NOR 86	DZA 90

crisis_inter

AUT 73	HUN 89	GRC 78
AUT 80	MRT 85	HND 90
BOL 90	MUS 79	IRL 86
COL 79	MOR 85	ITA 89
COL 90	MOR 90	NLD 73
CRI 74	TUN 77	NZL 78
DNK 74	TUN 85	PRY 89
DNK 86	TUN 89	PRT 77
FIN 78	DZA 86	PRT 86
FIN86	BWA 90	ESP 80
FIN 89	BDI 90	IDN 78
FRA 73	CYP 78	IDN 86
FRA 80	CYP 89	JAM 85
GRC 74	EGY 89	KOR 85
KWT 78	PHL 79	SGP 78
MYS 89	PHL 90	LKA 77

App. Table 13 Terminal node information for Binary model

TN no	Route	Competitor	Surrogate	*(Fix #)	*(Inter#)	*(Float#)	*(Tranquil#)	# of Cases	Class
1	OECDgrowth <= 3.77; Overvaluation of RER <= 12.36; Change in trade bal. <= 0.096; Trade bal. <= -15.52	Overvaluation <=13.79; M2 growth<= 15.1; OECD growth<=3.52; Inflation<= 0.83;	Change in US int.rate<=2.27; Change in RER apprec.<=8.3; Change in export to import ratio<= 0.93; Export to import ratio <=22.6;	55%(5)	33%(3)	12%(1)	84%(46)	55	Tranquil
2	OECDgrowth <= 3.77; Overvaluation of RER <= 12.36; Change in trade bal. <= 0.096; Trade bal. > -15.52;Bank liquid.to reserve <=2.07;	Overvaluation <=13.79; M2 growth<= 15.1; OECD growth<=3.52; Inflation<= 0.83;	Change in US int.rate<=2.27; Change in RER apprec.<=8.3; Change in export to import ratio<= 0.93; Export to import ratio >22.6;	30%(3)	50%(5)	20%(2)	83%(48)	58	Tranquil
3	OECDgrowth <= 3.77; Overvaluation of RER <= 12.36; Change in trade bal. > 0.096; Trade bal. > -15.52;Bank liquid.to reserve > 2.07; Domes.credit /GDP<=52.9088 ; Change in US int.rate <= -0.54;	Overvaluation <=13.79; M2 growth<= 15.1; OECD growth<=3.52; Inflation> 0.83; M2/GDP<= 64.73; Change in ToT <= 6.33	Change in US int.rate<=2.27; Change in RER apprec.<=8.3; Change in export to import ratio<= 0.93; Export to import ratio >22.6; Credit by bank<= 52.8; Change in OECD growth<=2.19;	25%(4)	44%(7)	31%(5)	83%(78)	94	Tranquil
4	OECDgrowth <= 3.77; Overvaluation of RER <= 12.36; Change in trade bal. > 0.096; Trade bal. > -15.52;Bank liquid.to reserve > 2.07; Domes.credit /GDP<=52.9088 ; Change in US int.rate > -0.54;	Overvaluation <=13.79; M2 growth<= 15.1; OECD growth<=3.52; Inflation> 0.83; M2/GDP<= 64.73;Change in ToT >6.33	Change in US int.rate<=2.27; Change in RER apprec.<=8.3; Change in export to import ratio<= 0.93; Export to import ratio >22.6; Credit by bank<= 52.8;Change in OECD growth>2.19;	28%(14)	58%(29)	14%(7)	60%(74)	124	Crisis Inter
5	OECDgrowth <= 3.77; Overvaluation of RER <= 12.36; Change in trade bal. > 0.096; Trade bal. > -15.52;Bank liquid.to reserve > 2.07; Domes.credit /GDP> 52.9088	Overvaluation <=13.79; M2 growth<= 15.1; OECD growth<=3.52; Inflation> 0.83; M2/GDP> 64.73;	Change in US int.rate<=2.27; Change in RER apprec.<=8.3; Change in export to import ratio<= 0.93; Export to import ratio >22.6; Credit by bank>52.8;	28%(15)	57%(31)	15%(8)	50%(53)	107	Crisis Inter

App. Table 13(continued)

6	OECDgrowth <= 3.77; Overvaluation of RER <= 12.36; Change in trade bal. > 0.096	Overvaluation <=13.79; M2 growth<= 15.1; OECD growth>3.52;	Change in US int.rate<=2.27; Change in RER apprec.<=8.3; Change in export to import ratio> 0.93;	29%(21)	61%(44)	10%(7)	80%(279)	351	Tranquil
7	OECD growth<= 3.771; Overvaluaiton of RER> 12.36	Overvaluation <=13.79; M2 growth> 15.1;	Change in US int.rate<=2.27; Change in RER apprec.>8.3;	10%(3)	58%(18)	32%(10)	34%(16)	47	Crisis Float
8	OECD growth> 3.771	Overvaluation >13.79	Change in US int.rate>2.27	34%(36)	45%(48)	21%(23)	45%(87)	194	Crisis Fix
				Total	Total	Total	Total	Total	
				101	181	63	681	1030	

*: Conditional Probability

App. Table 14 Crises observations in crisis prone TNs (FIX model)

TN 3			TN 6		
AUT 88	SVN 07	JOR 75	AUS 74	TGO 73	COG 74
BEL 81	SWZ 81	KOR 80	BEL 73	TGO 79	COG 79
BEL 91	BRB 81	MDV 95	BEL 77	UGA 89	DMA 79
FRA 91	BLZ 80	MDV 01	CIV 73	BRB 89	GAB 79
IRL 72	BDI 76	MDV 07	MLI 73	BLZ 85	IND 74
IRL 78	BDI 83	NPL 95	MLI 79	BLZ 89	JAM 73
NLD 91	CAF 72	QAT 96	NER 73	BEN 73	THA 77
PRT 96	CAF 76	SAU 78	NER 79	CMR 74	THA 89
GBR 72	COG 94	THA 84	SEN 73	CMR 79	
BGR 99	CYP 96	THA 95			
BFA 75	GAB 75	MOZ 01			
MNG 06					

App. Table 16 Crises observations in crisis prone TNs (Inter model)

TN1	TN2		TN3			TN 8		TN 9
PRY 03	CAN 76	PRY 93	BOL 95	SWE 88	TZA 99	AUT 73	ESP 80	ARG 81
ARM 98	CAN 92	ESP 76	BOL 98	CHE 84	BGD 99	AUT 80	HUN 89	AUS 82
HUN 93	CHL 93	SWE 76	BRA 97	CHE 91	BWA 05	BOL 90	MRT 85	HTI 91
SDN 92	COL 02	SWE 81	CAN 84	CHE 00	BDI 87	COL 79	MUS 79	HND 90
	DNK 82	SWE 02	COL 84	AZE 99	BDI 95	COL 90	MAR 85.	ITA 92
TN 4	DOM 02	HUN 03	COL 95	HRV 99	BDI 00	CRI 74	MAR 90.	NLD 76
CAN 98	FIN 82	KGZ 03	COL 98	CZE 96	IND 88	DNK 74	TUN 77	NLD 81
MLT 91	ITA 75	MUS 94	CRI 91	GMB 00	IND 97	DNK 86	TUN 85	PRY 89
KAZ 99	MLT 82	PNG 94	CRI 96	GIN 95	ISR 91	FIN 78	TUN 89	PRT 82
MAR 05.	MLT 94	TUN 81	DNK 91	GIN 05	ISR 98	FIN 86	DZA 86	MRT 92
BWA 98	NZL 75	ZWE 82	GTM 98	LBY 99	KWT 87	FIN 80	BWA 90	PNG 97
LAO 95	EGY 82	MYS 92	ISL 87	MKD 97	MMR 96	FRA 73	BDI 90	TZA 96
TTO 96	JAM 03	NPL 81	ISL 99	MRT 88	NPL 84	FRA 80	CYP 78	BWA 84
	KWT 82	PAK 92	IRL 91	MRT 97	NPL 91	GRC 74	CYP 89	EGY 89
TN 5	KWT 94	PHL 83	NZL 94	MUS 88	PAK 95	GRC 78	IDN 78	IDN 97
ISL 91	LBN 76	SGP 75	PRY 98	MUS 05	PAK 00	IRL 86	IDN 86	KOR 97
POL 99		LBN 81	PER 98	SVN 95	PHL 95	ITA 89	JAM 85	MYS 84
UGA 00	TN 7		PRT 91	SDN 96	SGP 91	NLD 73	KOR 85	MYS 97
JAM 95	TUR 01		ESP 87	TZA 99	SGP 97	NZL 78	KWT 78	LKA 84
			ESP 91	TUN 00	LKA 88	PRT 77	MYS 89	VEN 02
				LKA 95	LKA 00	PRT 86	PHL 79	
						PHL 90	SGP 78	
							LKA 77	

App. Table 15 Terminal Node information for FIX model

TN no	Route	Competitor	Surrogate	# of Cases	Conditional Probability (# Fix)	Class assignment
1	OECD growth <= 4.18; Import growth <= 15.21;	Durability<= 47.5;	Change in US interest rate<=2.28; Change in import growth <=7;	201	15%(31)	Tranquil
2	OECDgrowth<= 4.1765; Import growth > 15.21; Change in trade bal.<=0.897; Import growth <= 50.04; Change in ToT <= -4.7097	Durability>= 47.5; Import growth<=66.93; Change in ToT<= -6.04; Inflation<= 0.84;	Change in US interest rate<=2.28; Change in import growth>7; Change in export to import ratio<=3.75; Export growth<= 35; Export growth<= -12.25;	17	12%(2)	Tranquil
3	OECDgrowth<= 4.1765; Import growth > 15.21; Change in trade bal.<=0.897; Import growth <= 50.04; Change in ToT > -4.7097	Durability>= 47.5; Import growth<=66.93; Change in ToT<= -6.04; Inflation> 0.84;	Change in US interest rate<=2.28; Change in import growth>7; Change in export to import ratio<=3.75; Export growth<= 35; Export growth>-12.25;	65	54%(35)	Crisis
4	OECDgrowth<= 4.1765; Import growth > 15.21; Change in trade bal.<=0.897; Import growth > 50.04;	Durability>= 47.5; Import growth<=66.93; Change in ToT>-6.04;	Change in US interest rate<=2.28; Change in import growth>7; Change in export to import ratio<=3.75; Export growth>35;	21	10%(2)	Tranquil
5	OECDgrowth<= 4.1765; Import growth > 15.21; Change in trade bal.>0.897;	Durability>= 47.5; Import growth>66.93;	Change in US interest rate<=2.28; Change in import growth>7; Change in export to import ratio>3.75	35	14%(5)	Tranquil
6	OECD growth > 4.1765	Durability>= 47.5	Change in US interest rate>=2.28	35	74%(26)	Crisis
				Total	Total (#Fix)	
				374	101	

App. Table 17 Crises observations in crisis prone TNs (Float model)

TN 2	TN 3	TN 5	TN7	
DEU 80	BOL 79	SLV 90	AUS 85	NOR 78
	MEX 98	DEU 88	AUS 89	ZAF 98
TN 4	NZL 87	NOR 91	BRA 02	TUR 83
NZL 97	NOR 86	NOR 03	CHL 85	ALB 97
	NOR 97	PRY 84	DOM 85	CHN 84
TN6	ZAF 81	ZAF 75	GRC 84	CHN 92
SLV 86	ZAF 84	CHE 78	HTI 00	GEO 01
NOR 81	ZAF 01	UK 76	ITA 79	KEN 91
MWI 90	UK 81	NGA 86	JPN 80	MDG 94
MWI 94	UK 84	NIG 89	JPN 86	MDG 99
MWI 01	CHN 89	DZA 94	JPN 89	MWI 78
MNG 93		VEN 86	NZL 94	NGA 99
POL 05	TN 8		NGA 03	TZA 88
	MWI 85		TZA 83	ZWE 97

App. Table 18 Terminal node information for INTER model

TN no	Route	Competitor	Surrogate	# of Cases	Conditional Probability (# Inter)	Class assignment
1	Overvaluation of RER <=12.58; OECD growth<=3.77; OECD growth<=3.52; Output gap<= -4.13;	Capital acc. To GDP ratio<=0.82; Change in FDI to GDP ratio<=1.10; Change in domes.Real interest rate<=-3.81; Overvaluation<=4.2;	Change in overvaluation of RER<=12.21;Change in US interest rate<=3.14; Change in output gap level<=-8.02;	35	11%(4)	Tranquil
2	Overvaluation of RER <=12.58; OECD growth<=3.77; OECD growth<=3.52; Output gap>= -4.13; OECD growth<=2.09;	Capital acc. To GDP ratio<=0.82; Change in FDI to GDP ratio<=1.10; Change in domes.Real interest rate<=-3.81; Overvaluation>=4.2;	Change in overvaluation of RER<=12.21;Change in US interest rate<=3.14; Change in output gap level>=-8.02; Change in OECD growth<=-1.3;	118	28%(33)	Tranquil
3	Overvaluation of RER <=12.58; OECD growth<=3.77; OECD growth<=3.52; Output gap>= -4.13; OECD growth>=2.09; Reserve growth<=19.11; Change in openness<=3.05;	Capital acc. To GDP ratio<=0.82; Change in FDI to GDP ratio<=1.10; Change in domes.Real interest rate<=-3.81; Overvaluation>=4.2;Change in openness<=2.39;	Change in overvaluation of RER<=12.21;Change in US interest rate<=3.14; Change in output gap level>=-8.02; Change in OECD growth>=-1.3; M2 growth <=-7.08; Overvaluation<=-10.4;	105	59%(62)	Crisis
4	Overvaluation of RER <=12.58; OECD growth<=3.77; OECD growth<=3.52; Output gap>= -4.13; OECD growth>=2.09; Reserve growth<=19.11; Change in openness>=3.05; Change in inflation<=5.49;	Capital acc. To GDP ratio<=0.82; Change in FDI to GDP ratio<=1.10; Change in domes.Real interest rate<=-3.81; Overvaluation>=4.2;Change in openness<=2.39;Change in trade bal.<=-0.69;	Change in overvaluation of RER<=12.21;Change in US interest rate<=3.14; Change in output gap level>=-8.02; Change in OECD growth>=-1.3; M2 growth <=-7.08; Overvaluation>=-10.4;Infaltion <=18.8;	35	20%(7)	Tranquil
5	Overvaluation of RER <=12.58; OECD growth<=3.77; OECD growth<=3.52; Output gap>= -4.13; OECD growth>=2.09; Reserve growth<=19.11; Change in openness>=3.05; Change in inflation>=5.49;	Capital acc. To GDP ratio<=0.82; Change in FDI to GDP ratio<=1.10; Change in domes.Real interest rate<=-3.81; Overvaluation>=4.2;Change in openness<=2.39;Change in trade bal.>=-0.69;	Change in overvaluation of RER<=12.21;Change in US interest rate<=3.14; Change in output gap level>=-8.02; Change in OECD growth>=-1.3; M2 growth <=-7.08; Overvaluation>=-10.4;Infaltion >=18.8;	4	100%(4)	Crisis

App. Table 18 (continued)

6	Overvaluation of RER <=12.58; OECD growth<=3.77; OECD growth<=3.52; Output gap>= -4.13; OECD growth>=2.09; Reserve growth>=19.11;			9	0%	Tranquil
7	Overvaluation of RER <=12.58; OECD growth<=3.77; OECD growth>=3.52;	Capital acc. To GDP ratio<=0.82; Change in FDI to GDP ratio<=1.10; Change in domes.Real interest rate>=-3.81;	Change in overvaluation of RER<=12.21;Change in US interest rate<=3.14;	27	4%(1)	Tranquil
8	Overvaluation of RER <=12.58; OECD growth>=3.77;	Capital acc. To GDP ratio<=0.82; Change in FDI to GDP ratio>=1.10;	Change in overvaluation of RER<=12.21;Change in US interest rate>=3.14;	72	63%(45)	Crisis
9	Overvaluation of RER <=12.58	Capital acc. To GDP ratio>=0.82;	Change in overvaluation of RER>=12.21;	23	83%(20)	Crisis
				Total	Total(# Inter)	
				475	185	

App. Table 19 Terminal Node information for FLOAT model

TN no	Route	Competitor	Surrogate	# of Cases	Conditional Probability (# Float)	Class assignment
1	M2 growth<=5.57;			17	0%	Tranquil
2	M2 growth>=5.57; Export growth<=29.78; Change in short term debt<= 0.84; Change in cap.acc.to gdp<=0.04; Change in M2 growth<= -8.69;	Change in M2 growth rate>=-8.68; Overvaluation<=2.29; Capital acc. to GDP ratio<=0.03;	Change in dom.credit>=-18.24; Change in gov.expenditure<=-3; Change in industry<=2.69; Log of GDP<=9.64;	11	9%(1)	Tranquil
3	M2 growth>=5.57; Export growth<=29.78; Change in short term debt<= 0.84; Change in cap.acc.to gdp<=0.04; Change in M2 growth>= -8.69; Change in real interest rate<=1.15; Change in reserve growth<= -0.94;	Change in M2 growth rate>=-8.68; Overvaluation<=2.29; Capital acc. to GDP ratio<=0.03; Log of GDP<=11.33;Change in industry<=0.53;	Change in dom.credit>=-18.24; Change in gov.expenditure<=-3; Change in industry<=2.69; Log of GDP<=9.64;Volatility of ToT<=9.44; Reserve growth<=0.86;	20	55%(11)	Crisis
4	M2 growth>=5.57; Export growth<=29.78; Change in short term debt<= 0.84; Change in cap.acc.to gdp<=0.04; Change in M2 growth>= -8.69; Change in real interest rate<=1.15; Change in reserve growth>= -0.94;	Change in M2 growth rate>=-8.68; Overvaluation<=2.29; Capital acc. to GDP ratio<=0.03; Log of GDP<=11.33;Change in industry>=0.53;	Change in dom.credit>=-18.24; Change in gov.expenditure<=-3; Change in industry<=2.69; Log of GDP<=9.64;Volatility of ToT<=9.44; Reserve growth>=0.86;	14	7%(1)	Tranquil
5	M2 growth>=5.57; Export growth<=29.78; Change in short term debt<= 0.84; Change in cap.acc.to gdp<=0.04; Change in M2 growth>= -8.69; Change in real interest rate>=1.15;	Change in M2 growth rate>=-8.68; Overvaluation<=2.29; Capital acc. to GDP ratio<=0.03; Log of GDP>=11.33;	Change in dom.credit>=-18.24; Change in gov.expenditure<=-3; Change in industry<=2.69; Log of GDP<=9.64;Volatility of ToT>=9.44;	18	73%(13)	Crisis
6	M2 growth>=5.57; Export growth<=29.78; Change in short term debt<= 0.84; Change in cap.acc.to gdp>=0.04;	Change in M2 growth>=-8.68; Overvaluation<=2.29;Cap.account to GDP ratio>=0.03;	Change in domest.credit by banking sector>=-18.24;Change in govern.expend.<=-3.09;Change in industrial prod.to GDP<=2.69;Logof Gdp>=9.64;	26	27%(7)	Tranquil

App. Table 19 (continued)

7	M2 growth>=5.57; Export growth<=29.78; Change in short term debt>= 0.84;	Change in M2 growth>=-8.68; Overvaluation>=2.29;	Change in domest.credit by banking sector>=-18.24;Change in govern.expend.<=-3.09;Change in industrial prod.to GDP>=2.69;	44	64%(28)	Crisis
8	M2 growth>=5.57; Export growth>=29.78;	Change in M2 growth>=-8.68;	Change in domest.credit by banking sector>=-18.24; Change in govern.expend.>=-3.09	18	6%(1)	Tranquil

Total	Total(# Float)
181	63

Ek_A1

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ABSTRACT

THE RELATIONSHIP BETWEEN CURRENCY CRISES AND EXCHANGE RATE REGIME CHOICES

Chynara TOLUBAEVA

The crisis concept has long been an interest for economists. In this study, by using Classification and Regressin trees analysis which is a non-parametric approach, we are going to study possible relationship between regime choices and currency crises. More precisely, we are investigating whether the path leading to currency crises differs under different regimes. For instance, for a country under fixed exchange regime, the overvaluation of the real effective exchange rates could be considered as one of the causes of crises, but it is hard to find such vulnerability in a country pursuing an independently floating regime. The theoretical literature has been emphasizing the importance of regime choices, whereas it has been undervalued in empirical studies. One of our findings is that the paths leading countries to currency crises under fix, intermediate and floating regimes differ. Hence, by growing a binary classification tree for all regimes mixed in one sample, it becomes hard to detect exact relationship between crises and regime choices. Therefore, in order to get more reliable and significant results observations under each regimes should be analyzed separately. And this can be considered as the contribution of this study to the literature.

Keywords: Exchange rate regimes, Currency crises, CART analysis
Science Code: C14, E42, F31, F41

Ek_A2

Üniversitesi	: İstanbul Teknik Üniversitesi
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Programı	: Iktisat
Tez Danışmanı	: Yrd. Doç. Dr. Ahmet Atıl Aşıcı
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ÖZET

DÖVİZ KURU KRİZLERİ İLE DÖVİZ KURU REJİMİ ARASINDAKİ İLİŞKİLER

Chynara TOLUBAEVA

Bu deneysel çalışmada, Sınıflandırma ve Regresyon Ağaçları (Classification and Regression trees) adlı parametrik olmayan analiz yöntemini kullanarak ülkelerin izledikleri döviz kuru rejimleri ile krize götüren sebepler arasındaki ilişkiyi araştırıyoruz. Örneğin, sabit döviz kuru rejimi altında reel döviz kuru değerlenmekte ve bu o ülkeyi krize sebep sürükleyen önemli faktörlerden biri olabilirken serbest dalgalanma rejimi altındaki bir ülkede böyle bir sorun yaşanmayabilir. Teorik kriz çalışmalarında döviz kuru önemli bir rol oynarken deneysel literatürde bu göz ardı edilmiş, örneklem seçimlerinde kur rejimine dikkat edilmemiştir. Dolayısıyla bu çalışmanın amacı birbirine doğal olarak bağlı olan ancak varolan çalışmalar tarafından işlenmemiş olan bu bağıntıyı -döviz kuru seçiminin kur krizleri ile olan ilişkisini- kurmaktır. Dalgalı, sabit ve ara kur rejimi altında olan ülkelerin kriz ve durgun gözlemlerini bir örneklem içine alarak araştırmak yanlış sonuçlar verebilir. Bu yüzden her rejime ait gözlemleri üç ayrı örneklemlere ayırarak krize uğrama yollarını araştırmak ve istatistiksel ve iktisadi anlamda daha güvenilir sonuçlara ulaştırabilir. Bu da çalışmanın literatüre yaptığı bir katkı olarak değerlendirilebilir.

Anahtar Kelimeler: Döviz Kuru krizleri, Döviz kuru rejimleri, Spekülatif atak, CART analizi
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