

**SOM-based Data Analysis of Speculative Attacks' Real Effects**

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### Abstract

In some cases, currency crises are followed by strong recessions (e.g., recent Asian and Argentinean crises), but in other cases they are not. This paper uses *Self-Organizing Maps (SOM)* to search for meaningful associations between speculative attacks' real effects and 28 variables that characterize the economic, financial, legal, and socio-political structure of the country at the onset of the attack. SOM is a neural network-based generalization of *Principal Component Analysis (PCA)* that provides an efficient non-linear projection of the multidimensional data space on a curved surface. This paper finds a strong association of speculative attacks' real effects with fundamentals and the banking sector structure.

**Keywords:** exploratory data analysis; self-organizing maps; unsupervised neural networks; speculative attacks' real effects; banking crises; financial development; financial regulation and supervision; IMF.

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### 1. Introduction

A speculative attack is an economic event where a country's fixed exchange rate is under pressure by speculators. The economy's response to a speculative attack depends on the economy's characteristics at the onset of the attack as well as the government's response to it. Nasty recessions following speculative attacks occurred in the recent Asian crises as well as in Mexico 1995, Chile 1982, and many others.

Empirical research on speculative attacks has mostly focused on the factors that explain their occurrence. Research on the speculative attacks' real effects is scarce (See Demirguc-Kundt, Detragiache, and Gupta (2000), and Arciniegas, Arciniegas, and Embrechts (2001)). The aim of this paper is to use the power of Self-Organizing Maps (SOM) to better understand the determinants of speculative attacks' real effects. SOM is used to explore a database of recent speculative attacks' aftermaths in search of meaningful associations between the variables that characterize the economic, financial, and legal structure at the onset of the speculative attack and the economy's output.

Exploratory data analysis in empirical economics is important in detecting stylized facts and in model formulation. Typically in the economics of speculative attacks, exploratory data analysis is done by univariate techniques because they do not impose parametric structures and require fewer assumptions than other statistical methods (e.g., Eichengreen, Rose, and Wyplosz (1994)). However, univariate techniques just can analyze one variable at a time. A speculative attack is an economic event whose impact on the economic activity depends on complex interactions between many economic variables. Therefore, traditional univariate approaches may not be adequate for exploratory data analysis of speculative attacks' real effects given the high dimensionality of the problem and the non-linear behavior displayed by the problem's variables. SOM is a better technique to explore speculative attacks' data because it provides an efficient non-linear description of the multidimensional data distribution. The use of SOM in searching meaningful associations among an extensive list of variables characterizing speculative attacks' aftermaths is novel.

This research collected data on 73 speculative attacks that occurred in small open economies between 1970 and 1999. Each speculative attack is described with a list of 29 variables representing several characteristics of the country's economic, financial, and socio-political structure at the onset of the attack. After analyzing the SOM-based results, it was found that speculative attack's real effects were associated with: the development of the financial intermediation system; the regulatory framework; the economic fundamentals; the foreign interest rate; and the decade. No evidence was found of the beneficial roles played by the IMF's assistance or Deposit Insurance Schemes (DIS) in solving speculative attacks' aftermaths.

## **2. Review of the Economic Literature**

A speculative attack may end up in devaluation or not depending upon whether or not the central bank is able to use monetary policy to support the exchange rate. After a successful attack, the exchange rates are not only devalued but also floated, which severely restricts the government's capabilities to adopt policies consistent with the alignment in the exchange rate. Thus, a speculative attack is a more complex economic event than devaluation.

Shocks to the exchange rate may cause increases in interest rates, which raises the opportunity cost of consumption and therefore reduces output. On the other hand, exchange rate's shocks can also be associated with output gains when governments sacrifice exchange rates in order to achieve policy objectives. Empirically, IMF (1998) estimated that the average cumulative output loss per speculative attack was 4.3 %.

The economic literature suggests many ways in which the real effects caused by a speculative attack could be amplified by specific characteristics of the economic and financial environment at the onset of a crisis or by the government's policies in the aftermath. Several researchers have provided evidence that the banking system may amplify the speculative attacks' effects on output as exchange rate shocks can also trigger credit crunches. For instance, IMF (1998) estimated that the output loss in countries that had banking crises at the onset of the attack was 7% to 10% higher than in countries without banking crises. Caprio (1998) found that countries with poor banking regulation weathered the latest financial crises less well. Rossi (1999) argued that

indicators of banking supervision and safety net were associated with banking fragility and economic performance.

Creditors' rights, capital controls, terms of trade, foreign interest rates, and IMF's bailouts have been also suggested as factors that may amplify speculative attacks' real effects. Poor creditor's protection could cause capital outflows in the aftermath of the attack that may reduce the current account deficit causing further contractions in the aggregate demand and in output (See Hussain and Whilborg (1999)). Capital controls have been proposed as measures to reduce the magnitude of the withdrawal of capital during a financial crisis. Edison and Reinhart (2000) studied the effect of capital controls on economic performance following the 1997 currency crises in Malaysia and Thailand. They found that capital controls were effective in achieving policy objectives in Malaysia but not, in Thailand. The effect of the aggregate demand contraction on output depends on the country's ability to export the excess of output, which is determined by the country's terms of trade (See Higgins and Klitgaard (2000)). In addition, the crisis' recovery may be sped up by the return of the foreign capital, which depends on the behavior of foreign interest rates (See Frankel and Rose (1996)). In addition, the IMF's rescue packages may boost the investor's confidence on the economy in distress, but at the same time, they may enforce contractionary policies, which can exacerbate the recessions (See Bordo and Schwartz (1999)). Other variables that may influence the country's recovery from a speculative attack are: fiscal spending; stock market's liquidity; stock market's capitalization; socio-economic variables; and decade.

This work differs from previous empirical studies on speculative attacks' real effects in at least two respects. First, it does not rely on traditional univariate techniques to explore the data; it uses an unsupervised neural network (SOM) to efficiently explore the multidimensional data space. Second, it does not restrict the analysis to a dataset with few explanatory variables or to some crises in particular (e.g. Asian crises). It explores the associations among a large array of economic, financial, legal, and political variables during the speculative attacks' aftermaths occurred between 1970 and 1999.

### 3. Database

Historical evidence suggests that speculative attacks' aftermaths can be short-lived events. Therefore, in the construction of the database the highest available frequency (monthly) was used. Following Kaminsky and Reinhart (1999), this research dated the onset of the attacks by identifying large changes in the readings of an *index of market turbulence (I)*. The index was computed as a weighted average of the monthly changes in the nominal exchange rate and the monthly reserve losses. The weights were chosen such that the two components of the index have the same standard deviation; then no single variable dominates the average. A crisis was identified when the readings of the index  $I$  were above a threshold  $IT$  equal to *two and a half* standard deviations above the mean (i.e.,  $I > I_{\text{mean}} + 2.5 \sigma_e$ ).

$$I = \left( \frac{\Delta_e}{e} \right) - \left( \frac{\sigma_e}{\sigma_R} \right) * \left( \frac{\Delta_R}{R} \right) \quad (1)$$

where  $\Delta e/e$  is the rate of change of the nominal exchange rate (the nominal exchange rate is defined on a bilateral basis with respect to the deutsche mark for the European countries in the sample, and with respect to the U.S. dollar for the rest),  $\Delta R/R$  is the rate of change of international reserves, and  $\sigma_e$  is the standard deviation of the rate of change in nominal exchange rate. This index considers not only changes in the exchange rate, but also in the foreign reserves. Therefore, it allows the identification of currency crises that end up in devaluation and currency crisis that do not. Countries' samples are divided according to whether inflation in the previous six months was  $> 150\%$ . A value of  $IT$  is calculated for each sub-sample in order to correct for inflationary biases. A 24-month exclusion window was used to avoid counting a speculative attack twice. So, a new crisis was identified when the index of speculative pressure was above the threshold for any period that was outside of the exclusion window of the previously identified crisis. Based on this procedure 73 speculative attacks were identified (See Table 1).

The economic literature suggests many ways in which the real effects caused by a speculative attack may be amplified by specific characteristics of the economic environment during the attack's aftermath. Among all the "potentially influential" economic variables in the literature, the ones with sounder empirical and theoretical support were selected to describe speculative attacks' aftermaths.

Table 1. Speculative attacks' episodes<sup>a</sup>

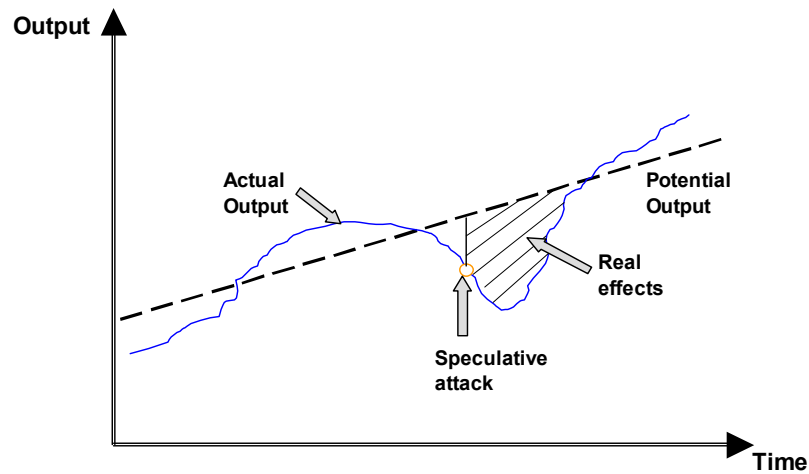
Argentina (83)	Denmark (79)	Indonesia (97)	Malaysia (97)	Portugal (76)	Sweden (92)
Argentina (89)	Denmark (93)	Ireland (76)	Mexico (76)	Portugal (83)	Turkey (94)
Bolivia (82)	Finland (73)	Ireland (86)	Mexico (82)	South Africa (84)	Venezuela (84)
Bolivia (85)	Finland (77)	Ireland (92)	Mexico (94)	South Africa (86)	Venezuela (86)
Brazil (79)	Finland (82)	Israel (74)	Norway (73)	South Africa (96)	Venezuela (89)
Brazil (82)	Finland (86)	Israel (77)	Norway (77)	South Africa (98)	Venezuela (95)
Brazil (86)	Finland (92)	Israel (83)	Norway (86)	Spain (73)	Zimbabwe (91)
Brazil (90)	Greece (73)	Kenia (93)	Norway (92)	Spain (76)	Zimbabwe (97)
Brazil (99)	Greece (83)	Kenia (95)	Norway (97)	Spain (82)	
Chile (72)	Greece (85)	Korea (71)	Peru (87)	Spain (92)	
Chile (74)	India (91)	Korea (80)	Peru (91)	Spain (95)	
Chile (82)	Indonesia (83)	Korea (97)	Philippines (83)	Spain (98)	
Colombia (85)	Indonesia (86)	Malaysia (75)	Philippines (98)	Sweden (81)	

<sup>a</sup> The numbers between parenthesis represent the year

The data set included the following 29 variables: *speculative attacks' real effects*; *size of financial intermediation*; *financial intermediation's development*; *financial intermediation's efficiency*; *banking health*<sup>3</sup>; *stock market's capitalization*; *stock market's turnover*; *stock market's trade value*; *legal origin*; *speculative attacks' severity*; *banking repression*; *deposit insurance scheme (DIS)*; *minimum capital requirements*; *capital controls (current account, capital account, and exports proceeds)*; *banking supervision*; *fiscal spending*; *trade balance*; *foreign interest rate*; *market development*; *OECD membership*; *IMF's agreements*; *decade (90's, 80's, and 70's)*; *latitude*; *political stability*; and *ethno-linguistic fractionalization*. The first variable measures the response of the economic activity to the speculative attack. This research defined the speculative attacks' real effects as the accumulated output gap from the month of the attack to the point at which the actual output recovers to reach its previous trend. Output trend is computed using the Hodrick-Prescott filter. The output gap, *GAP*, can be positive or negative and it is measured as a percentage of the output trend (2). Figure 1 illustrates real effects that are contractionary (output falls below trend after the currency crisis)

$$GAP_t = 100 * (Output_t - Trend_t) / Trend_t \quad (2)$$

<sup>3</sup> It measures whether or not at the onset of the speculative attack there was a banking crisis



**Figure 1 Speculative Attacks' Real Effects**

The 29 variables were grouped in 9 classes based on their characteristics: speculative attacks' response; financial intermediation; financial regulation; stock market; capital controls; socio-political variables; external variables; economic fundamentals; and others. Appendix 1 describes how the 28 explanatory variables were measured.

The data sources used in this research are: the International Financial Statistics (IFS) database from the IMF; Annual Report on Exchange Arrangements and Exchange Restrictions from the IMF; the Regulation and Supervision of Banks around the World (RSBAW) database from the World Bank; the Deposit Insurance around the World (DIAW) database from the World Bank; DataStream; and selected papers.

#### **4. The SOM's algorithm**

A self-organizing map is a feedforward neural network, which provides an efficient projection of the multidimensional data space on a plane. It uses an unsupervised training algorithm (local competitive learning) and through a process called self-organization, maps each multidimensional observation in the data space onto a two dimensional neuron in the *feature map*. Below, we summarize in four steps the basic SOM's algorithm developed by Kohonen (1982) for the construction of the feature map.



- [1] Initialization. A two-dimensional grid (lattice) of neurons is constructed. The number of neurons in the lattice is defined a priori depending on the  $n$ -dimensional data space. The SOM assigns to each neuron  $i$  in the lattice a random  $n$ -dimensional vector of weights  $W_c$  (real numbers). Geometrically, these weights can be seen as representing the initial coordinates of the neuron  $i$  in the  $n$ -dimensional data space (See **Figure 2**)

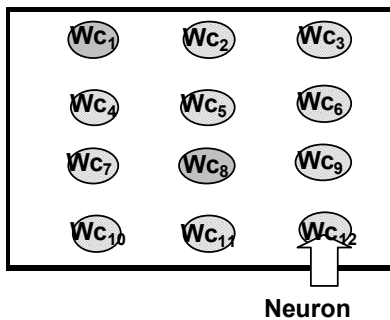


Figure 2 SOM lattice of neurons

- [2] Best matching. A layer of inputs  $x(t)$  is drawn from the multidimensional data space with a certain probability  $P(x)$ . When  $x(t)$  is presented to the network, the SOM algorithm selects among all the neurons in the grid the one with the shortest Euclidean distance to the layer of inputs. The selected neuron is called *the winner*. Next, the algorithm orders the *winner* to adjust its  $W_{winner}(t)$  weights toward  $x(t)$  (See Figure 3).

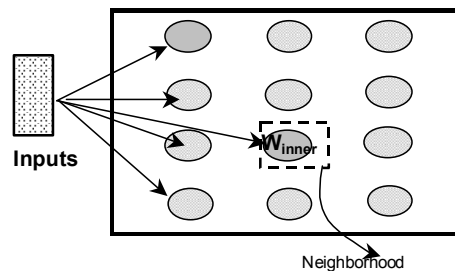


Figure 3 SOM best matching and updating

[3] Updating<sup>4</sup>. The algorithm adjusts not only the winner's weights, but also the weights of the adjacent neurons in close proximity. The winning neuron locates the center of a topological neighborhood of cooperating neurons. Therefore, by adjusting not only the winner but also the neighbors, the SOM's algorithm reflects the topological structure of the multidimensional data space on the neuron's weights. This means that close data in the input space will be mapped either to the same neuron or to two neurons that are close to each other. The amplitude of the neighborhood is defined by a time-varying Gaussian function<sup>5</sup>  $h_{c,j}$ .

$$h_{c,i}(t) = \exp\left\{\frac{-d_{c,i}^2}{2\sigma^2}\right\} \quad (3)$$

Where:

$d_{c,j}$  = is the "lateral distance" between the winner neuron and the neuron  $i$  in the display. The lateral distance is measured on the two-dimensional lattice<sup>6</sup>. The value of  $h_{c,j}$  decreases monotonically with the distance. Therefore,  $h_{c,j}$  takes the maximum value when  $d_{c,j}$  is zero, and decays to zero when  $d_{c,j} \rightarrow \infty$ . This is necessary for convergence.

$\sigma$  = is the "effective width" of  $h_{c,j}$ . It controls the degree to which the neurons in the neighborhood adjust their weights toward  $x(t)$ .  $\sigma$  is time decreasing such that the amplitude of the neighborhood shrinks with the number of iterations<sup>7</sup>.

Once a layer of inputs  $x(t)$  draw from the input space is presented to the network, the algorithm adjusts the neurons of the grid by a two step procedure. First, the

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<sup>4</sup> The Euclidean distance between two arrays of vectors of n-dimension is defined as the norm of their vectorial difference. The norm of a n-dimension vector  $x$  is defined as  $\|x\| = \sqrt{x_1^2 + x_2^2 + \dots + x_N^2}$

<sup>5</sup> Other neighborhood functions are possible (e.g. rectangular). However, the Gaussian function is chosen because is translation time invariant, and for reasonable values of  $\sigma$  it prevents overfitting.

<sup>6</sup> If  $\mathbf{r}_c$  and  $\mathbf{r}_i$  represents the location of the winner node  $c$  and  $i$  in the 2-dim lattice respectively, then  $d_{c,j} = \|\mathbf{r}_c - \mathbf{r}_j\|$

<sup>7</sup> The parameters of function  $\sigma$  are defined such as for the initial iterations the neighborhood includes all neurons in the network centered on the winning neuron.

winner node is identified and its weights  $W_c(t)$  are adjusted towards  $x(t)$ , and then, the nodes' weights in the winner's neighborhood are adjusted also towards  $x(t)$  by

$$W_i(t+1) = W_i(t) + h_{c,i}(t) * [x(t) - W_i(t)] \quad (4)$$

[4] Convergence. As new layers of inputs are drawn from the input space, the steps 2, and 3 of the algorithm are repeated. Hence, the "network" is trained as new observations are presented to it. The training process goes until no noticeable changes in the weights of the feature map are observed. At this point, the lattice is stationary.

Ritter, H, Martinetz, T, and Schulten, K, (1992) provided a geometrical description of the SOM's algorithm as follows: First, *the initialization step* consists on randomly passing through the data space  $X$  a two-dimensional lattice of neurons  $W$  (*feature map*). Each lattice's neuron is geometrically described by its coordinates in the input data space  $X$ . Second, *the best-matching step* consists on assigning to each node  $r \in W$  in the lattice a volume  $F_r$  containing all the vectors  $x \in X$  for which  $r$  is the surface node with the shortest Euclidean distance. Third, *the updating and convergence step* consists on the iterative deformation of the lattice (by altering its nodes' coordinates  $W_i(t)$ ) in such a way that the center of gravity of the density distribution  $P(x)$  contained within the volume  $F_r$  coincides with the node's weights  $W_r$  for every  $r$ . It can be proved mathematically that the updating step is equivalent to the fitting of the 2-D lattice in the data space so that the *expected distortion*  $D_f$  is minimized.  $D_f$  is defined as following:

$$D_f = \int d_f^2(x) P(x) d^L x \quad (5)$$

$x$  = vector of variables so that  $x \in X$ .

$P(x)$  = density distribution of points in  $X$ .

$d_f(x)$  = the shortest distance of a vector of variables  $x \in X$  to a lattice  $W$  in the data space  $X$ .

The algorithm described above has important properties that render SOM very suitable in the exploration of multidimensional and non-linear datasets. For instance, the feature map computed

by SOM provides a *good* non-linear projection of the multidimensional data space  $X$ , onto the 2D-feature map. This is because the map's weights  $W_i$  associated to each neuron are computed such that  $D_f$  is minimized. In addition, the SOM algorithm maps vectors that are near each other in the *input space* to nearby neurons in the feature map. Therefore, the spatial location of a neuron on the feature map corresponds to a particular domain of variables in the input space (See Haykin (1999)).

## 5. Preprocessing data

SOM is an artificial neural network algorithm, which has proved very powerful in data analysis. However, it is useful to preprocess the raw data before training the neural network. The objective of preprocessing is to pull the data apart and thus facilitate the learning of the neural network. Preprocessing the raw data also helps in the interpretation of the SOM's results.

An initial data analysis (IDA) was performed to see how the data should be preprocessed<sup>8</sup>. From the IDA, it was noted the wide variation in range among the variables used as inputs in the construction of the feature map. All the data should be scaled to the same level. Otherwise, variables with wider ranges would have stronger influence in the SOM's algorithm than variables with smaller ranges. The best scaling alternative depends on the characteristics of the data. All the variables were scaled by variance, because their ranges were smaller than 8 times the standard deviation.

Several applications have shown that the computation of SOM is more efficient in computer's time and map's quality when the distributions are uniform (See Deboeck (1998)). Typically, logarithmic and sigmoid transformations are used to obtain more uniform distributions of the original data. The logarithmic transformation is applied when the original density is concentrated in one of the tails, in order to give a higher resolution to the small values. The sigmoid transformation is used to handle influential observations without discarding them. It creates a more balanced distribution by stretching the center and squeezing the tails. Based on the IDA, sigmoid transformations were applied to speculative attacks' real effects, speculative attacks' severity, stock market's capitalization, and stock market's liquidity. On the other hand, size of

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<sup>8</sup> The IDA was carried out using descriptive statistics and non-parametric density estimations.

financial intermediation and financial intermediation's development were transformed with logarithmic transformations.

## 6. Computing self-organizing maps of speculative attacks

The economic literature suggests that speculative attacks' real effects are determined by complex interactions among several economic variables. In addition, the Initial Data Analysis (IDA) of our dataset showed evidence of non-normality in the distributions of some of these variables as well as evidence of non-linear associations among them (See Arciniegas (2002)). Therefore, for understanding speculative attacks' real effects it is necessary to account for the multidimensionality, non-normality, and non-linearity of the problem. These characteristics make traditional econometric methods for exploratory data analysis unreliable. The SOM is a non-parametric regression, which preserves the topological structure of the input space. The SOM is an adequate technique to explore speculative attacks' data because it computes a 2-D plane (feature map), which provides a faithful representation of the multidimensional data space.

The feature map is used for visual exploration so having good visual quality is crucial. The map's visual quality can be controlled by its size and tension. The map's size represents the number of nodes on it. The map's tension represents the reach (influence radius) of the *neighborhood* function in the last iteration of the training process. Large maps are more detailed as the input vectors can spread on a larger number of nodes. Lower tension increases also the detail of the map. Given the complexity of our economic problem a detailed map is desirable.

The SOM's algorithm is a non-linear optimization in which the neurons' weights are computed so that the expected dispersion  $D_f$  is minimized (See (5)). Non-linear optimization methods may be affected by problems of local minima and speed of convergence. Although SOM has showed to be not very sensitive to these problems, it is convenient to choose the parameters of the map (size and tension) so that a good stability is achieved (See Cottrell, Bodt, and Verleysen (2001)).

The *best feature* map was searched by trying different maps' tensions and sizes. The computed feature maps were compared using the following criteria:

- [1] Quantization error (QE): This is a measurement of the *expected distortion*  $D_f$ . It shows the average squared distance of all records in the data set to their respective projections onto the map. Hence, between two feature maps the one with the lowest quantization error was preferred.
- [2] Frequency Map: It indicates the number of data records matching each map. Maps in which the number of neurons without matched episodes is small are preferred.
- [3] Coefficient of variation of QE: Following Cottrell, Bodt, and Verleysen (2001) this variable measures the average variability of the quantization error (See equation (6)).

$$CV(QE) = 100 * \frac{\sigma_{QE}}{\mu_{QE}} \quad (6)$$

Where  $\sigma_{QE}$  is the standard deviation of QE, and  $\mu_{QE}$  is the mean of QE.

The five best combinations of tension and size using criterion [1] and [2] were analyzed with criterion [3]. We computed the CV(QE) per pair of tension and size using 100 bootstrap samples drawn from the data set. The combination of size and tension with the lowest CV(QE) was chosen. Table 2 summarizes the properties of the *best feature map*. The feature map was computed using the software Viscovery SoMine Standard. See Deboeck (1998) for a software's description.

Table 2. Characteristics of the best feature map.

Data	74
Component	28
Map	202
Tension	0.2
Principal Plane <sup>a</sup>	100:9
Training	9
Quantization	0.009
CV	53

<sup>a</sup>it shows the actual ratio of the principal plane to the dataset. The principal plane is spanned by the longest eigenvectors of the correlation matrix of the data distribution

## 7. Component planes

A component plane represents a cross-section through the feature map. It is obtained from the feature map by showing the data records associated with the variable under study and hiding the rest. A component map displays the relative distribution of *one* variable over the feature map. Thus, the component map can provide useful information in identifying the most important variables in explaining speculative attacks' real effects as well as in finding associations among them.

**Table 3 Summary of component maps' exploration**

Class	Ranking based on organization	Organized associated with real effects	Organized not associated with real effects	Poorly organized
Speculative attacks real effects	1			
Financial intermediation	1	Financial Intermediation Size		
	2	Financial Intermediation Dev		
	3	Banking crisis		
	4	Financial Intermediation Efficiency		
Banking regulation	1	Banking restrictions		
	2		DIS	
	3		Banking supervision	
	4			Minimum capital requirements
Stock market	1		Stock market's capitalization	
	2		Stock market's liquidity	
	3			Stock market's Turnover
Capital controls	1	Current account		
	2		Surrender export proceeds	
	3			Capital account
Socio-political variables	1		Legal origin	
	2		Political stability	
	3			Ethno-linguistic
External variables	1	Foreign interest rate		
Economic fundamentals	1	Speculative Attacks' Severity		
	2	Budget deficit/GDP		
	3	Ratio of exports to imports		
Additional variables	1	Decade 90		
	2	Decade 70		
	3	OECD		
	4	Market development		
	5			IMF
	6		Decade 80	
	7		Latitude	

A component map with good organization indicates that the variable is important in the non-parametric fitting of the two-dimension lattice on the multidimensional data space. On the other hand, a scattered component map indicates that the variable is not important in the non-

parametric fitting. Component maps were created for each one of the speculative attack's 29 variables<sup>9</sup>. An interesting feature of the component maps is that they allow us to rank the different variables based on their importance in the non-parametric fitting of the 2-D lattice. An analysis of each component map's organization indicates that the level of influence of each variable in the non-parametric fitting varies. The component maps were used for selecting the most dominant variables in the non-parametric fitting within each group class. In addition, a joint visualization of the component maps was used in discovering associations between speculative attacks' real effects and the other aftermaths' variables. Table 3 summarizes the results of the component maps' exploration.

### *7.1. Worst organized components*

Among the 29 component planes, the planes of minimum capital restrictions and ethno-linguistic fractionalization were the worst organized. Minimum capital restrictions (MCR) is the least organized component plane. MCR measures the existing banking regulatory requirements on the magnitude of capital and its relation to total assets at the onset of the attack. The adoption of MCR is intended to promote financial stability by limiting risk taking by banks relative to capital. Therefore, this variable may be relevant in explaining financial stability at the onset of the speculative attack (See Caprio (1998)). MCR is spread over its component plane without any order (See map 1 in appendix 2). Besides, computation of the SOM without this variable does not increase the quantization error. These results suggest that this indicator was not important in the fitting of the 2-D lattice in the multidimensional data set.

A visual inspection of the feature map computed without the MCR renders the ethno-linguistic fractionalization (ELF) as the least organized variable (See map 2 in appendix 2). This variable is a measure of ethnic fragmentation, which is a proxy of the homogeneity of the society. It is conjectured that governments may find easier to implement unpopular policies during the aftermath in homogenous societies (See La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1998)). Map 2 shows that speculative attacks occurred equally in both ethnic homogeneous and

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<sup>9</sup> The component maps were obtained using Viscovery SoMine. Appendix 2 contains the edited version of these maps.



ethnic non-homogeneous countries. A computation of SOM without ELF increases the quantization error; thus, although the distribution of this indicator over the feature map is poorly organized it is not completely random.

Arciniegas, Arciniegas and Embrechts (2001) using a machine learning sensitivity analysis also found that minimum capital restriction and ethnic-fractionalization were not significant in explaining speculative attacks' aftermaths.

### *7.2. Response component maps*

The variable speculative attacks' real effects measures the economy's response to the speculative attack (See Figure 1). The output gap<sup>10</sup> can be positive (output gains) or negative (output loss)<sup>11</sup>.

The component map of speculative attacks' real effects has a somewhat ordered transition from strong to low real effects, meaning that this was an important variable in the fitting of the lattice. The transition follows a northwest (strong effects) to southeast (low effects) direction (See map 3 in appendix 2). Map 3 also shows that most of the speculative attacks' aftermaths were characterized by moderate-low output losses. Very few episodes were associated with output gains. This evidence agrees with Calvo and Reinhart (1999), which argue that speculative attacks are contractionary. Interestingly, the episodes with the most contractionary aftermaths were located together suggesting that they have similar variables. However, not all the expansionary (output gains) aftermaths are located together, suggesting that they were not characterized by the same variables. Therefore, it seems that the selected variables can explain better contractionary than expansionary speculative attacks' aftermaths. In addition, episodes occurred in the same countries are not necessarily located close to each other.

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<sup>10</sup> The output gap is expressed as a percentage of the output trend

<sup>11</sup> Unlike our previous paper, here we included in our database both contractionary and expansionary speculative attacks' aftermaths. See, Arciniegas, Daniel and Embrechts (2001)

### 7.3. *Financial intermediation planes*

The analysis that follows investigates the relevance of the specific characteristics of the banking channels through which liquidity flows to investment opportunities in explaining speculative attacks' real effects. The banking system existing at the onset of the speculative attacks was described by eight variables of financial intermediation. Four are variables of the functioning of the banking system: *financial intermediation's size*; *financial intermediation's development*; *financial intermediation's efficiency*; and *banking health*. The other four are variables of banking regulation: *banking repression*; *banking supervision*; *deposit insurance scheme (DIS)*; and *minimum capital requirements*. See appendix 1 for details on the measurement of these variables.

#### 7.3.1. Financial intermediation

Theoretically, Haan, Ramey, and Watson (1999) argued that the larger the number of channels through which liquidity can flow to investment opportunities, the lower the probability that a financial crisis can trigger a capital outflow. In addition, Levine and Zervos (1998) provided evidence that the level of financial development is significantly correlated with output growth. Therefore, the economic literature suggests that indicators of the functioning of the banking system may be associated with speculative attacks' real effects.

Financial intermediation's efficiency measures how well the banking system provides risk management services. A visualization of the financial intermediation's component planes indicates that each one of them has a somewhat smooth transition from levels of high activation of the variable to levels of low activation (See map 4, map 5, and map 6 in appendix 2). Thus, the financial intermediation indicators have an important contribution on the construction of the SOM map. From comparing map 4, map 5, and map 6, we obtained a ranking of the variables based on their importance (See Table 3). Clearly, financial intermediation's size is the most important (organized) and financial intermediation's efficiency is the least important (organized).

Financial intermediation's (banking) size and financial intermediation's (banking) development components planes follow the same direction in organization (northwest to southeast) indicating that they are correlated. Thus, increases in banking size lead to increases in banking development. However, it is important to note that banking size has more variability than

banking development, suggesting that these two indicators do not fully contain the same information. On the other hand, map 4 and map 5 indicate that most of speculative attacks in the sample were associated with low levels of banking size and banking development.

A joint visualization of speculative attacks' real effects, banking size, and banking development planes suggests an association between them. We see that the episodes with high output contractions were associated with big banking sectors and viceversa. For instance, Korea 71 and Philippines 83 episodes have small banking size and low real effects, but Korea 97 and Philippines 98 were associated with big banking size and high real effects<sup>12</sup>.

A comparison of the component planes of banking size, banking development, and financial intermediation's (banking) efficiency indicates that although big banking sectors have high levels of efficiency so do small size banking sectors. Interestingly, most contractionary aftermaths are associated with big banking size, high financial development, and high banking efficiency. On the other hand, the episodes associated with the lowest level of banking efficiency, were associated with low banking development, small banking sizes, and expansionary speculative attacks. The direction of transition on the banking efficiency map is somewhat west-east which is not the same as the transition in map 3. Henceforth, if there is an association between speculative attacks' real effects and banking efficiency, this is probably non-linear and depending of other variables.

The banking health (See map 7 in appendix 2) variable assesses whether or not at the onset of the speculative attack there was a banking crisis. A visual inspection of map 7 indicates that this variable is not randomly scattered on the map, instead it is grouped in two separated areas (north and south), suggesting an ordering in the map.

An inspection of all financial intermediation component planes does not indicate that banking crises occurred more often in big banking sectors or in systems with high banking efficiency. Therefore, banking health, banking size, banking development, and banking efficiency could have an independent effect on speculative attacks' real effects. Map 7 shows that speculative attacks with high contraction in output were associated with poor banking health (banking crisis).

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<sup>12</sup> A similar observation can be made for banking development.

This finding can be explained by the fact that exchange rate collapses may undermine already ailing banking sectors leading to further contractions in output (See IMF (1998)). On the other hand, most of the expansionary aftermaths occurred in countries with no banking crisis. Moderate output contractions occurred in countries with and without banking crises. The direction of the transition in the real effects' size and banking health component maps is not the same suggesting that the association between these two variables is non-linear and depends on the values taken by other variables. We noted that banking crises occurred in episodes associated with small banking sizes had moderate to low real effects on output.

### 7.3.2. Banking regulation

Recently, several researchers have remarked the importance of the regulation of the banking system during financial crises' aftermaths (See Mishkin (2000)). Here, four variables of banking regulation are explored: *banking repression*; *deposit insurance scheme (DIS)*; *banking supervision*; and *minimum capital requirement*.

Banking repression measures the degree to which a country's regulatory system allows banks to engage in non traditional activities such as: underwriting securities; insurance underwriting; real estate; and owning or controlling non-financial firms. Banking repression may help to explain the stability of the banking system at the onset of the attack. Some researchers argue that banking repression may be associated with stronger real effects because banks at the time of attack are less diversified (See Barth, Caprio, and Levine (1998)). The smooth transition of the banking repression component map suggests that this is an important variable in the non-linear fitting of the feature map in the data space (See map 8 in appendix 2). The map's transition follows a southwest (low repression) to northeast (strong repression) direction.

Deposit Insurance Scheme (DIS) is a mechanism employed by governments to promote stability of the banking systems and to facilitate an orderly solution to financial crises (See Demirguc-Kundt, Detragiache, and Gupta (2000)). The DIS' component plane shows that the aftermaths associated with DIS at the onset of the crises are split in two clusters. This indicates that one group of DIS' aftermaths is associated with a different set of variables than the other (See map 9 in appendix 2).

Banking supervision is an index that measures the official supervisory power in the countries in which the attacks occurred. Rossi (1999) presented econometric evidence that lax prudential regulation is significantly associated with the likelihood of speculative attacks. The banking supervision's component map has poor organization suggesting that this variable has a little contribution to the SOM map (See map 10 in appendix 2). Minimum capital requirement was already discussed in section 7.1.

From a visual inspection of banking regulation's component planes, it was possible to obtain a ranking of the regulatory variables based on their importance in the fitting of the 2-D lattice in the multidimensional data space (See Table 3). Clearly banking repression is the most organized and supervision the least<sup>13</sup>. Comparing map 8 and map 10 is evident that most of the episodes associated with high banking supervision are also associated with high banking repression, but the opposite is not true. In addition, there is no clear association between DIS and the other regulatory variables. Therefore, the regulatory variables are not highly correlated.

A joint visualization of map 8, map 7, and map 5 shows that 71% of the aftermaths associated with high banking development were also associated with low levels of banking repression. However, several aftermaths associated with low banking repression were also associated with low levels of banking development. In addition, banking crises did occur in countries with high and low levels of banking repression. Thus, the SOM based evidence does not support the association between banking repression and the occurrence of banking crises suggested by Barth, Caprio, and Levine (1998).

A comparison of map 3 and map 8 shows that banking repression and speculative attacks' real effects have different direction of transition, suggesting a non-linear relation between them. It can be observed that moderately high levels of banking repression and small banking size are associated with low levels of speculative attacks' real effects. On the other hand, episodes with big banking sizes and low level of banking repression are associated with lower real effects than episodes with big banking sizes and high level of banking repression. These results suggest that the association between banking repression and speculative attacks' real effects is non-linear and depending on banking size.

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<sup>13</sup> Minimum capital requirement was already identified in 7.1 as the worst organized variable.

It can be noted that banking crises occurred in DIS and non-DIS aftermaths. Therefore, although the DIS variable is important in the organization of the map it seems not associated with the occurrence of banking crises. In addition, it does not have an obvious relation with the magnitude of the speculative attacks' real effects. This result agrees with Demirguc-Kundt, Detragiache, and Gupta (2000), which econometrically found a weak association between DIS and financial crises' real effects. We also noted that banking crises occurred in banking systems with high and low banking supervision. In addition, there is no clear association between banking supervision and aftermaths' real effects. Therefore, the SOM-based evidence does not agree with Rossi results. A caveat of our analysis is that the index of supervision used here does not account for the enforcement of the laws.

#### 7.4. Stock Market Planes

Recently, Levine and Zervos (1998) found evidence that equity markets and banking provide different services to economic development. They found that measures of stock market's development at the beginning of the period robustly predicted future rates of economic growth. Also, Edwards and Vegh (1997) suggested that the existence of a stock market might reduce the real effects of credit crunches caused by exchange rate's shocks because firms do not depend only on banking for financing. Below, the relevance of equity markets in explaining speculative attacks' real effects is explored with SOM. The following variables of the stock market at the onset of the crisis were analyzed: *stock market's capitalization*; *stock market's traded value*; and *stock market's turnover*. Appendix 1 describes how these variables were constructed.

Stock market's capitalization is a measure of stock market's size. Turnover ratio and value traded are proxies of stock market's liquidity, but they are different enough in their distribution on the feature map to suggest that they do not contain the same information (See maps 12 and 13 in appendix 2). A visual inspection of the component map for stock market's capitalization (map 11 in appendix 2) shows some ordering on the map as all the aftermaths associated with high stock market's capitalization are clustered together. This suggests that aftermaths with high stock market's size have similar values in their other variables. Map 11 also shows that most of speculative attacks' episodes occurred in countries with low stock market's size. A visual

comparison of maps 11, 12, and 13 indicate that stock market's capitalization is more organized than stock market turnover and value traded. From comparing maps 11 and 13, it is clear that high stock market's turnover is not necessarily associated with high stock market's capitalization.

A joint visualization of map 11 and the banking size component map (map 4) shows that most of the aftermaths with high stock market's capitalization have also big banking sizes. In addition, comparing map 11 and map 3 (real effects) shows that strong contractions on output occurred at high and low levels of stock market's capitalization. Henceforth, the SOM based data analysis does not indicate that stock market's capitalization is important in explaining speculative attacks' real effects.

A joint visualization of map 3, map 4, and map 12 shows that aftermaths with high value traded were also characterized by strong output contractions. This observation may support Bhidé (1993), which argued that more liquid equity markets may be characterized by lower incentives for monitoring managers and therefore more vulnerable firms may be functioning at the onset of the attack. On the other hand, a joint visualization of map 13 and map 3 shows that high market turnover was associated with low and high level of speculative attacks' real effects.

### 7.5. *Capital Controls*

Capital controls may play a role in explaining speculative attacks' real effects as they may isolate the economy by giving governments some autonomy in their monetary policy in times of financial distress. On the other hand, capital controls may also produce corruption problems as economic agents may try to bribe government officers to skip the controls (See Edison and Reinhart (2001)). Three measures of capital controls were studied in this research: *controls on current account (CAL)*; *controls on capital account (KAL)*; and *controls on surrender of export proceeds (SEL)*. Component maps were created for each capital controls' variables (See maps 14, 15, and 16 in appendix 2).

A visual inspection of maps 14, 15, and 16 shows that most countries had some form of capital control at the onset of speculative attacks. Most of the episodes were associated with KAL or

SEL but, just around half of them were associated with CAL. Interestingly, if a country implemented CAL, it also implemented KAL and SEL. A comparison of capital controls' component planes suggests that the CAL's component map is the most organized and the KAL's component map is the least organized (See Table 3). Thus, CAL is more significant in the non-linear fitting of the feature map than KAL.

Map 14 shows clearly two separated clusters suggesting that aftermath episodes with (without) CAL controls at the onset of the crises are characterized by similar variables. A joint visualization of map 14, map 7 (banking health), and map 8 (banking repression) indicates that most of banking crises occurred in aftermaths with CAL and aftermaths without CAL were associated with low banking repression. Analyzing the speculative attack's response (map 3) and map 14 together, shows that the direction of transition in these two planes was different. Thus, if there is an association between these two variables that is probably non-linear and depending on other variable's values. We observed that the more contractionary and expansionary aftermaths occurred in episodes with CAL controls. On the other hand, most of the episodes without CAL were associated with moderate real effects<sup>14</sup>.

No clear association between KAL and speculative attack's real effects is evident from a joint visualization of the component planes. Similarly, there was no evident association between SEL and speculative attacks' real effects. In summary, the exploratory data analysis using SOM suggest that CAL is a more meaningful indicator of capital controls than SEL or KAL in explaining speculative attacks' real effects.

### **7.6. Socio-Political Planes**

The country's socio-political structure directly affects the quality of government, the investor right's protection, and the quality of law enforcement, among others. Several researchers have suggested that those factors may be important in explaining speculative attacks' real effects (See Hussain and Wihlborg (1999)). Here, three socio-political variables are studied: *legal origin*; *political stability*; and *ethno-linguistic fractionalization*. See appendix 1 for details on the construction of these variables.



Comparative Law scholars classify the countries' legal systems in four legal origins: French; English; German; and Scandinavian. La Porta, Lopez-de-Silanes, Schleifer, and Vishny (1998) showed that the level of investor protection is statistically different among countries with different legal origins. Their results indicate that English Law countries had the best investor's rights protection among the legal origins. In this study, legal origin was included as a proxy of investor's rights as was not possible to build indicators of investor's rights for all the speculative attack's episodes. The component plane for law origin (map 17 in appendix 2) is split in two clusters indicating that countries with the same legal origins share similar aftermaths' variables. Map 17 shows that countries with French legal origin are more prone to speculative attacks than countries belonging to other legal families.

Camdessus (1999) argued that the political will to implement painful reforms was one of the main causes of Korea's fast recovery after the 1997 financial crisis. In the aftermath of a financial crisis some of the needed measures to stabilize the capital account require a good deal of political stability in order to be implemented. Thus, political stability may be associated with financial crises' real effects. Here, the frequency of changes in government was used as a proxy of political stability. The political stability's component map has poor ordering although it is not randomly distributed on the feature map (See map 18 in appendix 2). In addition, map 18 shows that most of speculative attacks occurred in countries with moderate to high political instability.

A visual inspection of the socio-economic component planes shows that law origin is the most relevant in the fitting of the 2-D lattice on the multidimensional data space (See Table 3). As was previously discussed ethno-linguistic fractionalization is one of the less organized variables (map 2). From comparing map 17 with the capital controls' component planes, it can be seen that most of the aftermaths without CAL were non-French. A possible explanation is that non-French countries have relatively better investor protection than French ones, then they may be less prone to capital outflows in moments of distress and therefore, capital controls are less needed<sup>14</sup>. In addition, non-French episodes were also associated with low level of banking repression and banking supervision (See maps 17, 8, and 10). Our SOM-based analysis suggests that countries

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<sup>14</sup> Comparing speculative attacks' real effects occurred in Malaysia 97 and Malaysia 75 indicates that the episode with CAL (1997) was associated with much stronger effects than the episode without CAL (1975)

<sup>15</sup> In this context a French country is understood as one with French legal origin.

with non-French legal origin are associated with relatively lower regulatory restrictions than countries with French ones.

From comparing map 7 (banking health) and map 17, we noted that banking crises occurred in both French and non-French countries. Therefore, legal origin does not seem a relevant variable in explaining the occurrence of banking crises. A joint visualization of map 17 and map 3 (real effects) does not show any clear association between legal origin and speculative attacks' real effects.

The analysis of SOM does not suggest any evident association between maps 18 and 3. Both strong and low real effects occurred in politically stable and non-stable countries. In summary, although, some of the socio-political variables are relevant in the fitting of the feature map they do not seem associated with the speculative attacks' real effects. These results agree with Arciniegas, Arciniegas, and Embrechts (2004) which using a support vector machine based algorithm studied the relevance of several variables explaining speculative attacks' real effects. They found socio-political variables to be non-relevant.

### *7.7. External variables*

The countries in the data set are small open economies, which mean that they cannot affect significantly the global economy, but they are strongly influenced by it. Calvo, Leiderman, and Reinhart (1993) pointed out that changes in foreign interest rates could lead to changes in the direction of capital flows to countries under attack. Foreign Interest rate was included here as a proxy of investor's sentiment. A visual inspection of the foreign interest rates' component map shows that it has a smooth transition from low levels (northwest) to high levels (southeast) (See map 19 in appendix 2). Thus, this variable was important in the construction of the feature map.

A joint comparison of map 19 and the financial intermediation component maps show that they follow similar transition patterns, suggesting that loose foreign monetary policy is associated with higher financial intermediation in small open economies. In addition, from comparing map 19 and map 7 (banking health), it can be seen that most of the banking crises occurred in periods with low foreign interest rates.

Interestingly, the most contractionary speculative attacks occurred at low levels of foreign interest rates. The transition low-high foreign interest rate is matched by a similar transition low-high real effects (See map 3 and map 19). A low foreign interest rate scenario may be associated with more dramatic capital reversals because low foreign interest rates triggered a high level of capital inflows before the attack that later were suddenly reversed after it. In addition, once the crisis starts the investors may be more interested in the probability of getting their money back than in interest rate differentials. Calvo and Reinhart (1999) argued that sudden stops of capital inflows are one of the main factors in explaining speculative attacks' contractionary effects.

### 7.8. *Economic fundamentals*

Mainstream economics points out to economic fundamentals as the most relevant variables in explaining the occurrence of speculative attacks (See Flood and Marion (1998)). The economic fundamentals during speculative attacks' aftermaths were characterized by: *fiscal spending; trade balance; and speculative attack's severity*. The first is an indicator of fiscal policy, the second is an indicator of trade, and the third is an indicator of monetary policy (Appendix 1 describes how these variables were constructed).

Speculative attack's severity is a measure of how bad was the attack that triggered the crisis. The most severe attacks were located in the northwest corner of the map (See map 20 in appendix 2). The recent Asian Crisis has motivated several commentators to reexamine the role of fiscal spending on currency crises' recovery. Stiglitz (2000) calls for the need to expand government spending to solve the recessions caused by the Asian crisis, and dismisses the IMF calls for fiscal contraction as counterproductive. The fiscal spending component map indicates a transition from deficit to surplus that follows a west to east direction. It can be noted that most of the episodes were associated with fiscal deficits (See map 21 in appendix 2).

Several researchers have point out to the external sector as an important factor for explaining the rapid recovery of some countries after speculative attacks (see Krueger and Tornell (1999)). Improvements in the current account through the export side following exchange rate depreciation may help the country's recovery from the crisis, as export may support the domestic

production affected by a contraction in demand. In this paper an indicator of trade balance was constructed as the ratio of exports to imports (See Map 22 in appendix 2).

A visual inspection of maps 20, 21, and 22 shows that fiscal spending is the most organized variable on the feature map and trade balance is the least organized. From comparing map 20 with map 7 (banking health) and map 4 (banking size), it can be seen that episodes associated with the highest speculative attacks' severity were also associated with banking crises and high level of financial intermediation. In addition, a joint visualization of map 20 and map 3 indicates that the most severe attacks were also the ones with highest contractionary effects. However, some severe attacks did not lead to very contractionary real effects. Thus, the evidence suggests that severity and speculative attacks' real effects are non-linearly associated.

A joint visualization of map 21 and map 7 (real effects) shows that the most contractionary attacks were related with contractionary fiscal policies during the aftermath. Interestingly, aftermaths with some fiscal surplus or very low budget deficits are associated with medium to low speculative attacks' real effects. Thus, SOM discovers evidence that supports Stiglitz arguments against the contractionary IMF policies often proposed during the speculative attacks' aftermath. Comparing the computed component planes so far, it can be seen that episodes associated with high trade balance were also associated with low budget deficits and low speculative attacks' real effects. The SOM based exploratory analysis suggests that a combination of strong fundamentals help a country's output recovery after a speculative attack.

### 7.9. IMF

IMF agreements may be relevant in explaining speculative attacks' real effects as they force countries to adopt stabilization programs that may affect output during the crises' solution. Bordo and Schwartz (1999) compared the performance of several economic variables in the period 1973-1998 between countries with and without IMF's programs. Their findings suggest that after a financial crisis non- IMF countries recover faster than IMF countries<sup>16</sup>.

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<sup>16</sup> Here, an IMF country is defined as the one that has an agreement with the IMF at the onset of the attack.

A visual inspection of the IMF's component map shows three patches in the distribution of the IMF variable over the component map (See map 23 in appendix 2). Interestingly two of those small patches (south) are far away from the third one (north). This suggests that there was a group (north) of episodes with IMF's bailout programs whose aftermaths' variables were quite different with respect to the other IMF episodes (south). Comparing map 23 with map 7, it can be noted that IMF's bailouts happened mostly in episodes associated with banking crises. In addition, IMF's assistance to countries with banking crises, budget deficits, and big banks had strong real effects. On the other hand, IMF's assistance to countries with banking crises, budget balance, and high terms of trade were associated with low real effects. These results suggest that the success of IMF's programs depends on the country's economic fundamentals at the onset of the attack. As poor fundamentals is one of the main causes of speculative attacks then IMF seems not very helpful in dealing with financial crises.

#### 7.10. Other variables

This research included four additional sources of heterogeneity across countries: *OECD*; *market development*; *decade*; and *latitude*. The OECD is an organization in which members are supposed to follow values of "open market economy, democratic pluralism and respect for human rights." Therefore, this is a broad measure of "development". On the other hand, market development focus on the investors' perception of the financial markets' development. These variables may play an important role in investors' decisions of whether or not to pull their money out. IMF (1998) found evidence that emerging markets tend to have deeper crises than non-emerging ones. The component planes of OECD and market development show a smooth organization of these two variables in the feature map (southwest-northeast). Therefore, they were important in the construction of the feature map. See maps 24 and 25 in appendix 2.

Decade was included with the conjecture that the speculative attacks' aftermaths were different in the financially liberalized period of the nineties respect to the highly regulated period of the seventies (See Calvo and Reinhart (1999)). Latitude was included to take into account geographical differences across countries. The component planes of these variables show smooth organizations in each of them (See maps 26, 27, 28, and 29 in appendix 2), suggesting that they have important contributions to the SOM map. Clearly, market development and decade 90's are

the most organized and decade of 80's and latitude are the least organized. In addition, it can be seen that OECD, market development, and latitude are closely correlated variables.

A visual inspection of maps 25, 8, 10, and 14 shows that developed markets were associated with low banking repression and supervision and no controls on current account. Therefore, developed markets seem associated with milder regulatory restrictions than emerging ones. Developed markets are also associated with high banking efficiency and development, non-French legal origin, and no IMF bailouts. Comparing map 7 and map 25, we noted that although banking crises and severe speculative attacks occurred in both emerging and developed markets, they were more common in emerging markets. Besides, severe speculative attacks occurred in both developed and emerging markets however, severe speculative attacks and banking crises occurred more often in emerging markets. Finally, most of the developed countries have non-French legal origin, high levels of financial intermediation, and followed contractionary fiscal policies during speculative attacks' aftermaths.

The organization of the speculative attack's real effects and market development component planes follow different directions of organization. This means that the association between these two variables is non-linear and probably dependent from other variables. Thus, SOM does not find evidence of the linear association between emerging markets and speculative attacks as suggested by IMF (1998)<sup>17</sup>. Our results agree more with the mixed evidence provided by Demirguc-Kund, Detragiache and Gupta (2000).

Looking at the decade component maps it can be seen that episodes occurred within the same decade are clustered together. Thus, episodes within the same decade are similar among themselves and clearly differentiate from episodes occurred in other decades. From a joint visualization of the computed component maps it can be seen that most of the episodes occurred in the nineties were associated with banking crises, high levels of financial intermediation, moderate banking repression, DIS, and low levels of foreign interest rates. Thus, the aftermaths in the nineties occurred in an environment of high financial liberalization, capital inflows, and weak banking systems. In addition, several of the episodes in the nineties were characterized by budget deficits, suggesting that economic fundamentals were not very strong either. On the other

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hand, in the episodes occurred in the seventies, there were no banking crises, the level of financial intermediation was low and the level of foreign interest rates was very high, suggesting a period of low financial liberalization, healthy banking systems and no capital inflows. On the other hand, the episodes occurred in the seventies were characterized by budget balance. It is noteworthy that the speculative attacks occurred in the nineties were associated with strong output contractions but, the episodes in the seventies were associated with mild-low real effects.

## **8. Conclusions**

In this paper we illustrated why SOM is a better technique than traditional univariate methods to explore the data of speculative attacks' aftermaths. Using SOM we showed evidence of the pivotal role that plays the banking system, in explaining speculative attacks' real effects. Our findings also suggest that speculative attacks' real effects are associated with the regulatory framework; the economic fundamentals; the foreign interest rate; and the decade. Interestingly, no evidence was found of the beneficial roles played by the International Monetary Fund (IMF) in solving financial crises.

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### Appendix 1

For each one of the observations (speculative attacks' aftermaths) the following explanatory variables were measured:

1. Speculative attacks' severity: it was measured as the unweighted average of the six-month percentage change in the exchange rate following the crisis month and the six-month percentage change in international reserves prior the crisis month. The real exchange rate was defined respect to the US dollar for all the countries in the sample. It was computed from the ratio of IFS line *rf* and IFS line *64*. Data on international reserves was retrieved from IFS (line *11.d*).
2. Banking health: this is a dummy variable that takes the value of *one* if the beginning of a banking crisis is followed by a currency crisis within 48 months. Data on banking crises come from Kaminsky and Reinhart (1999), and Glick and Hutchison (1999).
3. Financial intermediation's size: this variable is defined as the ratio of *liquid liabilities* of the financial system to *GDP*. Data was obtained from IFS line *551* when information was available or was constructed by the sum of IFS lines *34* and *35*. IFS line *34* (*Money*) equals the sum of currency outside banks, and IFS line *35* (*Quasi-money*) reflects the sum of time, savings, and foreign currency deposits of resident sectors other than central government. The sum of lines *34* and *35* is known as M2. GDP data came from the cubic spline (to obtain monthly data) interpolation of IFS lines *99 b.p*.
4. Financial intermediation's development: this variable measures the financial intermediary credits to the private sector relative to GDP. The financial intermediation indicator is constructed from the sum of lines *22-d* and *42-d* from IFS divided by GDP. The variables are adequately deflated to take into account that financial stock items are measured at the end of period, while GDP is measured over the period. When was possible, interpolation of missing data for *42-d* was done using SmartForecast expert system, otherwise the value was assumed to be zero.
5. Financial intermediation's efficiency: it measures the banking sector relative size respect to the central bank. It was measured as the ratio of deposit money bank domestic assets to

deposit money bank domestic assets plus central bank domestic assets. Deposit money bank domestic assets are constructed from the summation of IFS lines 22-*a* to 22-*d*. Central bank domestic assets are constructed from the summation of IFS lines 12-*a* to 12-*d*.

6. Legal origin: it takes the value of 1 if the origin of the country's law system is French and zero otherwise. This variable was included as a proxy of investors' protection.
7. Trade balance: this indicator is defined as the ratio of exports to imports expressed in FOB terms. Data comes from IFS lines 71 and 72. The average country's trade balance was measured over the duration of each crisis.
8. Foreign interest rate: it was measured as the average value of the US Three-month Treasury bill during the crisis duration.
9. IMF agreement: is a dummy variable that takes the value of *one* if the country was in an IMF agreement at the onset of the crisis. The data comes from Bordo and Schwartz (1999).
10. Banking repression: we followed Barth, Caprio and Levine (1999) which evaluated each country regulations and constructed an index that reflects the level of banking regulation restrictions. The index values vary between *one* and *four* were *one* stand for unrestricted, and *four* for prohibited regulations.
11. Banking supervision: this index is a quantitative measure of the official supervisory power in the countries in which the episodes occurred<sup>18</sup>. The index varies between 0 and 16, with a higher value indicating more power. The data source is the World Bank Database of Financial Regulation.
12. Minimum capital requirements: this index consists in the sum of scores rating the overall regulatory requirements and scores rating the definition of capital. This index varies from

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<sup>18</sup> World Bank database includes other indexes of banking supervision. We selected Official Supervisory Power because it is not correlated with measures of banking repression.

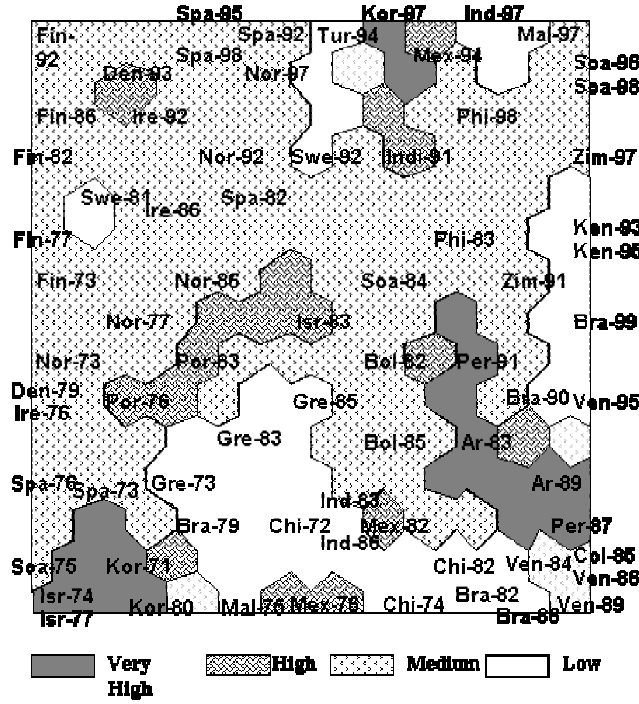
0 to 9, where the higher the index the higher the capital stringency. The data source is the World Bank Database of Financial Regulation.

13. Data insurance scheme (DIS): this paper used the recent World Bank Deposit Insurance Database explained by Demirguc-Kunt and Sobaci (2000) to construct a dummy variable that takes the value of *one* if at the time of the speculative attack an explicit DIS was already enacted and *zero* otherwise.
14. Stock market's capitalization: it is defined as the average value of the listed domestic shares on the country under attack in a year divided by GDP that year.
15. Stock market's value traded: this is computed as the value of trades of domestic shares on domestic exchanges over the year divided by GDP.
16. Stock market's turnover: is the value of the trades of domestic shares on domestic exchanges divided by the average value of domestic shares listed on domestic exchanges in that year.
17. Market development: it was measured by a dummy variable that takes the value of one if the market is considered developed at the onset of the attack and zero otherwise. The source of the episodes' classification came from Morgan Stanley Corp. (MSC), which ranked the financial markets as developed, emerging, and frontier.
18. OECD: is a dummy variable that takes the value of *one* if the country in which the observation was made belongs to the Organization of Economic Development.
19. Controls on current account: it takes the value of one if there are restrictions on payments for current transactions at the onset of the attack. The data source is the Annual Report on Exchange Arrangements and Exchange Restrictions.
20. Requirements to surrender export proceeds: it takes the value of one if there is requirements for repatriation of export proceeds at the onset of the attack. The data source is the Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).

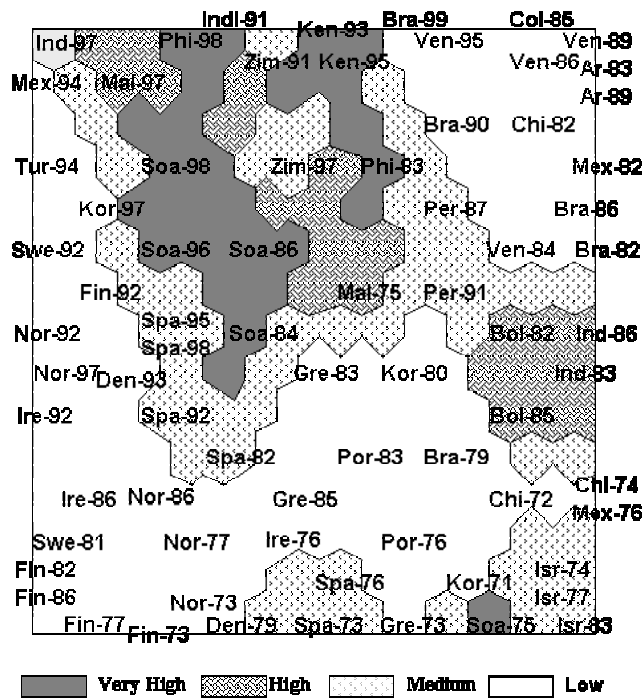
21. Capital account controls: it takes the value of one if there are restrictions on payments for capital transactions at the onset of the attack. The data source is the AREAER.
22. Fiscal Spending: It was computed by dividing government budget deficit or surplus (IFS *line 80*) by real GDP, which was obtained from IFS *line 99 bp* (base 1990). The monthly values were obtained from interpolation from annual data. The variable was measured as a percentage of GDP.
23. Latitude: this measure for geographical differences across countries.
24. Ethno-Linguistic Fractionalization: This is a measure of the society's homogeneity. This is the average value of five components: the probability that two randomly selected people from a given country will not belong to the same ethno-linguistic group; the probability that two randomly selected individuals of the same country speak different languages; the percent of the population not speaking the official language; the percent of the population not speaking the most widely used language; and the probability that two randomly selected individuals speak the same language.
25. Decade: three dummy variables, one for each decade were included in the data set.
26. Political Stability: Here the frequency of changes in government is used as a proxy for this variable.

Appendix 2

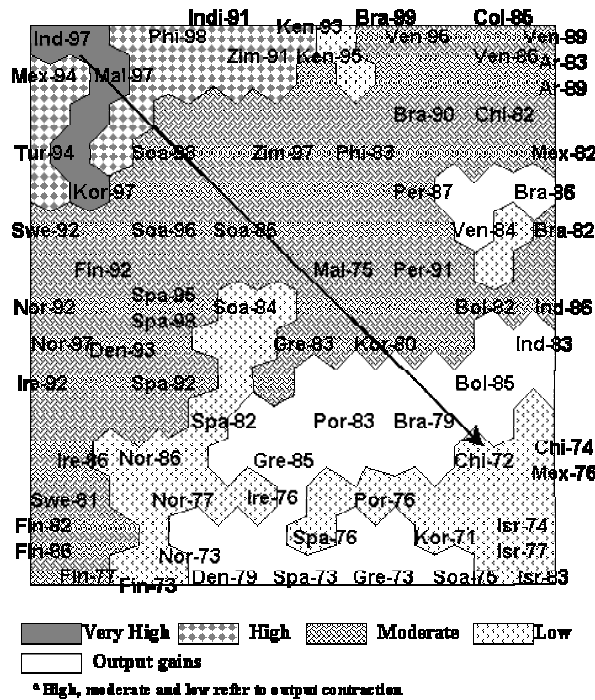
Map 1. Capital Requirements



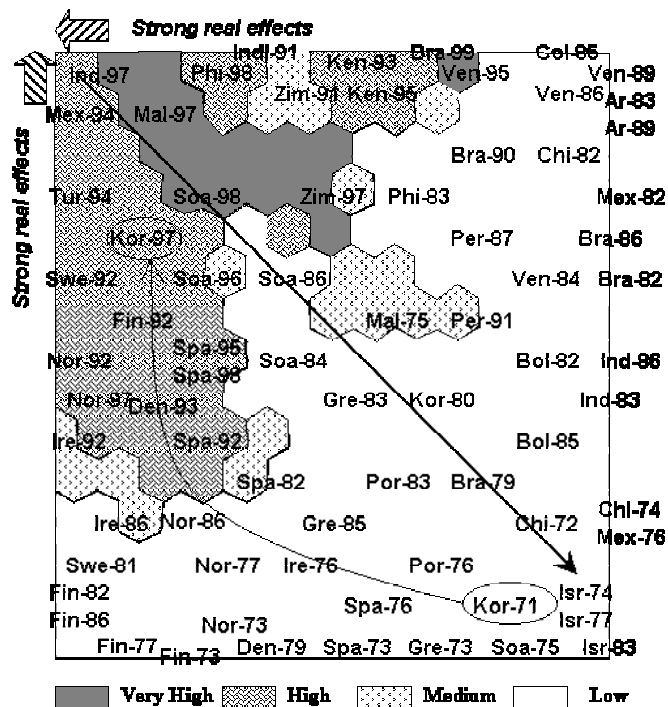
Map 2. Ethno-Lingualistic Fractionalization



Map 3. Speculative Attacks' Real Effects\*

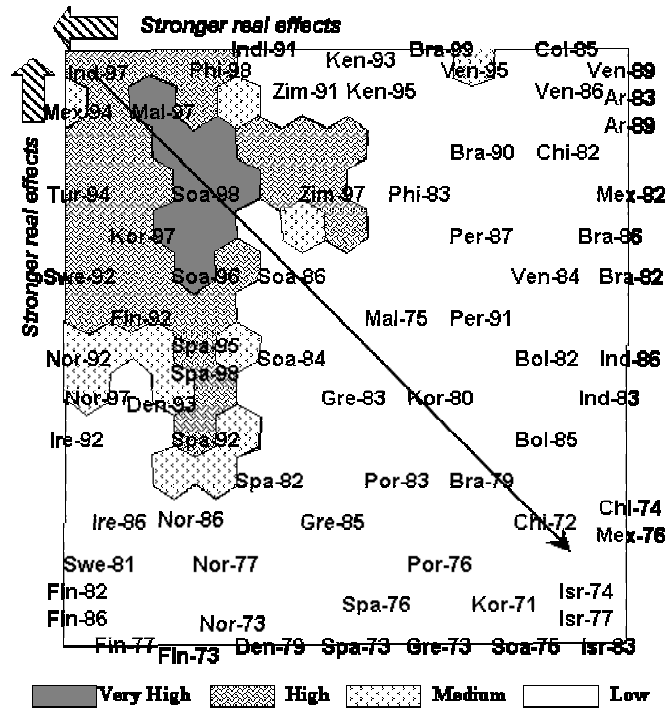


Map 4. Financial Intermediation Size

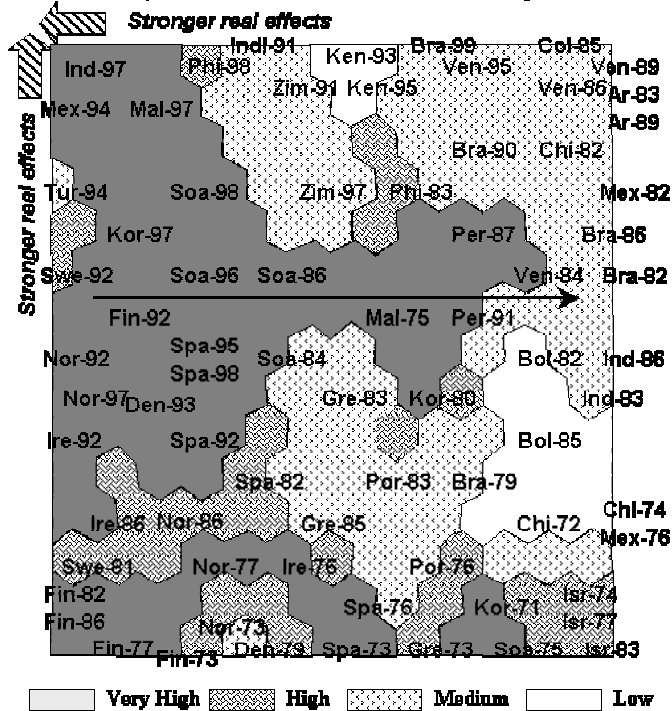


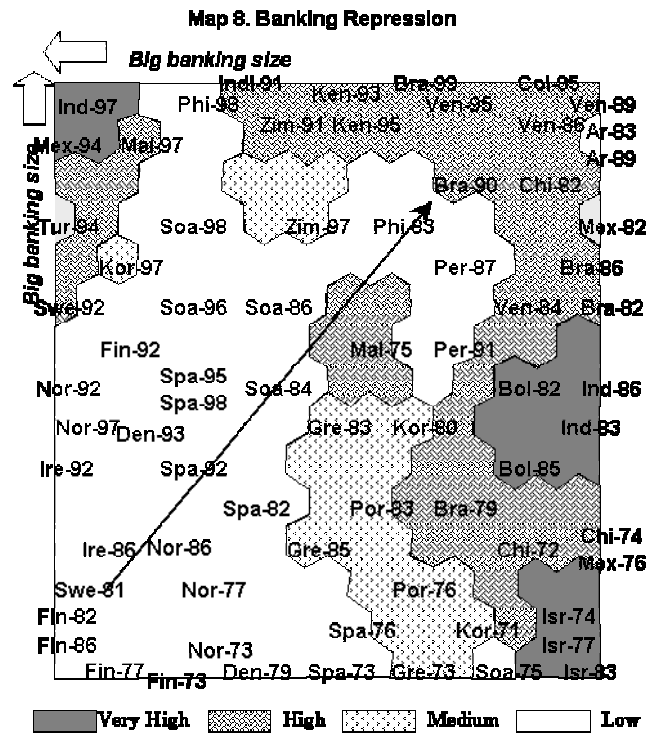
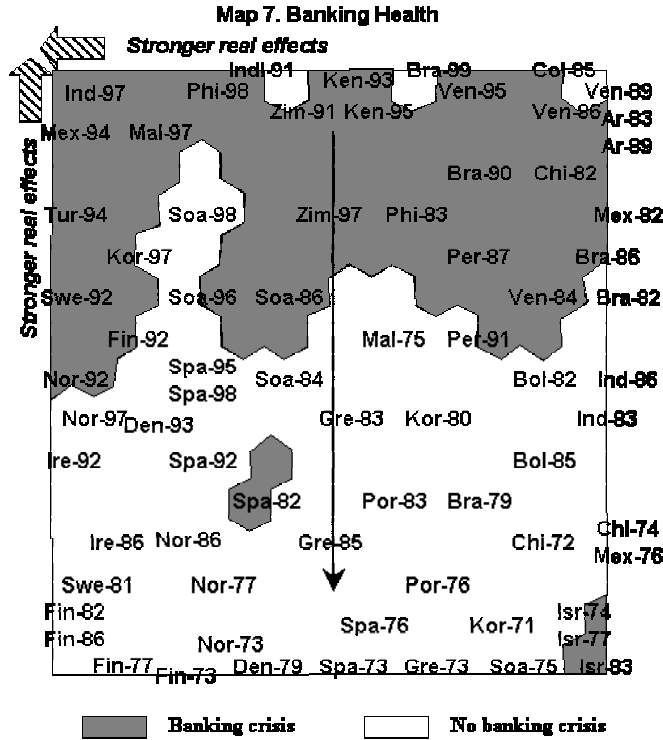


Map 6. Financial Intermediation Development

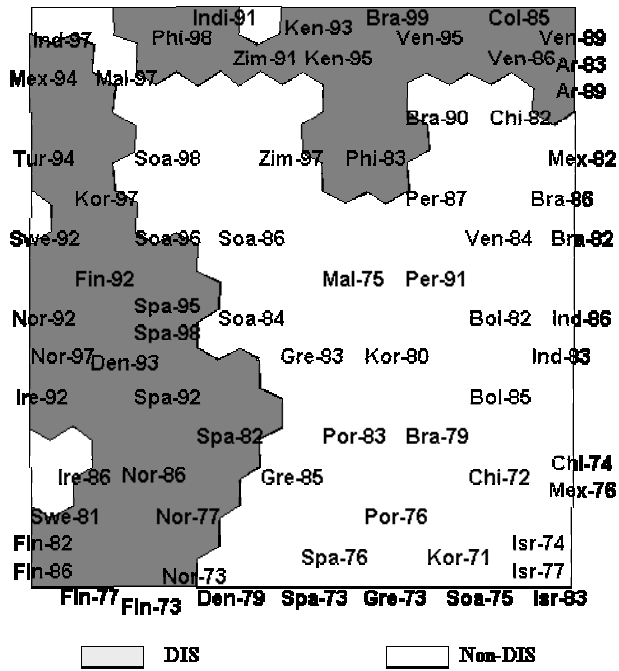


Map 6. Financial Intermediation Efficiency

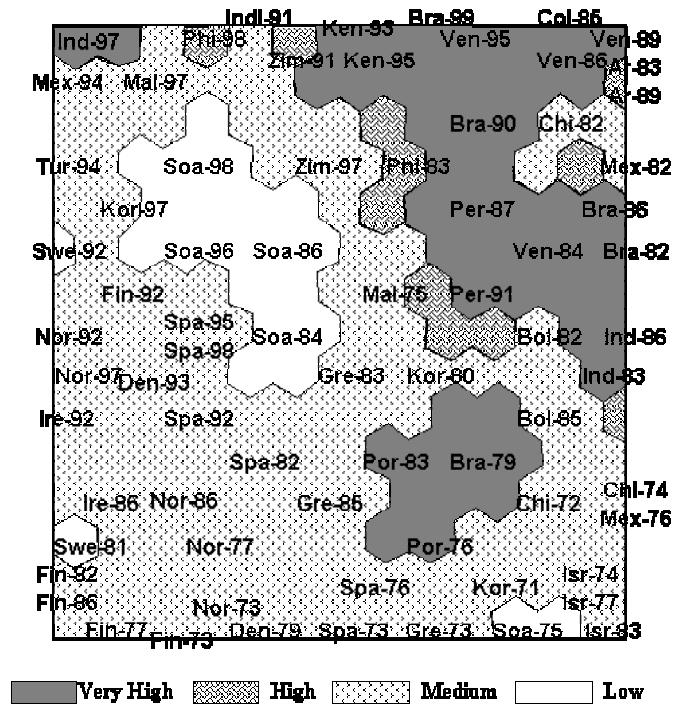


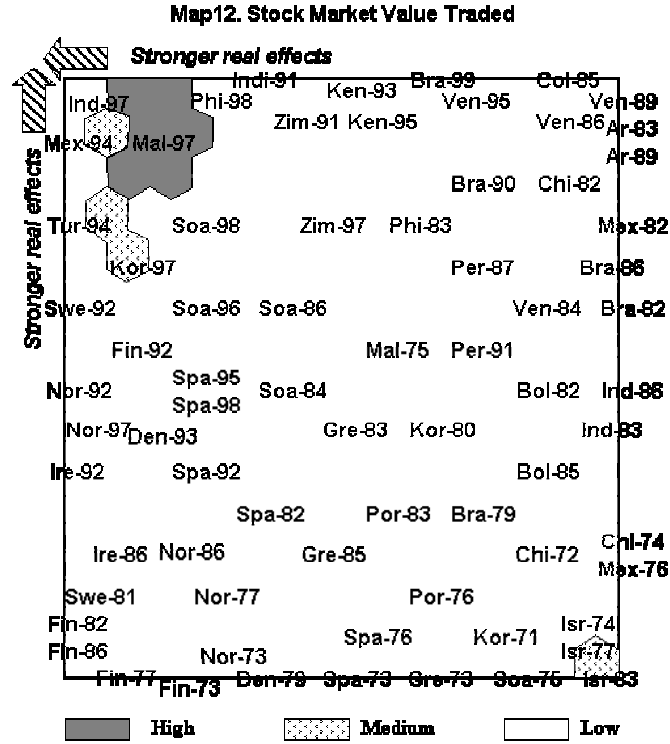
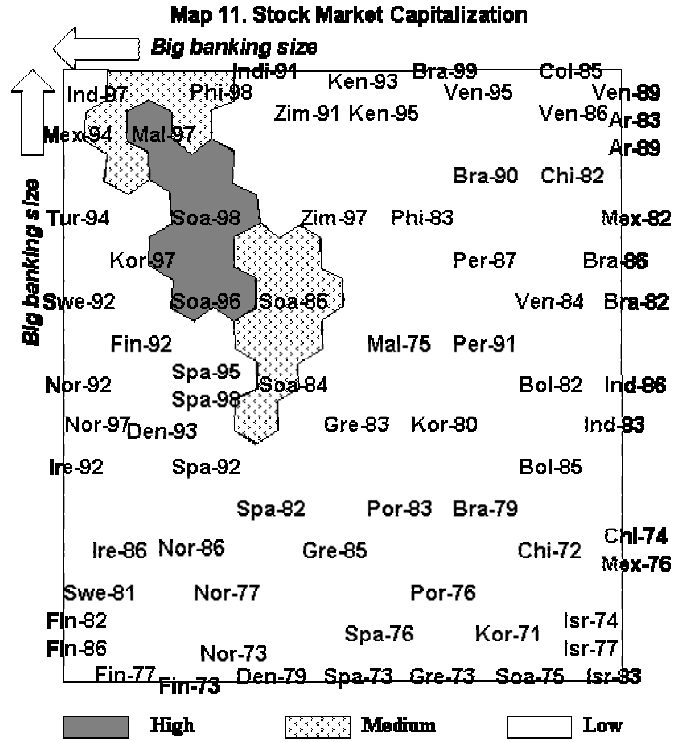


Map 9. Deposit Insurance Scheme (DIS)

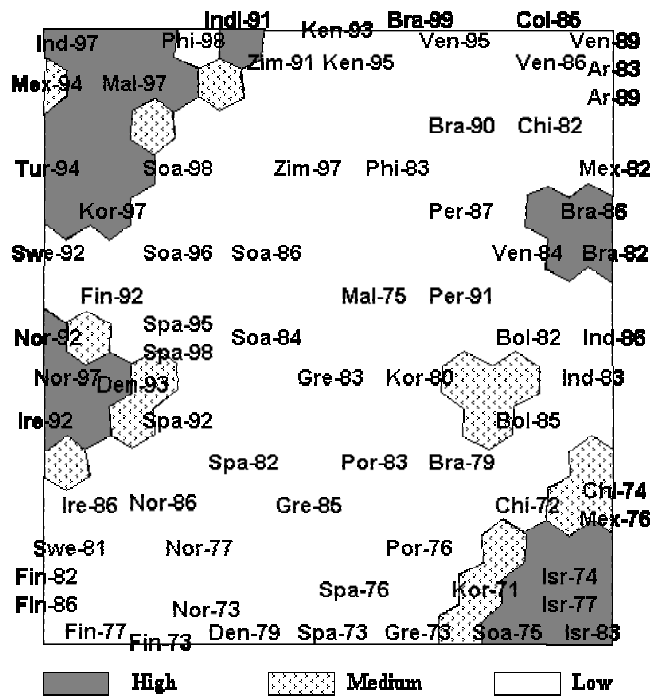


Map 10. Banking Supervision

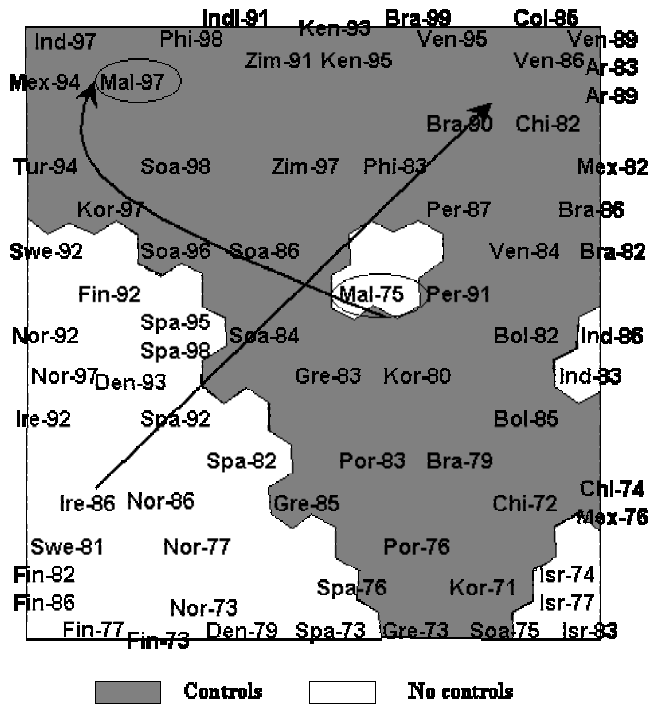




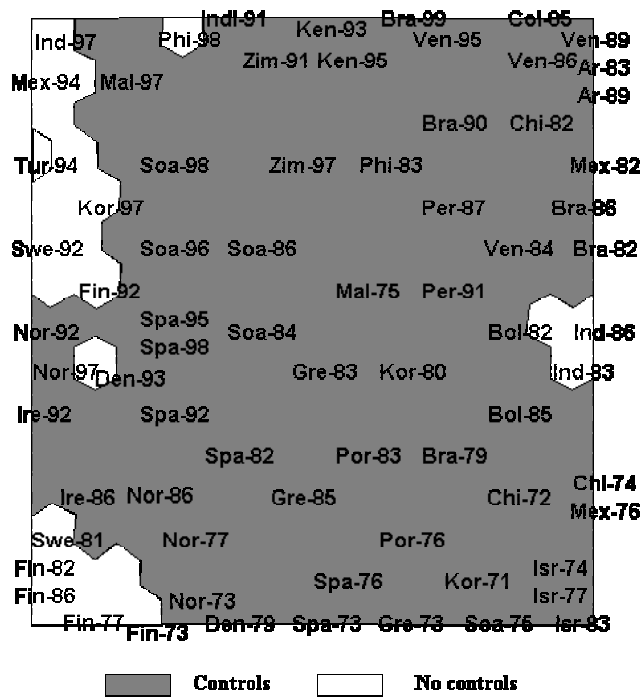
Map 13. Stock Market Turnover



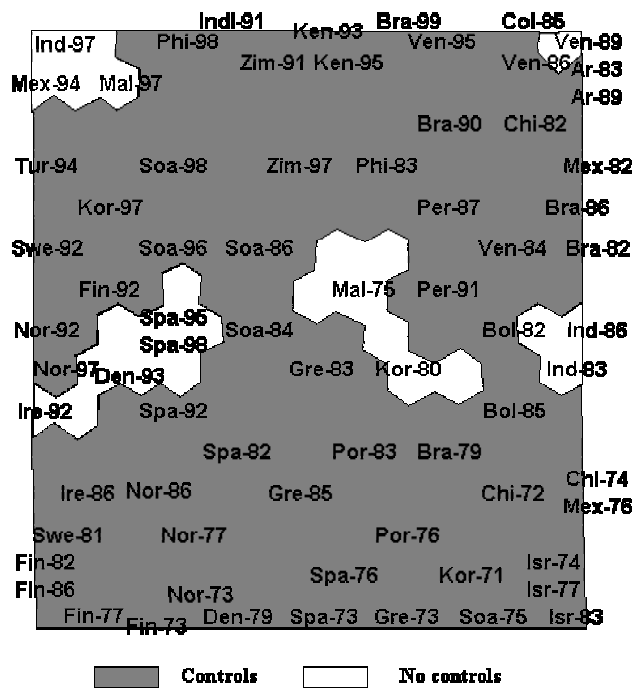
Map 14. Capital Controls (Current Account)

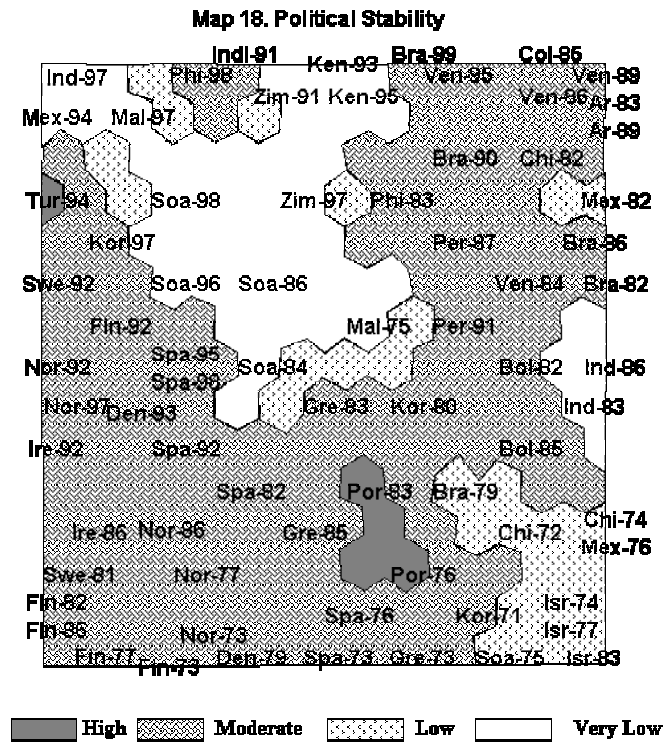
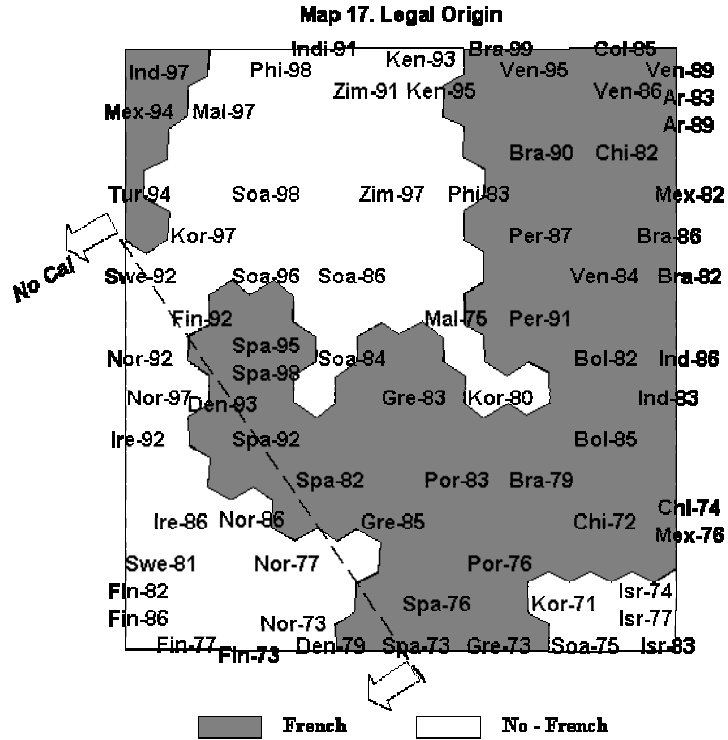


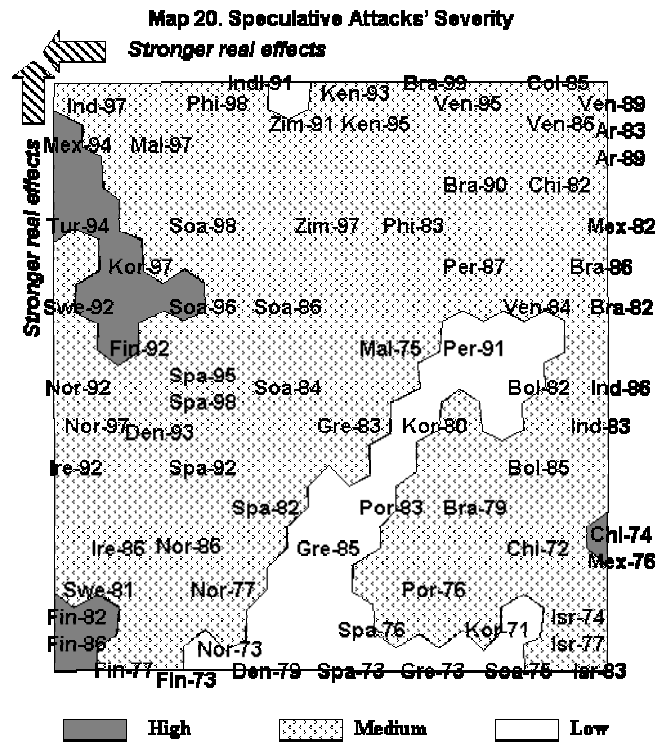
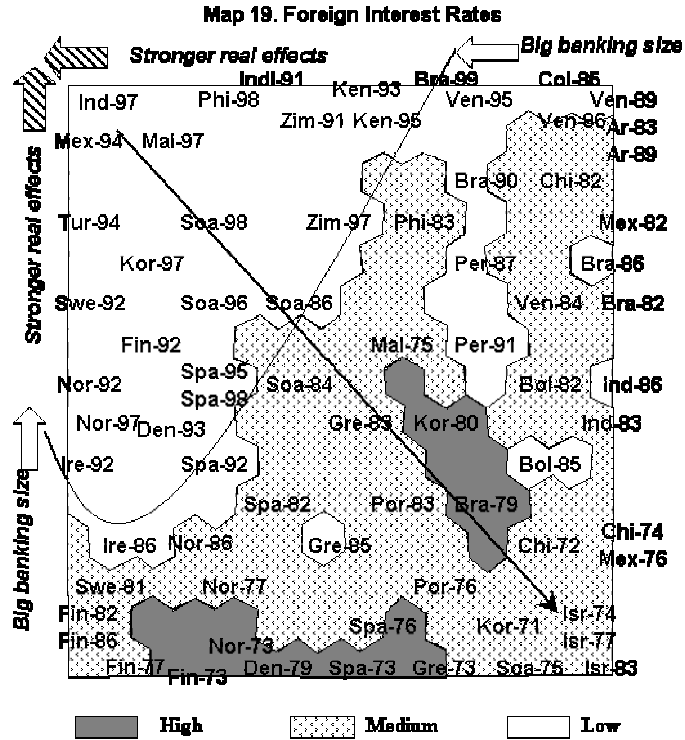
**Map 15. Capital Controls (Surrender Export Proceeds)**



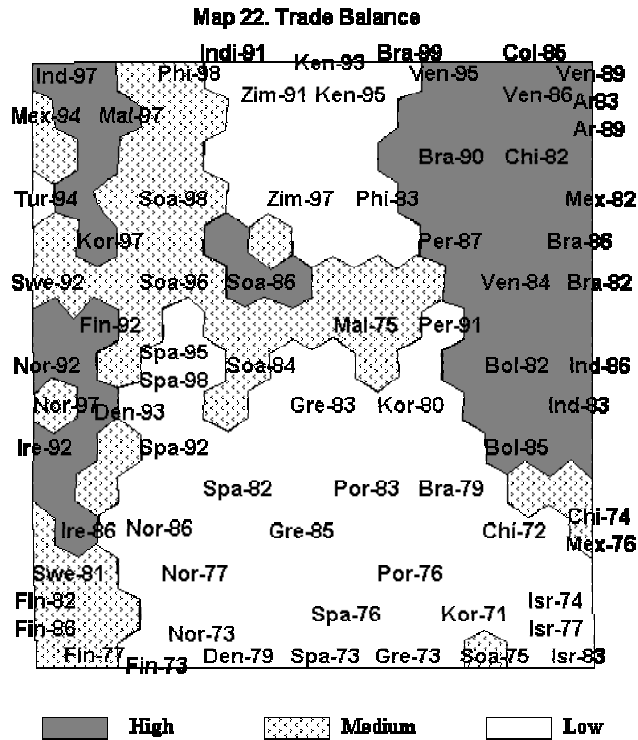
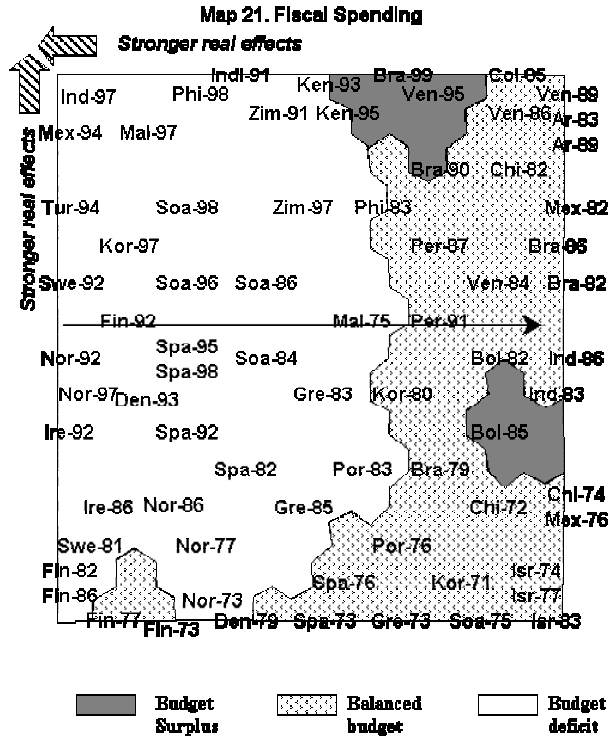
**Map 16. Capital Controls. (Capital Account)**

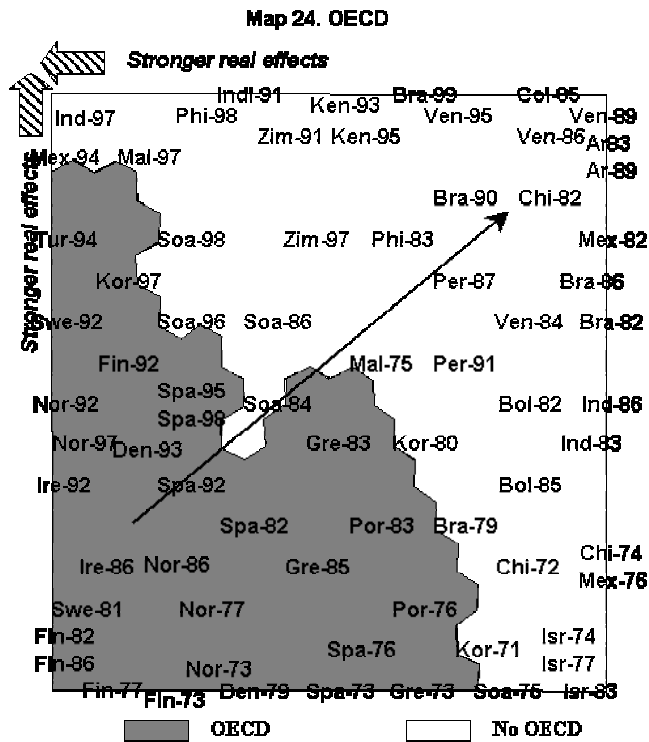
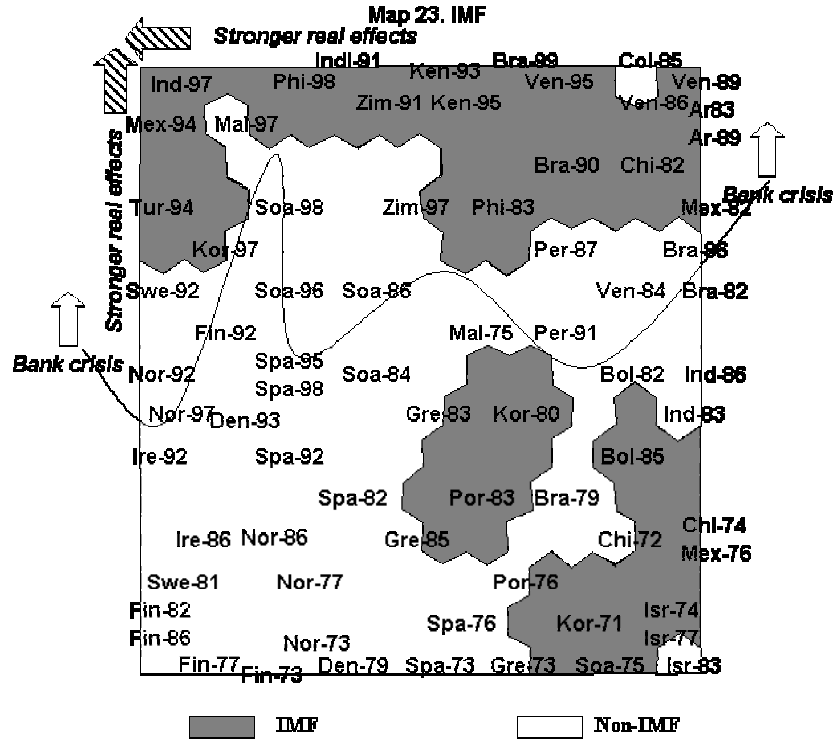


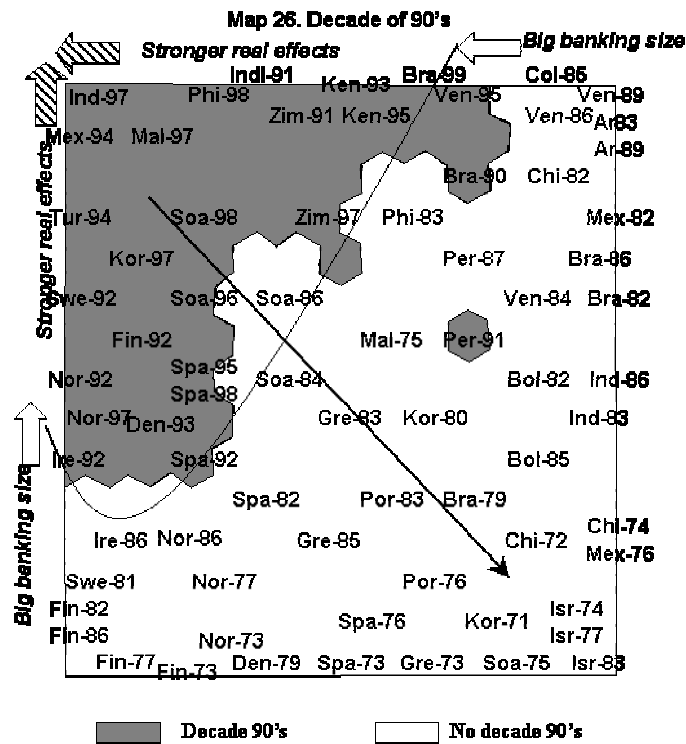
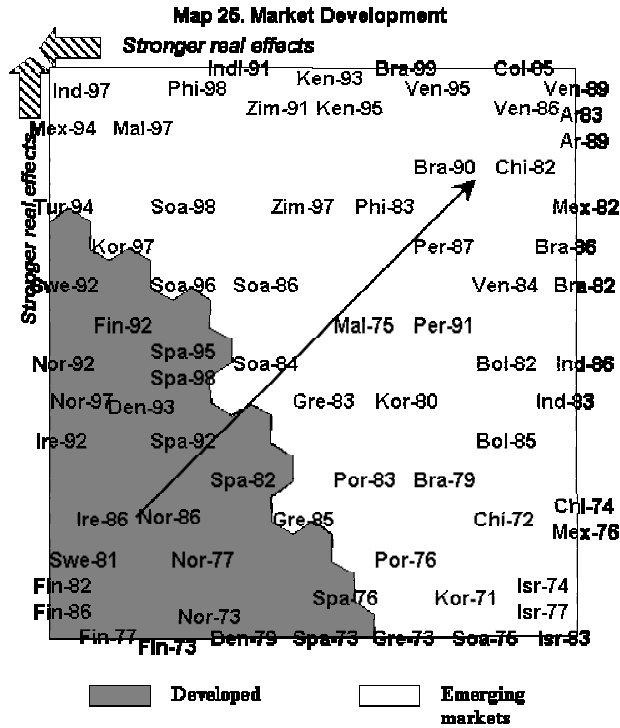


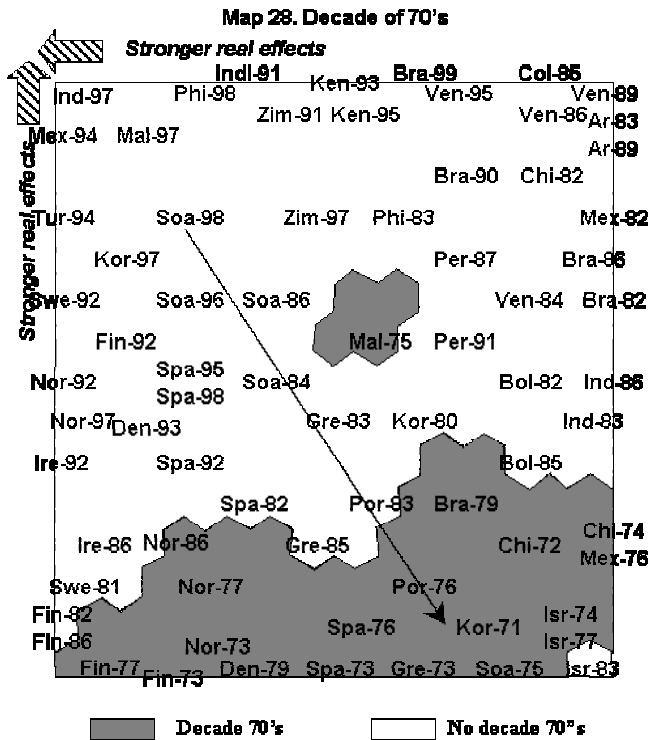
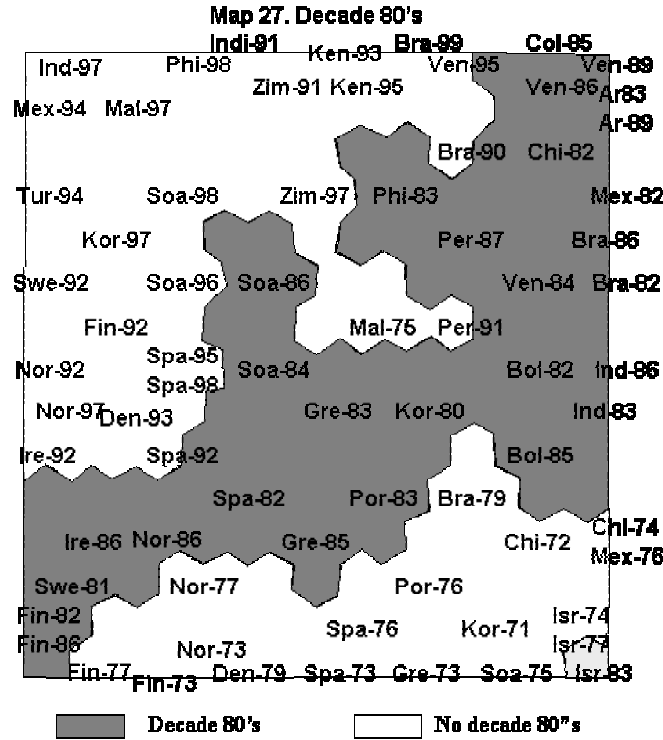


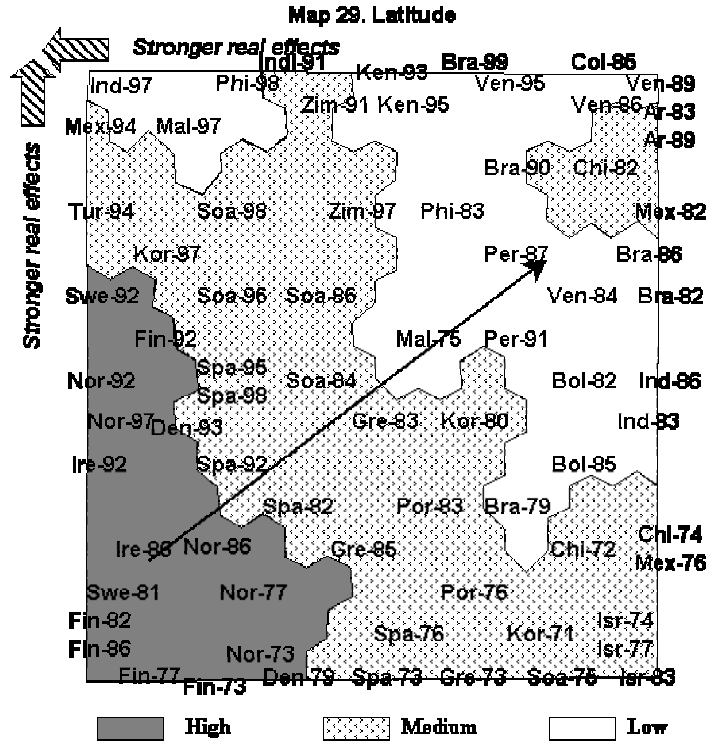












**TABLES AND FIGURES**