

**Forecasting Financial Markets**

Advances for exchange rates, interest rates and asset management  
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## Self Organizing Maps, Pattern Recognition and Financial Crises

(ongoing research)

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### Outline

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The aim of this paper is to present preliminary results of an ongoing research on vulnerable pattern recognition for predicting economic and financial crises in developing countries.

This research has been conducted in close cooperation between TAC & BNP Paribas. But the views expressed are those of the authors and do not necessarily reflect the position of TAC or BNP Paribas.

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## Structure of the presentation

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1. Introduction to Country Risk Assessment
2. RiskMonitor Methodology
3. Self Organizing Maps
4. Preliminary results on mapping country crises
5. Next Steps



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## 1. Introduction to country risk assessment



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## 1. Introduction to country risk assessment

A key operational element

- Banking and currency crises can be extremely costly
- Multinational companies and SME's need to target developing countries as growth drivers
- The perceived risk is not easily managed
- The ability to provide early warning signals on upcoming crises in emerging markets is a key operational input in firms' definition of their strategies.



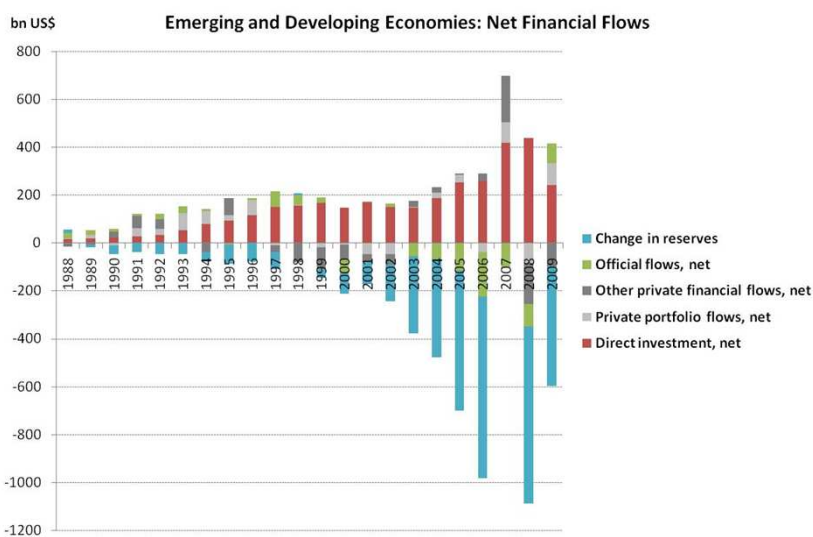
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## 1. Introduction to country risk assessment

A key operational element



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## 1. Introduction to country risk assessment

### Complex interactions...

- **Numerous empirical studies:** Krugman (1979), Obstfeld (1994), Cantor and Packer (1996), Eichengreen et al. (1996), Frankel and Rose (1996), Goldstein (1996), Goldstein and Turner (1996), Kaminsky and Reinhart (1999), Komulainen and Lukkarila (2003) , ...
- **But despite existing classification of country crises**, the large number of financial crises in emerging markets since the 80s has left many observers, both from academia and financial institutions, puzzled by **an apparent lack of homogenous causal relations** between economic variables and the bursting of large financial shocks.
- Moreover, heterogeneous and **complex interactions** between economic and financial variables **blur any clear identification of risky economic patterns** that could lead to large shocks on domestic financial systems.



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## 1. Introduction to country risk assessment

### ... and a changing concept

- **Until the mid-70s:** the risk is political (nationalizations or confiscation of non-residents' assets)
- **From the mid-70s to end 80s:** western banks recycle the financial surplus of oil-exporting countries. Borrowers are governments and state-owned companies of developing countries and lenders are commercial banks and public creditors from OECD countries.
- **Since the 90s:** integration of developing countries' markets into world financial flows.
- **Pure debt crises are now associated with other financial disruptions** (exchange rate collapse, banking crises and domestic defaults) and the restructuring is more complex
- **This phase is still prevalent today** but with signs of new forms of political risk



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## 2. RiskMonitor Methodology



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## 2. RiskMonitor Methodology

Lessons from the past?

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- Poor performances of rating agencies** over the past 15 years.
- Partly explained by institutional constraints but also related to the characteristics of the linear methods used.
- We argue that the issue is not the inability of a set of indicators to be a good predictor of country crises but the ability to combine these indicators**



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## 2. RiskMonitor Methodology

A skier in front of a foggy slope!

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- The skier wants to assess the risk of going down** (whether the ski-run is bumpy, irregular or flat).
- He also wants to know with the greatest degree of certainty if there is a deep ravine in the middle of this foggy route.**

*The ravine is the 'full-blown crisis' and the characteristics of the ski-run are the synthetic economic quality measures.*



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## 2. RiskMonitor Methodology

General Methodology

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- Six Fundamental Balances:** growth, debt, liquidity, exchange rate, cyclical & banking.
- 12 macroeconomic indicators,** calculated over the period 1970-2008 using official data (IMF/IFS, World Bank, United Nations, OECD, BIS, ...).
- A dataset on 72 developing countries** (8 regions).



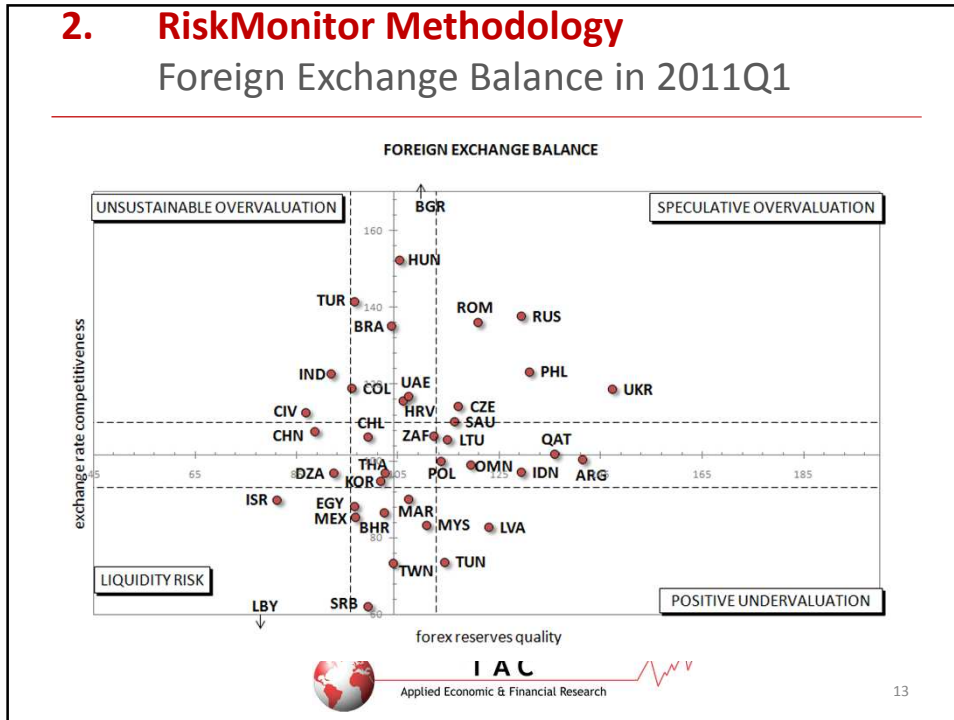
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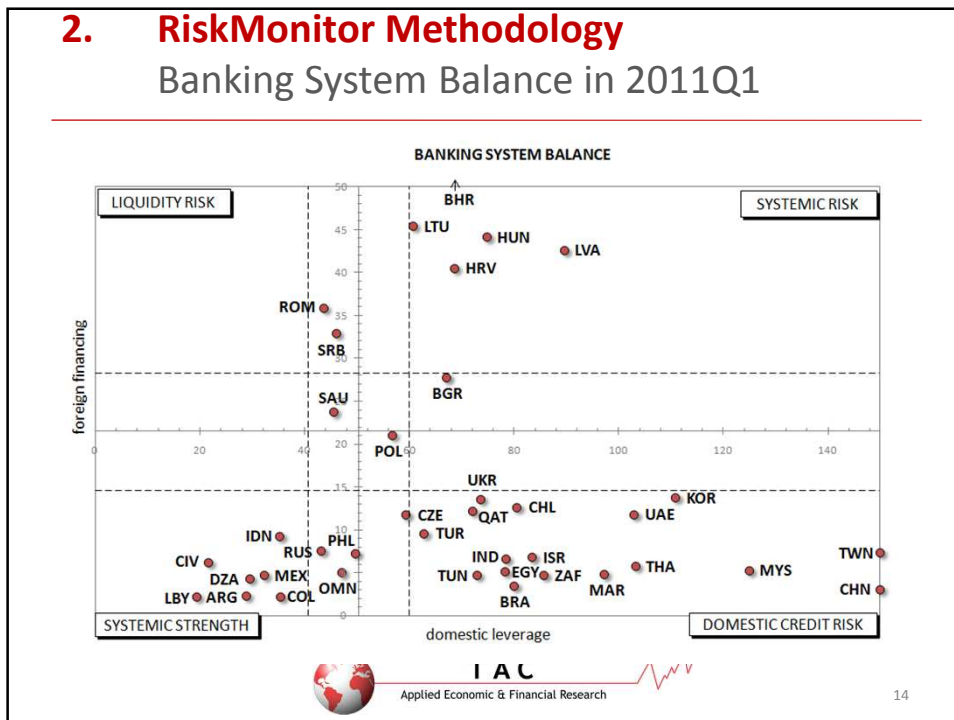
## 2. RiskMonitor Methodology

### Foreign Exchange Balance in 2011Q1



## 2. RiskMonitor Methodology

### Banking System Balance in 2011Q1



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### 3. Self Organizing Maps



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### 3. Self Organizing Maps

#### General Description

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- Kohonen neural nets are non linear projections of a multidimensional space into a space of reduced dimension (here 2D).
- A SOM is a grid where **units are connected with a neighbourhood relation**.
- Data that are “alike” are represented in the same area (“near”).



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### 3. Self Organizing Maps

#### Key Characteristics

- Allow unsupervised classification** (the supervised version of SOM is the Learning Vector Quantization) as well as data analysis (similar to a PCA)
- Manage missing data into the datasets
- Able to capture non-linearities**
- A robust and flexible tool
- An 'easy to explain' classification method



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### 3. Self Organizing Maps

#### Algorithm

- $w(1,i) \dots w(n,i)$  are randomly chosen weights (where  $n$  is the dimension of inputs)
- We choose a input vector  $X$  (observed patterns on an individual for a year)
- Find the best matching unit (BMU) or 'winning' node ( $|x(i)-w(i)|$ ).
- We update the neighbourhood of the BMU using the following formula (where  $a$  is the learning rate and  $H$  the neighbourhood function) :  

$$w(k,updated) = w(k,old) + a H(i,k) [x - w(k)]$$
- The process is iterated



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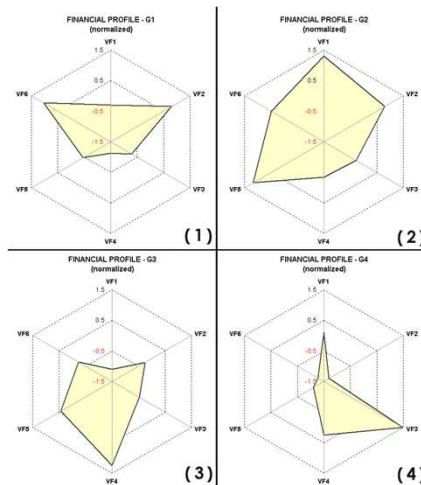
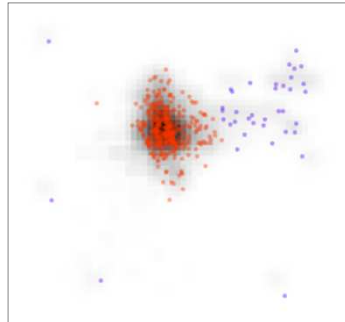


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### 3. Self Organizing Maps

Example of a SOM on French SME's

On the basis of Salais Storper  
**Worlds of Production theory**, an empirical typology of French SME's confirmed by a SOM (analysis for the French Ministry of Finance, 2000)



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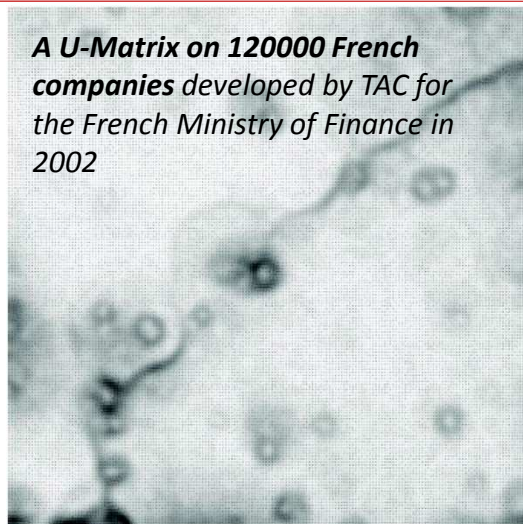


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### 3. Self Organizing Maps

SOM on 120000 French Companies

*A U-Matrix on 120000 French companies developed by TAC for the French Ministry of Finance in 2002*



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## 4. Preliminary Results on Mapping Country Crises



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## 4. Preliminary Results on Mapping Crises

- **We use 12 annual normalised indicators extracted from RiskMonitor over the period 1970-2008:** Economic Growth, External Balance, Financing Stability, Debt Service, Forex Liquidity, Maximum Potential Service, Forex Reserves Quality, Exchange Rate Competitiveness, Monetary Pressure, Real Economic Pressure, Domestic Leverage, Foreign Financing.
- **We try to identify similarities on country macroeconomic profiles.** We then compare these clusters on macroeconomic patterns to the occurrence of various types of economic and financial crises: currency crises, cyclical crises (economic downturns) and solvency crises (from IMF, IIF, World Bank).
- The underlying idea is to improve the early detection of country crises with more specific models... as an alternative to our global MLP, SVM & Random Forests approach.



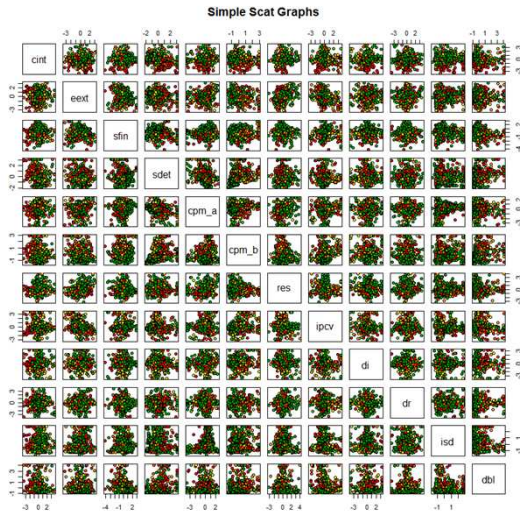
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### 4. Preliminary Results on Mapping Crises

Crises identified with simple scat graphs?



Analysis on all crises (currency, solvency & cyclical)

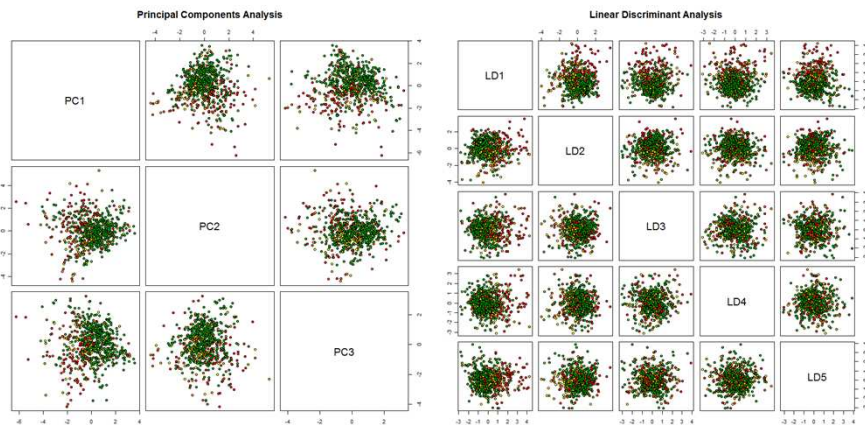
Crises are in red, stable periods in green and other periods in orange (less than 5 yrs before a crisis occur).

Crises and periods preceding crises are not clearly identified!



### 4. Preliminary Results on Mapping Crises

PCA, LDA,...

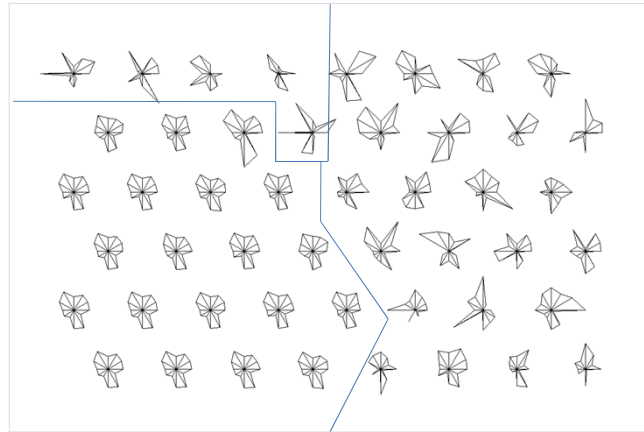


Only very small improvements by using PCA or LDA



### 4. Preliminary Results on Mapping Crises

Small self organizing map on all crises



A simple SOM clearly reveals strong similarities on macroeconomic patterns.



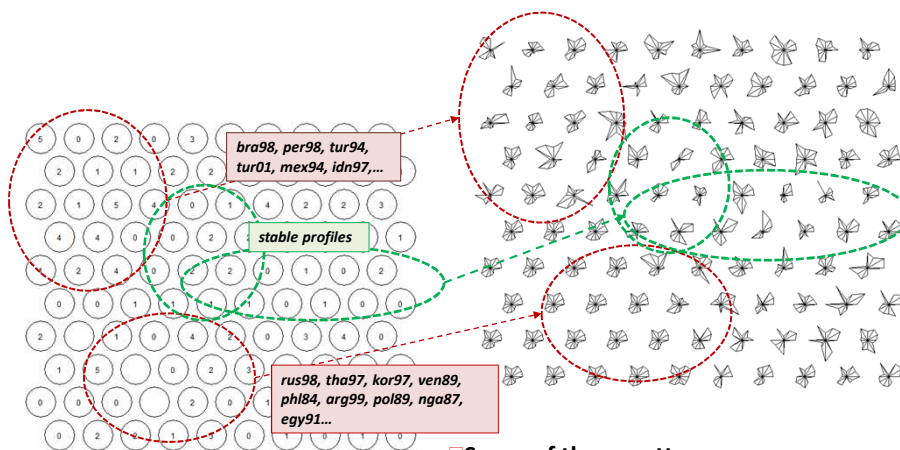
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### 4. Preliminary Results on Mapping Crises

SOM on all crises (10x10)



Some of these patterns are more vulnerable to country crises than others.



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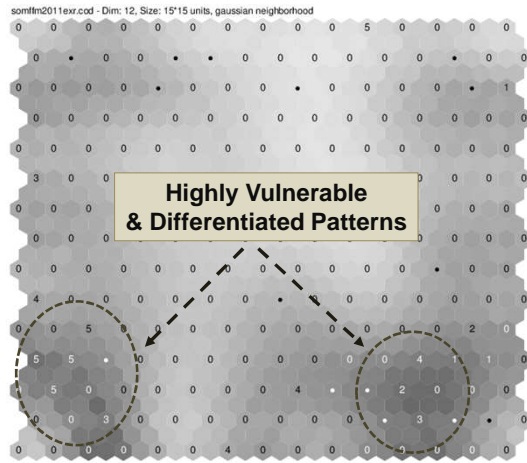
### 4. Preliminary Results on Mapping Crises

#### U-Matrix on Currency Crises

□ Same Analysis but on Currency Crises Only (T0=5, T-1=4, T-2=3,... 0=stability)

□ The U-Matrix also reveals strong similarities and **two clusters highly vulnerable to currency crises**.

□ Patterns are more **differentiated** that for the “all crises” model.



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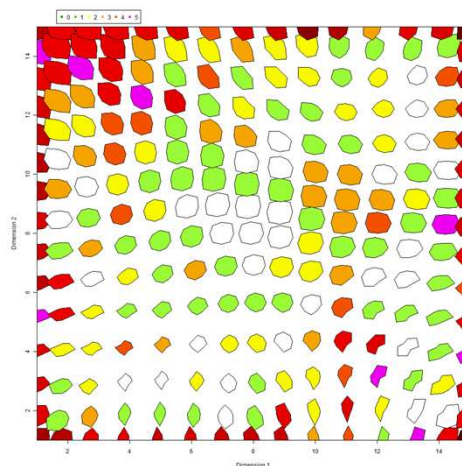
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### 4. Preliminary Results on Mapping Crises

#### Shard Plot on Currency Crises

□ The shards plot (Cottrel & Bodt plot) **confirms the differentiation of currency crises** from stable periods.

□ Vulnerable profiles (in violet: top left, left, right and bottom right) as well as more stable patterns (green and yellow) are clearly identified.



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## 4. Preliminary Results on Mapping Crises Planes on Currency Crises

- The analysis of ‘planes’, reveals a number of critical indicators for currency crises (similar to a PCA):
  - Economic growth and foreign financing for “top left” crises
  - External balance, maximum potential service (short-term external debt), exchange rate competitiveness, forex reserves quality and foreign financing for both types of currency crises.
- This analysis also confirms strong similarities between country not exposed to a high risk of devaluation (in the center of the map) and more irregularities between vulnerable profiles.

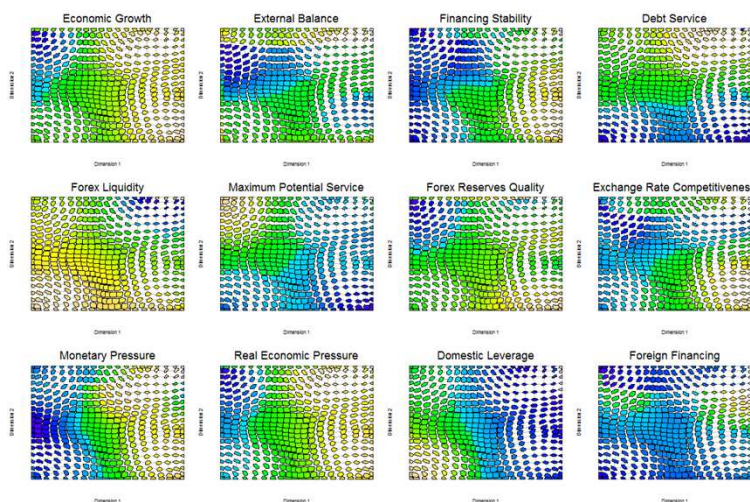


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## 4. Preliminary Results on Mapping Crises Planes on Currency Crises



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## 4. Conclusions

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- Interesting results on vulnerable profiles as well as on potential typologies of country crises. Clusters of stable countries and countries affected by economic and financial crises are clearly identified.
- But the “road to crisis” is more difficult to identify, because of a difficult differentiation of groups two or three years before the occurrence of country crises.
- These results are still very sensitive to sub-samples of countries / crises, partly due to the low number of country crises, as well as to the macroeconomic variables used.



## 4. Next Steps

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- Improvement of the methodology to increase the early warning properties of these SOM (LVQ, combination with other classification methods,...).
- Tests of stability of the different profiles identified and cross-validation of the algorithm and generalization to various types of crises and regions.
- Calculation of a similarity indicators or ‘distance to a risky profile’ (nearest neighbour algorithm).
- Introduction of indicators of ‘severity/intensity of country crises’ into the dataset.

