The interaction of Market and Credit Risk: an application of a FAVAR approach to Italy

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Motivation of the paper (1)

Related to the research on risk aggregation

Economic capital models for financial institution require an approach for aggregating different risk types, taking into account inter-risk correlation.

Two possible approaches:

a) **Top down approach** ➢ individual risk marginal distribution are aggregated through a variance covariance or copula approach (Rosenberg and Shuermann, 2006)

a) **Bottom up approach** ➢ based on a full modelling of common risk drivers and of their interaction, it accounts for the effect on risky assets of possible interdependencies between various risk components.
(Dimakos and Aas, 2005)

Motivation of the paper (2)

Why is it relevant?

- In risk aggregation, conventional separation in risk silos may lead to wrong aggregation results, because of non consideration of complex interactions
- Diversification gains may not emerge, sometimes even "***compounding effects***" (see previous paper in this section). **This is due to greater intereconnections**
- Ideally integrated risk modelling preferable

Objective of the paper

UNDERSTAND THE CHANNELS FOR INTERACTION

OF MARKET AND CREDIT RISK VIA A Factor-Augmented VAR APPROACH

Within the **bottom up** approach for risk aggregation, the paper provides a framework for the interaction of many possible risk drivers through a **FAVAR approach**

A competing framework: the GVAR approach

(Pesaran et al, 2004, 2007a, 2007b)

What it adds to previous work on risk aggregation

1. **Extend the space spanned by the risk factors**. Factors used in previous studies do not seem to explain too much of the variation in banks' risk exposures
   (Rosenberg and Shuermann 2006, Alexander and Pezier 2003, Shuermann and Stiroh 2006)

2. Analyze the common sources of risk and the dynamic interrelations among the risk factors through a **FAVAR approach:** the responses of key series in the original dataset to shocks derive --- through the factor structure of the system.

3. A distinctive feature of the approach is the **relationship between the financial system and the economy**.

The FAVAR approach

DYNAMIC FACTOR MODELS AND
FACTOR AUGMENTED VECTOR AUTOREGRESSION
(Bernanke – Boivin – Eliasz (2005)

The underlying assumption is that there is a small number of unobserved common dynamic factors that drive the observed comovement of economic and financial time series. These factor represent the main driving forces in the system

➔ ***common sources of risk***

(Stock and Watson 2002, Forni, Hallin, Lippi and Reichlin, 2001)

TWO STEPS

1. Summarize the information from a large number of economic and financial time series into a small number of underlying factors

2. Use the unobservable factors in a VAR framework to derive the responses of key series in the original dataset to some relevant, specific shock through the factor structure of the system.

DYNAMIC FACTOR MODELS AND FACTOR AUGMENTED VECTOR AUTOREGRESSION "FAVAR" (Bernanke – Boivin – Eliasz (2005)

1. Extract the factors

From a set of observable variables X (the "economy") extract the main common underlying (unobservable) sources of comovement (PC);
Interpret the factors as related to various types of risks

2. Link the variables to the factors

The dynamics of the variables Xt are driven
by the main unobservable common factors, Ft,
and by observable variables, Yt,
with pervasive effects on the economy
(e.g. the central bank's policy instrument)
in the observation equation (1)

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t \qquad (1)$$

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = a(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \upsilon_t \qquad (2)$$

3. Explore the dynamics

The main sources of risk inserted
into a VAR framework to analyze
the dynamics of the transmission mechanisms of specific shocks :
The FAVAR state transition equation (2)
represents the joint dynamics of the factors
and the observable policy variables (Ft, Yt).

4. Go back to the original variables

Invert the PC factor representation
to derive the IRF of the original variables
to the shock

ESTIMATION / IDENTIFICATION

System (1) - (2) is estimated through a two-step Principal Component approach

<u>In the first step</u>, the space spanned by the factors is estimated using the Principal Components of Xt matrix. To identify the factors, we use the Watson normalization.

<u>In the second step</u>, the (FA) VAR equation (2) is estimated, with F_t replaced by the estimated PC. To identify the VAR (the transition equation) we assumed a recursive structure where all factors entering in (2) respond with a lag to a change in the short term interest rate ordered last in the VAR system.

PROS

- It takes into account all the available information in a consistent way while preserving parsimony
- Robust to mis-specification, omitted variable and measurement errors → (in the literature on MP, no price and exchange rate puzzle)
- It allows to characterize the impulse response functions (IRF) of all observable variables to specific disturbances (shocks).
- Each IRF is derived from the interaction between the main sources of risk

CONS

- Data have to be transformed in order to induce stationarity. It is not clear how the transformation interacts with the autoregressive structure of data.
- The factors estimated through Principal Components are difficult to interpret. While this is not a relevant issue in forecasting, it might be for risk management purposes.
- When N goes to infinity it does not exist a unique criterion to determine the number of relevant factors.

Description of the exercise

An application to Italy using quarterly data from 1991:1 to 2006:3.

X_t consists of a balanced panel of 99 quarterly time series. Data are transformed in order to induce stationarity

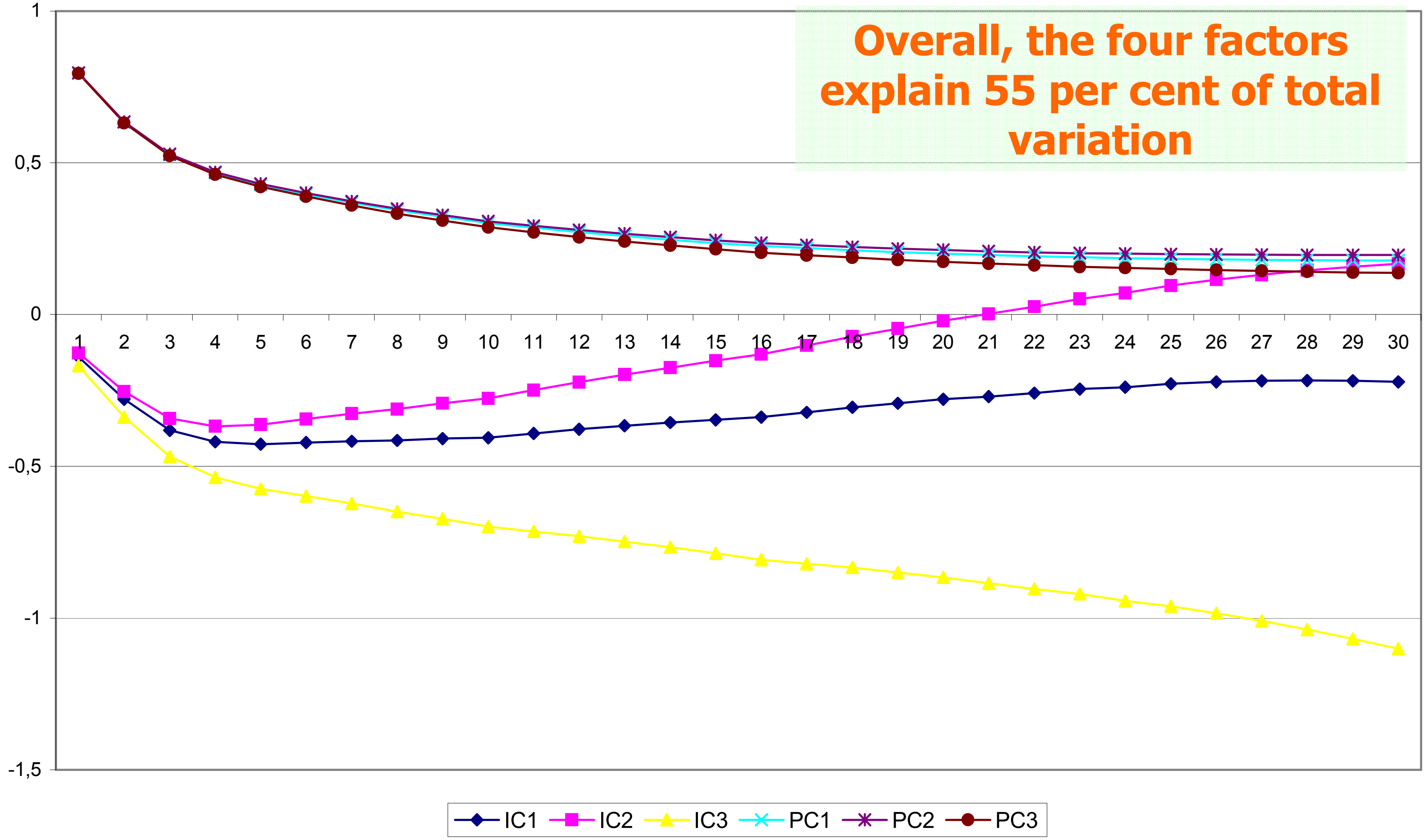
- **Macroeconomic risk variables**
- **Credit risk variables**
- **Market risk variables**
- **Interest rate risk variables**
- **Global cycle variables**

1. **How many factors? How to interpret the factors?**
2. **How do they interact in response to a shock? What about the original variables? ➔ FAVAR SPECIFICATION**
   1. Analyse the dynamic interaction of the common factors in response to a monetary policy shock.
   2. In the FAVAR specification we treat the short term interest rate *Yt* (the Italy T-Bill auction gross three month rate) as observable and the other variables as unobservable
   3. The shock is standardized to correspond to a 50-basis-point increase.
   4. Schwarz information criterion suggests one lag

Analysis of the risk transmission mechanism

How many factors:
Bai and Ng criteria say **4**

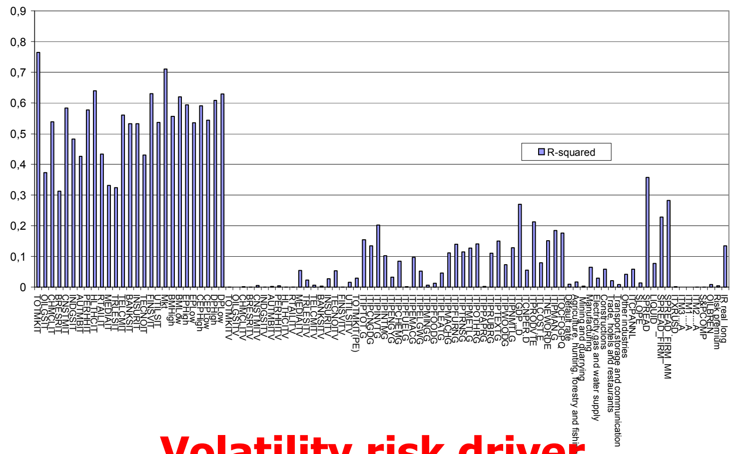
Bai and Ng criteria: 4 factors summarizing 98 economic and financial variables.



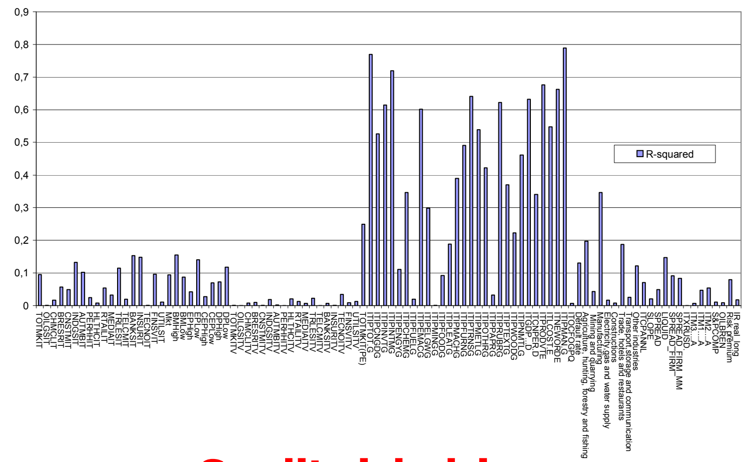
How to interpret the factors?

R-squared of the univariate regressions of each variable against each factor

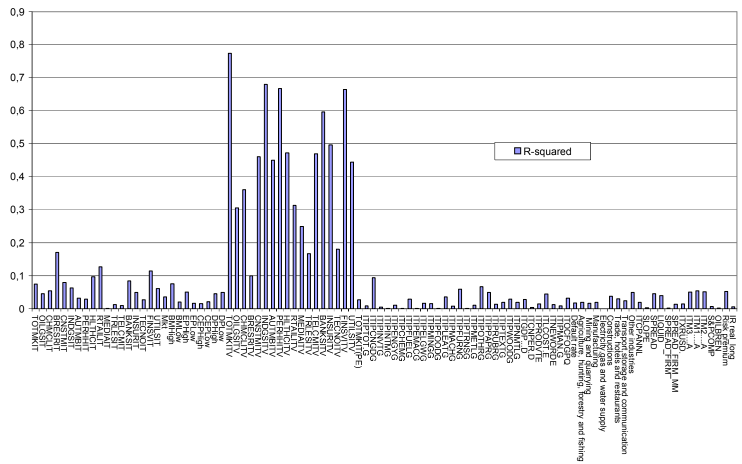
Equity risk driver



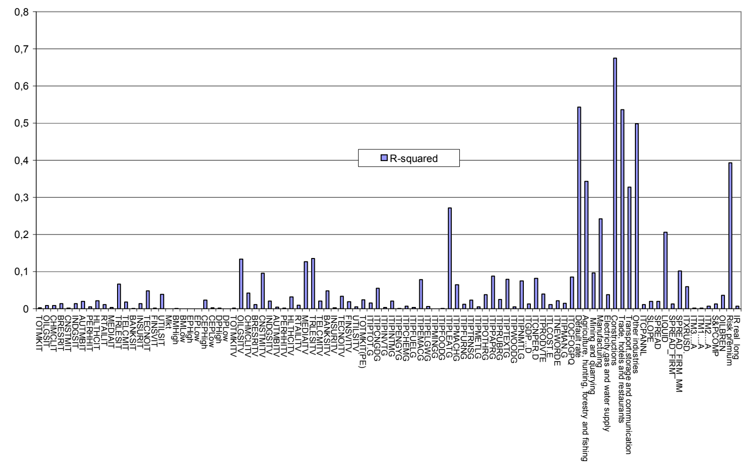
Macroeconomic risk driver (IP)



Volatility risk driver

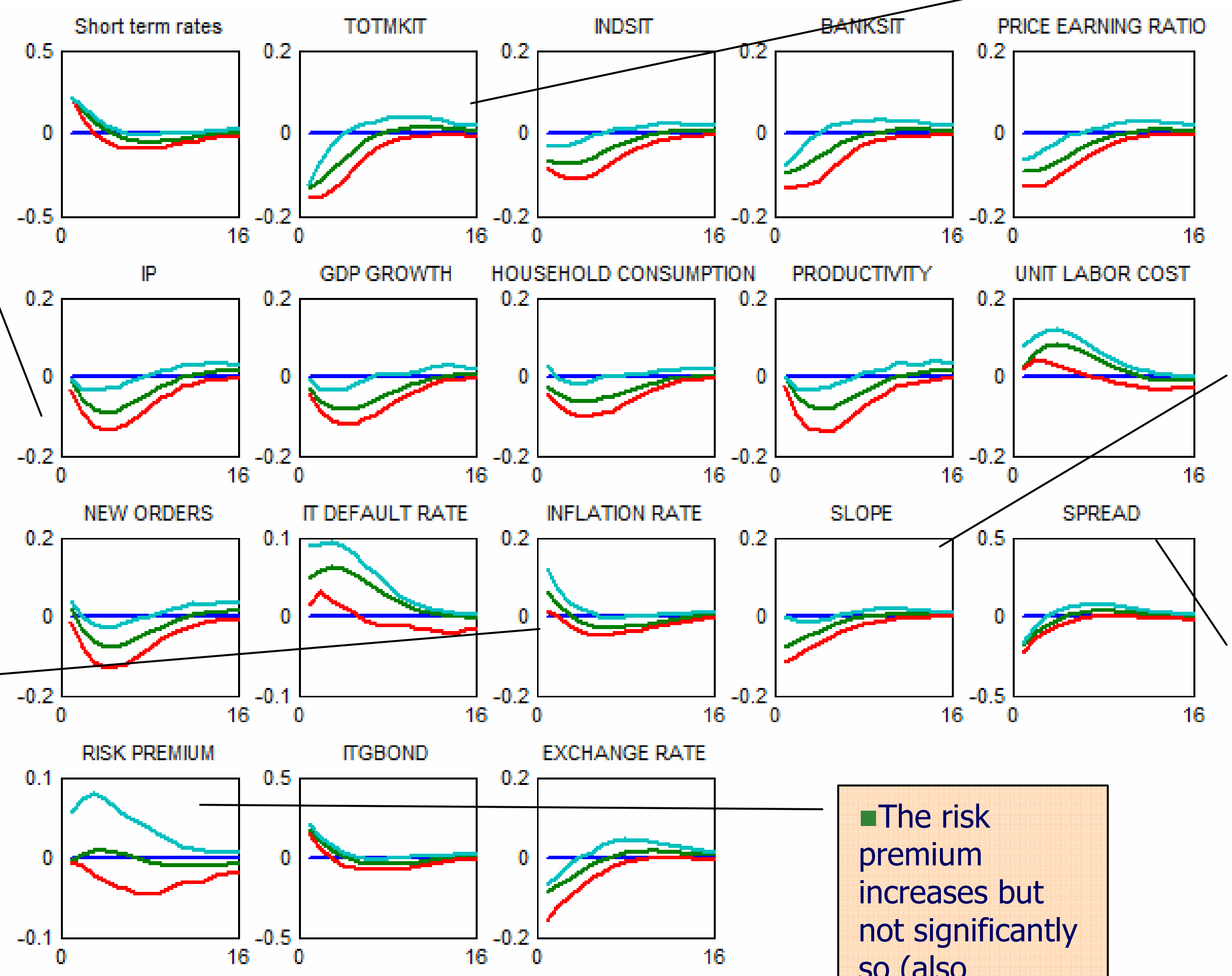


Credit risk driver



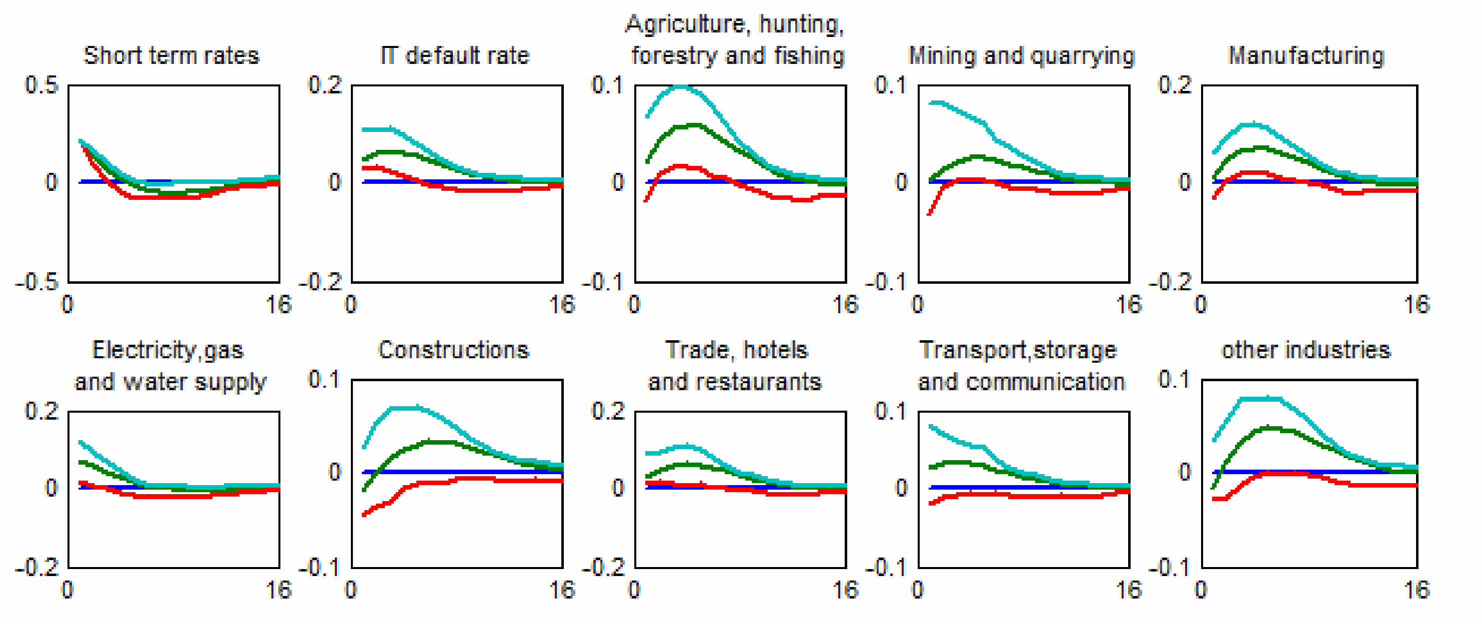
IRF – selected variables

The responses of key series in the original dataset
through the factor structure of the system.



- Returns on equity indices decline (flight to quality?)
- Real activity measures decline; the reduction is not immediate and goes back to previous levels in around 2 years.
- The slope declines but not significantly so. (lower volatility of long term rates)
- The spread also declines (banking rates are sluggish). The spread adjustment is more rapid than the slope adjustment.
- Inflation rate declines (it starts from higher level at t=0: no price puzzle?)
- The risk premium increases but not significantly so (also volatility is not significant).

IRF – selected variables



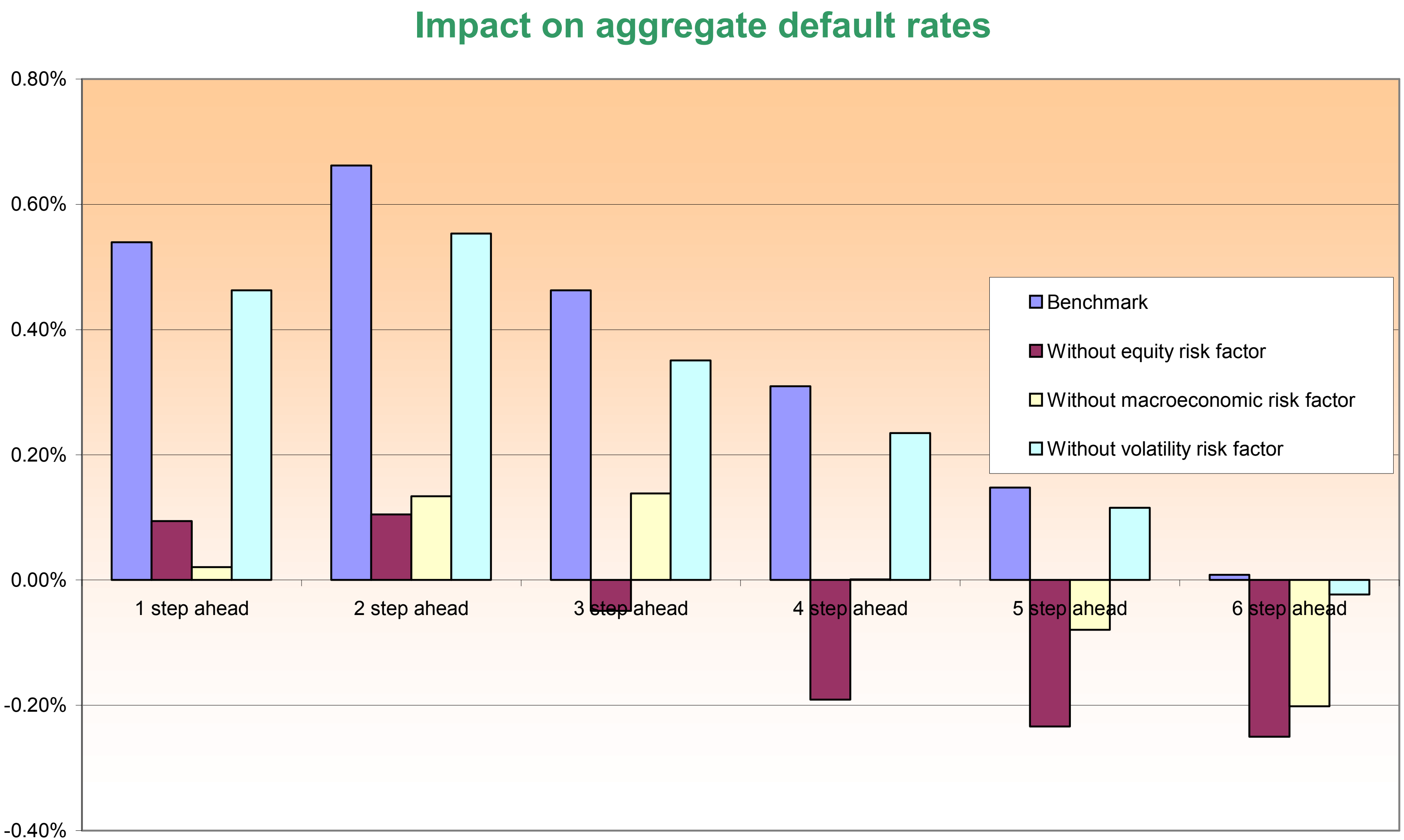
- Italian default rates increase, both in aggregate and at the sectorial level. The size and persistence of the impact changes depending on the industry sector.
- “Manufacturing” and “Trade, hotels and restaurants” show a large positive impact and ca be interpreted as more “cyclical”.
- The IRF of “Transport, storage and communications” and “Mining and quarrying” are not significant, hence they are less sensitive to systematic factors.

The role of interaction…

…emerges more clearly when considering the *indirect effect* of the shock, deriving from the dynamic response of other risk factors

- **Credit risk:**
  - The impact from a monetary policy shock on corporate default rates is strongly amplified by a deterioration of macroeconomic conditions
  - The response of the aggregate corporate default rate is six times higher when considering the role of the market risk driver and its dynamic interactions with other risk drivers.
- **Market risk:**
  - Impact mainly related to the equity risk and the volatility risk drivers; no major role for macroeconomic risk factor (different time horizon for the shock to deplete its effect)

The role of interaction (2)



Conclusions

- Our paper provides a framework for indentifying common sources of risk underlying an asset portfolio (risk drivers) and modelling their dynamic interaction
- The responses of the original variables of the system to a specific shock derive from the factorial structure of the system, that is from the interaction among risk factors.
- Interactions are indeed important
- The framework can be used as a joint modelling tool in the context of *bottom up approach* for risk aggregation
- Other applications: scenario analysis

  selecting relevant shocks (e.g. a real identified shock, or exchange rate shock or global stock market shock), one ca quantify the impact of such shocks on the variables of interest.

Thank you

☺

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Statistical appendix

Foglio di lavoro di Microsoft Excel

The Italian case - List of variables (1)

Type	Number of series	Transformation	Slow moving variables
Equity indexes	**18**	**Delta log**	
Italy Fama and French factors	**9**	**Level**	
Realized and historical volatility	**18**	**Level**	
Price/earning ratio - Italy Tot Mk	**1**	**Level**	
Macroeconomic variables			
IT INDUSTRIAL PRODUCTION	**24**	**Delta log**	Yes
IT GDP CONA	ITGDP...D	Delta log	yes
IT FINAL DOMESTIC CONSUMPTION: HOUSEHOLDS (NEW SCH.)CONA	ITCNPER.D	Delta log	yes
IT PRODUCTIVITY - INDUSTRY EXCLUDING CONSTRUCTION SADJ	ITPRODVTE	Delta log	yes
IT UNIT LABOUR COSTS - INDUSTRY EXCLUDING CONSTRUCTION SADJ	ITLCOST.E	Delta log	yes
IT NEW ORDERS SADJ	ITNEWORDE	Delta log	yes
Output gap	ITOCFOGPQ	Level	yes
Inflation rate	ITCPANNEL	First Diff	yes
Default rates			
Total	Default rate	Delta Logit Transformation	yes
1- Agriculture, hunting, forestry and fishing	S1	Delta Logit Transformation	yes
2 - Mining and quarrying	S2	Delta Logit Transformation	yes
3 - Manufacturing	S3	Delta Logit Transformation	yes
4 - Electricity,gas and water supply	S4	Delta Logit Transformation	yes
5 - Constructions	S5	Delta Logit Transformation	yes
6 - Trade, hotels and restaurants	S6	Delta Logit Transformation	yes
7 - Transport,storage and communication	S7	Delta Logit Transformation	yes
8 - Other industries	S8	Delta Logit Transformation	yes

The Italian case - List of variables (2)

Type	Number of series	Transformation	Slow moving variables
Monetary and financial variables			
ITGBOND. - ITBT03G	SLOPE	Level	
CORY - ITBT03G	SPREAD	Level	
LIQUIDITY	LIQUID	Level	
SPREAD_FIRM	SPREAD_FIRM	Level	
SPREAD_FIRM_MM	SPREAD_FIRM_MM	Level	
IT ITALIAN LIRE TO US $ (MTH.AVG.)	ITXRUSD.	Delta log	
IT MONEY SUPPLY: M3 - ITALIAN CONTRIBUTION TO THE EURO AREA CURN	ITM3....A	Delta log	
IT MONEY SUPPLY: M1 - ITALIAN CONTRIBUTION TO THE EURO AREA CURN	ITM1....A	Delta log	
IT MONEY SUPPLY: M2 - ITALIAN CONTRIBUTION TO THE EURO AREA CURN	ITM2....A	Delta log	
S&PCOMP	S&PCOMP	Delta log	
OILBREN	OILBREN	Delta log	
Risk premium	Risk premium	Level	
Long real interest rate - real (ITGBOND-E(infl))	IR real_long	First Diff	
Shock			
ITALY T-BILL AUCT. GROSS 3 MONTH - MIDDLE RATE	ITBT03G	First Diff	

Static factors: Properties

Stock and Watson (2002):

1. the principal components consistently recover the space spanned by Ft and Rt when N is large and the number of the principal components is at least as large as the true number of factors.
2. PC estimates are consistent even in presence of temporal instability in the original series: series' instabilities "average out" in the construction of common factors
3. The forecasts based on the factors outperform univariate regressions, small VARs and leading indicator models in simulated forecasting exercises.

See also Bai and Ng (2002) and Boivin and Ng (2002)

Static factors: Estimation

Static model: $x_{it} = \lambda'_i F_t + e_{it}$ $\quad i = 1..N;\ t = 1\ldots T.$

The Factors are estimated by the method of asymptotic principal components , which allows to estimate a number of factors equal to min [N,T]. Estimates of [Ft, Λt] are obtained by solving the minimization problem

$$V(k) = \min_{\Lambda,F} (NT)^{-1} \sum_i \sum_t (X_{it} - \lambda_i F_t)^2$$

The solution is not unique. To identify the factors one may impose two alternative sets of restriction

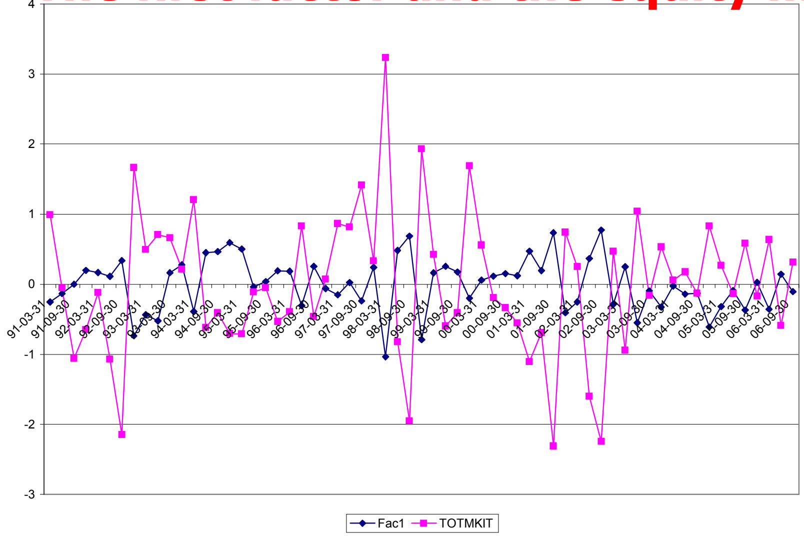
Bernanke normalization: $\frac{F'F}{T} = I$

or

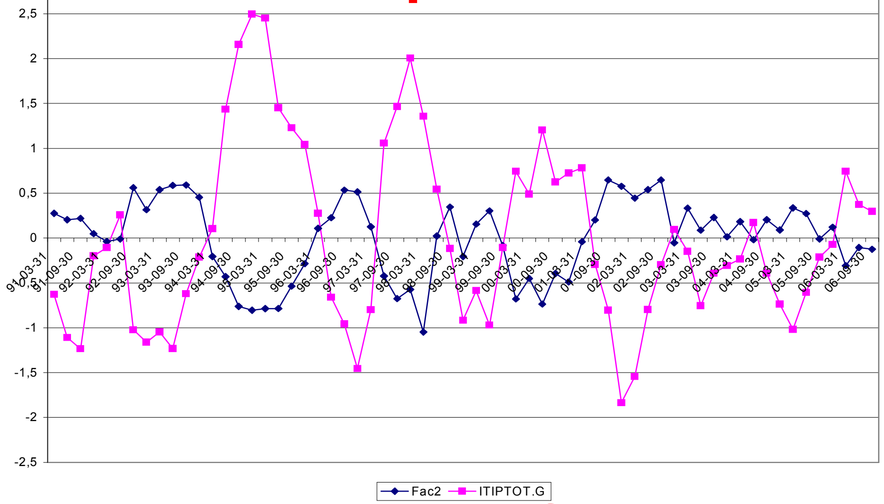
Watson normalization $\frac{\Lambda'\Lambda}{N} = I$

Factor interpretation

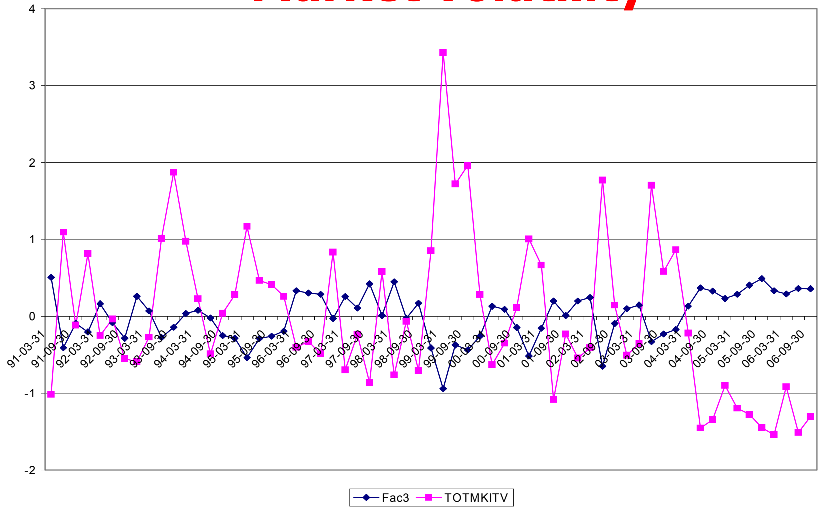
The first factor and the equity market



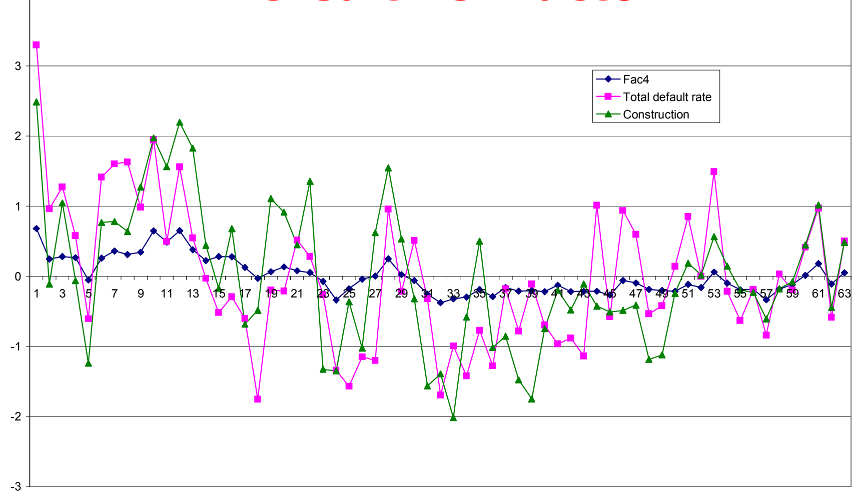
2° factor and total industrial production



Market volatility



Credit risk factor



FAVAR : the model

It is assumed that the informational time series are related to the unobservable factors and the observable variables by an **OBSERVATION equation**

(1) $$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t$$

That is, both Y_t and F_t (which in general can be correlated) represents common forces driving the dynamics of X_t

FAVAR : the model (2)

The dynamics of the economy is represented by the following VAR (transition) equation

(2)
$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = a(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \upsilon_t \qquad \upsilon_t \sim \mathrm{N}(0, \Sigma)$$

where: **Y_t** represents the observable variables affecting the the economy fluctuations and **F_t** the unobservable factors summarizing additional information contained in a wide set of informational variables

FAVAR: the endogeneity problem

Since the PCs are estimated from the entire dataset (*), the direct dependence of F_t on the shock variable (short term interest rate) must be first removed. Then:

Two categories of variables:

- **slow-moving variables**, assumed not to respond contemporaneously to changes in short term IR
- **fast-moving variables**, allowed to respond contemporaneously (e.g asset prices)

FAVAR : the endogeneity problem (2)

PROCEDURE:

- Extract PCs from the subset of slow-moving variables that (by assumption) are not affected contemporaneously by short term IR (**F***).

- Run the following multiple regression

$$F_t\hat{} = b_f F^*_t + b_y Y_t + e_t$$

- The unobservable factors are then constructed as

$$\hat{F}_t - \hat{b}_y Y_t$$

Selected references

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