CONSOB Commissione Nazionale per le Società e la Borsa

Marcello Minenna

Insider Trading, Abnormal Return and Preferential Information:

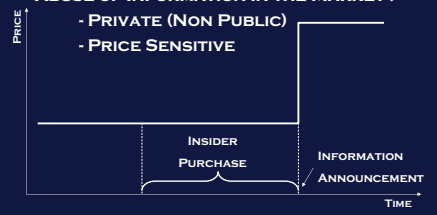
Supervising Through a Probabilistic Model

Market Abuse: Insider Trading

Definition:

Abuse of Information in the Market :

- Private (Non Public)
- Price Sensitive



Supervision System on *Insider Trading*

Elements:

1. Stock and Market trend Analysis
2. Study of the Impact of the Preferential Information on the Stock Price trend
3. Study of Intermediaries and Beneficial Owners Trading
4. Computation of the profit Gained by the Insider i.e. The Disgorgement

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Supervision System on *Insider Trading*

Computation of the profit Gained by the Insider

i.e.

the Disgorgement

Disgorgement Computation

Methods:

- Actual Disgorgement
- Potential Disgorgement
  - o Deterministic
  - o Econometric
  - o Probabilistic

Disgorgement Computation

Actual Disgorgement

Value of the Insider Closed Position

–

Value of the Insider Open Position

Actual Disgorgement

Issues:

- Applicability to all Insider Trading investigation cases

ex. The insider does not close the position

Disgorgement Computation

Potential Deterministic Disgorgement

Post-News Price x Quantity of Insider Open Position

–

Insider Open Position

Potential Deterministic Disgorgement

Issues:

- Applicability to all Insider Trading investigation cases:

ex. The insider opens his position on the stock in periods far from the disclosure of the Preferential Information

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Disgorgement Computation

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EVENT STUDIES ANALYSIS

Econometric Method for the Computation of the Disgorgement

Potential Econometric Disgorgement

Event Studies Analysis

Goals:

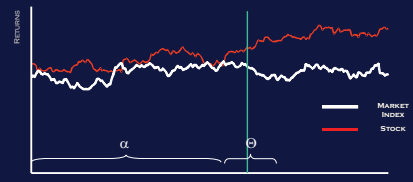
Quantification of the Event impact on the stock market value

Potential Econometric Disgorgement

Steps of the Methodology: 4

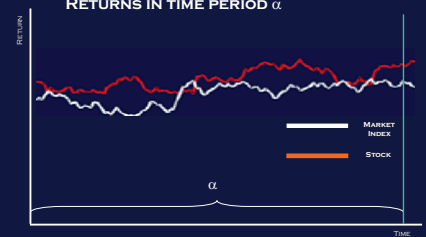
1) General Case Analysis:

Definition of 2 time horizons : α and Θ



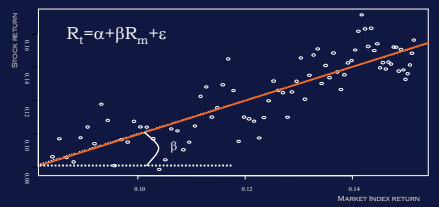
Potential Econometric Disgorgement

2.i) Analysis of Stock and market index Returns in time period α



Potential Econometric Disgorgement

2.ii) Market Model in time period α



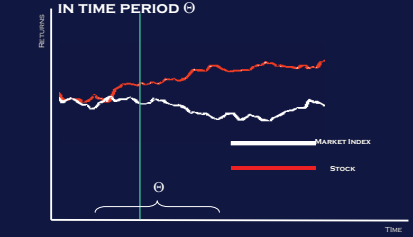
Potential Econometric Disgorgement

2.iii) Statistical Tests of the Robustness of the regression

- Regression Coefficients and T statistic on coefficients
- Graphical Tests: residual Plot, qqplot, Residuals vs fit, Recursive beta
- Numerical Tests: Breush - Pagan, Levene
- .....

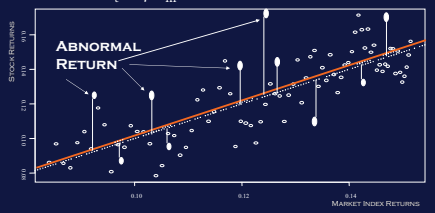
Potential Econometric Disgorgement

3.i) Stock and market index Return Analysis in time period Θ



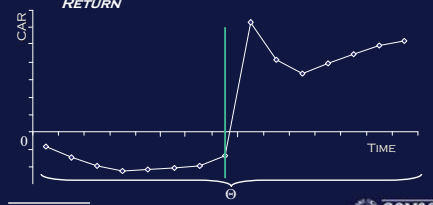
3.ii) Identification of Abnormal Return

$AR=R_t-\alpha-\beta R_m$



3.iii) Statistical Test of the Effective Return Abnormality

Computation of the *Cumulative Abnormal Return*



4) Computation of the *Disgorgement*

Value of Insider Open position
x
Abnormal Return

Econometric Method for the Computation of the Disgorgement

Issues

Considerations

Issues

1. **Applicability to all Insider Trading investigation cases :**
   - Wideness of α
     - Data set Availability
     - Time series discontinuity
     - rumors
     - .....
2. **Market Index statistically Robust**
   - Endogenous regression
   - Existence of the Index
   - .....
3. **Robustness of the regression**
   - Temporal stability of the Parameters
   - non – stationarity of the Time Series
   - .....

Considerations

1. **Time is not included in the model**
2. **Linear Method**
3. **Deterministic Method**
4. **Method based on the "past":**
   Not coherent with the weak form of market efficiency

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Probabilistic Method for Disgorgement Computation

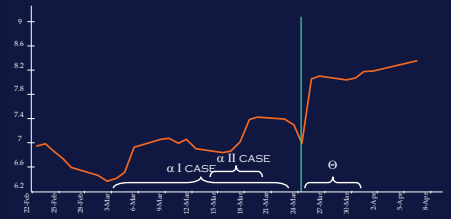
Steps of the Methodology: 4

1) General Case Analysis:
Definition of 2 time horizons : α and Θ

α = period in which the insider opens his position on the stock

Θ = period after the disclosure of the Preferential Information

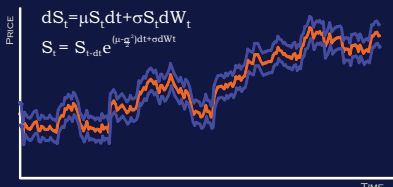
Each Insider has his α



2.i) Definition of the Probabilistic Model

$dS_t=\mu S_t dt+\sigma S_t dW_t$

$S_t = S_{t-dt} e^{(\mu-\frac{\sigma^2}{2})dt+\sigma dW_t}$



2.ii) Definition of the Probabilistic Model In period α

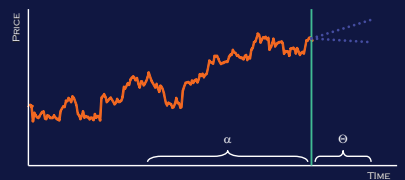
A) Simulate the trading strategy of the suspected Insider

B) Identify the stock price trend that the insider incorporates in his position

C) define the Stock Price trend <u>without</u> the *price sensitive* Information

3.i) Definition of a Price Fluctuation Band in period Θ

Describe the stock price Trend <u>without</u> the Information

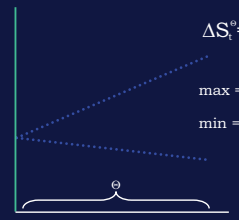


3.i) Price Fluctuation Band in period Θ

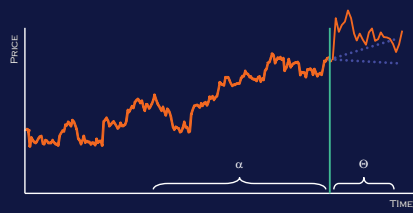
$\Delta S_t^{\Theta}=[S_0^{\Theta} e^{max}, S_0^{\Theta} e^{min}]$

$max = \sigma z_{\frac{\alpha}{2}}\sqrt{t} + (\mu-\frac{\sigma^2}{2})t$

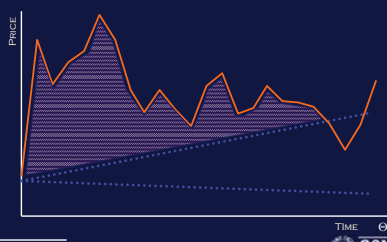
$min = \sigma (-z_{\frac{\alpha}{2}})\sqrt{t} + (\mu-\frac{\sigma^2}{2})t$



3.ii) Stock Price after the Disclosure of the Preferential Information



4) *Disgorgement* Computation



Probabilistic Method for the Disgorgement Computation

Advantages

Considerations

Advantages

1. Applicability to all Insider Trading investigation cases:
   - It is not affected by the Stock Liquidity
   - It is not influenced by the Discontinuity of the Time Series
   - It is not Influenced by the Lack of the Time Series (ex. Recent Quotations)
2. Customized Computation
   - Accuracy
   - Distinction between Insiders vs Followers
3. Forecast just based on the Stock price
   - It does not Require a Market index Regressor
4. Implementation
   - Straight forward Procedure: it works directly on price and not on return
   - Operative Efficiency

Considerations

1. The Statistical Hypothesis are verified a priori
2. It benefits from the Markov Property, that is coherent with the weak form of market efficiency
3. Time is included in the model
4. Use of a daily Abnormal Return instead of a Cumulative Abnormal return on Θ

Comparison of different Methodologies

Empirical case

Insider Trading Investigation related to the conversion of Preferential shares into ordinary ones

Analysis of 2 different Insider Disgorgements

Price Sensitive Event:

Board Decision of Converting the Preferential shares into Ordinary ones with an adjustment of 1 €.

Quantitative Information

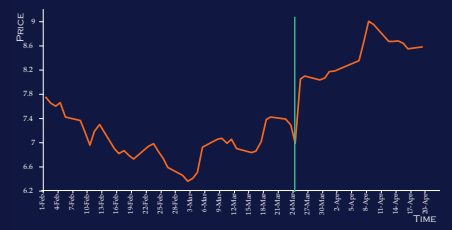
Before the disclosure of the Information:

Ord. Share Price – Pref. Share Price = 2.5 €

After the Disclosure of the Information:

Ord. Share Price – Pref. Share Price = 1.1 €

Stock Price Trend



Actual Disgorgement

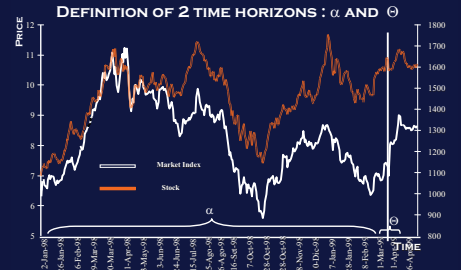
1st Insider 479.000 € 2nd Insider 124.000 €

Problems

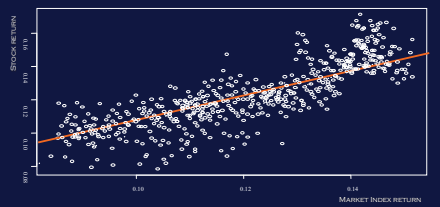
I Case: Purchases and sales far from the disclosure of the Information

II Case: Partial Sales before the Disclosure of the information

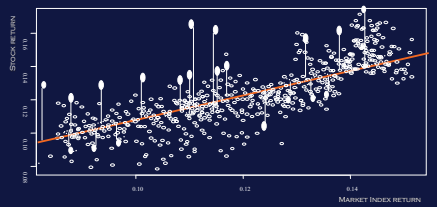
Definition of 2 time horizons : α and Θ



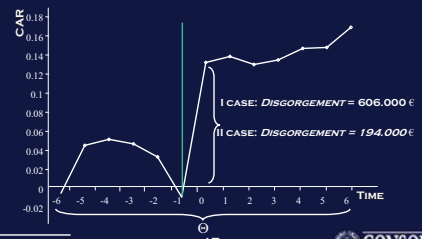
Stock and market index Return Analysis in time period α



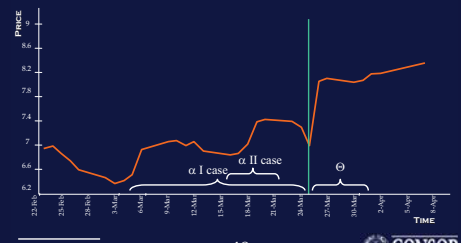
Abnormal Return



Cumulative Abnormal Return

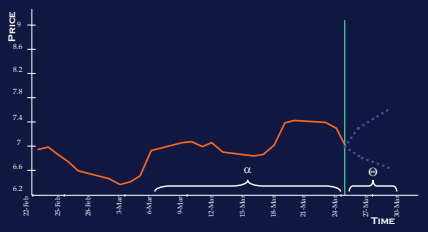


Definition of 2 time horizons : α and Θ



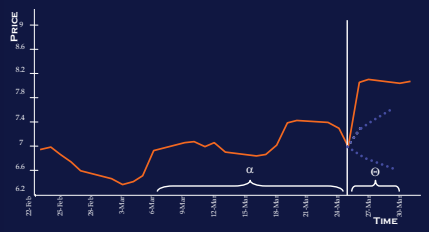
Case Study: Potential probabilistic Disgorgement

I case: determination of the band



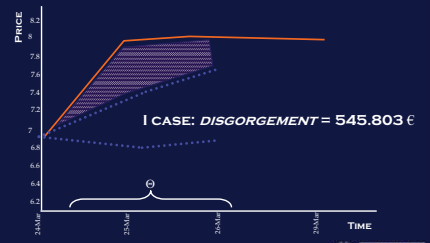
Case Study: Potential probabilistic Disgorgement

I case: Comparison to Market Price



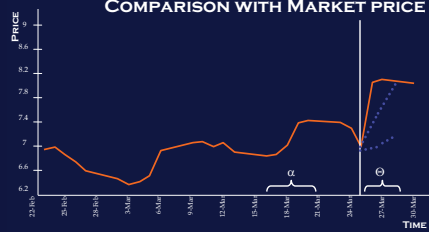
Case Study: Potential probabilistic Disgorgement

I case: *Disgorgement* Computation



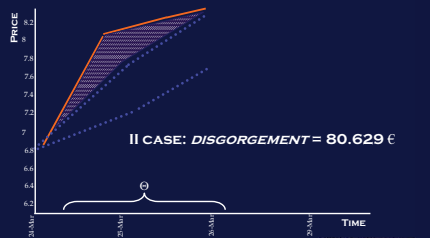
Case Study: Potential probabilistic Disgorgement

II case: determination of the band Comparison with Market price



Case Study: Potential probabilistic Disgorgement

II case: *Disgorgement* Computation



Disgorgement Computation: Empirical Case

Comparison of the three Methodologies

	Actual	Econometric	Probabilistic
I case	479.000 €	606.000 €	545.803 €
II case	124.000 €	194.000 €	80.629 €

Disgorgement Computation: Empirical Case

Comparison of the three Methodologies

	Actual	Econometric	Probabilistic
I case	479.000 €	606.000 €	545.803 €
II case	124.000 €	194.000 €	80.629 €

Insider Trading, Abnormal Return and Preferential Information:

References

1. Dolley, J., (1933), Characteristics and Procedure of Common Stock Split-Ups, Harvard Business Review, 316-326.
2. Langevoort, L., (1987) Insider trading: regulation, enforcement and prevention, Clark Boardman Co., New York.
3. Mitchell, M.L., Netter J.M., (February 1994) The role of financial economics in securities fraud cases: applications at the SEC. The Business Layer.
4. Minenna, M., (2000) A supervisory perspective on Insider Trading, Quaderni di Finanza n.45 CONSOB.
5. Minenna, M., (2002) Inside Insider Trading Risk, March 2002
6. Minenna, M., (2003) Insider Trading Abnormal return and Preferential Information: supervising through a probabilistic approach, Journal of Banking and Finance 27 (2003) 59-86.

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Insider Trading, Abnormal Return and Preferential Information:

Supervising Through a Probabilistic Model

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S.A.I.Vi.M.:

The probabilistic procedure for market abuses detection

Market Abuse Phenomenon: definition

Market Abuses

- Insider Trading
- Manipulation
  - Market Based Manipulation
  - Information Based Manipulation

Market Abuse Phenomenon and Supervisory Authority

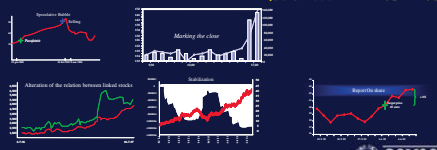
The problem for the Supervisory Authorities is:

The real time identification of market abuse phenomena

Market Abuse Detection

Market Abuse Phenomenon and Supervisory Authority

The real time detection of market abuse phenomena requires as a first step for each stock the determination on daily basis of signals of abnormalities (so-called FAILURES)



Market Abuse Detection and Failure

...that's because...

Actions which may be attributed to market abuse phenomena

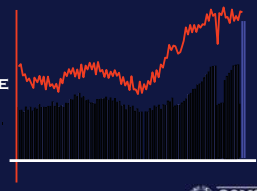
Failure

Particular occurrence/ event referred to a specific stock

Market Abuse Detectione and Failure

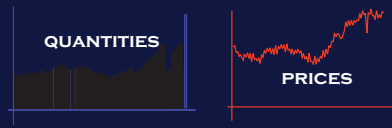
How to detect a failure?

Through the exam of the elementary components which mainly affect the pattern of a stock and which characterise the trades made by the intermediaries



Market Abuse Detectione and Failure

The elementary components:



How to Examine the elementary components in order to detect a Failure?

The Financial Literature | The Supervisory Experience

Quantitative Models

Prices

The Financial Literature

- The trading prices have to be analysed in terms of returns, through the study of the dynamics of the logarithm of the price;
- Auto-regressive models in discrete time capture both the mean reversion and the momentum effect components of the returns;
- The presence of abnormal returns is disclosed through an estimation of the returns which may be realysed employing diffusive processes

The Supervisory Experience

- Stock returns generally undergo sharp changes (for example at moment insider information is disclosed) or show movements that cannot be attributed to a mean-reverting type dynamic (for example in the presence of manipulation);

Quantities

The Financial Literature and The Supervisory Experience

- The quantities traded by each intermediary are examined in an aggregate way in terms of daily trading volumes according to an auto-gressive scheme
- The market composition is assessed through two levels of analysis:
  - the level of concentration of the intermediaries, that is the number of intermediaries and their shares in terms of trading volumes (so-called static concentration);
  - the evolution of the concentration of the intermediaries, that is the change of each intermediary's share in terms of trading volumes on a given security (so-called dynamic concentration).

...hence, a Market Abuse Detection Procedure ...

...requires the control of 4 financial variables:

- Prices
- Volumes
- Static Concentration
- Dynamic Concentration

...in order to implement models with predictive capabilities which allow the identification of abnormal movements in the variable examined (so-called Alerts)

Financial Variable ⇔ Reference Model

Alert

The joint reading of the results of the various alerts identifies the stocks for which there is a Failure, which becomes the Warning for the Consob

The S.A.I.Vi.M: the procedure for the Market Abuse Detection - implementation

Alerts — Construction of the tripwires in order to detect abnormal movements of the financial variables: so-called Alert

Warning — Definition of the algorithm that - by reading the alerts – identifies on a daily basis the stocks which entails some Failures, so-called Warning

Supervisory Activity — Comprehension of the reasons underlying the Warning and consequent decisions

The S.A.I.Vi.M: functioning

Construction of the S.A.I.Vi.M: Main Problems

- The stocks listed on the Market are different as regards:
  - Liquidity
  - Sector to which they belong
  - P/E
  - ....
- The market is characterised by moments of boost/ "euphory" or of "crisis" which may be generalized or bounded to some sectors (for example , the 2000 bubble on Technology stocks)
- The time horizon for the Failures analysis cannot be too long (for instance: a quarter, a semester , a year) in order to avoid the risk of losing sensitivity:
  - Changes in the Strategic Area of Business of the company;
  - New Listings
  - ...
- The construction of the tripwires and of the algorithm which produces the warning needs to be valid over all the stocks and to preserve the adequacy of its performance over time.

Il S.A.I.Vi.M: The choice of the Models

- Developing the models for the tripwires through the employment of diffusive processes: that's because diffusive processes exploiting some results of the stochastic limit theory prove to be:
  - Extremely suitable/proper for the representation of the phenomena
  - Good-performing even when the number of the observations is low
  - Able to simplify the problems concerning the estimation and the stability of the parameters

Financial Variable ⇔ Diffusive Processes (Stochastic differential equations)

Alert

The S.A.I.Vi.M.: The Calibration of the Procedure

The reference sample — the set of stocks and of the relative observation periods has been selected by looking at those cases for which both the Failures and their reasons were known

The Stocks Selection (n.40) was oriented by:

- The presence of an investigation carried on by Consob;
- The existence of a Consob signalling to the Judicial Authority regarding an hypothesis of market abuse;
- The Liquidity of the stock;
- The Historical Volatility of the Stock;
- The *price/earning ratio* of the stock;
- The diffusion/spreading of the stock on the market.

The S.A.I.Vi.M.: The Calibration of the Procedure

The reference sample — the set of stocks and of the relative observation periods has been selected by looking at those cases for which both the Failures and their reasons were known

The selection of the time horizons (average=20 months) was oriented by:

- The period of the investigation
- The moment in which the stock was listed
- The operations of M&A
- The moment of the stock *de-listing*

The S.A.I.Vi.M.: The Calibration of the Procedure

The reference sample — Aim: to explain the Failures observed in the reference sample (problem of Stochastic Programming)

Alerts — Choice of the discrete process, derivation of the relative diffusive process and estimation of the parameters for each financial variable

Warning — Choice of the algorithm for the identification of the Failure on the stock, i.e. the Consob warning

The S.A.I.Vi.M. and the Empirical evidence: Main Results

- All the trading periods highlighted as critical in the reports for the Commission, since related to market abuse phenomena, have been detected
- Moreover have been highlightened other periods characterised by one of the following situations:
  - The presence of *rumors* on the market, that is of news having the potential to be *price sensitive*;
  - The existence of considerable changes in the movements of the financial variables analysed.

EMPIRICAL EVIDENCE: SOME FIGURES

N° OF DAYS EXAMINED	N° OF WARNINGS
10.193	267

EMPIRICAL EVIDENCE: SOME FIGURES

INFORMATIONAL REFERENCE OF THE WARNING	%
REPORT TO THE COMMISSION	22%
CONSOB NEWS	11%
BALANCE SHEET	10%
INFORMATION ON THE NET	53%
DATA ANALYSIS	4%

CONSTRUCTION OF THE ALERTS

- STATIC CONCENTRATION
- DYNAMIC CONCENTRATION
- RETURNS
- VOLUMES

CONSTRUCTION OF THE INDICATOR

THE PRICE ALERT

7 LOGICAL AND COMPUTATIONAL STEPS

EMPLOYMENT OF AN AUTO-REGRESSIVE SCHEME

THE LOGARITHMIC TRANSFORMATION

$$R_t = logP_t$$

1) I. THE PROCESS IN DISCRETE TIME: AR(1)

$$R_k = \alpha + \lambda R_{k-1} + \hat{\sigma} Z_k$$

$Z_k \sim N(0,1)$

$R_k = Log(P_k)$

P_k is the stock price observed at time k

1) II. THE AR(1) PROCESS IN DIFFERENTIAL TERMS

by defining λ=1-γ e $\alpha = \gamma \cdot \eta$

$$R_k - R_{k-1} = \gamma(\eta - R_{k-1}) + \hat{\sigma} Z_k$$

1) III. THE STOCHASTIC INTERPRETATION

$(\Omega, \Im, P)$

$\{R_k\}_{k\geq 0}$ a discrete Markov process with respect to the filtration $\{\Im_k\}_{k\geq 0}$ where $R : \Omega \to \mathbb{R}^1$.

1. the initial distribution $\nu_0(\cdot)$
2. the transition probability $\Pi_{t,k}(\cdot,\cdot)$

both defined on $(\mathbb{R}^1, \mathcal{B}(\mathbb{R}^1))$

1) III. THE STOCHASTIC INTERPRETATION

Let:

$b_h(x,\ t) = \frac{1}{h}\int_{B(R^1)} (y-x)\Pi_{h,\left[\frac{t}{h}\right]h}(x,\ dy)$

the first conditional moment

$a_h(x,\ t) = \frac{1}{h}\int_{B(R^2)} (y-x)(y-x)'\Pi_{h,\left[\frac{t}{h}\right]h}(x,\ dy)$

the second conditional moment

$c_{h,i,\delta}(x,\ t) = \frac{1}{h}\int_{B(R^n)} \left|(y-x)_i\right|^{2+\delta} \Pi_{h,\left[\frac{t}{h}\right]h}(x,\ dy)$

any moment of superior order $\forall \delta > 0, \forall i = 1,2,\ldots,n$

2) I. THE 1ST RE-SCALING OF THE PROCESS:

THE k INTERVALS ARE DIVIDED INTO 1/h SUBINTERVALS WITH A LENGTH h

$$R_{kh} - R_{(k-1)h} = \gamma_h(\eta_h - R_{(k-1)h}) + \sigma\sqrt{h} Z_k$$

OR

$$R_{kh} - R_{(k-1)h} = \gamma_h(\eta_h - R_{(k-1)h}) + \sigma Z_{kh}$$

$Z_{kh} \sim N(0, \sqrt{h})$

2) II. THE STOCHASTIC INTERPRETATION

The re-scale of the discrete time process $\{R_k\}_{k\geq 0}$

a new discrete time Markov process $\{R_{kh}\}_{kh\geq 0}$

with respect to the filtration $\{\Im_{kh}\}_{k\geq 0}$

1. the initial probability $\nu_0(\cdot)$,
2. the transition probability $\Pi_{h,kh}(\cdot,\cdot)$

both defined on $(\mathbb{R}^1, \mathcal{B}(\mathbb{R}^1))$

3) I. THE 2ND RE-SCALING OF THE PROCESS:

IT IS DEFINED THE PROCESS IN THE SKOROHOD SPACE

$$R_t^h - R_{t-1}^h = \gamma_h(\mu - R_{t-1}^h) + \sigma Z_t^h$$

3) II. THE STOCHASTIC INTERPRETATION

The re-scale of $\{R_{kh}\}_{kh\geq 0}$

a continuous time process $\{R_t^h\}$

defined on D, where:

$D[0,\infty), \mathbb{R}^1) \overset{def}{=} \left\{ f : [0;\infty) \to \mathbb{R}^1 : \forall t, \begin{matrix} f(t^+) = f(t) \\ f(t^-) = \text{exists} \end{matrix} \right\}$

$kh \leq t < (k+1)h$

$\{R_t^h\}$ is a jump chain defined by:

1. the jump time that happens at times $J_{kh} = kh \ \forall \ k \geq 0$,
2. the holding time that has width $(k+1)h - kh$ for $k \geq 0$ where :

$\{R_t^h\} = \{R_{kh}\}$ per $kh \leq t < (k+1)h$

4) I. THE WEAK CONVERGENCE FOR $h \downarrow 0$

$$R_t^h - R_{t-1}^h = \gamma_h(\mu - R_{t-1}^h) + \sigma Z_t^h$$

4) I. THE WEAK CONVERGENCE FOR $h \downarrow 0$

$$R_t^h - R_{t-1}^h = \gamma_h(\mu - R_{t-1}^h) + \sigma Z_t^h$$

IN OTHER WORDS...

WE ARE GOING TO FIND A PROBABILISTIC RELATIONSHIP THAT WILL ALLOW TO INFER *A-PRIORI* SOME INFORMATION ON THE PROBABILITY DENSITY FUNCTION OF THE STOCHASTIC PROCESS

4) II. THE WEAK CONVERGENCE FOR $h \downarrow 0$

THE CONVERGENCY THEOREM

STROOCK, D.W. E VARADHAN S.R.S. (1979)
MULTIDIMENSIONAL DIFFUSION PROCESSES.
SPRINGER VERLAG, BERLIN.

THE CONVERGENCY THEOREM

the sequence $\{R_t^h\}$ weakly converges for $h \downarrow 0$ to the process $\{R_t\}$ which has a unique distribution and is characterised by the following stochastic differential equation:

$dR_t = b(x,\ t)dt + \sigma(x,\ t)dW_t$

if :

1. $\lim_{h\downarrow 0} c_{h,\delta}(x,t) = 0$
2. $\lim_{h\downarrow 0} b_h(x,t) = b(x,t)$
3. $\lim_{h\downarrow 0} a_h(x,t) = a(x,t)$
4. $\sigma(x,t) = \sqrt{a(x,t)}$

4) II. THE WEAK CONVERGENCE FOR $h \downarrow 0$

$$R_t^h - R_{t-1}^h = \gamma_h(\mu - R_{t-1}^h) + \sigma Z_t^h$$

THE CONVERCENCY THEOREM

$$\begin{cases} \lim_{h\downarrow 0} \frac{\gamma_h^3}{h}\left(\mu - \left(X_t^h\right)\right)^3 + 3\sigma^2\gamma_h\left(\mu - X_t^h\right) \overset{?}{=} 0 \\ \lim_{h\downarrow 0} \frac{\gamma_h}{h}(\mu - X_t^h) \overset{?}{=} b(x,t) \\ \lim_{h\downarrow 0} \frac{\gamma_h^2}{h}(\mu - X_t^h)^2 + \sigma^2 \overset{?}{=} a(x,t) \end{cases}$$

4) III. THE WEAK CONVERGENCE FOR $h \downarrow 0$

$$R_k - R_{k-1} = \gamma(\eta - R_{k-1}) + \hat{\sigma} Z_k$$

LIM $h \downarrow 0$

$$dR_t = q(\mu - X_t)dt + \sigma dW_t$$

5) THE SDE PROPERTIES

(ORNSTEIN-UHLENBECK ARITHMETIC PROCESS)

$$R_t \sim N\left((R_{t-1} - \mu)e^{-q} + \mu;\ \sqrt{\frac{\sigma^2}{2q}(1 - e^{-2q})}\right)$$

6) I. THE DISCRETE VS CONTINUOUS TIME RELATIONSHIP AND THE PARAMETERS ESTIMATION

THE PROCESS AR(1) SPECIFICATION ALLOWS TO AVOID NUMERICAL PROCEDURES

$$R_k - R_{k-1} = \gamma(\eta - R_{k-1}) + \hat{\sigma} Z_k$$

EMPLOYMENT OF THE SDE PROPERTIES

$$dR_t = q(\mu - R_t)dt + \sigma dW_t$$

6) II. THE DISCRETE VS CONTINUOUS TIME RELATIONSHIP AND THE PARAMETERS ESTIMATION

(THE IMPOSING OF THE EQUALITY BETWEEN THE FIRST AND THE SECOND CONDITIONAL MOMENTS)

$$R_k - R_{k-1} = (1 - e^{-q}) \cdot \mu + (e^{-q} - 1) \cdot R_{k-1} + \sqrt{\frac{\sigma^2}{2q}(1 - e^{-2q})} Z_k$$

6) III. THE DISCRETE VS CONTINUOUS TIME RELATIONSHIP AND THE PARAMETERS ESTIMATION

$$R_k - R_{k-1} = (1 - e^{-q}) \cdot \mu + (e^{-q} - 1) \cdot R_{k-1} + \sqrt{\frac{\sigma^2}{2q}(1 - e^{-2q})} Z_k$$

REGRESSION ANALYSIS

$$R_k - R_{k-1} = \hat{a} + \hat{b} R_{k-1} + \varepsilon_k$$

6) IV. THE DISCRETE VS CONTINUOUS TIME RELATIONSHIP AND THE PARAMETERS ESTIMATION

$$\hat{\mu} = -\frac{\hat{a}}{\hat{b}}$$

$$q = log(\hat{b} + 1)^{-1}$$

$$\sigma = \sqrt{\sum_k \frac{\varepsilon_k^2}{n-2}} \cdot \sqrt{\frac{log(\hat{b}+1)^2}{\hat{b}^2 + 2\hat{b}}}$$

$k = 15$ ⇒ INFRA-MONTHLY ANALYSIS

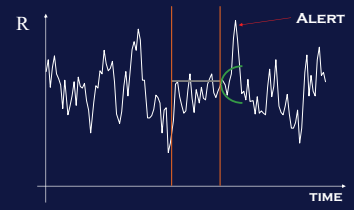
7) THE DETECTION OF THE ABNORMAL PATTERN FOR THE F.V.

LA NORMALITY PREDICTION INTERVAL

$$P\left(\begin{array}{c} \mu - z_{\frac{\alpha}{2}}\sqrt{\frac{\sigma^2}{2q}(1 - e^{-2q})} + (R_t - \mu)e^{-q} \leq \\ \leq R_{t+1} \leq \\ \leq \mu + z_{\frac{\alpha}{2}}\sqrt{\frac{\sigma^2}{2q}(1 - e^{-2q})} + (R_t - \mu)e^{-q} \end{array}\right) = \alpha$$

THE ALERT ACTIVATION

EXAMPLE: THE PRICE/RETURN ALERT



THE VOLUME ALERT

7 LOGICAL AND COMPUTATIONAL STEPS

RAW DATA EXAMINED ACCORDING TO AN AUTOCORRELATION SCHEME

THE RAW DATA

$$Q_t = \sum_i A(i) + V(i)$$

A = purchases
V = sales
j denotes the intermediary

THE MODELS IN DISCRETE AND IN CONTINUOUS TIME

$$Q_k - Q_{k-1} = -\gamma Q_{k-1} + \hat{\sigma} Z_k$$

$$dQ_t = -\theta Q_t dt + \sigma dW_t$$

THE SPECIFIED DISCRETE PROCESS AND THE PARAMETERS ESTIMATION

$$Q_k - Q_{k-1} = (e^{-\theta} - 1) \cdot Q_{k-1} + \sqrt{\frac{\sigma^2}{2\theta}(1 - e^{-2\theta})} Z_k$$

$$\theta = log(\hat{b} + 1)^{-1}$$

$$\sigma = \sqrt{\sum_k \frac{\varepsilon_k^2}{n-1}} \cdot \sqrt{\frac{log(\hat{b}+1)^2}{\hat{b}^2 + 2\hat{b}}}$$

$k = 15$ ⇒ INFRA-MONTHLY ANALYSIS

THE NORMALITY PREDICTION INTERVAL

$$P\left(\begin{array}{c} z_{\frac{\alpha}{2}}\sqrt{\frac{\sigma^2}{2\theta}(1 - e^{-2\theta})} + Q_t e^{-\theta} \leq \\ \leq Q_{t+1} \leq \\ \leq \mu + z_{\frac{\alpha}{2}}\sqrt{\frac{\sigma^2}{2\theta}(1 - e^{-2\theta})} + Q_t e^{-\theta} \end{array}\right) = \alpha$$

THE ALERTS ON THE CONCENTRATION

DEFINITION OF A SYNTHETIC INDICATOR

DATA EXAMINED ACCORDING TO A AUTOCORRELATION SCHEME

SEE TECHNICAL NOTE

Static Concentration

Entropy Index

$$\Theta_t = \frac{1}{n_t}\sum_{i=1}^{n_t}\left(\frac{\hat{Q}_t(i)}{\mu_t}\right)^{\alpha}$$

where

$\hat{Q}_t(i) = \sum_{i=1}^{n_t} Q_{t-\Delta}(i) \qquad \mu_t = \frac{\sum_{i=1}^{n_t}\hat{Q}_t(i)}{n_t}$

n_t is the number of intermediaries present on the market at time t

$Q_t(i),\ i = 1,\ldots,n_t$ are the quantities traded by the i^{th} intermediary at time t

Static Concentration

Consideration/Remark:

- The need to capture not only the movement in the variable for the total turnover of the market but also the possible directions taken by individual intermediaries and, hence the market, requires the definition of 3 differents PRE-ALERTS

Static Concentration

The pre-alerts

Quantities bought $Q_t^A = \sum_i A(i)$

Gross Turnover $Q_t = \sum_i A(i) + V(i)$

Quantities Sold $Q_t^V = \sum_i V(i)$

Static Concentration

See the technical note for the complete description of the Mathematics on:

- The models in discrete and in continuous time
- The specified discrete process and the parameters estimation
- The normality Prediction Interval

Static Concentration

The Alert's Generation

Θ_t^A, Θ_t^V, Θ_t → At least one of the three pre-alerts produces 1 alert → ALERT

Static Concentration

Consideration/Remark:

- Through some easy mathematical steps/passages it is possible to identify the intermediaries who generated the alert

Dynamic Concentration

Dissimilarity Index

$$\Psi_t = \sqrt{\frac{1}{\tilde{n}_t}\sum_{i=1}^{\tilde{n}_t}\tilde{Q}_t(i)^2}$$

where

$\tilde{Q}_t(i) = Q_t(i) - Q_{t-k}(i)$

$\tilde{n}_t \doteq n_t : \tilde{Q}_t(i) \neq 0$

Dynamic Concentration

Consideration/Remark:

- The need to capture not only the movement in the variable for the total turnover of the market but also the possible directions taken by individual intermediaries and, hence the market, requires the definition of 3 differents PRE-ALERTS

Dynamic Concentration

The pre-alerts

Quantities bought $Q_t^A = \sum_i A(i)$

Net Turnover $Q_t = \sum_i A(i) - V(i)$

Quantities sold $Q_t^V = \sum_i V(i)$

Dynamic Concentration

See the technical note for the complete description of the Mathematics on:

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- The specified discrete process and the parameters estimation
- The normality Prediction Interval

Dynamic Concentration

The Alert's Generation

Ψ_t^A, Ψ_t^V, Ψ_t → At least one of the three pre-alerts produces 1 alert → ALERT

Dynamic Concentration

Consideration/Remark:

- Through some easy mathematical steps/passages it is possible to identify/spot the intermediaries who generated the alert

Construction of the Algorithm for the Generation of the Warning

R_t, Q_t, Θ_t, Ψ_t → At least three of the four alerts generate the warning → WARNING

The Software implementation of this procedure of Market Abuse detection represents:

CONSOB
Commissione Nazionale per le Società e la Borsa

Automatic Integrated System for Market Surveillance

(S.A.I.Vi.M.)

Empirical Results

- Summary of the Key-Features of S.A.I.Vi.M.
- Analysis of the Warnings generation of S.A.I.Vi.M.
- Comparison between SAIViM and a Standard Econometric Procedure
- Consob market abuse investigations period 2000-2004

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Summary of the Key-Features of S.A.I.Vi.M.

- Adaptive capability
- Weak convergency of discrete time processes into continuous time treatable stochastic differential equations
- Consistent bridge between the discrete and the continuous time process parameters
- Short time – series data set

Summary of the Key-Features of S.A.I.Vi.M.

- **Adaptive capability**
- Weak convergency of discrete time processes into continuous time treatable stochastic differential equations
- Consistent bridge between the discrete and the continuous time process parameters
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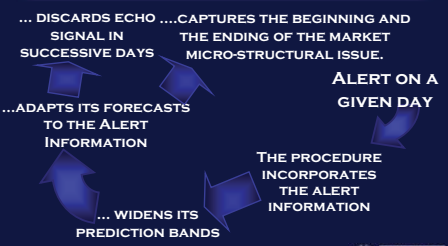
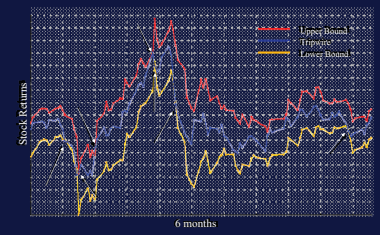
Adaptive Capability - intuition



Adaptive Capability - intuition



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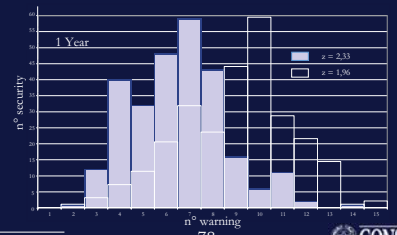
Analysis of the Warnings generation of S.A.I.Vi.M.

WARNIGS GENERATED IN AVERAGE OVER 1 YEAR

1.800 warnings for 270 listed securities on the Italian stock exchange

Italian listed securities in relation with the warnings generated by the procedure.



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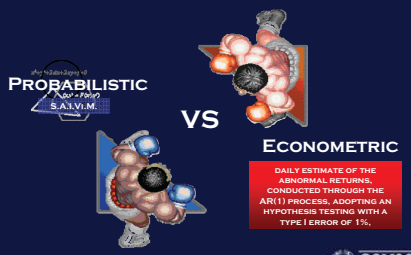
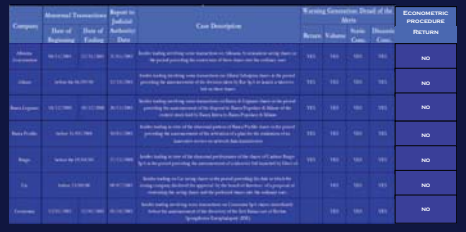
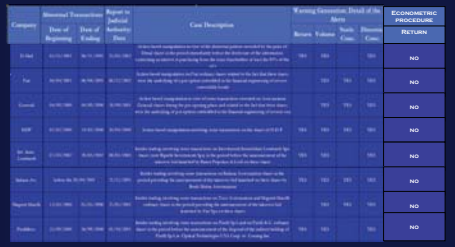
sample of 22 Market Abuse Cases



sample of 22 Market Abuse Cases





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Consob market abuse investigations period 2000-2004

- 2.200 data requests and interviews
- 500 subjects involved in a market abuse hypotheses
- 80 reports to the Judicial Authorities with a market abuse hypotheses
- 40 reports without a market abuse hypotheses finalysed to the dismissal of the case investigated

CONSOB Commissione Nazionale per le Società e la Borsa

S.A.I.Vi.M.:
THE PROBABILISTIC PROCEDURE FOR MARKET ABUSES DETECTION