Inside insider trading

To enforce insider trading laws, securities regulators need techniques both to detect insider trading if it occurs and determine the extent of possible sanctions. Marcello Minenna examines current approaches to the problem and presents a new probabilistic methodology particularly suited to illiquid markets

This article proposes a new probabilistic methodology to analyse insider-trading cases and calculate the proper amount of disgorgement, ie, the amount the insider should have to pay in order to relinquish (or disgorge) his capital gain from taking advantage of preferential information. This new methodology is an improvement on previous methodologies because it can easily be applied to all insider-trading schemes and is able to discriminate between insiders and followers (ie, tippees and other insiders).

According to Bhattacharya & Daouk (2000), only 87 out of 103 countries that have a stock market prohibit insider trading and only 38 enforce their laws against this crime. This partly results from differences in opinion about insider trading, which are reflected in the financial literature. One view contends that, since insider trading is a victimless crime, a ban on it reduces market efficiency. In fact, the insider, by carrying out his strategy, pushes the stock price faster towards the value that better reflects the fundamentals of the company (Finnerty, 1976). This is because transactions carried out by the insider move the stock price in the same direction as preferential information and, consequently, the counterpart of the insider also benefits from the insider's transactions (Herzel & Katz, 1987). Moreover, a ban means a company cannot effectively compensate managers through the exploitation of preferential information (Manne, 1966).

The opposing view states that an insider trader appropriates the value of preferential information to the detriment of other investors. This behaviour is not correct, according to the 'misappropriation' theory, because the preferential information is property of the company. Therefore, any exploitation of information carried out by a subject other than the owner, ie, the company, could be considered to be theft (Georges, 1976). As a consequence, other investors do not have the same investment opportunities as the insider and this is unacceptable according to the 'market egalitarianism' theory (Loss, 1983, and Langevoort, 1987). According to this view, making this a crime increases investors' trust in the market, and hence its integrity.[1]

Enforcing bans on insider trading implies the identification of preferential information and the calculation of disgorgement. A supervisor must accurately estimate the value of the information that the insider trader has exploited in order to evaluate the disgorgement. This estimate offers, in all legal jurisdictions punishing the crime of insider trading, a benchmark to identify the sanction to be imposed against the insider and, as such, can be considered the link between the financial and legal aspects. (In particular, in Italy the law presribes that this amount represents the value of the sanction itself.)

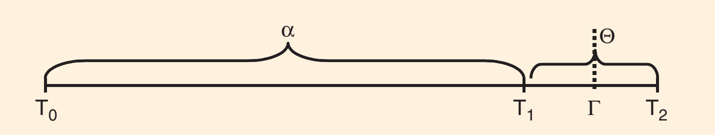
The computation of disgorgement[2]

One method adopted by supervisors to calculate disgorgement is to calculate the difference between the value of the insiders' position in the security when he disposes of it (usually after the disclosure of the preferential information) and the value of his position when he acquired it (referred to as actual disgorgement). However, this method is not effective if the insider disposes of the position well after the disclosure of the information, or if he does not dispose of it at all. In fact, in this case, the connection between the information and the insider trading may vanish.

A second method that tries to overcome these difficulties calculates a different measure, referred to as the potential deterministic disgorgement, ie, the difference between the value of the position after the disclosure of the information and the value of the position at acquisition. Yet, if the insider opens the position well before the disclosure of the information, this measure of disgorgement may be affected by events unrelated to the trading.

To deal with these problems, the US Securities and Exchange Commission (SEC) typically uses a methodology based on event studies[3], referred to as potential econometric disgorgement. The calculation of this measure is based on the relationship between the return on the security and the return on a reference market index.

1. Potential econometric disgorgement: time horizons definition



Potential econometric disgorgement

The SEC methodology, as described in Mitchell & Netter (1994), assumes that (see figure 1): Γ is the time when the insider information is disclosed to the market; α is the time horizon prior to Γ that is used to estimate the model parameters ($\alpha = T_0 \rightarrow T_1$); and Θ is the time horizon that contains the event Γ and is used to test the significance of the regression model estimated for the period α ($\Theta = T_{1+1} \rightarrow T_2$).

The statistical model commonly applied to the analysis is the market model, which explains the relationship between the returns of the stock under investigation (ie, R) and the market portfolio (ie, R_m) through a linear regression model:

$$\underset{\alpha x1}{R} = \underset{\alpha x1}{R_m}\underset{2x1}{\beta} + \underset{\alpha x1}{\varepsilon}$$

The parameters are estimated by ordinary least squares for the period α. This relationship will then be used as a statistical basis to identify the abnormal returns in the period Θ. In fact, using the regression model, the residuals ε represent the random variable, defined as AR, to be used to estimate the abnormal returns, ie:

$$\underset{\alpha x1}{AR} = \underset{\alpha x1}{\varepsilon} = \underset{\alpha x1}{R_m}\underset{2x1}{\beta} - \underset{\alpha x1}{R}$$

The random variable AR is normally distributed with mean equal to zero and variance equal to σ^2.

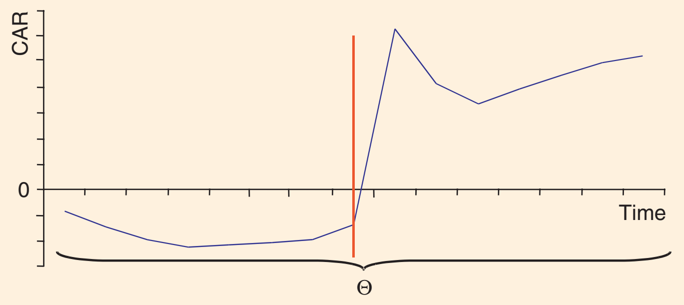
By standardising AR we get a statistic – standardised abnormal return (SAR) – that enables us to test the level of abnormality in the period Θ with respect to the relation identified by the market model in the period α.[4] Specifically, since the mean of the SAR is equal to zero by construction, the violation of its distribution property, ie, $E(SAR) \neq 0$, will coincide with the rejection of the model in period Θ. This means that the disclosure of the inside information that occurred in period Θ has determined an abnormality level in the return of the investigated stock. The test is then defined as follows:

[1] *The 'market integrity' theory states that the insider trader damages the market, particularly its microstructure. This damage occurs in two main ways: as a chain reaction involving the market-makers' and investors' trading, and with regard to the investment decisions of institutional investors (King & Roell, 1988, Bhattacharya & Daouk, 2000, and Milia, 2000)*

[2] *For further details on the sanctions definition, see Minenna (2000)*

[3] *The first publication on the event-study methodology dates back to 1933 (Dolley). Other important contributions include Fama* et al *(1969) and Copeland & Weston (1992)*

2. Potential econometric disgorgement: cumulative abnormal returns



☐ H_0: $E(SAR = 0)$ => the inside information does not determine abnormal returns.
☐ H_1: $E(SAR \neq 0)$ => the inside information determines abnormal returns.
To wholly represent the abnormality of the return over the period of analysis, the random variable cumulative abnormal return (CAR) needs to be defined. The CAR is given by the sum of the potential abnormal returns observed in the period Θ:

$$CAR = \sum_{j \in \Theta} AR_j$$

The graphical representation of this random variable, with respect to time, offers a clear and straightforward test of the abnormality of the returns over the period Θ (see figure 2).

The line that represents the CAR, after the event occurred (indicated by the vertical line), moves far from zero, increasing over time according to the value of the event and to its impact on the stock return.

Calculating disgorgement consists of multiplying the cumulative abnormal return by the quantity involved in the insider transactions (Θ) valued at the current price (P_Γ):

$$Disgorgement = CAR \times P_\Gamma \times Q$$

Problems

Although the SEC's methodology represents an improvement in disgorgement estimation, it presents some drawbacks that can reduce its applicability to some insider trading cases. More specifically:
☐ The methodology requires time-series data that is not available if the company has only recently been listed on a stock exchange (eg, only five days before).
☐ The insider-trading investigation is subordinated to the determination of a statistically significant reference index, which plays the role of a market portfolio proxy.[5] While this approach would be difficult to implement in any financial market, in the case of the Italian market the presence of a large number of thinly traded stocks severely hampers the implementation of the model. Moreover, the fact that there are some stocks that account for the bulk of the market reference index can cause the regression analysis to appear to be statistically meaningful when it is really meaningless.[6]
☐ The choice of a long time horizon could include events that changed the company capital structure, such as mergers, acquisitions, regulation variation, etc. In this case, data harmonisation techniques may help, but sometimes these can be difficult to implement and lead to bias and spurious results.
☐ This methodology requires the testing of all the hypotheses related to a linear regression model.[7] If those hypotheses cannot be verified, the results can be invalid or lead to inevitable methodological problems.[8]
☐ Rumours relating to the stock could generate spikes in the returns during the period α (the reference time for the estimate).
☐ The event-study methodology applied to insider trading estimates the future stock returns by a linear regression model. Therefore, it relies on the weak assumption that the returns on a narrow interval Θ are generated by the same linear model coming from a set of information belonging to a definitely wider time window α.
☐ The methodology calculates only one cumulative abnormal return in relation to the preferential information. By doing so, it does not take into account differences in the trading strategies of insiders that usually represent differences in their knowledge of the preferential information.

Potential probabilistic disgorgement

To overcome these problems, I propose a probabilistic approach that simulates the time stock trend through a stochastic differential equation. I refer to the resulting measure as potential probabilistic disgorgement. I will show that this methodology allows for the discovery of the economic value of the information exploited by each insider. Moreover, this approach calculates disgorgement through the analysis of the entire future price scenario by assigning to each insider a suitable probability measure, on the basis of the insider's strategy.

The stochastic differential equation adopted is the geometric Brownian motion applied by Black & Scholes (1973) to their option-pricing model[9]:

$$dS_t = \mu S_t dt + \sigma S_t dW_t \tag{1}$$

This model assumes that the stock price S is characterised by a stochastic process as shown by the diffusion equation (1).[10] This equation admits a strong solution S_t with initial condition S_s:

$$S_t = S_s e^{\left(\frac{\mu - \sigma^2}{2}\right)(t-s) + \sigma(W_t - W_s)}$$

where $s \leq t$, which describes the price fluctuations of the single stock S over time.[11]

Our model assumes that:
☐ The insider cannot control what happens to the stock price dynamic before the event (ie, the insider is a price-taker). This is mainly because the insider wants to hide his insider-trading strategy.[12]
☐ The insider builds his operative strategy (portfolio) during the period α (ie, before the disclosure of information) by creating a long (short) position in the stock if the event has a bullish (bearish) effect on the stock trend.

This methodology, like event-study analysis, identifies two time hori-

[4] *Ignorance of the value of σ^2 in the period Θ calls for the use of an estimator S^2. The estimator to be used is simply the variance estimator connected with the fitted prediction in the period Θ, using the parameters determined in the period α. The single element of the vector S^2 is determined as follows:*

$$S_i^2 = \frac{\sum_{j \in \alpha} \varepsilon_i^2}{n-2} \left(1 + \frac{1}{N} + \frac{\left(E(R_m) - R_{m_{T_1+1}} \right)^2}{\sum_{i \in \alpha} \left((R_{m_i}) - E(R_m) \right)^2} \right)$$

It is clear that the distribution of the SAR is t-student with α – 2 degree of freedom
[5] *Take, for example, the case of newly regulated markets where the market index does not exist during an initial phase, as only one or, preferably, a limited number of companies are listed. Once again, there are not enough data points to apply this econometric methodology*
[6] *It may be possible to overcome this problem by excluding the subject security from calculation of the reference market index*
[7] *For further details on these statistical measures, see Neter* et al *(1996) and Greene (1993)*
[8] *For example, the 120-day time horizon may not be sufficient for the time-series analysis to eliminate serial correlation phenomena. If this is so, some procedure such as the first difference of returns should be implemented, but there is no certainty that this technique would also be effective for the period Θ*
[9] *For further details, see Musiela & Rutkowski (1997)*
[10] *This equation benefits from the strong Markov property, which is consistent with the weak form of market efficiency and complies with the normality probability distribution of the logarithmic stock returns*
[11] *With this solution, it is possible to simulate the path that the single stock will follow in the future using just the current position of the stock itself and hypothesising a stock return increase rate equal to $\mu - \sigma^2/2$ and a dispersion in this rate quantified in the parameter σ*
[12] *However, this hypothesis is not a necessary condition for the working of the model. In fact, our model does not require any hypotheses on the kind of competition between operators. Operators (and insiders) could be price-makers or price-takers*

zons α and Θ, but it defines them in a different way. α is defined as the period when the insider builds his position on the stock, ie, α starts with the first insider transaction and ends with the last one before the spreading of the preferential information.[13] In other words, α is the period that contains all the insider-trading days. As a consequence, it differs according to the trading strategy of each insider. Moreover, it is no longer a continuous time period, since the model considers only the insider-trading days and discards the other market transactions. Θ is defined as the time horizon that starts from the day when the preferential information is disclosed and ends the first, second or the nth day later, according to the liquidity of the stock under investigation (see figure 3).

μ and σ are the mean and the standard deviation of the stock prices of the insider transactions in the period α.[14] The methodology uses these parameters filtered by the diffusion equation to estimate the stock price dynamic after the disclosure of the preferential information (ie, after the period Γ). The main feature of the model is its ability to filter the insider's operativity. In other words, the diffusion process determines the price bound by using prices and quantities that constitute the insider-trading strategy. This implies that if the insider trades the stock at almost identical prices, the model will adopt a null drift and a very low volatility.

This forecast develops, in every nth day of the period Θ, through an oscillation band for the prices of the stock, as follows[15]:

$$\Delta\hat{P}_n(\Theta) = \left[P_0^{\alpha} e^{\max}, P_0^{\alpha} e^{\min}\right]$$

where:

$$\max = \sigma z_x \sqrt{n} + \left(\mu - \frac{\sigma^2}{2}\right)n, \qquad \min = \sigma(-z_x)\sqrt{n} + \left(\mu - \frac{\sigma^2}{2}\right)n$$

P_0^{α} is the average price of the stock, weighted for the traded quantity, in the insider portfolio before the event information; and z_x is the value of the density function of a standard normal random variable. In other words, z_x determines the percentage of price evolution scenarios included in the price band.[16]

The abnormal return is defined as the difference between the actual stock price after the time Γ (ie, in the period Θ) and this estimate $\Delta\hat{P}_n(\Theta)$. In mathematical terms, it is:

$$AR_n^{\Theta} = \left(P_0^{\Theta}\right)^{-1} \max\left[0, sign\left(P_n^{\Theta} - P_0^{\Theta} e^{\max}\right) sign\left(P_n^{\Theta} - P_0^{\Theta} e^{\min}\right)\right]$$
$$\min\left[\left|P_n^{\Theta} - P_0^{\Theta} e^{\min}\right|, \left|P_n^{\Theta} - P_0^{\Theta} e^{\min}\right|\right]$$

(The sign function gives back 1(–1) if its content is positive (negative).) To wholly represent the abnormality of the return, as well as the econometric procedure, we define the random variable CAR given by the sum of the potential abnormal returns observed in the period Θ:

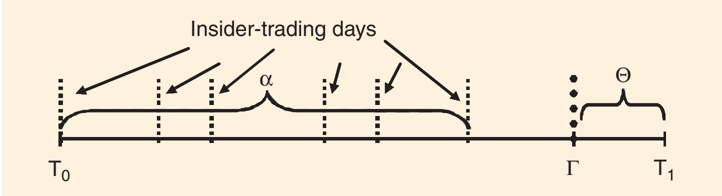
$$CAR^{\Theta} = \sum_{j \in \Theta} AR_j$$

The disgorgement estimate is simply calculated as the quantity involved in the insider trading, valued at price P_0^{α}, multiplied by the CAR:

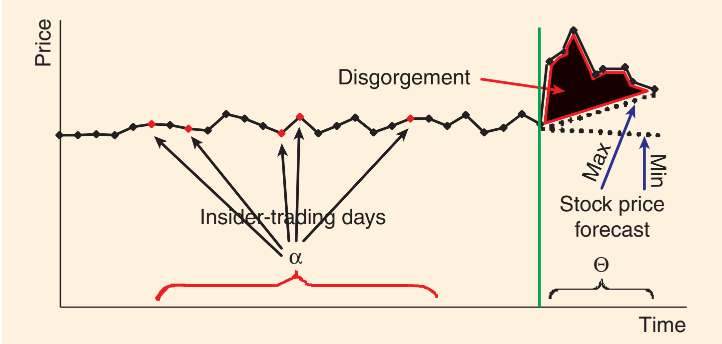
$$Disgorgement = CAR^{\Theta} \times P_0^{\alpha} \times Q^{\alpha}$$

so that the price band will be very narrow and the model returns a disgorgement value unless the stock price after the disclosure of the preferential information is very close to the prices that compose the insider portfolio. In fact, if the information is not price-sensitive, it is not insider trading. Vice versa, if an insider's portfolio includes high price volatility, the price band will be wider, and the model will return a disgorgement value only if the information is very influential on stock prices. This is correct because high volatility in the trader's portfolio prices means great uncertainty and, in this case, the law requires a prudent evaluation. In other words, the rationale behind the model is that, provided that the stock price weighted average of the insider portfolio is lower than the stock prices after the disclosure of the information, the model will calculate a disgorgement value.

3. Potential probabilistic disgorgement: time horizons definition



4. Potential probabilistic disgorgement: a graphical representation



The higher the portfolio price volatility, the lower the disgorgement.

Figure 4 summarises the key steps of the procedure. The insider will profit if the disclosure of the information leads to higher prices than those in the insider's portfolio. Consequently, if the insider profits based on his calculation of μ and σ in the period α, to correctly calculate the stock price dynamic and quantify the insider-trading disgorgement these parameters must be incorporated into our probabilistic model.

More formally, the model defines a probability measure Q in a continuous trading economy with a finite horizon $t \in \alpha$. The uncertainty in this economy is classically modelled by a complete probability space (Ω, F, Q) and it depends on the parameters defined by the trading strategy of the insider. This value evolves according to the augmented filtration $\{F_t, t \in \alpha\}$ generated by a one-dimensional geometric Brownian motion $(S_t)_{t \in \alpha}$. The insider will profit if the disclosure of information at time Γ leads stock prices, through the parameters filtration realised by the diffusion equation, to oscillate more during the period Θ than during the period α.

Since the model estimates the future price stock dynamic by using the trading strategy of the insider, it calculates different stock price forecasts and consequently different disgorgement estimates for different trading strategies.

By construction, this model attributes a higher disgorgement to the insider who has the better strategy, meaning the strategy that generates the smallest σ.

To better represent this point, we can compare two different insiders' strategies. Specifically, we assume that both insiders have the same strategy for the first trade, ie, they purchase the same number of shares at the

[13] This definition does not necessarily refer to the last exchange transaction on the day before the disclosure of the information, because the last stock transaction carried out by the insider could also occur some time before the disclosure of the preferential information
[14] It is clear that the stock prices are weighted for the quantity of shares effectively dealt with by the insider
[15] Where there is only one insider trade, the band becomes just a line. In other words, the probabilistic computation becomes deterministic. Consequently, there is no longer a confidence interval and the disgorgement becomes the potential deterministic disgorgement
[16] For instance, $|z_x|$ = 1.96 means that the band will include 97.5% of all the possible price scenarios. In real cases, the Italian enforcement officer will apply the 99% computation. This is due to the conservative disgorgement computation required by the Italian legislator. However, given that we assume the Θ period is short, the choice of adopting 97.5% rather than 99% does not influence the final results of the model

same price. Later, one insider does no more trading, but the second continues to buy more shares for several days. We have to distinguish two cases:
- The second insider buys more shares but at lower (or equal) prices than in the first trade (ie, the one that is equal for the both the insiders). In this case, the disgorgement will be higher for the second insider.
- The second insider buys more shares but at higher (or equal) prices than in the first trade (ie, the one that is equal for both insiders). In this case, the disgorgement will be lower for the second insider.

In other words, the model gives value to the volatility included in the insider portfolio. The higher the volatility, the higher the risk the trader undertakes and the lower should be the disgorgement inflicted. Trading volatility becomes a sort of proxy variable of the certainty of the value of the information the insider owns through defrauding other investors.

It is assumed that whoever is closer to the information will have the more profitable strategy. Hence, the model is able to distinguish between insiders and tippees. More precisely, the filtration $\{F_t, t \in \alpha\}$ governing the stock price dynamics will continuously represent the insider's closeness to the preferential information. In particular, the more precise the information the trader possesses, the more likely he will choose an α time period, which will allow him to implement an optimal trading strategy. Hence, the filtration $\{F_t, t \in \alpha\}$ will be reflected in the parameters governing the stock price stochastic differential equation in the latter period Θ, ensuring minimal volatility (ie, maximal potential probabilistic disgorgement) to the insider who has complete and immediate access to preferential information. The best strategy for the model is the one that defines the probability space (Ω, F, Q) with lowest drift $\mu - \sigma^2/2$ and lowest dispersion rate σ.

Advantages of the potential probabilistic disgorgement

The advantages of the probabilistic approach are:
- The definition of the parameters is extremely realistic and robust, since it represents the insider-trading strategy in the period α on the stock under investigation. Consequently, the model is able to fit the trading strategy of each insider. Moreover, the possible market noises affect the model as long as these affect the insider transactions. By doing so, the probabilistic disgorgement will exactly represent the effectiveness of the insider-trading strategy according to the value of the preferential information.
- The model is valid independently of the fact that the stock refers to a company that has been recently listed on the stock exchange or is affected by liquidity issues, the discontinuity of the time series and other classical econometric problems. If the insider can trade the stock, the procedure can return a parameters estimation, and therefore an abnormal return computation and eventually a disgorgement figure.
- The stock path forecast depends only on the prices of those transactions included in the insider portfolio and its determination is subject to a predictive dynamic logic.
- The peculiar parameters estimation procedure enhances the flexibility of the model by offering a customised methodology applicable to individual cases. By assuming that the insider who is closer to the information will have the more profitable trading strategy, the model gives a higher disgorgement to the subjects who are closer to the preferential information and therefore it is able to distinguish between insiders and followers (ie, tippees and other insiders).

Conclusion

The quantitative methodology used to measure disgorgement determines the sanction imposed against insider traders. This study has analysed the different methodologies used in this field and explained why calculating disgorgement by the traditional method does not work, as the insider strategy cannot be easily reduced to a simple scheme. Although the SEC's econometric procedure represents an improvement, it has some structural weaknesses that can invalidate it. It requires both long time-series data and a statistically robust regressor. In this article, I have proposed a new probabilistic methodology to analyse insider-trading cases that calculates disgorgement by incorporating the stock price into the insider-trading strategy. This methodology is very robust from the statistical viewpoint and, unlike the econometric procedure, can be easily generalised to take into account all sorts of insider-trading schemes. Moreover, the proposed approach overcomes the problems affecting the traditional event-studies methodology, such as the identification of the market proxy portfolio, the need for long time-series datasets, the temporal stability of the regression parameters, and the consistency of the linearity and deterministic relation among the variables of the model.

Finally, the proposed approach is able to identify a specific disgorgement for each insider according to his trading strategy, instead of applying, as in the econometric approach, one unique value (ie, the CAR) for all the insiders related to the same preferential information. This new methodology is used by Consob (the Italian securities and exchange commission). ■

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